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Ionising radiation exposure from medical imaging – A review of Patient's (un) awareness

A. Ribeiro [a, *], O. Husson [b], N. Drey [c], I. Murray [a], K. May [a], J. Thurston [a], W. Oyen [a, b]

[a] The Royal Marsden Hospital NHS Foundation Trust, Sutton, United Kingdom
[b] Institute of Cancer Research, Sutton, United Kingdom
[c] City University of London, London, United Kingdom

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ABSTRACT

Introduction: Medical imaging is the main source of artificial radiation exposure. Evidence, however, suggests that patients are poorly informed about radiation exposure when attending diagnostic scans. This review provides an overview of published literature with a focus on nuclear medicine patients on the level of awareness of radiation exposure from diagnostic imaging.
Methods: A review of available literature on awareness, knowledge and perception of ionising radiation in medical imaging was conducted. Articles that met the inclusion criteria were subjected to critical appraisal using the Mixed Methods Appraisal Tool.
Results: 140 articles identified and screened for eligibility, 24 critically assessed and 4 studies included in synthesis. All studies demonstrated that patients were generally lacking awareness about radiation exposure and highlighted a lack of communication between healthcare professionals and patients with respect to radiation exposure.
Conclusion: Studies demonstrate a need to better inform patients about their radiation exposure, and further studies focusing on nuclear medicine patients are particularly warranted.
Implications for practice: Adequate and accurate information is crucial to ensure the principle of informed consent is present.

Introduction

Exposure to ionising radiation is inherent in daily life and the average worldwide exposure from all sources is ~3 mSv/year. Natural background radiation exposure contributes to ~2.4 mSv/year, however this can vary greatly according to location as it originates from a variety of sources such as cosmic rays, rocks and atmosphere. Medical imaging and therapeutics is the largest man made source of exposure and contributes to ~0.6 mSv/year.[1]

Diagnostic imaging and therapy have substantially improved health care services and patient outcomes over the years. Integral to diagnostic imaging is ionising radiation which is now relied on heavily for patient diagnosis and treatment.[2] Nuclear medicine diagnostic and therapeutic applications have seen an increase in the field of medical imaging, with over 625,000 diagnostic and therapeutic oncological and non-oncological procedures performed each year in England alone.[3]

Nuclear medicine involves the use of radioactive material to diagnose and treat different conditions by providing both structural and functional analysis. The use of hybrid modalities such as Single Photon Emission Tomography/Computed Tomography (SPECT/CT) and Positron Emission Tomography/Computed Tomography (PET/CT) have seen a rise in recent years, particularly in developed countries and predominantly in the oncology field, leading to an increase in the whole body annual dose of patients.[1,4] Nuclear medicine has been around for decades and despite its growth, radiation exposure derived from nuclear medicine procedures continues to be a difficult subject to explain to patients and there are different opinions on how and when such explanations should take place, and who should be communicating this to patients.[5] Often the terminology and jargon used by medical staff is not easily understood by patients which can lead to unnecessary feelings of anxiety, fear and distress.[6]

Recent studies on patient awareness and knowledge of ionising radiation exposure predominantly relate to radiology, specifically to Computed Tomography (CT)[7–11] and overall report a lack of knowledge. At present, there is limited information on

* Corresponding author.
E-mail address: ana.ribeiro@rmh.nhs.uk (A. Ribeiro).

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nuclear medicine patient's knowledge and awareness of ionising radiation.[12–15] In "Communicating radiation risks in paediatric imaging"[1] the World Health Organization (WHO) states that the lack of knowledge from healthcare professionals about radiation protection together with underestimation of doses and associated risks of different procedures is a major barrier to effective communication, which is central to patient centred care. The WHO suggests a number of strategies to improve communication with patients, carers and peers. These strategies include the use of common comparators such as X-rays or natural background radiation for each of the procedures alongside the rational of procedure chosen and the risk and benefits of potential alternatives.

Recent studies evaluating the awareness and knowledge of healthcare professionals including physicians, radiographers and nuclear medicine technologists demonstrate that there is a lack of awareness and knowledge about ionising radiation exposure.[16–21] A systematic review conducted in 2013 evaluated 14 peer reviewed articles and concluded there was a lack of knowledge among physicians with a tendency to underestimate the level of ionising radiation exposure from medical imaging, including a lack of knowledge on which imaging modalities use ionising radiation.[16] A cross-sectional questionnaire study conducted in 2010 in Hong Kong amongst medical doctors (physicians, radiologists and interns) also reported similar results. Physicians and radiologists had a tendency to underestimate radiation doses with interns underestimating the radiation dose in all questions. This study also reported that 93% of doctors would not routinely offer a discussion to patients regarding radiation exposure, and that 95% of patients would also not raise these questions themselves.[17] A focus group study in 2013[19] with clinicians demonstrated they would welcome more information and guidelines to help them to initiate discussions with patients and engage them in the informed decision-making process.

With an increase in the number of medical imaging and particularly nuclear medicine procedures, the number of studies focusing or including nuclear medicine patients to assess their awareness of radiation exposure remains unclear. This review was conducted to present an overview of the most recent evidence on patient awareness and knowledge on ionising radiation exposure from medical imaging procedures that also included nuclear medicine scans.

Methods

The review follows the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analysis Protocols (PRISMA - P) 2015 statement.[22] The literature review research question was developed using PICOS: Population, Intervention, Comparator, Outcome and Studies (Table 1), which enabled the search strategy to be developed. The results of the search are illustrated in the PRISMA flow diagram (Fig. 1).

Table 1
Population intervention comparator outcome and studies.

P-Population	Patients undergoing diagnostic imaging procedures (radiology and/or nuclear medicine procedures).
I-Intervention	Ionising radiation exposure information verbally and/or departmental leaflets.
C-Comparator	Not Applicable
O-Outcome	Obtain information on patient awareness and knowledge of ionising radiation exposure from diagnostic imaging.
S-Studies	Quantitative or Qualitative studies that include nuclear medicine patients.

Search strategy

The final search was performed on the 21st of February 2018 using the recommended databases from the Cochrane Handbook[23] Medline (EBSCO), EMBASE (OVID) and CINAHL. WEB OF SCIENCE was also used, as this is a particularly relevant database for multidisciplinary topics. Only full articles, in English from 2010 onwards were included, so that the most up to date research was accessed. The subject or the title had to include at least three of the following: Ionising radiation or radiation; patients or public; awareness or knowledge or perceptions; medical imaging or imaging; Radiology or radiologic; and nuclear medicine.

Full-texts studies identified in this way were screened; only studies that included nuclear medicine patients were selected; studies aimed at health professionals or the public in general were excluded.

The review was conducted by two reviewers (AR and OH) independently who later generated a consensus for the quality score. The review was performed with adherence to the protocol in order to minimize bias. Selected articles were critically assessed using the Mixed Methods Appraisal Tool (MMAT).[24] This particular tool was considered the best fit for the nature of the review since it is designed to critically appraise a variety of study designs.

Thematic analysis of selected studies was performed and codes were selected from results, discussion and conclusion sections of included studies. These were further developed into themes and a global theme.[25]

Results

The computerised search identified 160 articles after duplicates were removed 140 articles remained and a further 116 articles did not meet the inclusion criteria for this review (Fig. 1). Full text review for the remaining 24 articles was performed which resulted in further 20 articles excluded. Six studies relating to health professionals[16–21] and eight studies not including nuclear medicine patients.[7–11,26–28] Further six studies were also not relevant due to: i) literature review on medical imaging and exposure to ionising radiation as public health issue[29]; ii) review article on a diagnostic test itself[30]; iii) time trade-off methodology study applied to physicians[31]; iv) retrospective study evaluating radiation doses from a particular radiological procedure[32]; v) cross sectional study to analyse awareness and perception of ionising radiation applied to public only[33] and vi) a recent mixed methods study applied to the general population with no specific nuclear medicine questions.[34]

A total of four studies were selected for inclusion in the review: two mixed methods studies[12,15] were appraised using MMAT, one study[13] appraised with MMAT for quantitative descriptive studies and one qualitative study[14] appraised using the MMAT for qualitative studies. No studies applied exclusively to nuclear medicine were found, however, all studies selected included PET/CT patients. One study also included bone scan patients.[15] No meta-analysis was performed since the variation in cross sectional questionnaires, sample population, sample size, ionising radiation exposure sources and comparisons was too wide to allow a meta-analysis. The synthesis of the results is therefore descriptive.

Thematic analysis

Recurrent themes

Across the four studies, three recurrent themes were identified:

a) Lack of patient knowledge regarding ionising radiation in medical imaging

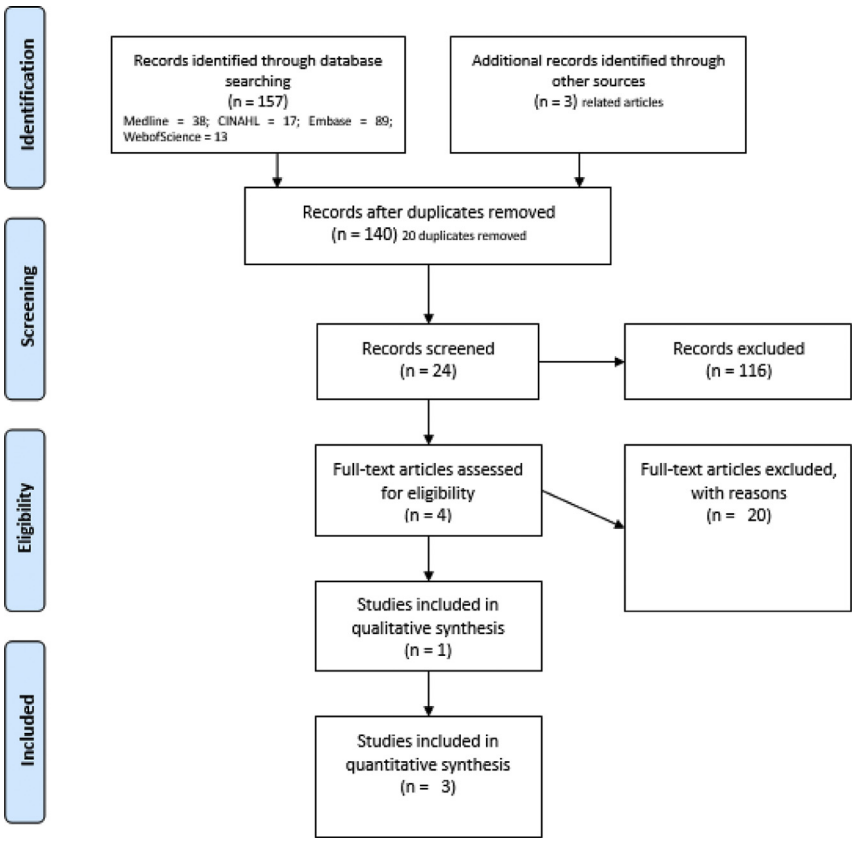

Figure 1. Flow diagram illustrating the four phases of the review.[22]

Patients lack knowledge when it comes to ionising radiation used in medical imaging, with a tendency to underestimate the exposure and associated risk. The mixed methods study from the Australian clinic[12] (n = 242, with 4 PET and 7 PET/CT patients) reported that a substantial proportion of patients (48.3%) identified Magnetic Resonance Imaging (MRI) as being a source of radiation and simultaneously failed to identify mammography, dual energy X-ray absorptiometry (DEXA) and PET/CT as sources of ionising radiation.

The study conducted in Hong Kong[13] (n = 173, with 18 PET/CT patients), reported that patients generally underestimated the equivalent radiation dose from CT when compared to X-rays, with only 32.2% answering correctly; and 60.7% and 32.7% failed to identify Magnetic Resonance Imaging (MRI) and Ultrasound (US) respectively as non-ionising radiation imaging modalities. The authors report the findings as poor awareness and knowledge but when compared to other studies,[9] aimed at radiology and CT predominantly these findings demonstrate a slightly higher awareness of radiation exposure. The qualitative study consisting of focus groups[14] also assessed ionising radiation understanding about imaging modalities and reported the results were substantially variable. They reported an overall knowledge that X-ray, CT and PET/CT utilise ionising radiation, but with many participants not confident that MRI does not use ionising radiation.

b) Lack of communication between healthcare professionals and patients regarding ionising radiation dose exposure and the associated benefits and risks

The Australian study[12] reported that 85.6% of participants indicated no discussion on radiation dose exposure or associated risk took place with the referring clinician when patients were referred for a particular diagnostic imaging procedure and when attending for previous procedures; 76.1% also reported that they received no information from the radiographers with regard to dose exposure and risk. The study from Finland[15] (n = 147, with 13 PET/CT and 11 bone scan patients) reported that only 3% (4 patients) were informed of the estimated radiation dose and 1% (2 patients) were informed of radiation risks associated with the diagnostic imaging procedure. The study from Hong Kong[13] reported better results with 42.7% of participants being advised of the radiation dose and 49.4% being advised of the risks associated, with 45.2% expecting the clinicians to provide more information and 31.3% expecting the radiographers to do so. This sample however is a highly educated one which may have contributed to better results and not necessarily be representative of a typical treatment population.

c) Patient engagement in decision-making

The qualitative study included, conducted in 2015 to cancer patients[14] (n = 30, unknown number of diagnostic nuclear medicine patients included) has limitations in terms of generalisability to non-cancer patients, but the findings are nevertheless similar to the other studies included in this review and indeed to some of the excluded articles.[11,28] It showed that patients wanted to be engaged with their clinicians on risk-benefit discussions regarding ionising radiation, particularly cancer survivors who during the course of treatment and during surveillance have frequent diagnostic imaging procedures. In general patients reported they would like to receive more information "because tests like CT scans have been offered for many years and doctors are obligated to know the risks", routinely this should be available and this could be achieved by engaging clinicians and patients with the support of written material. Similar results come from the Australian study,[12] 75.6% of

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participants reported they would like to receive information with regard to radiation exposure dose and the risks associated with it, and engage with their clinician in making decisions about their medical care. Only 8% stated they would prefer not to be aware and not be involved in any discussions.

Global theme

The three recurrent themes from across the four studies can be synthesised in one overarching theme - *Informed consent for medical imaging procedures.*

The process of informed consent involves a discussion between patients and carers, or both, and health professionals in order to provide patients with sufficient information in order to understand what the procedure involves, what the benefits and risks are, what the potential alternatives are and what would happen if the procedure does not take place. The individual must have capacity to make this decision and do so voluntarily.[35]

These studies have highlighted the lack of discussion between patients and health professionals regarding radiation exposure and its associated risks, and that patient's lack such knowledge about radiation exposure and risk, failing to identify which procedures use ionising radiation and the ones that do not.[12] Similar results were found in studies regarding the process of informed consent in medical imaging, not included in this review.[36–38] The included studies also demonstrated that patients want to be engaged with a discussion about their scanning options as part of their treatment, including the risks and benefits of potential alternatives. Information and knowledge provided to patients forms the basis of informed consent, which is compulsory as part of the imaging procedure.

Discussion

The studies included in this review reported that patients lack knowledge on ionising radiation exposure, there is a need to increase communication between healthcare professionals and patients about ionising radiation exposure and patients expect to be provided with information about ionising radiation exposure.[12–15]

Similar results from a study applied to professionals in 2011[39], concluded that experts within nuclear medicine and radiology should aim to educate and inform not only patients but also referring clinicians who also lack knowledge.

A recent mixed methods study comprising a survey and focus groups conducted in Spain[34] aimed to evaluate the general population's understanding of the benefits and risks associated with five different imaging modalities, though not including nuclear medicine, as well as their opinions on how that information should be delivered. This study reported similar findings to this review; the general population lacked information concerning ionising radiation exposure from medical imaging; and more information should be provided to patients to make them aware of the radiation exposure when undergoing scans involving ionising radiation.

This raises the question of who should discuss radiation exposure and the associated risks with patients and at what point? Patients and carers, radiologists, radiographers/technologists and referring physicians have different opinions. Referring physicians will discuss the clinical need for the imaging procedure but the discussion about radiation exposure is more likely to occur at the point of imaging, this alongside the referring physician's knowledge about radiation exposure will determine what is conveyed to patients.[8,39] Local practice across institutions, imaging centres and departments, differences in education and training in different countries can also influence discussion of radiation exposure. Factors such as who do patients see when attending diagnostic scans, information leaflets sent in advance or not, content of the leaflets, knowledge of the healthcare professionals, all can influence the discussion with patients.

A systematic review on communication of radiation risks from medical imaging to patients identified that there is no consensus on the subject, but there is consensus on the fact that information and discussion should take place.[8] Better-informed patients are less likely to request unnecessary scans but simultaneously they need to be correctly informed of potential consequences that can derive from not having a scan.[34]

Healthcare professionals are seen as a reliable source of information by patients and the imaging community should inform patients by providing them with clear information regarding the benefits and potential long term risks from their exposure to ionising radiation so enabling patients to make informed decisions.[40,41]

The information conveyed to patients is not always consensual as described by a recent collaborative project involving 15 Nuclear Medicine Departments in England and Scotland and the Butterfly Thyroid Cancer Trust who looked at the standardisation of patient restrictions following the treatment of thyroid cancer. They found that there is a wide range of variation in the advice given to patients, especially in respect of contact with pregnant women and children under five. They proposed standardised guidance on practice and radiation protection advice in order to improve patient's experience, understanding and compliance.[42]

The connotations of the word radiation is often negative and it is therefore very important that health professionals are well prepared to communicate and discuss with patients, carers and other physicians the radiation exposure derived from a particular scan. In particular, what they are most likely to be questioned about: the risks involved by having such procedure. This is a common theme across all medical imaging, but perhaps even more so in nuclear medicine an imaging modality not as widely used and less common than X-ray or CT imaging.

The risk assessments from ionising radiation are based on the linear no-threshold (LNT) model which has been in practice for the last 70 years and it was introduced as a mean to simplify radiation protection.[43] It is based on the fact that any exposure to ionising radiation, including very low dose such as X-ray can lead to carcinogenesis's and the risk is proportional to the dose – i.e. double the radiation exposure dose means double the risk. The validity of the LNT model is under debate in the scientific community with supporting evidence contradicting the LNT model with an attempt to inform the system of radiation protection applied at national and international level for ionising radiation.[2,44,45] Potential changes to risk assessments may have an impact on how risk is perceived for the different imaging modalities and what is communicated to patients. The LNT model is, however, the commonly accepted model and the impact of alternative models remains unclear, therefore this review concurs with the LNT and the current risk assessments for the different diagnostic imaging modalities that use ionising radiation.

In the UK, recent changes in legislation have been in force since February 2018. The Ionising Regulations (Medical Exposure) Regulations (2017) now state that imaging departments need to provide information to patients to ensure patients are informed of the benefits and risks associated with the exposure derived from imaging procedures. This will result in some departments having to adapt their current information policies and content which will hopefully improve the awareness of patients, public and the medical profession of ionising radiation, the exposure and risks associated with the various imaging procedures.

It is crucial that healthcare professionals understand and are able to inform patients about the benefits and potential risks of ionising radiation for medical purposes based upon evidence-based practice and guidelines.[41,46,47] With the growing awareness of the

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benefits of involving service users, patients themselves should be engaged in the development of materials to improve patient and public knowledge. Such an involvement would reflect a shared decision making process where clinicians actively engage with patients for patient centred care.

Limitations

This review followed the PRISMA guidelines but the protocol was not registered with PROSPERO International Prospective Register of Systematic Reviews. We followed the protocol faithfully when undertaking the review, but we recommend that future systematic reviews protocol use the PROSPERO database to register their protocol prior to conducting the review to ensure transparency in the review process and avoid duplication of reviews.

Conclusion

The findings of this review suggest that across imaging in general there is a reported lack of knowledge from patients, a general underestimation from the healthcare professionals concerning ionising radiation exposure and a need for improved communication between health professionals and patients.

Healthcare professionals and the imaging community should promote a discussion with patients and carers by providing clear and appropriate information regarding the benefits and potential long-term risks from their exposure to ionising radiation enabling patients to make informed decisions. Only four studies included a small proportion of nuclear medicine patients, which demonstrates there is a need for further research in patient's awareness and knowledge of ionising radiation from diagnostic scans and therapies specifically in nuclear medicine.

Conflict of interest statement

None.

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