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Examination of effects of radiation awareness on protection from radiation via structural equation modeling

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Abstract

This study aims to determine the radiation awareness levels and radiation protection information of university students and to model the effects of radiation awareness levels on radiation protection information. For this purpose, a questionnaire both including the demographic features and the scale is applied to 580 university students to obtain the data set. The data set is analyzed by Explanatory Factor Analysis (EFA), Confirmatory Factor Analysis (CFA), Structural Equation Modeling (SEM). As the results of EFA, while four dimensions for Radiation awareness are determined and they are named; Physics Knowledge, Technical Device Knowledge, Professional Knowledge and Radiation Security Knowledge respectively, Radiation protection knowledge determined in a single dimension. As well as the Physics Knowledge has the greatest effect, Radiation Security Knowledge and Technical Device Knowledge have statistically significant effects on radiation protection information of the students. Improving Physics Knowledge, Radiation Security Knowledge and Technical Device Knowledge via some extra seminars, giving theoretical and applied educations should improve radiation protection information of these students. Even if the results indicate that Professional Knowledge does not have statistically significant effect on radiation protection information, it has an indirect effect. Some improvements about this sub-factor may also improve the radiation protection information. As "entering to radiation areas needs attention" has a direct and significant effect on radiation protection information, the importance of this situation must keep its priority and theoretical and applied educations must be in progress.

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1. Introduction

The term radiation refers to energy that is emitted from a source. Although the term is normally reserved for wave phenomena (like electromagnetic radiation) it can also be used to describe emitted particles (like alpha and beta radiation) [1]. Radiation is a very general term, used to describe any process that transmits energy through space or a material away from a source. Light, sound, and radio waves are all examples of radiation.

Studies on occupational exposures, especially large-scale cohort studies, can provide useful information in this regard. The main challenge is to find a sufficiently large cohort for which accurate dose information is available, with a sufficiently period of follow-up to evaluate cancer risk. The National Dose Registry is well suited for this purpose [2]. In the studies conducted, it was stated that the physicians' knowledge about radiation safety was insufficient and hundreds of unnecessary examinations were carried out every year [3]. Awareness is an understanding of the activities of others, which provides a context for your own activity. This context is used to ensure that individual contributions are relevant to the group's activity as a whole, and to evaluate individual actions with respect to group goals and progress [4].

This study aims to determine the radiation awareness levels and radiation protection information of university students and to determine the effect of radiation awareness levels on radiation protection information with SEM.

2. Materials and Methods

2.1. Population and sample

By the purpose of determining the university students' knowledge levels and the effects of radiation awareness levels on their radiation protection knowledge, the population of this study is determined

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as the total 3400 students at health occupation high school and health services occupation high school of the University. Because of time, money and etc. restrictions, a sample is chosen among these students via stratified sampling, considering the departments and the classes of these students. The sample size is calculated as 550 according to $n = s^2.z^2/d^2$ formulation where s: standard deviation z: critical value and d: precision.

2.2. Data collection

In this study, a questionnaire is used to collect the data set. The questionnaire is developed by the authors of this study by examining the related literature and considering the ideas of the experts in this field. It is composed of three parts. First part includes 8 items related to the socio-demographic features of the students while second part which measures the radiation awareness of students, includes 16 items with four dimensions named as: Physics Knowledge, Technical Device Knowledge, Professional Knowledge, Radiation Security Knowledge and the third part which measures the radiation protection knowledge of students includes 4 items. Second and the third sections of the questionnaire are prepared as a Likert scale type questionnaire, ranging from 1 'strongly disagree' to 5 'strongly agree'. The data set is collected by applying this questionnaire to 600 university students between the dates 1-30 September 2017. Statistical analyses are conducted over 585 questionnaires due to some unfilled forms. Scale of this study in the questionnaire form is also approved by research ethics review committee by protocol number: 2011-KAEK-2.

2.3. Data analysis

As the data analysis, first off all descriptive statistics of the socio-demographic features of the students are given. Then, EFA, CFA and SEM are applied to find out the dimensions of Radiation awareness scale, to confirm them and to model the relations between the sub-factors of radiation awareness and protection Knowledge. The results are given in related tables and figures. SPSS and LISREL softwares are used to perform the statistical analysis.

EFA attempts to bring intercorrelated variables together under more general, underlying variables. More specifically, the goal of factor analysis is to reduce "the dimensionality of the original space and to give an interpretation to the new space, spanned by a reduced number of new dimensions which are supposed to underlie the old ones" [5]. CFA is generally used as a deductive approach to testing whether some a priori formulated theoretical model adequately explains covariances among observed variables [6]. SEM is a comprehensive statistical method used in testing hypotheses about causal relationships among observed and unobserved (latent) variables and has proved useful in solving the problems in formulating theoretical constructions [7].

3. Results and Discussion

3.1. Demographic features of the participants

Descriptive statistics of the participants are; as their gender, while 71,1% of the participants are female, 28,9% of them are male. Related with their departments; 14,2% of them are at Nursing, 6,2% of them are at Health Management, 11,3% of them are at Physiotherapy and Rehabilitation, 0,5% of them are at Nourishment and Dietetic, 6% of them are at Elderly Care, 19,3% of them are at Medical Laboratory Techniques, 13,2% of them are at Medical Screening, 8% of them are at Electroneurophiysology, 12,3% of them are at Medical Documentation and Secretarial and 9,1% of them are at Orthopedic Prothesis and Orthesis. The percentages of the students attending to first, second third and fourth classes are 55,4%, 40%, 2,1% and 2,6% respectively. According to their age category, 45,1% of them are at the ages between 18-19, 43,1% of them are at the ages between 20-21, 8% of them are at the ages between 22-23and 3,8% of them are at the ages 24 and more. While mother education level percentages of these students are 7% Literate, 51,8% Primary School, 19,5% Secondary School, 17,3% High School and 4,4% University, the percentages of their father education levels are 1.5% Literate, 36.2% Primary School, 18,5% Secondary School, 28.43% High School and 15.4% University. Related to their monthly income, while 18.6% of them get 1400 TL and less, the percentages for 1401-2500 TL, 2501-4000 TL and 4001 TL and more are, 48.4%, 26.7% and 6.3% respectively. They also mentioned that as their residence, 14% of them live in Village, 33.8% of them live in County, 26.3% of them live in Province and 25.8% of them live in Metropolis.

3.2. EFA results of radiation awareness and protection knowledge

Results of EFA for Radiation awareness and protection knowledge scales are given in Table 1 and Table 2. Table 1 indicates that, the total variance explanation ratio for the Radiation awareness scale is 54.8% the variance explanation ratios of the sub-factors which are named; Physics Knowledge, Technical Device Knowledge, Professional Knowledge and Radiation Security Knowledge are 18.132%, 13.601%, 13.614% and 9.479% respectively.

Table 1.EFA Results and Cronbach's α values for Radiation awareness scale

Factors/Items	Factor Loading	Eigen value	Explained Variance (%)	α
FB. Physics Knowledge				
cted dose amount of human body decreases by moving away from the radiation source.	0.736	4.179	18.132	0.780
FB2. There may be some precautions to protect against exposure to radiation.	0.741			
FB3. The damage of radiation is related to the exposure time.	0.740			
FB4. The amount of the radiation changes the damage level	0.675			
TCB. Technical Device Knowledge				
TCB1.Koroner Angio devices work with radiation	0.661	2.126	13.601	0.669
TCB2.Bonedensitometry includes radiation	0.651			
TCB3.Magnetic Rezones (MR) do not include radiation.	0.596			
TCB4.Torax computer-based tomography includes much radiation compared with lung roentgen.	0.537			
TCB5.Mamografy includes radiation.	0.489			
MB. Professional Knowledge				
MB1. I have information about X-rays.	0.803	1.237	13.614	0.697
MB2. I know when the radiation is first used in medicine.	0.677			
MB3. I have information about school levels of radiology education	0.631			
MB4. I was aware of the effects of radiation on human health when I preferred this profession.	0.612			
RGB. Radiation Security Knowledge				
RGB1. I think that the education that I will get is enough to work on my professional.	0.800	1.211	9.479	0.513
RGB2. I believe in my knowledge about protection from radiation and patient dose.	0.734			
RGB3. I don't have any information about the apparatus protecting from radiation.	0.519			

According to the factor loadings, the item " There may be some precaution to protect exposure to radiation (FB2) has the greatest loading (0.741) on factor *Physics Knowledge*. For the factor *Technical Device Knowledge*, it can be seen that the loading of the item "Koroner Angio devices work with radiation" (TCB1) is the greatest (0.661). for the factor *Professional Knowledge*, the item having the greatest factor loading is "I have information about X rays" (MB1) with the loading 0.803 and for the last factor named as *Radiation Security Knowledge*, the factor loading of the item "I think that the education that I will get is enough to work on my professional" (RGB1) is the greatest among other loadings (0.800). The Eigenvalues and the Cronbach's alpha values of each factor is also given in Table 1.

Table 2. EFA Results and Cronbach's α values for Radiation protection scale

Factors/Items	Factor Loading	Eigen value	Explained Variance (%)	α
RKB. Radiation Protection Knowledge				
RKB1.There is a relation between Cancer and Radiation	0.742	1.211	50.683	0.675
RKB2.Radiation is harmful for the living beings.	0.776			
RKB3.Radiation has no side effect	0.560			
RKB4.Entering to radiation areas needs attention	0.749			

Table 2 indicates that the factor named Radiation Protection Knowledge, explains the 50.683% of total variance and the most important item on this factor is "Radiation is harmful to the living beings" (RKB2) with the factor loading of 0.776. Besides the Cronbach's alpha value is calculated as 0.675.

3.3. Confirmatory factor analysis results of radiation awareness scale

Results of Confirmatory Factor Analysis for the sub-factors (Physics Knowledge (FB), Technical Device Knowledge (TCB), Professional Knowledge (MB), and Radiation Security Knowledge (RGB)) of Radiation awareness Scale is given in Figure 1. As it can be seen from Figure 1. some modifications related to the suggestions of the software are applied by setting the error covariances between the variables free to obtain statistically the best and the most significant model.

According to model given in Figure 1. it can be seen that the most important items on Physics Knowledge (FB) are FB1 "Effected dose amount of human body decreases by moving away from the radiation source", FB2 "There may be some precautions to protect against exposure to radiation", and FB3 "The damage of radiation is related with the exposure time" with the coefficients of 0.70. Besides MB1, “I have information about X rays" found the most effective item on Professional Knowledge (MB) with the coefficient of 0.69, TCB5, "Mamografy includes radiation" found the most effective item on Technical Device Knowledge (TCB) with the coefficient of 0.65 and RGB3, "I don’t have any information about the apparatus protecting from radiation" found the most effective item on Radiation Security Knowledge (RGB)with the coefficient of 0.79.

Figure 1. also indicates that the highest correlation among all the latent variables (factors) is between FB and TCB with the coefficient of 0.65. While between FB and MB, FB and RGB and MB and TCB have positive correlations with the coefficients of 0.38, 0.15 and 0.59 respectively, there is a negative correlation between MB and RGB and RGB and TCB with the coefficients of -0.40 and -0.20 respectively. Goodness of fit statistics for the CFA is given in Figure 2. is also given in table 3. On the other hand, the $\chi2/df$ =2.41 is also one of the other indicators of acceptable model criteria.

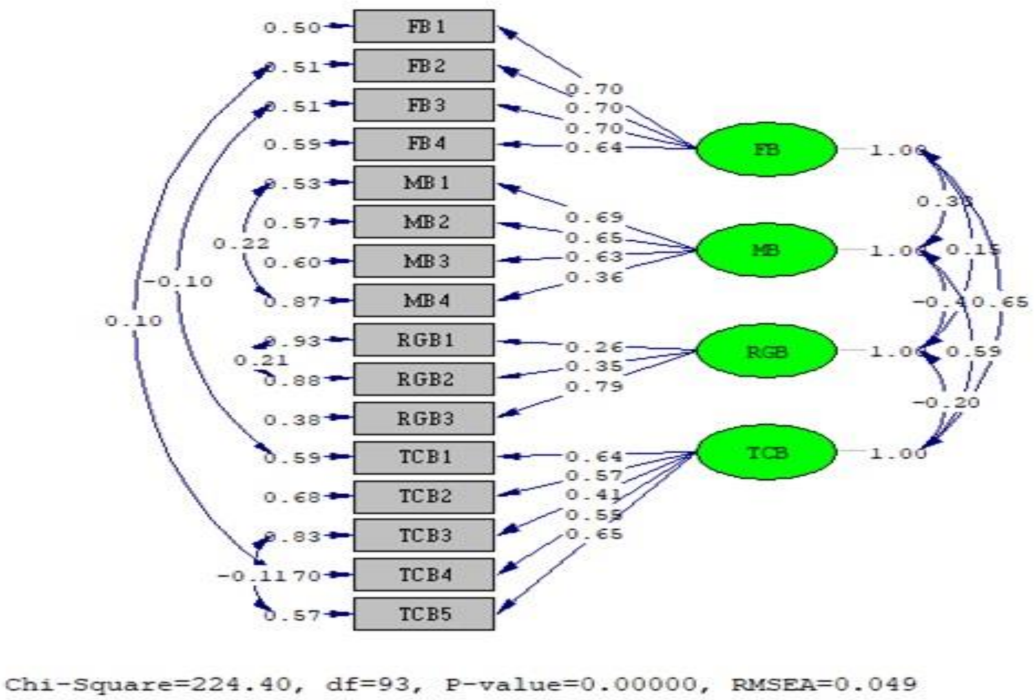

Figure 1. CFA results of radiation awareness scale

3.4. SEM results for radiation awareness and radiation protection knowledge.

Results of SEM is given in Figure 2. For this model Alternative Study Hypotheses are generated as below.

- **H_1:** Radiation Protection Knowledge of the students increases as their Physics Knowledge increases.
- **H_2:** Radiation Protection Knowledge of the students increases as their Professional Knowledge increases.
- **H_3:** Radiation Protection Knowledge of the students increases as their Radiation Security Knowledge increases.
- **H_4:** Radiation Protection Knowledge of the students increases as their Technical Device Knowledge increases.

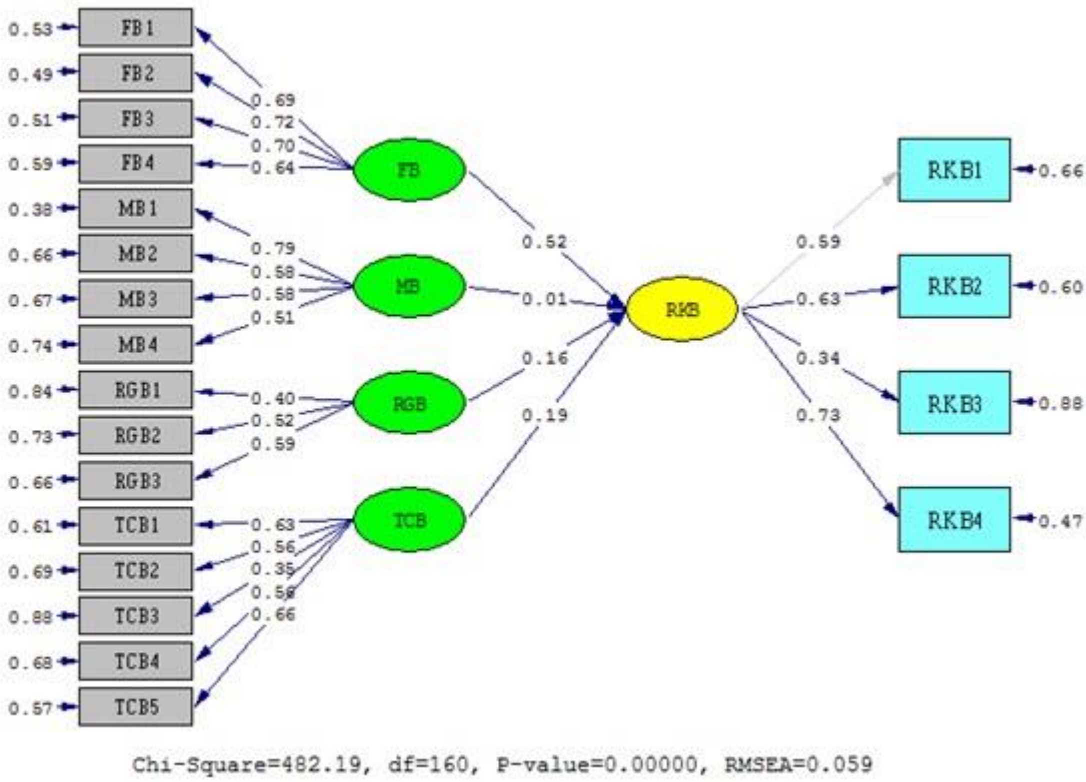

Figure 2. SEM results of radiation awareness and protection knowledge

Similar to the findings of CFA, Figure. 2. indicates that, on Physics Knowledge, FB2 "There may be some precautions to protect against exposure to radiation", on Professional Knowledge MB1, "I have information about X rays", on Radiation Security Knowledge RGB3, "I don't have any information about the apparatus protecting from radiation", on Technical Device Knowledge TCB5, "Mamografy includes radiation" and on Radiation Protection Knowledge, RKB4 "Entering to Radiation areas needs attention" found most effective items. The partial correlation coefficients between these items and factors can be seen in the Figure 2.

As a result of SEM, it can be said that if there will be one unit increase on the Physics Knowledge of students, there will be 0.52 unit increase on their Radiation Protection Knowledge. Similarly, if there will be one unit increase on the Radiation Security Knowledge of students, there will be 0.16 unit increase on their Radiation Protection Knowledge and if there will be one unit increase on the Technical Device Knowledge of students, there will be 0.19 unit increase on their Radiation Protection Knowledge. As it can be seen from Figure 2, there is almost no effect of Professional Knowledge on these students Radiation Protection Knowledge. The correlation coefficient between these latent variables (factors) also statistically not significant. Goodness of fit statistics for the structural model given in Figure 2. is also given in Table 3. On the other hand, the $\chi 2/df = 3.01$ is also one of the other indicators of acceptable model criteria.

Table 3. Limits and the results for CFA and SEM.

Fitness Criterion	Perfect Fitness	Acceptable Fitness	CFA	SEM
RMSEA	0 < RMSEA <0.05	0.05 ≤ RMSEA < 0.10	0.049	0.059
NFI	0.95 ≤ NFI ≤ 1	0.90 < NFI < 0.95	0.94	0.92
NNFI	0.97 ≤ NNFI ≤ 1	0.95 ≤ NNFI < 0.97	0.96	0.94
CFI	0.97 ≤ CFI ≤ 1	0.95 ≤ CFI < 0.97	0.97	0.95
SRMR	0 ≤ SRMR <0.05	0.05 ≤ SRMR < 0.10	0.060	0.063
GFI	0.95 ≤ GFI ≤ 1	0.90 ≤GFI < 0.95	0.95	0.92
AGFI	0.90 ≤ AGFI ≤ 1	0.85 ≤ AGFI < 0.90	0.93	0.90

Source: [8] (RMSEA: Root Mean Square Error of Approximation, NFI: Normed Fit Index, NNFI: Non-Normed Fit Index, CFI: Comparative Fit Index, SRMR: Standardized Root Mean Square Residual, GFI: Goodness of Fit Index, AGFI: Adjusted Goodness of Fit Index).

As it can be seen from Table 3; all criteria of the goodness of fit statistics obtained from CFA and SEM are within the acceptable and perfect fitness bounds. These results also confirm that the models given in Figure 1 and Figure 2 are statistically significant.

The results of the hypotheses testing related to the structural model given in Figure 2, standardized parameter estimates and *t* values are given in table 4.

Table 4. Standardized parameter estimates, *t* values and results of the hypotheses testing.

Hypotheses	Paths	Standardized parameter estimates	*t* values	Results
H_1	(FB)→(RKB)	0.52	5.14	Confirmed
H_2	(MB)→(RKB)	0.01	0.20	*Not Confirmed*
H_3	(RGB)→(RKB)	0.16	2.04	Confirmed
H_4	(TCB)→(RKB)	0.19	1.96	Confirmed

Table 4 shows that the paths, which also indicate the relations, from Physics Knowledge to Radiation Protection Knowledge, from Radiation Security Knowledge to Radiation Protection Knowledge and Technical Device Knowledge to Radiation Protection Knowledge are all statistically significant. Only the relation between Professional Knowledge and Radiation Protection Knowledge is statistically not significant.

3.5. Discussion

In this study, which is aimed to statistically model the effect of radiation awareness levels on radiation protection information, the results indicate that, within the four sub-factors of radiation awareness, three of them have a significant effect on radiation protection information. As well as the Physics Knowledge has the greatest effect, improving this knowledge via some extra seminars, theoretical and applied educations and should improve radiation protection information of these students. On the other hand, the same improvements in Radiation Security Knowledge and Technical Device Knowledge may also improve the radiation protection information. We believe that even if the results indicate that Professional Knowledge does not have statistically significant effect on radiation protection information, it has an indirect affect. Some improvements about this sub-factor may also improve the radiation protection information. As entering to radiation areas needs attention has a direct and significant effect on radiation protection information, importance of this situation must keep its priority and theoretical and applied educations must be in progress.

This research has also some limitations. First, even if the scale in the questionnaire is prepared with the help of earlier studies and the professionals on radiology, reliability of this scale may change according to different samples. However, this could be a first step in developing further research to test the causal hypotheses on the various dimensions of university students' radiation protection knowledge. Upcoming studies should increase the reliability and importance of this study. Secondly, the data here are collected from the students at the specific date interval at the University. Even if the sample size is enough for this study, the results may differ for different samples.

4. Conclusion

It's a known fact that radiology experts are at some risk at their work because of the harmful effects of radiation. Considering this fact, awareness of radiation may have much positive effect on protection from radiation. This study emphasizes the importance of radiology awareness on protection from radiation for radiology experts. Related to the results of this study, radiation awareness of the radiology experts can be measured by Physics Knowledge, Technical Device Knowledge, Professional Knowledge and Radiation Security Knowledge. Within this awareness, Physics Knowledge has the greatest effect on Radiation Protection Knowledge. As a conclusion; importance of well-educated staff will affect obtaining both correct and well results and help to medical improvements in radiology. At that point; educational improvement about radiology may give better rollback on radiology.

Conflicts of interest

The authors declared no conflicts of interest.

Authorship Contributions

This study is a part of Olcay Ulucan's MS thesis supervised by Sinan Saraçlı at Afyon Kocatepe University Institute of Science.

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