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Awareness of Turkish Pre-Service Teachers about the Risks of Electromagnetic Radiation in Daily Life Cases

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ABSTRACT This study aimed to investigate Turkish pre-service teachers' awareness about electromagnetic radiation risks, which stem from diagnostic imaging at the hospitals and cell phone use in daily life. The study was based on survey research. A total of 138 education faculty students from the fields of Science Teaching [ST], Classroom Teaching [CT], and English Language Teaching [ELT] participated in the study. Data were collected with the help of a questionnaire involving five cases. Both qualitative and quantitative approaches were utilized in data analysis. The results showed that most of the participants agreed on the hazardousness of the cases. However, their risk awareness varied from case to case. Most ST and CT students were determined to possess acceptable responses in addition to partially acceptable responses. On the other hand, ELT students were determined to favor unacceptable responses. Besides, the participants held several misconceptions. To conclude, the participants' awareness levels were found to be significantly related to their educational field for all cases except the first case. Addressing such popular subjects in the elective courses for all undergraduate students during university education is expected to provide beneficial results.

Keywords Electromagnetic Radiation, Pre-service Teachers, Daily Life, Risk Awareness, Misconceptions

1. INTRODUCTION

The developments in the modern world have numerous effects on human life. Although it is intended to enhance the quality of life with those improvements, the individuals consider various points in this respect. Otherwise, it is likely to get undesired consequences rather than enhancements. One of such consequences might be on health due to the electromagnetic radiation. Electromagnetic radiation is generally divided into two types of radiation; ionizing and non-ionizing radiation (Lu & Huang, 2012). Figure 1 displays the electromagnetic spectrum, including an array of electromagnetic waves increasing in frequencies (Radio Spectrum, n.d.).

As shown in Figure 1, it is clear that electromagnetic radiation takes place in several fields in daily life. For example, power lines, radio/TV broadcasting, mobile phones, TV remote controls, and visible light produce electromagnetic radiation. All of them lead to non-ionizing radiation in this respect. However, ultraviolet light, X-rays, and gamma rays cause electromagnetic radiation, which leads to ionizing radiation. In this paper, two main subjects are taken into consideration: Hospitals and cell phones. The reason for selecting those subjects is that everyone visits hospitals, and almost everyone carries a cell phone in daily life. Hence, those cases are believed to be significant for everyone.

The first case addressed in this paper is related to the electromagnetic radiation at the hospitals. There are several machines used for diagnostic imaging at the hospitals, and they emit radiation. In this respect, I will consider the cases for Computer Tomography (CT) and X-ray machines. Those machines might constitute challenges both for the patients and staff. Smith-Bindman et al. (2009) stated that radiation doses from commonly performed diagnostic CT examinations were higher and more variable than generally quoted and highlighted the need for greater standardization across institutions. Memon, Godward, Williams, Siddique, and Al-Saleh (2010) indicated a significant relationship between dental X-rays and increased risk of thyroid cancer. In their paper, Damilakis, Adams, Guglielmi, and Link (2010) mentioned the need for low-dose protocols in X-ray-based imaging techniques to reduce health risks

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associated with radiation exposition. The researchers especially specified dose optimization of X-rays for children who were more vulnerable to such hazards than adults.

The second case is related to electromagnetic radiation, which stems from the use of cell phones. Cell phone usage throughout the world has increased significantly during the last two decades (Gorpinchenko, Nikitin, Banyra, & Shulyak, 2014). Too much talking on cell phones, carrying them in the left pocket of jackets and shirts, living near base stations have also been discussed. Here, I will focus on suppressing them on-ear and not using wired earphones while talking on the cell phone. Gandhi et al. (2012) signified the customary use of phones in pockets and held directly next to the head, which resulted in the absorption of more cell phone radiation. The researchers pointed out radiation's effects, especially in children. Lu and Huang (2012) reported that many cell phone users defined the symptoms such as headache, sleep disorder, and memory loss during or after mobile handsets. In another study, Gorpinchenko et al. (2014) stated a correlation between mobile phone radiation exposure, DNA–fragmentation level, and decreased sperm motility. In their study, Christopher, Mary Y., Khandaker, and Jojo (2021) examined the effect of radiofrequency wave exposures of ten different cell phones to the brain, eye, and skin tissue under laboratory conditions. As a result, the researchers recommended reducing the extended use of cell phones to avoid unwanted health problems.

The research above provides valuable data to raise the awareness of humans about the impacts of radiation. When this situation is investigated from the perspective of individuals in different fields, it is seen that they carry different awareness levels. In their study, Scali, Mayo, Nicolaou, Kozoriz, and Chang (2017) indicated that senior medical students in Canada were not familiar with, and commonly underestimate, the relative doses and risks of common imaging studies. Besides, Zhou, Wong, Nguyen, and Mendelson (2010) showed that Australian senior medical students and interns lacked the awareness of ionizing radiation from diagnostic imaging. Similarly, Kada (2017) reported that Norwegian senior medical school students carried a low level of knowledge about radiation dose and the risks associated with ionizing imaging examinations. Additionally, Yoshida et al.'s (2020) study implied that Japanese nursing students perceived X-rays as the riskiest in the fifth rank among 30 items. The researchers underlined the need for an adequate education to overcome such fears.

There are also several studies conducted with participants apart from medical students. Dolu and Ürek (2015) determined that Turkish graduate students studying natural sciences were more conscious about electromagnetic pollution and took more precautions to avoid it than the students studying social sciences. Köklükaya, Güven Yıldırım, and Selvi (2017) determined that gender was not effective on Turkish pre-service science teachers' awareness level on electromagnetic pollution. On the other hand, students who took environmental science courses were found to have higher awareness levels than the students who did not take this course. In another study, Kirk and Greenfield (2017) examined university students' knowledge, attitudes, and behaviors on the harmful effects of UV radiation exposure in the UK. The results showed that although the students had a high level of knowledge about UV radiation and skin cancer, their behavior was not sufficiently preventive. Similar results were also obtained from the study of Gunarić et al. (2019) conducted with medical students and non-healthcare-related faculty students in Bosnia and

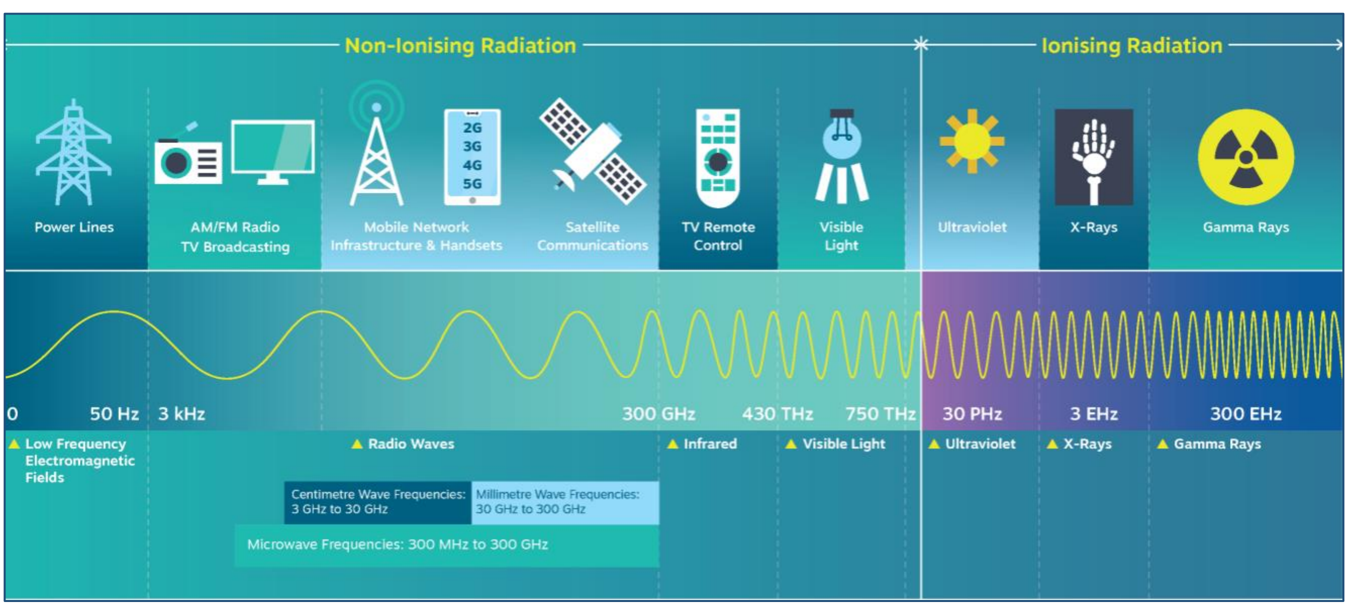

Figure 1 Electromagnetic spectrum

Herzegovina. In this study, medical students were found to take more preventions than the other faculty students in this respect.

In another study conducted in England, Colclough, Lock, and Soares (2011) indicated that physics pre-service teachers had a higher level of knowledge about radioactivity and ionizing radiation than chemistry, biology, and history pre-service teachers. Also, Kartal Taşoğlu, Ateş, and Bakaç (2015) found that most Turkish physics pre-service teachers lacked the knowledge about ionizing and non-ionizing radiation. They concluded that the pre-service teachers' awareness of radiation needed to be improved. Both research reported several misconceptions possessed by the pre-service teachers.

Siersma, Pol, van Joolingen, and Visscher (2021) determined that high school level Dutch students possessed various conceptions which were divergent from the scientific one related to radiation and radioactivity. Henriksen and Jorde (2001) utilized museum visits to teach radiation-related environmental issues (such as greenhouse effect, global warming, ionizing radiation, and health) to Norwegian high school students and detected improvements in their conceptual understanding of the issues.

As can be seen, the literature approaches the concept of radiation from different sides, and various problems are detected in different educational background students on this issue.

Electromagnetic radiation is a concept that is firmly attached to daily life. Although students who study in natural science-related fields are more familiar with this concept theoretically, all students require a certain level of awareness about it as everyone gets affected by its impacts. This study aims to investigate the awareness of Turkish pre-service teachers about the risks of electromagnetic radiation. The study focuses on different educational field participants' association of their scientific knowledge to explain several daily life cases about electromagnetic radiation related to hospitals and cell phone use. Thus, it is intended to make comparisons among the participants' explanations regarding their field of education.

The study is believed to be significant as it focuses on a popular subject from young individuals who will join society as teachers in the near future. First of all, all pre-service teachers require scientific literacy considering the current conditions in the world. Improvement of pre-service teachers' scientific literacy is stated to be seriously taken into account (Chin, 2005). Students might bring various questions to the classroom about the things they observe, which do not have to be strictly related to the subject matter. This case is pervasive in the primary level children posing explanatory types of questions to satisfy their curiosity (Cakmakci et al., 2012). Those questions can involve the issues addressed in this paper since it concentrates on prevalent daily life cases. When they meet such questions, teachers should be able to provide proper explanations to their students. The teacher factor influences student behavior (Laguna et al., 2020) since young students appreciate their teachers. Accordingly, all of the pre-service teachers involved in the present study will teach young children. Hence, they will deliver teaching in their field, but they might also be role models to the students with their behaviors or opinions in this respect.

The research questions are as follows: (1) What do pre-service teachers think of the hazardousness of several cases related to electromagnetic radiation? (2) What are the awareness levels of pre-service teachers about the risks of electromagnetic radiation for the given cases? (3) Do the awareness levels of pre-service teachers display a statistically significant difference among different fields of education? (4) Do pre-service teachers' awareness levels in the same field display a statistically significant difference among their responses?

2. METHOD

2.1 Participants

The study was conducted with 138 pre-service teachers studying at a governmental university's education faculty in the west part of Turkey. All of the participants were year-3 students in the four-year programs. Their ages varied from 21 to 24 years. Ninety-four (68.1%) were females, whereas 44 (31.9%) were male students. The participants studied in three different fields: 41 (29.7%) of them were Science Teaching (ST) students, 49 (35.5%) of them were Classroom Teaching (CT) students, and 48 (34.8%) of them were English Language Teaching (ELT) students. The participants were selected via a purposeful sampling method. Thus, it aimed to make a representative sample with the individuals from different levels of the critical variable (Crain-Dorough, 2019), the educational field in this study to make the necessary comparisons in the study's context.

2.2 Study Design

The study was based on a much smaller scale survey research. Andres (2012) states that "The goal of survey research may be to generalize to larger populations or it may be intended to be transferable." Thus, the study results are expected to make generalizations to improve the awareness levels of university students.

The study group involved pre-service teachers who came to the university from different educational backgrounds. They all took good scores from the university entrance exam conducted all over Turkey to enter education faculty. When the details are considered, ST candidates enter university after taking science and mathematics-focused courses in their teaching programs during the last two years of high school. In the university, they continue to get more courses in the field of science. For example, they learn general physics, chemistry, and biology courses in addition to more specific courses such as geology, astronomy, and evolution.

On the other hand, CT candidates generally get more social sciences and Turkish language-based courses in the last two years of their high school education. The university takes basic introductory courses in mathematics, science, history, geography, and the Turkish language. Also, they focus on writing and reading skills in the Turkish language during their professional education.

ELT candidates study English courses intensively during the last two years of their high school education. They specialize in English Language teaching by taking English Literature, linguistics, and English Language teaching methods in their university education. As it can be seen, there are apparent distinctions among the sub-groups of the participants. Hence, those distinctions are believed to be reflected in study data to compare the research questions.

2.3 Data Collection Instrument

Data were collected with the help of a questionnaire involving five open-ended two-tier questions developed by the researcher. The questions aimed to examine the participants' opinions and explanations on electromagnetic radiation with the help of the cases selected from daily life. Those cases were linked to the use of cell phones and diagnostic imaging at the hospitals. The cases were named as follows:

Case 1: The pregnant and X-ray
Case 2: Suppressing cell phones on-ear
Case 3: Radiology staff
Case 4: CT
Case 5: Wired earphones and cell phones

As mentioned above, each question involved two parts. The first part of the question asked the participant to determine the given case was hazardous or not hazardous. The second part of the question dealt with the explanation of the participant for his/her determination. Here, the participant is required to associate his/her scientific knowledge with the given case.

The instrument was presented to science education experts several times to check the content validity of it. "Content validity assesses whether items are comprehensive and adequately reflect the perspective for the population of interest. Also, content validity provides evidence that formatting, instructions, and response options are relevant, and the measure is understandable and acceptable." (Brod, Tesler, & Christensen, 2009). Also, it was presented to language experts to avoid any misunderstandings that might stem from the sentences structure.

Although there is no uniform approach for examining an instrument's content validity, several methods can be utilized in this respect (Almanasreh, Moles, & Chen, 2019). One of those quantitative approaches, Content Validity Ratio (CVR), was proposed by Lawshe (1975). It is a method for measuring experts' agreement regarding how essential a particular item is (Almanasreh et al., 2019). The formula devised for CVR was as follows (Lawshe, 1975):

$$\mathrm{CVR} = \frac{\mathrm{n_e} - {}^{\mathrm{N}}\!/_{2}}{{}^{\mathrm{N}}\!/_{2}}$$

In the formula, ne indicates the number of reviewers who state the item is essential. Also, N denotes the total number of reviewers. The reviewers are asked to determine whether an item in the test is essential, helpful, but not essential or not necessary. Lawshe (1975) states that when all reviewers indicate that an item is essential, the CVR value is computed to be 1.00. In the present study, seven reviewers were involved in this process. Those reviewers were two associate professor doctors, two instructor PhDs, two teachers with master's degrees, and one graduate student in science education. All of the reviewers were found to agree on the essentiality of the items. Thus, CVR was calculated to be 1.00 for each item in the test.

A pilot study was conducted with a group of 60 participants before the actual application. Finally, the instrument was applied to each group of pre-service teachers in 40 minutes to collect the study data.

2.4 Data Analysis

In data analysis, the instruments were coded with numbers to indicate each participant and his/her field. For example, ST1 meant number-1 student in the field of Science Teaching. Similarly, CT16 meant number-16 students in the field of Classroom Teaching. Next, qualitative approaches were applied to data. Firstly, the participants' determination of the given cases was analyzed descriptively as hazardous, not hazardous, or no response. Next, in the explanation part analysis, the researcher evaluated the participants' responses according to the evaluation scheme of Tsaparlis, Hartzavalos, and Nakiboglu (2013). The researchers explained the scheme as follows:

(1) Acceptable, showing ability to think and understand;
(2) Partially acceptable, showing partial understanding/restricted ability of thinking;
(3) Unacceptable, showing fundamental error(s)/lack of understudying/irrelevant thinking.

Students' responses that mentioned several details about the case were gathered under the present study's acceptable category. Those responses mainly explained the reason for the harm on health acceptably. However, responses with a general approach to the case were evaluated under the partially acceptable category. They made restricted explanations by mentioning only one point about the case. On the other hand, responses that involved misconceptions, incorrect information, or insufficiencies were determined as unacceptable responses.

In the analysis, another researcher in science education was also asked to take part in this process. So, the inter-rater consistency was calculated to be 94%, indicating the

Table 1 Analysis of the participants' responses for case-1

Responses	Participants' Fields						χ^2	p value
	ST		CT		ELT			
	n	%	n	%	n	%		
Acceptable	29	70.7	32	65.3	24	50.0	6.050	.195
Partially Acc.	10	24.4	12	24.5	15	31.2		
Unacceptable	2	4.9	5	10.2	9	18.8		
Total	41	100.0	49	100.0	48	100.0		

*p<.05

reliability of data analysis (Miles & Huberman, 1994). The frequency and percentage distributions were obtained for each question to indicate the participants' awareness levels about electromagnetic radiation risks.

In the following procedure, the categories were coded with numbers to quantify data and perform statistical tests. As for the category, acceptable was coded with "3", partially acceptable was coded with "2", and unacceptable was coded with "1". Data were transferred to IBM SPSS 25 to test whether the participants' responses showed a meaningful differentiation in their group and make comparisons among the groups with the help of Chi-square tests from non-parametric statistics tests. The reliability of the questionnaire was calculated to be α= .703.

3. RESULTS

3.1 Case 1: The Pregnant and X-ray

Question-1: It is hazardous/not hazardous for the pregnant women to enter the X-ray room because….

All of ST (100.0%) and CT students (100.0%), in addition to the majority of ELT students (95.8%), agreed that pregnant women's entrance to the X-ray room was hazardous, as shown in Figure 2. When their explanations were examined in detail, different awareness levels, as shown in Table 1, were obtained:

As shown in Table 1, the highest percentages indicated acceptable responses from the participants in all fields regarding their explanations. Partially acceptable responses followed this category. The percentages of unacceptable responses constituted lesser in value. The result of the Chi-square test showed that there was no significant difference among the categories of responses in different fields. In another words, the participants' responses were similar to each other for case-1, $\chi2$ (df= 4, N=138) =6.05, p>.05.

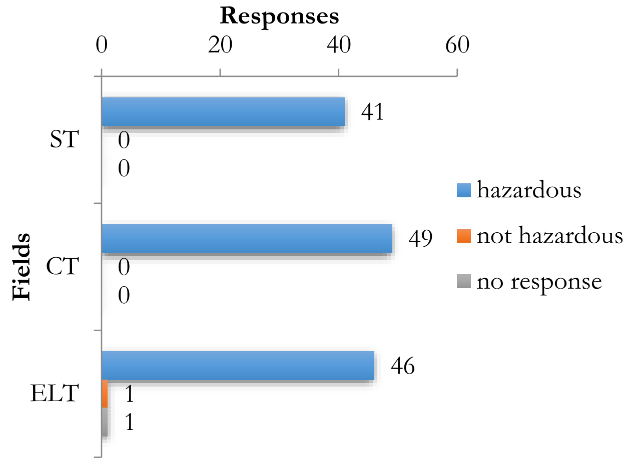

Figure 2 The Agreement of the participants on the hazardousness of case-1

When the findings were evaluated in each field, the analysis of ST students' responses implied a significant difference among the categories $\chi2$ (df= 2, N= 41) = 28.146, p<.05. The analysis of CT students' responses also indicated that the differentiation among the categories was significant $\chi2$ (df=2, N=49)=24.041, p<.05. Similarly, the results obtained from ELT students demonstrated a significant difference among the categories $\chi2$ (df= 2, N= 48)=7.125, p<.05.

Several student responses are given below to illustrate the categories utilized in the analysis of case-1.

Acceptable

ST18: X-rays might harm the baby and mother. They might cause mutations.

CT21: They might cause an impaired baby to born.

Partially Acceptable

ELT28: There is radiation.

Table 2 Analysis of the participants' responses for case -2

Responses	Participants' Fields						χ^2	p value
	ST		CT		ELT			
	n	%	n	%	n	%		
Acceptable	21	51.2	34	69.4	17	35.4	30.463	.0001*
Partially Acc.	18	43.9	9	18.4	10	20.8		
Unacceptable	2	4.9	6	12.2	21	43.8		
Total	41	100.0	49	100.0	48	100.0		

*p<.05

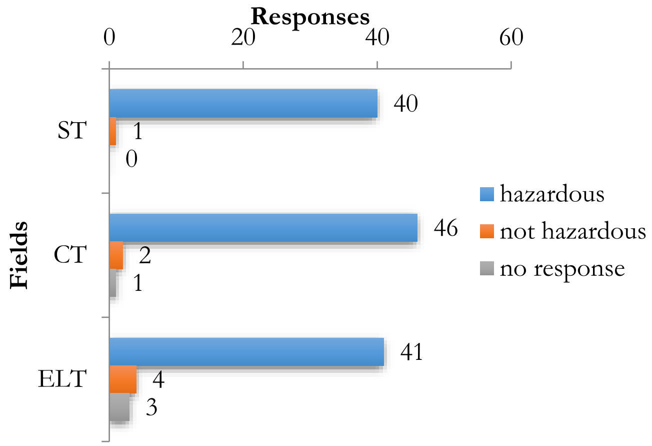

Figure 3 The agreement of the participants on the hazardousness of case-2

CT1: The baby might be affected.

Unacceptable

ST36: X-ray machine emits UV light.

CT31: X-ray machine emits ultrasound.

ELT8: X-ray machine emits Bluetooth.

3.2 Case 2: Suppressing Cell Phones on Ear

Question-2: It is hazardous/not hazardous to suppress the cell phone heavily on the ear while talking because….

Most participants (ST: 97.6%, CT: 93.9%, ELT: 85.4%) stated that suppressing the cell phone heavily on the ear was hazardous while talking. The distribution is displayed in Figure 3. Table 2 displays the detailed analysis results obtained from the participants' explanations for case-2.

According to Table 2, the highest percentages showed acceptable responses for ST and CT students. This category was followed by partially acceptable responses of ST and CT students. However, ELT students' responses showed a different tendency in this respect. The highest percentages indicated unacceptable responses for them. When the significance of the participants' responses in different categories was examined with the Chi-square test, it was seen that there was a significant difference among their responses. In other words, the participants' responses in different fields displayed a statistically significant differentiation $\chi 2$ (df= 4, N=138)= 30.463, p<.05.

The analysis of the participants' responses in their fields also yielded a statistically significant differentiation for ST $\chi 2$ (df=2, N=41)= 15.268, p<.05 and CT students $\chi 2$ (df=2, N=49)= 28.939, p<.05 whereas ELT students' responses did not show such a differentiation $\chi 2$ (df= 2, N=48)= 3.875, p>.05.

Here are several student responses to provide examples for the analysis of case-2.

Acceptable

ST4: … radiation and loud voice give harm to the body.

Partially Acceptable

ST29: … it is disadvantageous for the health.

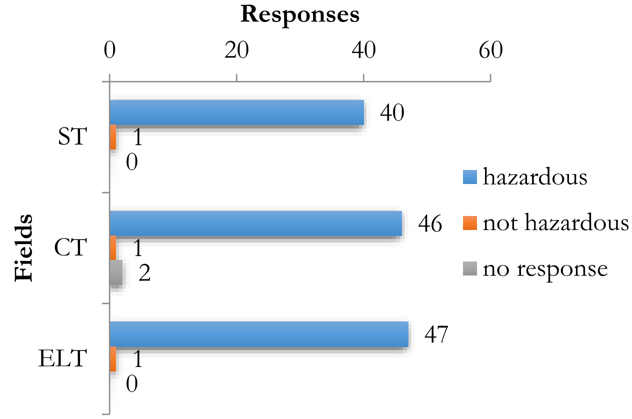

Figure 4 The agreement of the participants on the hazardousness of case-3

CT20: … it applies pressure on the ear.

Unacceptable

ELT1: … the battery might explode.

ELT12: … the ear might explode.

3.3 Case 3: Radiology Staff

Question-3: It is hazardous/non-hazardous for the staff to work for long periods at the hospitals' radiology departments without making small vocations because….

According to Figure 4, most of the participants (ST: 97.6%, CT: 93.9%, ELT: 97.9%) agreed that it was hazardous for the radiology staff to work at hospitals for an extended period without vocations.

Table 3 introduces the risk awareness levels of the participants with Chi-square test results for case-3.

When Table 3 is considered, it is seen that there is a decreasing tendency in the percentages of ST and CT students' responses from acceptable to unacceptable categories. However, ELT students' responses displayed a different tendency. According to the Chi-square test result, there was a statistically significant relationship between the awareness levels and educational fields of the participants $\chi 2$ (df= 2, N=48)=7.125, p<.05.

A significant difference was also determined among the categories obtained from ST students $\chi 2$ (df= 2, N=41)= 24.341, p<.05 and CT students $\chi 2$ (df= 2, N= 49)=9.959, p<.05 as a result of Chi-square test. However, ELT students' responses did not show a significant differentiation among the categories $\chi 2$ (df= 2, N=48)=2.375, p>.05

Several student responses are given below to illustrate the categories utilized in the analysis of case-3.

Acceptable

ST3: … constant exposition to the radiation might cause cancer/genetic mutations.

Table 3 Analysis of the participants' responses for case-3

Responses	Participants' Fields						χ^2	p value
	ST		CT		ELT			
	n	%	n	%	n	%		
Acceptable	28	68.3	25	51.0	14	29.2	7.125	.005*
Partially Acc.	10	24.4	17	34.7	21	43.8		
Unacceptable	3	7.3	7	14.3	13	27.1		
Total	41	100.0	49	100.0	48	100.0		

*p<.05

Table 4 Analysis of the participants' responses for case-4

Responses	Participants' Fields						χ^2	p value
	ST		CT		ELT			
	n	%	n	%	n	%		
Acceptable	9	22.0	9	18.4	5	10.4	14.654	.005*
Partially Acc.	25	61.0	26	53.1	17	35.4		
Unacceptable	7	17.1	14	28.5	26	54.2		
Total	41	100.0	49	100.0	48	100.0		

*p<.05

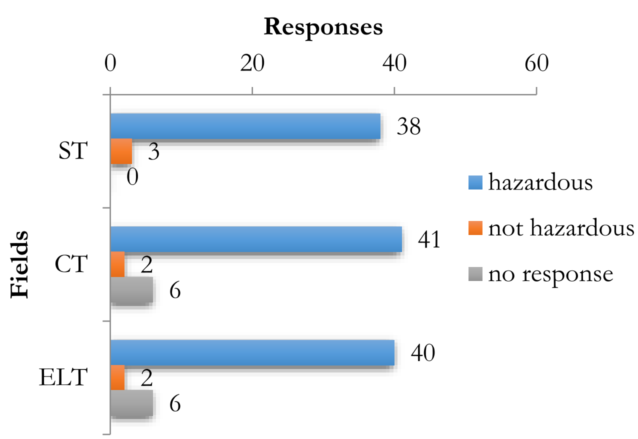

Figure 5 The agreement of the participants on the hazardousness of case-4

Partially Acceptable

ELT14: … they take radiation.

ELT30: … it might harm humans.

Unacceptable

ST23: ... radiation might transmit the disease to a human.

ST27: … they might be affected by UV light.

3.4 Case 4: CT

Question-4: It is hazardous/not hazardous to be exposed to computer tomography machine used for diagnosis at the hospitals for various times because….

Figure 5 displays that most participants (ST: 92.7%, CT: 83.7%, ELT: 83.3%) agreed that it was hazardous to be exposed to computer tomography machines used for diagnosis at the hospitals for various times.

When the participants' explanations are examined in detail, their awareness levels and differentiation are displayed in Table 4. The highest percentages indicated partially acceptable responses for ST and CT students, whereas it indicated unacceptable responses for ELT students. Chi-square test result showed that the differentiation of participants' responses in different fields was statistically significant $\chi2$ (df= 4, N=138)=14.654, p <.05.

When the participants' responses were evaluated in their own fields, all groups' responses differentiated in a statistically significant manner; for ST students $\chi2$ (df=2, N=41)=14.244, p<.05; for CT students, $\chi2$ (df= 2, N=49)=9.347, p<.05; for ELT students, $\chi2$ (df= 2, N=48) = 13.875, p<.05.

Several statements are presented below to illustrate the categories used in the analysis of case-4.

Acceptable

ST19: … it emits radiation which harms the body and causes cancer.

Partially Acceptable

CT21: … it emits radiation.

Unacceptable

ELT9: … it emits UV light.

CT22: … it is a strong magnet and has a powerful magnetic field.

ELT13: … it does not emit radiation.

3.5 Case 5: Wired Earphones and Cell Phones

Question-5: Talking on a cell phone by putting it on a naked ear is more hazardous/not more hazardous than talking on it by wearing wired earphones because….

According to Figure 6, most of the students (ST: 87.8%, CT: 67.3%, ELT: 62.5%) indicated that it was more hazardous to talk on a cell phone by putting it on a naked ear than talking on it by wearing wired earphones.

Table 5 provides different awareness levels of participants and the significance of the differentiation of their responses among their fields.

Table 5 Analysis of the participants' responses for case-5

Responses	Participants' Fields						χ^2	p value
	ST		CT		ELT			
	n	%	n	%	n	%		
Acceptable	5	12.2	-	-	4	8.3	22.625	.001*
Partially Acc.	26	63.4	26	53.1	13	27.1		
Unacceptable	10	24.4	23	46.9	31	64.6		
Total	41	100.0	49	100.0	48	100.0		

*p<.05

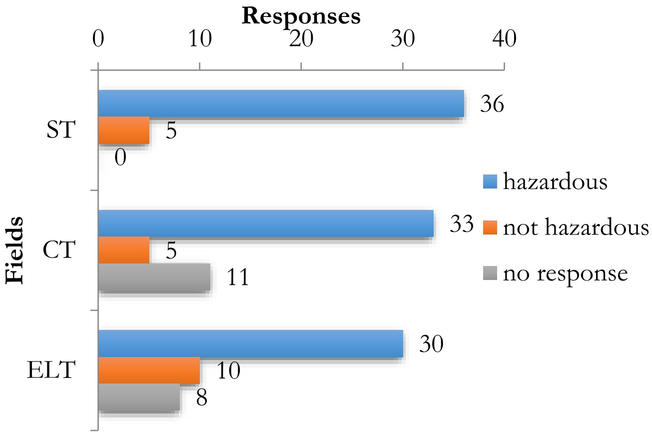

Figure 6 The agreement of the participants on the hazardousness of case-5

According to Table 5, the highest percentages belonged to partially acceptable ST and CT students' responses, whereas it indicated unacceptable responses for ELT students as in the previous case. It was also seen that CT students had no acceptable response for this case. When the Chi-square test result was considered, a significant relationship among the students' educational fields and awareness levels was detected, $\chi 2$ (df=4, N=138)=18.302, $p<.05$.

When the participants' responses were evaluated in their own fields, all groups' responses differentiated in a statistically significant manner as in the previous analysis; for ST students $\chi 2$ (df= 2, N=41)=9.707, $p<.05$; for CT students, $\chi 2$ (df= 2, N=49) = 18.898, $p<.05$; for ELT students, $\chi 2$ (df=2, N=48) = 22.625, $p<.05$.

Here are some examples from student responses for the analysis of case-5.

Acceptable

ST5: ... earphones take the phone away from the head for some amount and protect us from the dangerous effects of radiation.

Partially Acceptable

CT45: … we get more radiation without wired earphones.

Unacceptable

ELT39: …it is the same thing, with earphones or not.

ELT9: … we might have electric shock without earphones.

4. DISCUSSION

The results obtained from the present study indicated that most of the participants in three fields agreed on the hazardousness of the impacts of all given health cases. Among five cases, the participants were most sensitive for the pregnant not to enter the X-ray room. This finding was consistent with what was found from the comparison of three fields; there was no significant differentiation among their responses in this respect. Rego and Peralta's (2006) study also showed that university-level students agreed with this situation's hazardousness. The radiology staff case followed a high percentage of agreement on this case. Similarly, Rego and Peralta (2006) reported that university students accepted that several people were exposed to more radiation in some jobs and sports. On the other hand, grade 7-12 students were not as sensitive as the university students.

The first part of the cases also showed that the participants were less concerned about the hazards of talking on the cell phone without wearing wired earphones than in the other cases. Significant differentiation was detected among their responses. According to the educational field, their responses also differentiated significantly for the cases suppressing cell phones on-ear, radiology staff, and CT. Thus, it might be concluded that the field of education constitutes an important place in students' awareness about the risks of electromagnetic radiation. Another study conducted with university students from different science backgrounds showed that they possessed similar radioactivity responses and ionizing radiation before the instruction (Prather & Harrington, 2001). However, after the instructional activities and inquiry learning approaches, all students and the non-science majors demonstrated a significant improvement in their conceptual and theoretical knowledge.

When their explanations were compared in each field, ST students' responses were found to differentiate in a statistically significant manner for all cases. Most of them were determined to possess acceptable responses for the first three cases, whereas partially acceptable responses were detected most for the last two cases. The results obtained from CT students might be stated to be similar to ST students. However, ELT students' responses showed a different tendency. The results obtained from the cases; the pregnant and X-ray, CT and wired earphones and cell phones demonstrated a statistically significant differentiation for ELT students. The first case showed a significant differentiation in favor of acceptable responses, whereas the other cases favored unacceptable responses. It might be stated that students possess higher understanding levels and thus more awareness towards the risks of electromagnetic radiation as they get more formal education which is in line with Colclough et al. (2011). It is also possible for the students to get information from several informal ways and formal education. However, the internet, which is one of the first choices of young people as an information source, has been detected to include various misconceptions on this subject (Acar Şeşen & İnce, 2010).

When the participants' agreement rates on the hazardousness of the cases and their acceptable explanations are considered in terms of the present study, it might be asserted that ST students possess a higher awareness level than the other students. On the other hand, ELT students might be asserted to have a lower level of awareness in this respect. This result indicated the educational field's positive effect on students' awareness towards radiation in line with the earlier research (Colclough et al., 2011; Dolu & Ürek, 2015; Gunarić et al., 2019). However, the knowledge and awareness about radiation become fruitful when it is reflected in daily life. The present study did not deal with the reflection of participants' knowledge in their behavior. However, Kirk and Greenfield (2017) depicted that medical students failed to display their knowledge about UV radiation in their behavior, although they were expected to possess the highest level of awareness about radiation due to their professional education. This point might also be considered in terms of future studies.

The study also indicated insufficiencies and several misconceptions of the participants as in the previous research (Cardoso, Nunes, Silva, Braghittoni, & Trindade, 2020; Colclough et al., 2011; Henriksen & Jorde, 2001; Kartal Taşoğlu et al., 2015; Mubeen, Abbas, & Nisar, 2008; Plotz & Hopf, 2016; Siersma et al., 2021; Tabor-Morris, Briles, & Schiele, 2017). In most of the given cases, the students were seen to assert the wrong type of electromagnetic waves to explain the cause of radiation for radiological devices such as X-ray and CT machines. For example, some students mentioned UV light, Bluetooth, and ultrasound to be emitted by X-ray machines. Several reasons might be mentioned for getting this result. First of all, the language structure might be listed as the top factor. The term used for X-ray machines in Turkish does not involve X-ray in it. It is called in a form such as 'Röntgen Device'. So, the students might think of other types of radiation other than X-ray. Neumann and Hopf mentioned another linguistic effect (2012), stemming from the German language structure. Also, Siersma et al. (2021) listed several conceptions of the students based on language difficulties. Besides, UV was detected to be one of four terms among the students' spontaneous associations with the term 'radiation' (Neumann & Hopf, 2012), which might be concluded to be parallel to the present study's finding.

Asserting Bluetooth for those cases might be because young people frequently use Bluetooth technology such as headphones in their daily lives. The term Bluetooth is used for high-frequency radio waves. However, the literature showed that students lacked knowledge about radio waves on a statistically significant level (Tabor-Morris et al., 2017). Although nearly all of the participants agreed on X-ray machines' hazardousness for pregnant women, several students explained that X-ray machines emitted ultrasound. However, ultrasound is a type of sound wave, and it has no risks for the individuals. The study of Zhou et al. (2010) also indicated various medical students and interns who believed that ultrasound machines emitted ionizing radiation.

When it is considered that most young individuals' knowledge about radioactivity and ionizing radiation comes from media (Colclough et al., 2020; Rego & Peralta, 2006) and it caused various misconceptions (Cardoso et al., 2020), it might be acceptable to encounter such opinions of students which are not in line with science. So, students' confusion about radiation concepts might be triggered due to the role of media and their daily life experiences.

The study also showed that several students mixed CT with MRI (Magnetic Resonance Imaging) because they mentioned that CT had a giant magnet in it. The research indicated that students did not have a clear view of CT and MRI. Mubeen et al.'s (2008) study conducted with fourth and final year medical students in Pakistan showed that more than 80% of the students mentioned MRI emitted ionizing radiation. Also, Rego and Peralta (2006) determined that Portugal students thought that MRI had the same radiation as used in the radiography. Besides, high school students were determined to believe that all medical imaging technologies and medical treatments utilized harmful radiation (Siersma et al., 2021).

Several students thought that radiation might transmit diseases to humans. This finding was similar to the confusion of the concept of irradiation with contamination (Colclough et al., 2011; Kartal Taşoğlu et al., 2015; Siersma et al., 2021). Also, Mubeen et al. (2008) determined that about 60% of the medical students thought that the room's objects emitted radiation after the completion of an X-ray examination. Additionally, Prather and Harrington (2001) reported that half of the college students believed that an object exposed to radiation became radioactive. On the other hand, a few students thought that diagnostic imaging devices emitted X-rays were not dangerous for humans. This was in line with the finding of Plotz and Hopf (2016). Those researchers reported that the damage of X-ray on the human body was not apparent for the students. Similarly, Neumann and Hopf (2012) determined that several students believed something widely used in medicine could not possibly be harmful to the human body.

5. CONCLUSION

In sum, the results obtained from the present study showed that the awareness levels of different educational field university students varied from case to case about the subject, electromagnetic radiation. It is required to enhance all the students' ability and literacy about electromagnetic radiation with rapid curricular improvements (Otsuji, Toda, Nobeoka, & Taylor, 2014). Addressing such popular subjects in the elective courses for all undergraduates during university education is expected to make contributions to young individuals in this respect. For example, Alsop (2001) found that a group of non-science university graduates who lived and get educated in an area with higher than average radiation levels were more knowledgeable about the everyday practicalities of living with increased risk due to elevated radon concentrations than those who did not. Also, diagnosis of students' misconceptions might help educators develop teaching-learning activities to overcome them (Cardoso et al., 2020).

To conclude, the study provided valuable data that showed that Turkish pre-service teachers' conceptual understanding levels mainly depended on their educational field. ST students were determined to have a higher level of awareness towards daily life cases related to electromagnetic radiation. On the other hand, ELT students were found to have less awareness than the other students. However, the study was limited to the participants from three fields. Participants from different fields might be included in a more comprehensive future study that considers electromagnetic radiation risks by using a Likert-type scale. Data presented in this paper might contribute to the development of such a scale. Conduction of similar studies in different parts of the world is believed to be beneficial.

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