Awareness and Knowledge of Ionizing Radiation Risks Between Prescribed and Self-Presenting Patients for Common Diagnostic Radiological Procedures in Bahrain

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ABSTRACT
Objectives: Between 20 to 50% of medical imaging examinations are considered inappropriate, and unnecessary ionizing radiation exposures may lead to cancer. We hypothesized that Bahraini patients who self-present for ionizing radiation procedures are not aware of, and lack the requisite knowledge of, the inherent risks associated with their use than patients prescribed for diagnostic purposes. We attempted to examine and compare the awareness and knowledge of the associated risks of ionizing radiation in common diagnostic radiological procedures between prescribed and self-presenting patients in Bahrain. Methods: A cross-sectional survey was carried out among 416 Bahraini patients attending the radiology department of the Salmaniya Medical Complex (SMC), a secondary health care center, who had been referred by primary care physicians or self-presented to the center. Data was collected via face-to-face interviews. Results: Prescribed patients (n = 358) had a better awareness than self-presenting (n = 58) patients on all ionizing radiation awareness statements (i.e., risks, permissible levels, willingness to undergo the procedure, and preference for a clinical examination over a radiological procedure) (p < 0.050). Of the 10 knowledge statements, the prescribed patients agreed on four statements than the self-presenting patients: preventing or minimizing exposure improves health, people can prevent or minimize exposure, a lifelong health concern, and radiological procedures offer best diagnoses compared to medical tests or procedures (p < 0.050). Conclusions: Bahraini patients who reported to SMC lack awareness and knowledge on ionizing radiation. The proportion of appropriate responses to awareness and knowledge questions were paltry for self-presenting patients and deficient for the prescribed patients in the knowledge segment alone.

ARTICLE INFO

Diagnostic radiology plays an essential role in medical practice and uses ionizing and non-ionizing radiation. Ultrasound and magnetic resonance imaging (MRI) are non-ionizing and are not associated with any known adverse effects or health risks as they utilize sound waves and magnetic fields, respectively. Whereas the use of gamma rays and X-rays in diagnostic radiological procedures (i.e., angiography, mammography, fluoroscopy, computed tomography (CT), nuclear medicine, and radiographic imaging) are risky and can have harmful results due to their ionizing effect.¹ The risk of inducing biological effects increases as the dose increases (dose response), increasing the lifetime risk of cancer. The lag period between radiation exposure and cancer diagnosis is typically five years but can extend to one or two decades, or more, in most cases.² Worldwide, radiation exposure from medical imaging may be responsible for 1–3% of cancers.³ Children are particularly prone to ionizing radiation as the molecular processes within the brains of children are not yet complete.⁴ Radiation protection (RP) endorses no explicit “safe” radiation level. Nonetheless, RP standards for public and radiation workers are recommended.
The Kingdom of Bahrain is an archipelago made up of 33 islands located in the Arabian Gulf with a total area of 780 km². The population is around 1.3 million, which includes Bahrainis and multiethnic expatriates. The Ministry of Health provides the primary health care services through 24 health centers and three health clinics. The Salmaniya Medical Complex (SMC) is the oldest and largest multispecialty health care facility providing emergency and secondary care to all Bahrainis and residents of Bahrain.

There are no reports on the awareness and knowledge of the risks associated with ionizing radiation for radiological procedures in Bahrain, as well as comparisons between prescribed and self-presenting patients. We hypothesized that Bahraini patients who self-present are not aware of, and lack the requisite knowledge of, the inherent risks associated with the use of ionizing radiation compared to patients prescribed radiological procedures for diagnostic purposes. Therefore, we sought to examine and compare the awareness and knowledge of the associated risks of ionizing radiation between prescribed and self-presenting Bahraini patients at a secondary care center, SMC in Bahrain.

**METHODS**

This study was carried out after review and approval by the Institutional Research and Ethics Committee of the Ministry of Health, Bahrain, and the Research and Ethics Committee of the College of Health Sciences, University of Bahrain. A cross-sectional survey by a face-to-face interview rendered the data collection process. All consecutive Bahraini patients attending the radiology department of SMC either referred by primary health care physicians or directly reporting at the SMC due to an illness or self-presenting were included in the study. Parents responded if the patient was a minor (< 18 years of age). Pregnant women, patients attending the accident and emergency department, and non-Bahrainis were excluded from participating in the study.

A structured questionnaire was built following an in-depth literature review on ionizing radiation. The questionnaire was written in English language and translated into Arabic. To ensure originality of the questions, the questionnaire was back translated.
from Arabic into English. For affirming face and content validity, the questionnaire was scrutinized by a panel of experts from the College of Health Sciences. Pretesting and piloting the questionnaire in 30 patients allowed for suitable modifications before embarking on the main study. The questionnaire was specific, realistic, measurable, and reliable that had an acceptable internal consistency (Cronbach’s alpha = 0.72).

The survey questionnaire had four sections. The first part of the questionnaire gathered participants’ demographics, including age, gender, and education level. The second part of the questionnaire, made up of three-items, collected participants’ clinical information (i.e., purpose of hospital visit, any prior radiological procedure, and type of radiological procedure). The third and fourth parts of the questionnaire (multiple-choice questions) containing four and 10 items, respectively, were used to evaluate participants’ radiation awareness and knowledge (e.g., health risks, prevention, maximum number of examinations per year). A standalone question on patient’s preference to obtain information about ionizing radiation concluded the questionnaire.

The sample size was estimated using the following conservative parameters for prevalence: expected population proportion of 50%, 95% confidence interval, and a 5% precision estimate on two sides of the true population proportion. These parameters indicated a required sample size of 385. The required sample was increased to 400 participants (a level of precision of 4.9% either side) to account for potential invalid or incomplete responses. An estimated sample size of 400 was considered adequate.

Informed consent was obtained from the patients without persuasion after describing the purpose of the study. Patient data was protected throughout the study and after. The data from the questionnaire was cleaned, coded, and entered into Microsoft Excel and exported to IBM SPSS Statistics for Windows, version 23 (IBM Corp., Armonk, N.Y., USA) for statistical analysis. Descriptive statistics of frequency and percentages were used for the demographic characteristics. Differences in distribution of the awareness and knowledge responses between prescribed and self-presented patients were evaluated using the chi-squared test. Two-tailed tests were used, and a $p$-value < 0.050 was considered to be statistically significant.

## Results

A total of 416 patients completed the survey with complete responses. The majority of patients ($n = 358$) were in the prescribed group: 55.2% were female, and 44.7% were male [Table 1]. Half of the patients reported to SMC due to illness and 37.2% due to injury. Almost 85% had a radiological procedure before, and 14.6% reported for the first time. Two-thirds reported for the plain radiological procedure, 12.7% for a fluoroscopy, 10.5% for CT and, 10.3% for more than one procedure.

The level of awareness about the effect of ionizing radiation was evaluated using four statements [Table 2]. The prescribed patients had better awareness than the self-presented patients on all awareness statements concerning the risks,
permissible levels of ionizing radiation, willingness to undergo ionizing radiation, and willingness to undergo a clinical examination rather than a radiological procedure (p < 0.050). The median appropriate responses to awareness for prescribed patients was 52.35 (interquartile range (IQR): 46.78) compared to 3.75 (IQR: 3.85) in the self-presented patients. The level of knowledge about the effect of ionizing radiation was evaluated using 10 statements [Table 3]. A significantly greater percentage of prescribed patients agreed with the following four statements than the self-presented patients: Would preventing or minimizing ionizing radiation exposure improve a person’s health? Can people prevent or minimize ionizing radiation? Is ionizing radiation a lifelong health concern, and does radiological procedure offer best diagnoses than other medical tests or medical procedures? (p < 0.050). Appropriate responses to other knowledge statements were not significant between the prescribed and self-presented patients. The median appropriate responses for prescribed patients was 17.45 (IQR: 40.9) and 3.75 (IQR: 5.83) for the self-presented patients.

Prescribed patients preferred to learn more about ionizing radiation from a health care provider (49.0%), internet-based resource (52.0%), or via a family member, friend, and other sources (21.0%). A lesser proportion of self-presenting patients preferred to learn more about ionizing radiation

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**Table 2: Patients awareness on ionizing radiation for common radiological procedures (n = 416).**

<table>
<thead>
<tr>
<th>Awareness question (appropriate response)</th>
<th>Prescribed patients with an appropriate response, %</th>
<th>Self-presented patients with an appropriate response, %</th>
<th>95% CI</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Are you aware of the risks of ionizing radiation? (Yes)</td>
<td>32.2</td>
<td>4.1</td>
<td>4.741–37.6291</td>
<td>0.016</td>
</tr>
<tr>
<td>Are you aware of the maximum ionizing radiation dose permissible? (Yes)</td>
<td>85.0</td>
<td>1.8</td>
<td>72.878–87.408</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Are you willing to undergo ionizing radiation procedure even if harmful? (No)</td>
<td>38.0</td>
<td>6.7</td>
<td>13.415–41.318</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Are you willing to undergo a clinical examination compared to a radiological procedure? (Yes)</td>
<td>66.7</td>
<td>3.4</td>
<td>37.281–70.279</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>

CI: confidence interval.

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**Table 3: Knowledge on ionizing radiation between prescribed and self-presented Bahraini patients for common radiological procedures who attended a tertiary care center (n = 416).**

<table>
<thead>
<tr>
<th>Knowledge questions (appropriate response)</th>
<th>Prescribed patients with an appropriate response, %</th>
<th>Self-presented patients with an appropriate response, %</th>
<th>95% CI</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Have you heard the term ionizing radiation before? (Yes)</td>
<td>12.5</td>
<td>4.1</td>
<td>-14.869–21.188</td>
<td>0.328</td>
</tr>
<tr>
<td>What does the term ionizing radiation mean? (Any type of energy that is capable of ionizing matter)</td>
<td>12.5</td>
<td>0.0</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Is ionizing radiation dangerous to your health? (Yes)</td>
<td>6.3</td>
<td>0.7</td>
<td>-65.265–22.523</td>
<td>0.697</td>
</tr>
<tr>
<td>Would preventing or minimizing ionizing radiation exposure improve a person’s health? (Yes)</td>
<td>45.4</td>
<td>7.5</td>
<td>20.916–47.640</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>What is the maximum number of radiological examinations permissible per year for the categories of radiological procedures? (Multiple responses)</td>
<td>5.8</td>
<td>1.7</td>
<td>-37.847–21.884</td>
<td>0.662</td>
</tr>
<tr>
<td>Can people prevent or minimize ionizing radiation? (Yes)</td>
<td>53.8</td>
<td>7.2</td>
<td>29.588–55.705</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Is ionizing radiation a lifelong health concern? (Yes)</td>
<td>22.7</td>
<td>7.0</td>
<td>-1.206–24.689</td>
<td>0.052</td>
</tr>
<tr>
<td>Does radiological procedure offer best diagnoses than other medical tests or medical procedures? (Yes)</td>
<td>62.7</td>
<td>10.1</td>
<td>37.970–61.849</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Can radiological procedures be avoided as part of diagnosis? (No)</td>
<td>22.4</td>
<td>3.4</td>
<td>-7.422–29.395</td>
<td>0.098</td>
</tr>
<tr>
<td>Can ionizing radiation reduce pain? (No)</td>
<td>6.7</td>
<td>1.7</td>
<td>-37.017–21.281</td>
<td>0.615</td>
</tr>
</tbody>
</table>

CI: confidence interval; NA: not available.
from a health care provider (19.0%), internet-based resource (12.0%), or via a family member, friend, and other sources (7.0%).

Overall, the appropriate responses to awareness and knowledge statements were higher for prescribed than self-presenting patients. However, no significant differences were found in the awareness and knowledge statements for the demographic characteristics of age, gender, and levels of education.

**DISCUSSION**

This study was carried out on the basis that common diagnostic radiologic procedures using ionizing radiation carry potential health risks; hence, patients’ awareness and knowledge about ionizing radiation would play an important role in minimizing needless imaging and its ramifications. The results of our study in Bahrain show that awareness and knowledge of ionizing radiation are heterogeneous among prescribed patients and higher than the self-presented patients’ confirming the hypothesis of this study.

Analyzing our study outcomes in detail, prescribed patients had a higher awareness of the minimum ionizing radiation permissible (85.0%) and preferred to undergo a clinical examination compared to a radiological procedure (67.0%). On the other hand, although significantly different to the self-presenting patients, it is of concern that the prescribed patient’s awareness of the risks of ionizing radiation and their willingness to undergo the procedure even if harmful was below 50.0%. It is of serious concern to note that the awareness of self-presenting patients to ionizing radiation was poor since all their appropriate responses to awareness statements were below 10.0%. The results of our study closely mirrors one on the knowledge of radiation exposure in medical imaging in parents and legal guardians, who were largely unaware that medical imaging carries an inherent risk of exposure to radiation for their child.  

Only four out of 10 statements relating to knowledge had a statistically significantly higher proportion of appropriate responses in the prescribed category than the self-presenting category of patients. Of these four, only two statements (does radiological procedure offer best diagnoses than other medical tests or medical procedures, and can people prevent or minimize ionizing radiation?) had more than 50.0% appropriate responses. The proportion of appropriate response was below 50.0% for the questions, would preventing or minimizing ionizing radiation exposure improve a person’s health, and is ionizing radiation a lifelong health concern? Among the patients who self-presented, the results were identical to their awareness responses and particularly worrying as their appropriate responses to knowledge statements were below 10.0% for nine out of 10 statements.

Although over 85.0% of patients were adults, 65.0% were university or high-school graduates, and 85.0% had a prior radiological procedure, their awareness and knowledge of ionizing radiation was inadequate, and no significant differences were found between age, gender, and education level.

The proportion of appropriate responses to awareness and knowledge were paltry for self-presenting patients and deficient for the prescribed patients in the knowledge segment. Thus, it must be construed that the Bahraini patients who reported to SMC lack awareness and knowledge on ionizing radiation, in particular, self-presenting patients. Other studies have also suggested that the exposure to ionizing radiation from medical procedures is not a concern to the general public. Patients probably trust that healthcare professionals are competent in minimizing any risks because of their comprehensive training in radiation protection.

Public health care services are delivered free to all Bahraini nationals. Therefore, most often, self-presenting patients insist on radiological procedures and physicians are urged to oblige, or else patients may rate a care low when they perceive that their legitimate requests for a diagnostic radiological procedure was denied or ignored. Additionally, they may seek a private practitioner to have it done.

Our work is not bereft of limitations. Firstly, this study was carried out only in SMC, so our sample refers to this specific population and may limit the generalizability of these findings to populations with access to other health care settings. Secondly, the population represented in our sample does not include pregnant women, those attending the accident and emergency department, and non-Bahraini patients, therefore, the results of our study could only be compared to similar patient populations. Thirdly, there is no standardized survey instrument available to assess awareness and knowledge of ionizing radiation, particularly in common diagnostic radiological procedures.
We utilized the existing literature and the opinion of experts in the field to design a data collection instrument that was comprehensive and detailed with an acceptable internal consistency. Fourthly, we did not attempt to create an overall index for the results of our data for a comparison between prescribed and self-presented patients as the data was not normally distributed, hence the median and interquartile range alone were presented. Further, we believed that each statement or question on awareness and knowledge provided necessary and sufficient information related to the aim of the study. Finally, the number of prescribed and self-presenting patients for common diagnostic radiological procedures is not equal since the patients were enrolled consecutively in the study and may serve as a surrogate of the prevailing proportion of self-presenting patients in the Bahraini population.

In recent years, improved recognition of the impacts of ionizing radiation has been identified as one of the major public health and medical challenges. Our findings suggest that a great need exists for health promotion in basic concepts of ionizing radiation exposure and risk in patients, caregivers, and the general population. Organizational efforts involving healthcare professionals should augment the public awareness and knowledge regarding diagnostic radiological procedures. A shared decision-making platform between healthcare professionals and patients offers the opportunity to discuss the benefits and risks associated with diagnostic radiological procedures.22 Thereby, healthcare professionals become agents of public health in counseling on the risks and benefits of diagnostic radiological procedures and providing evidence-informed health care to their patients. To the best of our knowledge, this study is a first of its kind to assess the awareness and knowledge of ionizing radiation risks to patients for common diagnostic radiological procedures in Bahrain and, furthermore, on the comparison between prescribed and self-presenting patients. Further studies are required to assess the magnitude of the self-presenting patients including other health care settings in the country.

CONCLUSION
The Bahraini patients who reported to SMC lack awareness and knowledge on ionizing radiation. The appropriate responses to awareness and knowledge questions were paltry for self-presented patients and deficient in the prescribed patients in the knowledge segment. This study provides the first data on the differences in awareness and knowledge of ionizing radiation risks between prescribed and self-presenting patients for common diagnostic radiological procedures in Bahrain. Further studies are needed in diverse clinical settings among the population to validate our results and recommend a policy on exposure to ionizing radiation on common diagnostic radiological procedures. We strongly believe health promotion can play a significant role in preventing unnecessary ionizing radiation exposure to self-presenting patients, irrespective of their clinical condition.

Disclosure
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