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ORIGINAL ARTICLE

Using the theory of planned behaviour to determine radiation protection among South African diagnostic radiographers: a cross-sectional survey

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Abstract

Introduction: The use of ionising radiation in medicine accounts for the majority of radiation exposure from artificial sources. Therefore, all measures to safeguard against unnecessary radiation exposure must be taken. As radiographers are central to radiation protection, this study aimed to determine South African radiographers' attitude towards radiation protection, subjective norm and perceived behavioural control concerning radiation protection. **Methods:** This quantitative cross-sectional study used an online theory of a planned behaviour radiation protection questionnaire shared through social media platforms from August 2019 to February 2020. Diagnostic radiographers registered with the Health Professions Council of South Africa and employed at radiology departments in South Africa were invited to participate in the study. **Results:** Four hundred and seventeen radiographers in South Africa responded to the questionnaire. The majority of respondents (90%, $n = 376$) plan to use radiation protection; however, only 16% continuously used radiation protection in the past. Respondents felt that using radiation protection was extremely good (72.2%), pleasant (47%), beneficial (74.1%), rewarding (55.2%) and worth the time (52.5%); 57% of respondents indicated that using radiation protection takes longer to complete the examination. Respondents report that approval from patients (43.5%), patients' family (32%), radiographer coworkers (31%), radiology managers (47%) and radiologists (43.9%) is very much important to them. **Conclusion:** The study shows that even though fewer respondents use radiation protection at present, most respondents plan and intend to use radiation protection measures. Respondents felt that radiation protection was good and beneficial, with some respondents feeling that radiation protection is not worth the time, which coincide with lengthening the examination. Overall, South African radiographers' attitudes towards radiation protection, subjective norm, perceived behavioural control and radiation protection intention were high.

INTRODUCTION

A century after the discovery of X-rays, the use of ionising radiation (hereafter referred to as radiation) in medicine accounts for the majority of radiation exposure from artificial sources.[1] Therefore, all measures to safeguard against unnecessary radiation exposure must be taken.[2] Consequently, radiation protection in medicine encompasses all steps to keep the radiation exposure to patients, radiation workers, staff and the public as low as reasonably achievable.[2] Diagnostic radiographers (hereafter referred to as radiographers) are central to

radiation protection and are responsible for the radiation exposure a patient receives.[3] The energy of the X-ray beam and how much and for how long that X-ray beam is used are selected by the radiographer performing the X-ray examination.[3] Optimal radiographic technique and positioning are also the responsibility of the radiographer. However, incidents of using the wrong protocols and imaging the wrong site and side of patients have been reported.[4] Exposure creep was observed in an ethnographic study when radiographers did not adjust exposure factors and selected exposure factors higher than necessary.[5]

In South Africa, Modiba reported that 29% of radiographers in the study indicated using radiation protection on patients.[6] Likewise, a retrospective evaluation of 100 pre-processed neonatal chest X-rays revealed that 77% were not collimated optimally.[7] Other studies in Gauteng, South Africa, revealed that only 33% of radiographers knew the function of exposure indicators[8] and a quarter of patients received more radiation exposure than was necessary to produce a diagnostic radiograph.[9] However, the reasons for South African radiographers' radiation protection behaviour remains largely unexplored.[7,8,10–12] The theory of planned behaviour posits that behaviour depends mostly on the intention to perform a behaviour.[13] Therefore, the theory of planned behaviour formed the theoretical framework of the study.

Intention to perform a behaviour depends on three constructs: attitude towards a behaviour, subjective norm and perceived behavioural control.[13] Attitude towards a behaviour depends on behavioural beliefs and the subjective probability of the outcome of that behaviour. When evaluating the outcome of a behaviour, a person who believes the outcome to be positive and in their own judgement more probable to occur places greater importance on the outcome and, thus, will most likely intend to perform the behaviour.[13] Subjective norm is based on normative beliefs. Normative beliefs are an individual's belief that society, either an individual or a group that is perceived as being important, believe they should or should not perform a behaviour (also known as social pressure).[13] Perceived behavioural control is based on control beliefs and influences both intention and behaviour. Perceived behavioural control takes into account the potential constraints on the action as perceived by the individual and their confidence in performing the behaviour.[13] The aim of the study was to determine South African radiographers' attitude towards radiation protection, subjective norm and perceived behavioural control concerning radiation protection. For the purpose of this study, radiation protection considered all aspects that justify, optimise and limit exposure of ionising radiation to patients, radiation workers, health care workers and the public during general, computed tomography, fluoroscopy, theatre and bedside unit/mobile imaging.

METHODS

This quantitative cross-sectional study administered an online questionnaire using the QuestionPro platform and shared it through South African radiography Facebook and WhatsApp groups from August 2019 to February 2020. Questionnaires were completed anonymously, and no incentives were offered for responses to the study. The questionnaire asked respondents to confirm if they were South African radiographers currently employed in South Africa. Once respondents agreed, informed consent was assumed, and they could begin to answer the questionnaire. The population consisted of 6552 South African diagnostic radiographers registered with the Health Professions Council of South Africa (HPCSA) and who worked at South African radiology departments at the time of data collection.[14] The questionnaire used in the study was developed by Boyd to predict radiographers' radiation protection and digital radiography behaviour using the theory of planned behaviour.[15] Permission to use the questionnaire was obtained from Boyd.[15] As the questionnaire was developed within an American context, 'radiologic technologist' was changed to radiographer and demographics of the job role, place of employment and size of the hospital was amended to reflect the South African context. The questionnaire consisted of eight sections. Section A obtained demographic and general information required for the study, and B examined intentions and past behaviour. Intention was explored using three statements: I plan to use radiation protection practices in X-ray examinations; I will make an effort to use radiation protection practices in X-ray examinations, and I intend to use radiation protection practices in X-ray examination with a seven-point rating scale. Past intention was explored with a single question: in the past, how often have you used radiation protection practices in X-ray examinations? Sections C and D determined attitudes towards radiation protection. Sections E and F explored the subjective norm, and G and H studied perceived radiation protection behaviour control. The data collected from the online questionnaire were analysed by a statistician using IBM SSPS version 27. Preliminary statistical analysis of the quantitative diagnostic phase involved descriptive statistics of the various constructs.

The reliability of the questionnaire was determined using Cronbach's alpha[16] and validity using factor

analysis. Table 1 demonstrates Cronbach's alpha scores obtained in the current study together with Cronbach's scores of the original theory of planned behaviour radiation protection questionnaire.[15,16] An acceptable level is greater than 0.7.[17] The internal consistency of the questionnaire of the current study aligns with the original questionnaire.[15] As the questionnaire was adopted, a pilot study was conducted by sharing the study information letter with five retired radiographers to review the study information letter and the online questionnaire as well as to trial the online platform. The study received ethical clearance from the University of Johannesburg Faculty of Health Sciences Research Ethics Committee (REC-01-28-2019).

RESULTS

The response rate for the study was 6.4% (417/6552). However, of the 417 responses, 368 questionnaires were completed in full, with no missing data. Using Krejcie and Morgan's[18] sample size formula, 368 responses for a population of 6552 allow for a 95% confidence level and 5% margin of error. The 20–29 year age group (221, 53.0%) constituted the majority of the respondents. A total of 215 (51.6%) of the respondents reported that they planned to use radiation protection; 16.3% of respondents indicated that they always used radiation protection in the past.

Attitude towards radiation protection

Respondents reported their behavioural beliefs of using radiation protection as good (301, 72.2%), pleasant (196, 47%), beneficial (309, 74.1%), rewarding (230, 55.2%) and worth the time (219, 52.5%). Subjective probability, displayed in Table 2, was determined by radiographers' perception of the likelihood and importance of the outcome of using radiation protection.

Table 1. Cronbach's alpha scores for current and original study.[18]

Factor	Cronbach's alpha (good =≥ 0.7)	
	Current study	Original study (Boyd, 2013:81,82)
Scale: Intention to use (1-3) radiation protection practices	0.913	0.916
Scale: Attitude: direct	0.904	0.824
Scale: Attitude: indirect	0.502	0.383
Scale: Social pressure/norms: direct	0.537	0.549
Scale: Social pressure/norms: indirect	0.851	0.797
Scale: Perceived behavioural control: direct	0.300	0.117
Scale: Perceived behavioural control: indirect	0.408	0.420

Subjective norm

Normative beliefs were assessed directly by five statements, as seen in Tables 3 and 4. Direct measurement of subjective norm explored radiographers' perception of opinions of individuals they consider important.

Normative beliefs were assessed indirectly by radiographers' perception of patients', patients' family, coworkers', radiology managers' and radiologists' expectations of their radiation protection practices (Table 5). Normative beliefs were also assessed indirectly by radiographers' perception of the importance of patients', patients' family, coworkers', radiology managers' and radiologists' approval of practising radiation protection (Table 6).

Perceived behavioural control

Perceived behavioural control directly revealed that 296 (71.6%) of respondents strongly agreed that they were confident in their own ability to use radiation protection, 181 (43.4%) of respondents strongly agreed that whether they use or do not use radiation protection was entirely up to them, 96 (23.1%) strongly agreed that using radiation protection is beyond their control, 281 (67.7%) of respondents believed that it is possible to use radiation protection. Perceived behavioural control indirect through likelihood indicated that almost 45% of the respondents reported that getting the examination done takes priority over other considerations in trauma or challenging situations. Perceived behavioural control indirectly through agreement indicated the overall universal agreement that practising radiation protection would be easier if some elements/factors were available, such as availability of lead rubber shields, recognition in

Table 2. Subjective probability.

Using radiation protection	Likelihood *n* (%)	Extremely important *n* (%)
Will reduce the patients' exposure to harmful radiation.	317 (76.2%)	335 (80.3%)
I can be a positive role model to other radiographers.	292 (70.5%)	271 (65.1%)
I will be doing something ethical/moral.	342 (82.2%)	345 (82.7%)
I will take longer to complete exams.	80 (19.3%)	87 (20.9%)

Table 3. Subjective norm (normative beliefs) direct.

Variable	Frequency (percentage) *n* (%)	Variable	Frequency (percentage) *n* (%)
Most people who are important to me think that		Most people in my role who are radiographers, use radiation protection practices in X-ray exams	
I should not use radiation protection practices in X-ray exams	13 (3.1%)	Unlikely	34 (8.2%)
2	5 (1.2%)	2	39 (9.4%)
3	6 (1.4%)	3	61 (14.6%)
4	45 (10.8%)	4	73 (17.5%)
5	63 (15.1%)	5	90 (21.6%)
6	72 (17.3%)	6	54 (12.9%)
I should use radiation protection practices in X-ray exams	213 (51.1%)	Likely	66 (15.8%)

the form of awards for compliance and working in a department that promotes safety culture.

DISCUSSION

The aim of the study was to determine South African radiographers' attitude towards radiation protection, subjective norm and perceived behavioural control concerning radiation protection. Respondents' intention to use radiation protection is discussed first, together with an exploration of past use of radiation protection. Thereafter, a discussion of attitude towards radiation protection, subjective norm and perceived behavioural control will follow.

Respondents' intention to use radiation protection is higher than their past use of radiation protection. Azjen[13] explains that behavioural intention is the intention to try to perform a certain behaviour; therefore, not all intentions are carried out. Even though respondents may intend to use radiation protection, their self-reported past actions indicated contrary action. The use of radiation protection may be hindered because respondents reported they felt rushed when using radiation protection practices in X-ray examinations and trauma or challenging situations; getting the examination done takes priority over other considerations. Furthermore, respondents reported that the availability of lead rubber shields, recognition in the form of awards for compliance and working in a department that promotes a safety culture would aid in radiation protection compliance. Resource distribution in the South African health sector varies from well-resourced to under-resourced.[19,20] The resource disparities may result in using imaging available, rather than imaging that exposes patients to the least ionising radiation.[20] The past use of radiation protection reported in the current study aligns with findings in a South African Limpopo study where only 29% of radiographers indicated using radiation protection on patients.[6] A South African study found that a quarter of patients received more radiation exposure than was necessary to produce a diagnostic radiograph.[11] Likewise, a retrospective evaluation of 100 pre-processed neonatal chest X-rays revealed that 77% were not collimated optimally.[7] A South African study explained that radiation protection practices were lacking because radiation is invisible, and effects possibly occurring later in life.[21] Similarly, an Iranian study showed that the majority of radiographers had a weak or moderate performance of radiation

Table 4. Subjective norm (normative beliefs) direct.

Variable	Disagree Frequency (percentage) *n* (%)	2 *n* (%)	3 *n* (%)	4 *n* (%)	5 *n* (%)	6 *n* (%)	Agree *n* (%)	Missing *n* (%)
It is expected of me that I use radiation protection practices in X-ray exams.	8 (1.9%)	4 (1%)	8 (1.9%)	16 (3.8%)	23 (5.5%)	54 (12.9%)	303 (72.7%)	1 (0.2%)
I feel under social pressure to not use radiation.	189 (45.3%)	29 (7%)	23 (5.5%)	54 (12.9%)	47 (11.3%)	29 (7%)	46 (11%)	0
People who are important to me want me to use.	11 (2.6%)	10 (2.4%)	16 (3.8%)	61 (14.6%)	52 12.5%)	74 (17.7%)	193 (46.3%)	0

Table 5. Subjective norm, indirect: expectation.

Variable	I should not use radiation practices *n* (%)	2 *n* (%)	3 *n* (%)	4 *n* (%)	5 *n* (%)	6 *n* (%)	I should use radiation protection practices *n* (%)
My patients who come in for an X-ray think	12 (2.9%)	3 (0.7%)	14 (3.4%)	173 (41.5%)	55 (13.2%)	44 (10.6%)	116 (27.8%)
The family of my patients think I	12 (2.9%)	4 (1.0%)	8 (1.9%)	150 (36.1%)	58 (13.9%)	49 (11.8%)	135 (32.5%)
My radiographer coworkers	13 (3.1%)	3 (0.7%)	8 (1.9%)	66 (15.9%)	40 (9.6%)	65 (15.6%)	221 (53.1%)
My radiology manager	10 (2.4%)	3 (0.7%)	4 (1.0%)	44 (10.6%)	21 (5.0%)	45 (10.8%)	289 (69.5%)
The radiologists	10 (2.4%)	4 (1.0%)	3 (0.7%)	101 (24.4%)	24 (5.8%)	41 (9.9%)	231 (55.8%)

Table 6. Subjective norm, indirect: importance.

Variable	Not at all *n* (%)	2 *n* (%)	3 *n* (%)	4 *n* (%)	5 *n* (%)	6 *n* (%)	Very much *n* (%)
My patients approval of my radiation protection practices is important to me.	26 (6.3%)	4 (1.0%)	20 (4.8%)	51 (12.3%)	62 (14.9%)	72 (17.3%)	181 (43.5%)
The approval of the patients family is important to me.	50 (12.0%)	9 (2.2%)	36 (8.7%)	75 (18.1%)	62 (14.9%)	50 (12.0%)	133 (32.0%)
The approval of my radiographer coworkers is important to me.	62 (14.9%)	16 (3.8%)	24 (5.8%)	79 (19.0%)	51 (12.3%)	55 (13.2%)	129 (31.0%)
The radiology managers approval is important to me.	36 (8.7%)	8 (1.9%)	18 (4.3%)	40 (9.6%)	52 (12.5%)	66 (15.9%)	195 (47.0%)
The radiologists approval is important to me.	39 (9.4%)	12 (2.9%)	26 (6.3%)	61 (14.7%)	45 (10.8%)	50 (12.0%)	182 (43.9%)

protection.[22] Studies in Northern Nigerian[23] and California[24] also indicated poor radiation protection practices. However, a Yobe, Nigerian study showed radiographers had an overall high adherence to radiation protection practices.[25]

The majority of respondents demonstrated a positive attitude towards radiation protection was radiation protection was indicated to be good, pleasant, beneficial, rewarding and worth the time. These responses reflect radiography education that encompasses principles of radiation protection. Higher education institutions in South Africa that offer radiography education, guided by the HPCSA practice standards, are bound by the qualification exit-level outcomes outlined by the South African Qualifications Authority. Among the outcomes are the justification of practice, optimisation of protection, dose limitation principles, radiation protection and radiation safety awareness and practice.[26] Radiographers in South Africa are guided by the HPCSA's ethical guidelines for healthcare professionals of non-maleficence and the moral obligation to adhere to the duties and responsibilities of a qualified and licenced radiographer.[27] In radiography, non-maleficence encompasses adhering to principles of radiation protection, justification of practice, optimisation of protection and radiographers' role in this regard.[28–30] Similarly, Southern Californian radiographers, in general, were found to have an attitude that patient radiation protection best practices are good, pleasant, beneficial, rewarding and worth the time.[15] The majority of respondents indicated that using radiation protection reduces harmful exposure to patients, they are positive role models to other radiographers and they will be doing something ethically and morally correct. Therefore, respondents in their own judgement (subjective probability) believe that the benefits of radiation protection are likely to occur.[13] The majority of respondents' positive attitude to radiation protection in the current study was similar to 60% of health workers who had a positive attitude towards radiation protection, as was indicated in a systematic review of 41 studies conducted from 2000 to 2019 22 countries.[31] Talab

et al.[23] also found that majority of radiographers had a high attitude towards radiation protection. In contrast, a study in Tehran, Iran, found that 70.7% of medical radiation workers had a poor attitude to radiation protection.[32] Even though the majority of respondents in the current study have a positive attitude to radiation protection, just over half of the respondents indicated that using radiation protection will take longer to complete the examination and only 16.3% of respondents reported always using radiation protection in the past.

Normative beliefs are beliefs underlying subjective norms.[13] Normative beliefs are radiographers' belief that patients, patients' families, coworkers, radiology managers and radiologists think they should or should not practice radiation protection. In the current study, respondents felt that people who are important to them thought they should and would want them to practice radiation protection. Most of the respondents reported that patients who came in for X-ray examinations and their families, radiology managers and radiologists were aware that radiographers should practice radiation protection. In addition, respondents also valued the approval of their patients, family members of patients, coworkers and radiology managers for practising radiation protection. Therefore, most respondents felt that patients, patients' families, coworkers, radiology managers and radiologists' expectations and approval were important; hence, they have a high subjective norm.

Even though the majority of respondents in the current study perceive that patients who come in for an X-ray think they should use radiation protection, the knowledge of ionising radiation of patients in a South African Limpopo province was considered sparse, as was the radiation awareness of Jordanian patients.[6,33] Also, the majority of patients responding to a survey in Milan indicated not knowing which imaging examination used radiation.[34] These findings are confirmed by Ribeiro et al.[35] who noted in their systematic review of four studies on patients' awareness, knowledge and perception of ionising radiation in medical imaging that in all studies showed that patients generally lacked awareness about radiation exposure. In contrast, a North Carolina study showed that patients were generally aware of the harmful effects of ionising radiation.[36]

The majority of respondents in the current study perceive that most radiographers use radiation protection. However, a South African study showed that only 29% of Limpopo radiographers surveyed agreed to the use of radiation protection on patients.[6] The study attributed the diminished use of radiation protection to the lack of knowledge of the hazards of ionising radiation or even radiographer negligence.[6] In the same vein, respondents in Rose et al.'s[21] South African study, acknowledged that radiation protection practices were lacking because radiation is invisible and effects may occur much later. Respondents in Rose et al.'s[21] South African study indicated that they would rather perform interventional procedures without personal protective equipment than compromise the care of patients.

Perceived behavioural control is based on control beliefs that account for perceived constraints and an individual's confidence in performing the action.[13] Therefore, because the majority of respondents in the current study felt strongly that they were confident in their ability to perform radiation protection, their perceived behavioural control would be high. Respondents' confidence in their abilities may be related to radiography higher education institutions in South Africa being bound by the qualification exit-level outcomes of justification of practice, optimisation of protection, dose limitation principles, radiation protection and radiation safety awareness and practice.[26]

Even though just half of the respondents in the current study indicated that using radiation protection was under their control, some believed that radiation protection was out of their control in some instances. Radiation protection measures in fluoroscopy, theatre and ward radiography involve patients, nurses, doctors, the public and radiographers, unlike in an X-ray room where only the radiographer and the patient or companions are considered. Providing optimal radiation protection in areas with the varying power dynamics of differently ranked medical personnel is challenging. Rose et al.'s[21] South African study noted that power disparities and 'egos' of the medical team might hinder radiation protection compliance. A similar finding was noted in an Australian study showing medical dominance as a hindrance to radiation protection.[37] Rwandan radiographers report that some clinicians do not value their input and have a 'do as I say' attitude.[38]

Overall, the respondents in the current study agreed that practising radiation protection would be easier if they worked in a department that promoted a safety culture. The International Radiation Protection Association (IRPA) provides guiding principles for establishing a radiation protection culture. Elements and traits of a radiation protection culture include a pattern of knowledge and behaviour encompassing science, values and ethics. In addition, a radiation protection culture has well-established justification, optimisation and dose limitation principles shared through training and education.[39] By embedding radiation protection at a cultural level, organisations may influence the attitude and behaviour of all stakeholders.[40] The IRPA guide suggests that institutions investigate their current radiation protection culture and then look at ways of

creating an optimal radiation protection culture entrenched at the institution's core so that radiation protection becomes a moral imperative. Hayre et al.[41] found that radiographers own beliefs, values and cultural norms towards radiation protection and risk have led to the initiation of ideologies that justify limited radiation shielding. In the current study, 46 (11%) of respondents indicated that they felt social pressure not to implement radiation protection measures, and therefore, questions are raised about the current radiation protection culture.

Limitations of the study

As the questionnaire was shared on social media platforms, it is unclear if all 6552 radiographers were reached to participate in the study. Because radiation protection is multifaceted, respondents' specific understanding of radiation protection needs to be considered. The selected sample was from South Africa but may resonate transnationally. The response rate may be considered a limitation; however, this article a single phase of a multiple phase study.

CONCLUSION

South African radiographers' intentions and attitude towards radiation protection, as well as their subjective norms and perceived behavioural control, were found to be high. However, the questionnaire's individual question responses were approximately 50% of the radiographers believing that using radiation protection is pleasant, rewarding and worth the time requires further deliberation. In the same vein, even though most radiographers believed that their radiographer coworkers use radiation protection, all radiographers not using radiation protection is concerning. Further research may consider observational studies of radiation protection practices and exploring reasons for reported behaviour.

Conflict of Interest

The authors declare no conflict of interest.

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