Open Journal of Radiology, 2022, 12, 163-175
https://www.scirp.org/journal/ojrad
ISSN Online: 2164-3032
ISSN Print: 2164-3024

Evaluation of Radiation Exposure Literacy among Mammography Examinees Using Radiation Dose Distribution in Mammography Examinations

Tokiko Nakamura[1,2], Kyoichi Kato[3], Shoichi Suzuki[4], Kenichiro Tanaka[5], Sachila Niroshani[2], Toru Negishi[2], Ryusuke Irie[1]

[1]Department of Radiology, Juntendo University Shizuoka Hospital, Izunokuni, Japan
[2]Department of Radiological Sciences, Graduate School of Human Health Science, Tokyo Metropolitan University, Tokyo, Japan
[3]Department of Radiology, Graduate School of Health Sciences, Showa University, Tokyo, Japan
[4]School of Health Sciences, Fujita Health University, Toyoake, Japan
[5]Department of Breast Surgery, Juntendo University Shizuoka Hospital, Izunokuni, Japan
Email: tokikonakamura1095@yahoo.co.jp

How to cite this paper: Nakamura, T., Kato, K., Suzuki, S., Tanaka, K., Niroshani, S., Negishi, T. and Irie, R. (2022) Evaluation of Radiation Exposure Literacy among Mammography Examinees Using Radiation Dose Distribution in Mammography Examinations. *Open Journal of Radiology*, **12**, 163-175.
https://doi.org/10.4236/ojrad.2022.124017

Received: October 5, 2022
Accepted: December 5, 2022
Published: December 8, 2022

Abstract

Introduction: Radiation is indispensable for diagnosis and treatment and is widely used in medicine. This study aimed to determine patients' knowledge and ability to understand radiation exposure to assess the usefulness of providing information on radiation doses to examinees. **Material and Methods:** The radiation exposure literacy of mammography examinees was assessed using a new scale consisting of the following five items: "collection of information from various sources", "selection of information necessary for oneself", "understanding and communication of information", "judgment of the reliability of information", and "ability to plan and act based on information". We analyzed the relationship of these items with examinees' attributes and clarified the level of understanding of radiation exposure dose associated with mammography examinations by providing examinees with visual information in the form of color maps. **Results:** The relationship between "information collection" and several attributes of radiation exposure literacy was strong. In addition, providing visual information on radiation doses using dose distribution maps in mammography examinations could deepen the understanding of radiation doses among examinees. **Conclusion:** By understanding the radiation exposure literacy of examinees and comparing it with their attributes, it is possible to provide suggestions for developing methods of providing radiation dose information tailored to individual examinees. In addition, improving radiation exposure literacy will enable the development of skills necessary to provide safe medical care to medical examinees.

Keywords

Radiation Dose, Literacy, Mammography, Radiation Dose Distribution, Surveys, Questionnaires

1. Introduction

Radiation is indispensable for diagnosis and treatment and is widely used in medicine. In Japan, the average age of women giving birth for the first time coincides with the age at which the number of breast cancer cases begins to increase [1] [2]. Furthermore, mammography screening is recommended for women in their 40s in Japan; hence, it is presumed that many women who may conceive in the future are included in the target population. Therefore, the radiation dose during mammography must be seriously considered [3]. Additionally, mammography systems equipped with Digital Breast Tomothinsehis (DBT), a high-performance function enabling observation of the breast in any cross-sec-tional view, have emerged, raising concerns about increased radiation doses [4].

In the recent years, with the rapid spread of mass media reports and the internet, information from different sources has become available to patients. Moreover, in today's medical environment, patients are expected to manage their medical conditions independently and be actively involved in various medical decision-making processes, such as examinations and treatments. To make such decisions appropriately, they must have access to comprehensive information that meets their individual needs. In the past, doctors and other medical professionals were the primary sources of information on medical care, such as medical tests and treatments. Presently, it has become easier for the general public to disseminate various medical information on their illnesses. However, false information is also circulated with available information, and it is important to distinguish between reliable and useful information and use it [5]. In this context, health literacy has been attracting attention. Health literacy refers to the cognitive and social skills related to a patient's motivation and ability to access, understand, and use information to maintain and improve his or her health. With these skills, people can make effective decisions and act accordingly. However, as previous studies have shown, it is difficult for patients to understand and act on professional medical information, even if they have access to it [6] [7] [8] [9]. Additionally, although the explanation of examinations by medical personnel is among the information available to examinees, the disclosure of radiation doses to examinees is not widely practiced during radiological examinations. Nonetheless, an explanation regarding examination methods is provided. There are many reports on radiation doses during breast examinations; however, there are no reports on the measurement of air radiation dose also available to the examinee and the area around the examinee to enlighten the understanding of radiation doses during examinations. Therefore, we measured the air dose around the examinee using the jungle gym method in our previous study, created a dose distribution map [10], and successfully provided information on radiation dose to examinees visually by dose distribution charts. It is necessary to understand radiation exposure literacy, defined as the knowledge and ability of mammography examinees to understand radiation exposure, to determine the usefulness of providing information on radiation doses to examinees. Although the importance of education on radiation exposure for health care workers [11]-[18] has been reported, thus far, no reports have analyzed radiation exposure literacy among mammography examinees and considered the effects of their attributes.

This study aimed to clarify the level of understanding of radiation exposure dose associated with mammography examinations by providing visual information to examinees in the form of dose distribution charts and clarifying the relationship between examinee background and their radiation exposure literacy, which affects their understanding. This will clarify how to convey the difficult specialized medical information presented in previous studies [6] [7] [8] [9]. This information can be used to provide suggestions for developing methods for improving radiation exposure literacy among mammography examinees in the future.

2. Material and Methods

2.1. Study Subjects

This cross-sectional study was conducted in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines, including 108 patients who visited the Department of Breast Surgery at our institution and underwent mammography. The purpose and content of the study were explained to the participants, and those who consented were included in the study. The minimum sample size required to meet the 95% confidence level, 5% margin of error, and 95% expected response rate was 73. Hence, the minimum sample size was set at 100, taking missing data into account.

2.2. Survey Method and Survey Period

The radiologist in charge of the mammography examination distributed an anonymous self-administered questionnaire to examinees who had consented to the survey. After answering the questionnaire, the examinees dropped it in the collection box in the mammography room. The survey was conducted from June 10, 2020, to February 25, 2021.

2.3. Contents of the Survey

2.3.1. Basic Attributes

The participants were instructed to answer questions regarding the following basic attributes: age group (30 - 39, 40 - 49, 50 - 59, 60 - 69, and ≥70 years), occupation (office workers or medical workers, homemakers, and others), marital status, and the presence of children.

2.3.2. Radiation Exposure Literacy

The scale for radiation exposure literacy was based on the health literacy scale Communicative and Critical HL (CCHL) developed by Ishikawa *et al.* [19]. The scale consists of five communicative and critical health literacy items, reflecting the World Health Organization's definition of health literacy. These questions are asked regarding the information sources in the following ways: "Can you gather information from a variety of sources (information gathering)", "Can you select the information you need (selection)", "Can you understand and communicate the information (understanding and communication)", "Can you judge the reliability of information (judgment)", and "Can you plan and act on the information? Can you plan and take action based on the information (planning and action)"? We asked the respondents to answer questions about the five items of "information gathering", "selection", "understanding and communication", "judgment", and "planning and action" on a five-point scale from "totally disagree (1 point)" to "strongly agree (5 points)" regarding the information on radiation exposure in mammography. Each item was assigned a score.

2.3.3. Comprehension of Radiation Exposure Dose Distribution Maps

Figure 1 shows the dose information related to radiation exposure, which was provided in the form of a color map to assess the level of understanding of the dose distribution map during mammography. Furthermore, the respondents were asked whether they could judge the dose at the height of each part of the body using a two-factor method.

2.4. Statistical Analysis

Descriptive statistics were used for corresponding percentages of demographic data, and the mean, standard deviation, and radiation exposure literacy scores were calculated. The mean value was used as the standard, and those below and

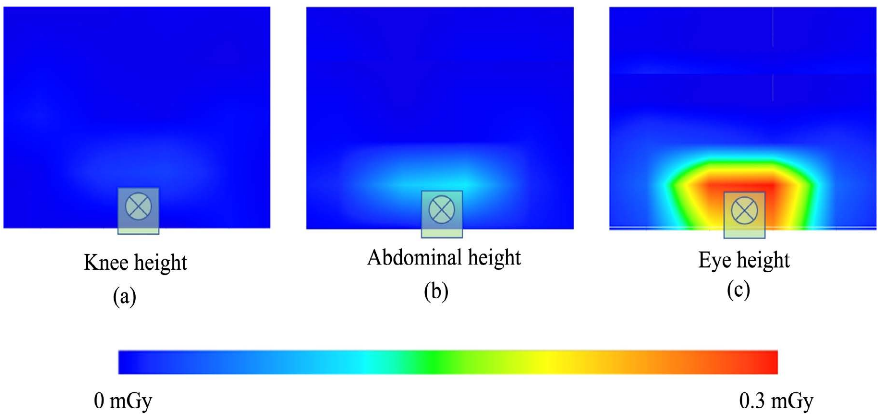

Figure 1. Radiation dose distribution in color, at the level of (a) knee height, (b) abdominal height, and (c) eye height.

above the mean value were designated as the low and high groups, respectively. Since χ^2 statistics commonly used to examine the differences between the categorical variables in the same population, χ^2 test was conducted as a group comparison analysis with the basic attribute items. Additionally, multiple comparisons using the Tukey method were conducted for the attributes with significant differences in the tests. The level of understanding of radiation exposure was determined by selecting each question item using a two-factor method, scoring 1 point for knowing, understanding, and thinking and 0 points for not knowing, not understanding, and not thinking. Then, a χ^2 test was conducted to determine the association with the basic attribute items. SPSS Statistics Ver. 27.0 (IBM Corp., Armonk NY) was used for statistical analysis, and the significance level was set at 5%.

2.5. Ethical Considerations

The study was conducted with approval from the Juntendo University Shizuoka Hospital Ethical Review Committee (approved June 10, 2020: permission number 756). Informed consent was obtained from the examinees. The completed questionnaires were placed in the radiation room collection box, and submission of the questionnaires constituted consent to the survey.

3. Results

The self-administered questionnaire was distributed to 108 patients, and 100 questionnaires (collection rate: 92.6%) were collected. However, missing data were deleted, and 76 patients (valid response rate: 76.0%) gave valid responses, which were analyzed. The Kolmogorov-Smirnov normality test results on the questionnaire results indicated that the data obtained followed a normal distribution. The equality of variances was also shown using the Levene test.

The participant characteristics are shown in **Table 1**, and the results of evaluating the radiation exposure literacy scores are shown in **Table 2**.

3.1. Relationship with Radiation Exposure Literacy by Score Group

The mean score for each of the five-radiation exposure literacy scale items was 4 for "information gathering", 3 for "selection", "understanding and communication", and "judgment", and 2 for "planning and action". The total mean score for the five scale items was 16, with participants having score values of ≤16 classified in the low group and those with scores ≥ 16 in the high group. The relationship between the basic attributes and radiation exposure literacy is shown in **Table 3**. As a result of multiple comparisons using the Tukey method with the exposure literacy score as the dependent variable and the basic attribute items as the independent variables, significant differences were found for "*information gathering*" according to the participant *age groups* (*the 30*s > *60*s [p = 0.017]), *occupation* (*medical workers* > *homemakers* [p = 0.02]), *marital status* (*never married* > *married* [p = 0.048]), and the *presence of children* (*no children* > *with*

Table 1. Basic attributes of the participants.

		n	%
Age (years)	30 - 39	27	35.5
	40 - 49	10	13.2
	50 - 59	18	23.7
	60 - 69	15	19.7
	70 or older	6	7.9
Occupation	Office workers	22	28.9
	Medical workers	10	13.2
	Homemakers	31	40.8
	Others	13	17.1
Marital status	Yes	55	72.4
	No	21	27.6
Presence of children	Yes	44	57.9
	No	32	42.1

Table 2. Evaluation of radiation exposure literacy scores in terms of age groups, various occupations, marital status, and presence/absence of children among the study participants.

		Five items on the health literacy scale CCHL (Communicative and Critical Health Literacy (CCHL) developed by Ishikawa *et al.* [19]					
		Information gathering	Selection	Understanding and communication	Judgment	Planning and action	Radiation exposure literacy total scores
Age (in years)							
Total	n = 76	4.14 ± 0.91	3.84 ± 1.06	3.07 ± 0.88	2.88 ± 0.92	2.25 ± 0.82	16.30 ± 3.5
30 - 39	n = 27	4.56 ± 0.58	4.30 ± 0.91	3.33 ± 0.73	3.22 ± 0.70	2.22 ± 0.64	17.63 ± 2.7
40 - 49	n = 10	4.10 ± 0.88	3.80 ± 1.03	2.80 ± 0.79	2.70 ± 1.25	2.40 ± 1.27	16.90 ± 3.0
50 - 59	n = 18	3.94 ± 1.11	3.50 ± 0.99	3.00 ± 0.91	2.89 ± 0.96	2.50 ± 0.99	16.06 ± 4.0
60 - 69	n = 15	3.67 ± 0.98	3.47 ± 1.25	2.80 ± 1.15	2.40 ± 0.83	1.93 ± 0.59	14.00 ± 3.9
70 or older	n = 6	4.17 ± 0.75	3.83 ± 0.98	3.17 ± 0.75	2.83 ± 0.98	2.17 ± 0.41	16.17 ± 2.9
p-value		0.026	0.063	0.301	0.081	0.366	-
Occupation							
Total	n = 76	4.14 ± 0.91	3.84 ± 1.06	3.07 ± 0.88	2.88 ± 0.92	2.25 ± 0.82	16.30 ± 3.5
Office workers	n = 22	4.36 ± 0.58	4.05 ± 0.90	2.95 ± 0.72	3.00 ± 0.82	2.00 ± 0.69	16.36 ± 2.7
Medical workers	n = 10	4.80 ± 0.42	4.60 ± 0.70	3.80 ± 0.63	3.70 ± 0.48	2.80 ± 0.79	19.70 ± 1.8
Homemakers	n = 31	3.87 ± 1.09	3.61 ± 1.17	2.87 ± 0.99	2.58 ± 0.92	2.06 ± 0.86	15.06 ± 3.9
Others	n = 13	3.92 ± 0.86	3.46 ± 0.97	3.15 ± 0.80	2.77 ± 1.01	2.69 ± 0.86	16.53 ± 3.3
p-value		0.014	0.025	0.028	0.006	0.006	-

Continued

Marital Status							
Total	n = 76	4.14 ± 0.91	3.84 ± 1.06	3.07 ± 0.88	2.88 ± 0.92	2.25 ± 0.82	16.30 ± 3.5
Yes	n = 21	4.48 ± 0.60	4.24 ± 0.89	3.24 ± 0.70	3.05 ± 0.81	2.10 ± 0.70	17.10 ± 2.8
No	n = 55	4.02 ± 0.97	3.69 ± 1.09	3.00 ± 0.94	2.82 ± 0.96	2.25 ± 0.82	16.00 ± 3.7
p-value		0.048	0.043	0.297	0.336	0.312	-
Presence of Children							
Total	n = 76	4.14 ± 0.91	3.84 ± 1.06	3.07 ± 0.88	2.88 ± 0.92	2.25 ± 0.82	16.30 ± 3.5
Yes	n = 44	3.80 ± 0.95	3.50 ± 1.01	2.93 ± 0.97	2.73 ± 0.98	2.34 ± 0.94	15.41 ± 3.9
No	n = 32	4.63 ± 0.55	4.31 ± 0.82	3.25 ± 0.72	3.09 ± 0.78	2.13 ± 0.61	17.46 ± 2.5
p-value		0	0.001	0.122	0.088	0.259	-

All values are expressed as mean ± standard deviation.

Table 3. Relationship between the basic attributes and radiation exposure literacy by score group.

		low group ≤ 16		**high group ≥ 16**		**χ^2-value**	**p-value**
		n = 27	%	n = 49	%		
Age (years)	30 - 39	5	19	22	45	6.747	0.150
	40 - 49	4	15	6	12		
	50 - 59	7	26	10	20		
	60 - 69	9	33	7	14		
	70 or older	2	7	4	8		
Occupation	Office workers	8	30	14	29	6.822	0.078
	Medical workers	0	0	10	20		
	Homemakers	14	52	17	35		
	Others	5	19	8	16		
Marital status	Yes	6	22	15	31	0.613	0.433
	No	21	78	34	69		
Presence of children	Yes	21	78	22	45	7.660	0.006
	No	6	22	27	55		

children [p = 0.000]). For "*Selection*", there was no significant difference among the age groups. However, there was a significant difference among the participants based on their *occupations*: *medical workers* > *homemakers* (p = 0.043), *marital status*: *never married* > *married* (p = 0.043), and the *presence of children*: *no children* > *with children* (p = 0.001). For "*understanding and communication*", there was no significant difference among the participants based on their *age groups*, *marital status*, and the *presence of children*. In contrast, there was a significant difference based on participants' *occupation* (*medical workers* > *homemakers* (p = 0.018)). For "*judgment*", there were significant differences according to participants' *age group* (*the 30s* > *60s*, p = 0.044) and *occupation* (*medical workers* > *homemakers*, p = 0.004); contrastingly, there were no significant differences in participants' *marital status* or the *presence of children*. Regarding "*planning and action*", significant differences were found among the participants based on their *occupation*: *medical workers* > *office workers* (p = 0.038), *medical workers* > *homemakers* (p = 0.049), and no significant differences were found among the participants in terms of their *age group*, *marital status*, or the *presence of children*.

3.2. Comprehension of Radiation Exposure Dose Distribution

The level of understanding of radiation exposure dose during mammography using the dose distribution chart was 65 (85.5%) for understanding and 11 (14.5%) for not understanding. The 95% confidence interval of the mean value of the two-factor method was 77.43 - 93.62, and the accuracy was high because the error from the mean value was about 10%. Table 4 shows the results of cross-tabulation

Table 4. Cross-statistical tabulation between comprehension of dose distribution chart with age groups, occupation, marital status, and presence/absence of children.

		Comprehension of dose distribution chart	
		Understood	**Not understood**
Age			
Total	n = 76	65	11
30 - 39	n = 27	27	0
40 - 49	n = 10	8	2
50 - 59	n = 18	15	3
60 - 69	n = 15	12	3
70 or older	n = 6	3	3
Occupation			
Total	n = 76	65	11
Office workers	n = 22	22	0
Medical workers	n = 10	10	0
Homemakers	n = 31	24	7
Others	n = 13	9	4
Marital status			
Total	n = 76	65	11
Yes	n = 21	21	0
No	n = 55	44	11
Presence of children			
Total	n = 76	65	11
Yes	n = 44	33	11
No	n = 32	32	0

between the level of understanding of the radiation exposure dose distribution maps and the basic attributes. A χ^2 test was conducted based on the results, and significant differences were found in all of them (*age*; $\chi^2(4) = 11.37$, $p = 0.023$, *occupation*; $\chi^2(3) = 9.850$, $p = 0.020$, *marital status*; $\chi^2(1) = 4.911$, $p = 0.027$, *presence of children*; $\chi^2(1) = 9.354$, $p = 0.020$).

4. Discussion

The term "exposure" is defined as "exposure of the human body to radiation" and is distinguished from "bombing", which refers to damage caused by bombing [20]. The term "medical exposure" refers to exposure to radiation in the medical field. In current medical care, the use of radiation is essential for the treatment of patients, and there are two types of medical exposure: 1) radiation diagnosis, such as X-rays and CT scans; nuclear medicine scans, which detect diseases and obtain imaging information necessary for treatment; and 2) radiation therapy, which aims to irradiate cancerous lesions and kill cancer cells. Patients benefit from radiological diagnosis and treatment. In addition, the premise of radiological diagnosis and treatment is that the benefit to the patient is sufficiently greater than the possibility or risk of injury due to radiation exposure. Additionally, preventing or minimizing the occurrence of radiation damage is essential; hence, doctors and radiographers regulate patients' exposure to radiation doses. The Japan Association of Radiological Technologists, a professional organization in Japan, advocates the need for appropriate and easy-to-understand explanations for each patient to ensure they can understand and accept radiological examinations. This organization also emphasizes the importance of communicating with each patient, as each patient has a different level of understanding; the same can be applied for exposure to radiation doses [21]. It is necessary to provide individualized information according to the background and literacy of each patient, and the understanding can be deepened by explaining via various approaches. This study provided information on radiation exposure dose in mammography examinations to examinees using dose distribution charts. The degree of understanding by providing information on radiation exposure dose visually and the relationship between the attributes of examinees and radiation exposure literacy were ascertained and are discussed below.

The results of dividing the participants of this study by age group showed that the largest number of participants were in their 30s. As is evident from the average age of first marriage in Japan being ≥29.4 years, according to the Monthly Vital Statistics Report of the Ministry of Health, Labour and Welfare [22], 70% of people in this age group were married. According to the Ministry of Internal Affairs and Communications' Labour Force Survey (Detailed Summary), among the 26.57 million women in the non-working population in 2019, 2.31 million were willing to work. However, the most common reason for not seeking employment was "childbirth or childcare [23]". This clearly indicates that there were many homemakers in the occupation group. In other words, understanding the basic attributes of patients who undergo mammography examinations can be as important as general questionnaires, statistics, and analysis in understanding the "personality" of patients who undergo mammography examinations.

The results of Radiation exposure literacy revealed significant differences in "information gathering" and "selection" in relation to no marital history and no children, and taking into account Tanaka *et al.*'s point of view that most married women are responsible for both "work and household" and have long housework times [24], we can infer that the difference is not due to the time available due to marital status, but to the difference in time used since the information derives from the same media. The significant differences between the 30s and 60s age groups and between those with and without children may be because the 30s is the optimal age group for childbearing. This suggests that the concern about radiation exposure dose increases closer to childbirth and the radiation exposure literacy score for "information" is higher. It was also found that these women not only had a high ability to collect information on radiation dose but also a high level of understanding of radiation dose. However, in the "planning and action" scale, those in their 50s responded that they could plan and seek action to reduce radiation dose in mammography examinations based on the information. In other words, even if a person can collect information on radiation doses, the decision to take action to reduce radiation doses is a different matter. Moreover, it can be inferred that differences in radiation exposure literacy levels alone will not solve the problem pertaining to "planning and action". Therefore, people need to understand radiation exposure doses first and then raise their literacy level for "understanding and communication".

Patients undergoing mammography examinations, as the participants of this study, can obtain "information" on radiation exposure to some extent, but their ability to "understand and communicate" the information, "make decisions", and "plan and act" based on the information is low. The first step is understanding, and the corresponding provision of accurate information is required. In radiological examinations, mammography examinations and specific support methods must be provided to those in their 20s and 30s to ensure they understand the necessity of radiological examinations and change their attitude, especially during pregnancy. Briefly, we believe that medical workers must provide information that is appropriate to the individuals in an easy-to-understand manner. However, many patients are reluctant to discuss their anxiety related to radiological examinations with their doctors [25]. Therefore, it is necessary for medical diagnostic centers and local occupational health support centers to provide radiation exposure education and guidance during medical consultations and after medical checkups and health examinations. For this purpose, it is essential to provide risk communication education to medical personnel, including explanations on radiological examinations regarding radiation exposure.

Furthermore, since radiation is invisible, it is difficult to recognize its characteristics and effects visually. Visualization of dose distribution maps using projection mapping [26] [27] and experiential communication methods using virtual reality are among the methods that appeal to the eyes and can communicate radiation exposure in an easy-to-understand manner. However, while such a hands-on method can improve radiation exposure literacy and retention in memory, it requires a high level of knowledge and specialized equipment, making implementation difficult. A simple alternative to provide safe medical care more attentively to patients is using the results of this study as a reference and preparing explanatory cards with color radiation exposure dose distribution maps used in this study. For example, illustrations can be used to prevent excessive fear of radiation exposure and indicate that the radiation dose at the position of the knees, stomach, and eyes is about this level, in accordance with the radiation exposure literacy level of mammography examinees.

Limitations and Challenges of This Study

The results of this study were based on a single-center survey and included outpatients of the Department of Breast Surgery at our hospital. Therefore, patients who underwent mammography examinations during physical examinations were not included in the survey. Many outpatients visited the clinic due to concerns regarding their health, such as suspicion of illness. Therefore, the results of patients who underwent medical examinations without anxiety about their health were different from those who underwent outpatient examinations. Additionally, if we can evaluate the dose, ensure the image quality necessary for diagnosis, and acquire the skills to dispel concerns about radiation dose, we can increase the number of patients receiving necessary mammography examinations and reduce the incidence of breast cancer in Japan.

In conclusion, the visual information on radiation dose distribution in mammography was used to enhance the understanding of radiation dose among examinees. By understanding the radiation exposure literacy of the examinees and comparing it with their attributes, it is possible to provide suggestions for the development of methods for formulating radiation dose information tailored to the needs of individual examinees, leading to improved radiation exposure literacy and radiation exposure skills among patients, necessary for the provision of safe medical care.

Acknowledgements

We would like to express our gratitude to past and present members of the Department of Radiation at the Juntendo Shizuoka Hospital, Japan, and to the staff members for their support and guidance throughout this study.

Research Ethics and Patient Consent

This study was approved by the Juntendo University Shizuoka Hospital Ethical Review Committee (approved June 10, 2020: permission number 756). Informed consent was obtained from the participants.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

References

[1] Trends in Mean Age of Father and Mother by Live Birth Order. Ministry of Health, Labour and Welfare. https://www.mhlw.go.jp/english/database/db-hw/outline/index.html

[2] Foundation for Promotion of Cancer Research (2018) Cancer Statistics in Japan—2017. https://ganjoho.jp/public/qa_links/report/statistics/pdf/cancer_statistics_2017.pdf

[3] Chetlen, A.L., Brown, K.L., King, S.H., Kasales, C.J., Schetter, S.E., Mack, J.A., *et al.* (2016) JOURNAL CLUB: Scatter Radiation Dose from Digital Screening Mammography Measured in a Representative Patient Population. *AJR*: *American Journal of Roentgenology*, **206**, 359-365. https://doi.org/10.2214/AJR.15.14921

[4] Olgar, T., Kahn, T. and Gosch, D. (2012) Average Glandular Dose in Digital Mammography and Breast Tomosynthesis. *RoFo*, **184**, 911-918. https://doi.org/10.1055/s-0032-1312877

[5] Ishikawa, H. and Kiuchi, T. (2010) Health Literacy and Health Communication. *BioPsychoSocial Medicine*, **4**, Article No. 18. https://doi.org/10.1186/1751-0759-4-18

[6] Nakayama, K., Osaka, W., Togari, T., Ishikawa, H., Yonekura, Y., Sekido, A. *et al.* (2015) Comprehensive Health Literacy in Japan Is Lower than in Europe: A Validated Japanese-Language Assessment of Health Literacy. *BMC Public Health*, **15**, Article No. 505. https://doi.org/10.1186/s12889-015-1835-x

[7] Setoyama, Y. and Nakayama, K. (2011) Literature Review for Information Needs, Information Resources, and Difficulties of Information Use among Patients with Breast Cancer in Japan. *Iryo Shakai*, **21**, 325-336. (In Japanese) https://doi.org/10.4091/iken.21.325

[8] Kokufu, H. (2012) Conflict Accompanying the Choice of Initial Treatment in Breast Cancer Patients. *Japan Journal of Nursing Science*, **9**, 177-184. https://doi.org/10.1111/j.1742-7924.2011.00200.x

[9] Matsumoto, A., Aragaki, M., Zheng Y.F., Inokuchi, T., Sakai, K., Shiota, S., Takano, M. and Takahashi, M. (2005) How Japanese Breast Cancer Survivors Perceive the Internet as a Health Information Resource: An Internet Survey with Mailing List Participants. *Japan Journal of Medical Informatics*, **25**, 151-159. (In Japanese)

[10] Nakamura, T., Suzuki, S., Takei, Y., Kobayashi, M., Cruz, V., Kobayashi, I., *et al.* (2020) A More Accurate and Safer Method for the Measurement of Scattered Radiation in X-Ray Examination Rooms. *Radiological Physics and Technology*, **13**, 69-75. (In Japanese) https://doi.org/10.1007/s12194-019-00550-6

[11] Morishima, Y., Chida, K., Shigeizumi, K., Katahira, Y., Seto, H. and Chiba, H. (2012) Importance of Radiation Education for Nurses. *Nihon Hoshasen Gijutsu Gakkai Zasshi*, **68**, 1373-1378. (In Japanese) https://doi.org/10.6009/jjrt.2012_JSRT_68.10.1373

[12] Kanda, R., Tsuji, S., Shirakawa, Y. and Yonehara, H. (2008) Preliminary Survey for Communicating Risk in Medical Exposure—Perception of Risk among Nurses Working in Radiology. *Nihon Hoshasen Gijutsu Gakkai Zasshi*, **64**, 937-947. (In Japanese) https://doi.org/10.6009/jjrt.64.937

[13] Oishi, F., Shiratori, S., Itou, M. and Yamahata, A. (2018) Anxiety in Radiology Nurses about Occupational Exposure: A Qualitative Analysis. *The Journal of Radiological*

Nursing Society of Japan, **6**, 22-32. (In Japanese)

[14] Masujima, Y. and Noto, Y. (2018) Investigation about Recognition of Occupational Exposure and Radiation Education in Nurses Engaged in Intervention Radiology. *The Journal of Radiological Nursing Society of Japan*, **6**, 12-21. (In Japanese)

[15] Katoh, T., Ono, K. and Kusama, K. (2018) The Expected Role of Nurses by Perspectives of Radiologists and Radiologic Technologists. *The Journal of Radiological Nursing Society of Japan*, **6**, 3-11. (In Japanese)

[16] Matsuda, N., Yoshida, M., Takao, H., Kaneko, M., Yamaguchi, Y., Horikawa, M., Kobayashi, H., Goto, S., Ochi, M. and Okumura, Y. (2005) A Collaborative Effort of Medical and Educational Facilities for Radiation Safety Training of Nurse. *Japanese Journal of Radiation Safety Management*, **3**, 336-344. (In Japanese)

[17] Vano, E., Kleiman, N.J., Duran, A., Rehani, M.M., Echeverri, D. and Cabrera, M. (2010) Radiation Cataract Risk in Interventional Cardiology Personnel. *Radiation Research*, **174**, 490-495. https://doi.org/10.1667/RR2207.1

[18] Takenishi, A., Yokoyama, S., Takenishi, M., Takahashi, K., Wakashiro, Y. and Kanagawa, C. (2020) Examining Memory of Risk Information on Medical Exposure: An Experimental Study Using Recognition Test on the Web Site. *Hoken Butsuri*, **55**, 71-85. (In Japanese) https://doi.org/10.5453/jhps.55.71

[19] Ishikawa, H., Nomura, K., Sato, M. and Yano, E. (2008) Developing a Measure of Communicative and Critical Health Literacy: A Pilot Study of Japanese Office Workers. *Health Promotion International*, **23**, 269-274. https://doi.org/10.1093/heapro/dan017

[20] Japan Atomic Energy Relations Organization. Exposure to Radiation and Atomic Bombing. (In Japanese) https://www.ene100.jp/fukushima/317

[21] Explanation (2019) Guidelines for Radiation Inspection Explanations. The Japan Association of Radiological Technologists-Subcommittee on Examination. (In Japanese) http://www.jart.jp/activity/ib0rgt0000005g2r-att/kensasetumei_R1_8.pdf

[22] Summary of the 2018 Vital Statistics Monthly Report Annual Total (Approximate). Ministry of Health, Labour and Welfare (MHLW). (In Japanese) https://www.mhlw.go.jp/toukei/saikin/hw/jinkou/geppo/nengai18/index.html

[23] Gender Equality Bureau, Cabinet Office and Cabinet Office, Government of Japan (2020) White Paper on Gender Equality 2020—Summary. https://www.gender.go.jp/english_contents/about_danjo/whitepaper/pdf/ewp2020.pdf

[24] Tanaka, Y. (2017) A Review of Gender Norms and Working Patterns Using NHK Time Use Surveys: Changing Working Styles and Continued Roles of Women. *Doshisha University Policy and Management Review*, **19**, 341-358. (In Japanese)

[25] Iida, H., Yamamoto, T. and Shimada, Y. (1997) Understanding of Radiation Protection in Medicine: Part 1: Knowledge about Radiation Exposure and Anxiety about Radiation Injury. *Nippon Hoshasen Gijutsu Gakkai Zasshi*, **53**, 1551-1563. (In Japanese) https://doi.org/10.6009/jjrt.KJ00001355267

[26] Daioku, T. and Kobayashi, M. (2020) Using Projection Mapping for Nurses' Radiation Protection Education. *The Journal of Radiological Nursing Society of Japan*, **8**, 3-10.

[27] Fujibuchi, T., Ueda, K., Kadoyanagi, S., Ueno, D. and Nakamura, C. (2019) Examination of Application to Radiation Protection Education by Four-Dimensional Visualization of Scatter Distribution in Radiological Examination Using Virtual Reality. *Nihon Hoshasen Gijutsu Gakkai Zasshi*, **75**, 1297-1307. (In Japanese) https://doi.org/10.6009/jjrt.2019_JSRT_75.11.1297