How should clinicians inform patients about radiation exposure from imaging tests?

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**Background/Introduction**

Healthcare overuse is an increasing problem with adverse consequences for patients and physicians, and serious economic implications [1]. Several attempts to deal with this problem have been made, most of which primarily involve healthcare providers. However, there is a general consensus that any strategy should also include the individual patient's opinion and preferences [2].

In the last decades, a significant part of healthcare overuse is attributable to a massive increase in medical imaging [3]. This increase, mainly observed in Computerized Tomography (CT), has led some institutions such as the Food and Drug Administration [4] and the European Commission [5] to introduce legislation to prevent overuse of medical imaging and avoid unnecessary radiation exposure to the population. One of their main initiatives is to enforce the recording of the radiation dose received by each patient undergoing a medical imaging test [5]. This will increase physicians' awareness of the risks associated with the imaging tests. It is also necessary that patients understand the risks of radiation associated with imaging tests, given that previous studies have shown that well informed patients are less likely to request unnecessary diagnostic tests [6]. At the same time, patients need to be informed about the risks associated with not undergoing a specific imaging test as well.

To accomplish this, physicians need to be aware of how much patients know and how they feel about radiation exposure. However, to our knowledge, no studies have analyzed patients' preferences for different presentation formats comparing these approaches when communicating risks associated to radiation exposure, and very few have investigated patients' knowledge of and attitudes towards radiation [7-10] and even less have focused on the general population [11].

The aim of this study was to evaluate the general populations' awareness about the radiation exposure associated with five specific diagnostic imaging tests, and their preference regarding three different formats for receiving the information before undergoing a medical imaging test.
Description of activity and work performed

We carried out a quantitative and qualitative evaluation through a survey and focal groups to achieve a comprehensive picture of patients' understanding of the benefits and risks associated with medical imaging and their opinions about how this type of information should be delivered.

Quantitative study:

We estimated that, for a precision of 5% with 95% confidence intervals, at least 384 people would be required to answer. To allow for analysis by subgroups we increased this number to 600. Sampling was carried out in stages and stratified by age. Participants were contacted by phone, oral informed consent was obtained. We were unable to contact 50 participants and 10 declined to answer the survey. Details of the sampling are shown on Fig 1.

The questionnaire (see Fig 2.) was filled out by 602 people. 418 (70.3%) participants stated that they were aware of the risk associated with radiation in imaging tests. Awareness was higher among women, in Health Department 17 and among people who said the had been informed about a prescribed imaging test.

People who received either written or both, written and oral information were more likely to share the decision of having an imaging test with their physicians. The same thing happened with people who thought the information they received was easy to understand.

On the other hand, knowledge about what imaging test are related to radiation was inconsistent. Most participants knew x-rays involve radiation, but fewer were aware about the presence of radiation in CT and mammography and a substantial proportion believed MRI and ultrasound have radiation. Fig 3 shows the results, divided between participants who said they were aware about radiation risks and those who said they were not aware.

Qualitative study:

The two groups used an identical protocol and procedure, which began with a short presentation by the head of the radiology department in each hospital and all participants being informed and consenting to the study. The focus group discussions lasted between 60-90 minutes and were audio recorded.
The research team developed a semi-structured focus group protocol to guide the discussion based on a literature review of radiation exposure topics. The protocol was divided into two main themes: topic 1) Assessment of the information they receive before having an imaging test, and topic 2) what information they would like to receive before undergoing an imaging test. Moreover, the participants assessed three potential information sheets detailing the radiation exposure risk associated with specific imaging tests to determine which they felt would be easiest to understand. The information sheets (translated to English) are shown in figures 4-6. The focus group discussions lasted between 60-90 minutes and were audio recorded.

A careful transcription reading was made and the text then split up into meaningful information units. These units were coded following a mixed strategy (emerging and predefined codes according to the study objectives), and categories were developed on the basis of grouping codes with the same topic. Later, the points of agreement and disagreement were analysed and triangulation of the results were performed to qualitatively analyse the degree of agreement.

Overall 20 people participated in the two focal groups, 12 women (60%) and 8 men. Overall, the interviewed population stated that they received little information regarding the radiological test they were going to have. However, few of the participants felt the need to ask the physicians for more information. In fact, most of them stated that they did not know enough about radiation exposure terms to understand the physicians' explanation. Despite this lack of specific information regarding the risks, most of them agreed to sign the written informed consent especially as it was delivered to them just before the test was performed, which could be perceived as being too late to say no.

Regarding the information sheets and what information would they like to receive before undergoing an imaging test, participants stated that communication between health professionals regarding tests was limited. They also pointed out the importance of keeping count of the number of tests carried out on each patient. Interviewed participants preferred both verbal and written information, describing the benefits and risks of diagnostic imaging tests. Furthermore, they underlined the importance of receiving information in a summarized form that should include a brief description of the test and the purpose of doing it.

All of the participants agreed that the most appropriate way to present information was a table showing a number of imaging tests and their corresponding radiation equivalence in terms of chest X-rays and background radiation exposure (as shown in Fig 5).
Images for this section:

**Supplementary text 1: Survey:**

The following survey aims to assess the health professionals' knowledge about the radiation risk associated with imaging tests, as well as knowledge of the available recommendations. Please complete the sections of the entire survey and if you have any comment, you can fill in the comments section at the end of it.

**Identification data:**
- Sex:
- Age:
- Health Department: □ 10 □ 17

1. Are you aware of the risks associated with radiation exposure in imaging tests?
   - Yes □ No □
   If yes, do you know the type of risks associated?

2. Check which one of the following tests is associated with radiation exposure:
   - X-ray
   - Ultrasound
   - Magnetic resonance imaging
   - Mammography
   - CT

3. Have you had an imaging test in the last 12 months? Which one?

4. Did the physician inform you about the risks associated with imaging tests involving radiation?
   - Yes □ No □
   Who?

4.1 Type of information given:
   - Oral □ Written (informed consent) □ Both

4.2 Amount of information given:
   - Very little □ Sufficient □ A lot

4.3 What do you think about the information you receive from the physician?
   - Difficult to understand □ Can be understood with some difficulty
   - Easy to understand □ Very easy to understand

4.4 The effect of the information you receive is:
   - I do not trust it □ It has no special effect on me □ It reassures me

4.5. Does the information you receive enable you to share the decision with the physician regarding whether to order an imaging test?
   - Yes □ No

5. Did the physician inform you about the benefits of the imaging test and why you are having it?
   - Yes □ No □
   Who?

Observations:

**Fig. 2: Survey**

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Fig. 3: Percentage of respondents that associated each test with radiation exposure grouped by those that said they were aware of the risks associated with radiation exposure and those who stated they were not aware.

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Most frequently associated risks

Irradiation:
A CT is associated with ionizing radiation (x-rays) so it should be avoided in the case of pregnant women. In the rest of the population, the CT is only carry out when there is a precise indication to do it, because it has associated a high amount of radiation exposure.
As a guideline it should be noted that the dose received by the patient with the practice of a Skull CT scan radiation (2.3 mSv) is equivalent to 115 chest X-rays and is similar to 1 year of background radiation. Spiral CT (8mSv) radiation is equivalent to 400 chest X-rays and 3.5 years of background radiation. Abdominal CT scan is equivalent to 500 chest X-rays and 4.5 years of background radiation.
The potential risk of radiation includes a slightly elevated risk of cancer within a few years. This risk is less than 0.5%, so it can be considered very low compared to the normal incidence of cancer in the population, which is 33% for women and 50% for men, according to the American Society of Cancer.

Fig. 1: Flow diagram of selection procedure.
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Fig. 4: Official information given in current clinical practice the participant hospitals. Information sheet nº1 out of 3 test information sheets to be given to patients detailing the radiation exposure associated with imaging.
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Most frequently associated risks

Irradiation:

A CT is associated with ionizing radiation (x-rays) so it should be avoided in the case of pregnant women. In the rest of the population, the CT is only carry out when there is a precise indication to do it, because it has associated a high amount of radiation exposure.

As a guideline, the following table shows the equivalence between different imaging tests. For instance, the skull CT, with a radiation dose associated of 2.3 mSv, is equivalent to 115 chest x-rays and 1 year of background radiation (a person is exposed to 2.4 mSv of background radiation by year). The risk of cancer associated is from 1/100,000 to 1/10,000 (which is 33% for women and 50% for men, according to the American Society of Cancer).

<table>
<thead>
<tr>
<th>Imaging test</th>
<th>Effective dose (mSv)</th>
<th>Chest x-rays equivalent</th>
<th>Background Equivalent Radiation Time</th>
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<tbody>
<tr>
<td>Chest x-rays</td>
<td>0.02</td>
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<td>Chest CT</td>
<td>8</td>
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<td>10</td>
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**Fig. 5:** A radiation equivalence table (adapted from [8]), showing the effective dose received by the different imaging tests expressed as radiation exposure units (u) equivalent to one chest X-ray. Information sheet nº2 out of 3 test information sheets to be given to patients detailing the radiation exposure associated with imaging.

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As a guidelines, the following graphs shows the equivalences between the radiation absorbed by each imaging test and other radiation sources, according to the long-term potential risk: low (green), medium (yellow) and high (red):

Fig. 6: 3: A figure showing a visual representation of the medical radiation exposure (compared to background radiation exposure). Information sheet nº3 out of 3 test information sheets to be given to patients detailing the radiation exposure associated with imaging.

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Conclusion and Recommendations

This study highlights the lack of knowledge in the general population and the limited information received from the health professionals regarding the radiation exposure associated with five different diagnostic imaging tests.

Although more than 70% of the participants affirmed that they were aware of the risks associated with radiation exposure in imaging tests, only 30% of them knew that CT or mammography involve radiation. Moreover, 38% of the participants thought that MRI involves radiation. In the qualitative study, most of the participants stated that they did not know enough radiation exposure terms to understand the physicians' explanation and some of them had misconceptions about radiation exposure that could alter their expectations of benefits versus risks.

Less than 20% of the interviewed population indicated that the physician informed them about the risks associated with imaging tests involving radiation. Similarly, in the qualitative evaluation, the participants stated that they received little information regarding the radiological risks and they pointed out that they only received information about how they should prepare themselves for the test.

The survey pointed out that when participants received comprehensive information about radiation exposure from diagnostic imaging tests they appeared to be more likely to share the decision with the physician regarding whether to order the imaging test or not.

When participants were asked about the best written format to explain the risks related to radiation, the equivalent number of chest X-ray procedures and the equivalent time exposed to background radiation were the preferred formats (Fig 5).

In conclusion, this study highlights the lack of knowledge in the general population and the limited information delivered by the health professionals regarding the risks associated with radiation exposure from imaging tests. Initiatives should be designed to reinforce patients' awareness of radiation exposure and their role when ordering a diagnostic imaging test. Some tools could help, such as a table detailing the radiation equivalence in terms of x-rays, of background radiation, or of associated cancer risk, or the availability of the patient's radiation dose history.
Most frequently associated risks

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**Personal/Organisational information**

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Fig. 7: Funded by

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References


