A MODEL FOR PROTECTIVE BEHAVIOR AGAINST THE HARMFUL EFFECTS OF RADIATION FOR RADIOLOGICAL TECHNOLOGISTS IN MEDICAL CENTERS

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Protective behavior of radiological technologists against radiation exposure is important to achieve reduction of the patient doses without compromising medical achievements. This study attempts to provide a basic model for the sophisticated intervention strategy that increases the level of the protective behavior of the technologists. The model was applied to real situations in Korea to demonstrate its utility. The results of this study are summarized as follows: First, the protective environment showed the highest relationship in the factors considered, r=0.637 ($p<0.01$). Secondly, the important factors were protective environment in environment characteristics, expectation for the protective behavior 0.228 ($p<0.001$), self-efficacy 0.142 ($p<0.001$), and attitude for the protective behavior 0.178 ($p<0.001$) in personal characteristics, and daily patient -0.112 ($p<0.001$) and number of the participation in the education session for the protective behavior 0.074 ($p<0.05$). Thirdly, the final protective behavior model by a path analysis method had direct influence on the attitude 0.171 ($p<0.01$) and environment 0.405 ($p<0.01$) for the protective behavior, self efficacy 0.122 ($p<0.01$), expectation for the protective behavior 0.16 ($p<0.01$), and self-efficacy in the specialty of projects 0.154 ($p<0.01$). The acceptance of the model determined by the absolute fit index (GFI), 0.969, and by the incremental fit index (CFI), 0.943, showed very significant levels. Value of χ^2/df that is a factor applied to verify the acceptance of the model was 37, which implies that the result can be accepted in the desirable range. In addition, the parsimonious fit index configured by AGFI (0.890) and TLI (0.852) was also considered as a scale that accepts the model in practical applications.

In case of the establishment of some specific intervention strategies based on the protective behavior model against harmful radiation effects proposed in this study, the strategy will provide an effective way to prevent medical harmful radiation effects that could cause severe injuries to people.

Keywords : Harmful Effects of Radiation, Protective Behavior Model, Radiological Technologists, Medical Centers

1. INTRODUCTION

In Korea, radiation equipments and radioactive isotopes have been used in about 24,000 medical centers. the wide use of diagnostic radiation equipment increased radiation exposure levels in patients and radiological technologists in 41,137 medical centers [1-6]. The International Commission on Radiological Protection (ICRP) emphasizes importance of optimization of medical exposure of patients because doses from medical exposure increase fast particularly in developed countries. There are many ways to reduce patient doses without compromising beneficial uses of medical radiation [6]. But there are few studies on this issue even though the protective behavior for radiological technologists has been stressed.

This study considered the protective behavior as a way of health behavior in order to precisely describe the protective behavior for radiological technologists in medical centers.

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In addition, some advanced theories, such as Health Belief Model (HBM), Theory of Reasoned Action (TRA), Theory of Planned Behavior (TPB), Transtheoretical Model (TTM), and Social Cognitive Theory (SCT), were used to select certain variables related to the protective behavior and to draw a conceptual frame for the study [7-10]. This study also, classified the variables that affect the protective behavior as general, environmental, and personal (recognition) characteristics. This study attempted to deduce a theoretical model for the protective behavior model against harmful effects of radiation that is suitable to the actual situation in Korea. It is hoped that this study would help to protect

Table 1. Variables Considered in the Investigation.

Variable	Subvariable		Description	Number of Items
Behavior Characteristics	Protective behaviors in patients and guardians		adjusting an iris, equipment performance test, wearing protective gear, prohibition of duplicated tests(imaging), shielding gonad of infant patients, pregnancy checking of child-bearing women, wearing a protective gear for guardians, shielding doors for imaging, application of a personal dosimeter, periodic health screening, periodic education, wearing apron, checking exposure, checking equipments before use, adjusting distance, proper keeping aprons, and protective behavior for performance tests	11
	Protective behaviors in radiological technologists themselves			6
	General protective behaviors			4
General Characteristics	Sociology of population characteristics		gender, age, marriage, education level	4
	Organization and occupation characteristics		area where they work, organization type, protective equipment, wearing period of a personal dosimeter, working hours, number of daily imaging, number of patients, occupation type, number of radiological technologists, experiences in radiation related education and education type	11
Personal Characteristics	Protective knowledge against harmful effects of radiation		radiological technologists themselves, patients and guardians, theoretical knowledge on the protection for performing general protective behaviors against harmful effects of radiation	15
	Protective attitude against harmful effects of radiation	Patients and guardians	adjusting an iris, equipment performance test, wearing a protective gear, prohibition of duplicated tests (imaging), shielding a gonad of infant patients, pregnancy checking of child-bearing women, wearing a protective gear for guardians, shielding doors for imaging, application of personal dosimeter, periodic health screening, periodic education, wearing apron, checking exposure, checking equipments before using it, adjusting distance, proper keeping aprons, and protective behavior for performance tests	11
		Radiological technologists themselves		6
		General protective behaviors		4
	Behavior expectation			4
	Self-efficacy		general self-efficacy	14
			self-efficacy in the specialty of projects	4
Environmental Characteristics	Organizational personality		position structure	6
			individual autonomy	6
			consideration, warmth, and support	6
			reward incentive	6
	Organizational effectiveness		job satisfaction	6
			organization commitment	6
	Protective environment against harmful effects of radiation			10
	Sum			140

patients from radiation exposure that affects harmful effects for the national health by providing a basis for a theoretical frame for establishing detailed intervention strategies for the direction and protective behavior that improve the protective behavior for radiological technologists in medical centers.

2. METHODS

2.1 Subjects

The survey data were collected from 1,322 subjects. All were radiological technologists working with diagnostics x-ray. Ten percent of radiological technologists were selected by using a proportionate stratified sampling method from among 13,535 radiological technologists (Seoul-3,394, Busan-1,132, Incheon and Gyunggi-3,204, Daegu and Gyungbuk-1,607, Daejeon and Chungnam-1,011, Chungbuk-379, Gangwon-412, Gwangju and Jeonnam-977, Jeonbuk-593, Gyungnam and Ulsan-1,140, and Jeju-142 registered in the National Dose Registry of the Korea Food & Drug Administration as of 2006). Male radiological technologists were 993 (75.9%) and female were 315 (24.1%). The subjects in their 20's were 498 (38.48%), and those in their 30's 490 (37.86%), those in their 40's 247 (19.08%), and those over 50 were 59 (4.56%). Subjects who graduated from junior college were 866 (66.4%), those from colleges 354 (27.1%) and graduate student 85 (6.5%).

2.2 Research Tool

The tool used in this study was a structured questionnaire and consisted of the protective behavior (behaviors in patients and guardians, behaviors in radiological technologists themselves, and general protective behaviors), general characteristics (demographic and social characteristics, organization and occupation characteristics), personal characteristics (protective knowledge, protective attitude, expectation of the protective behavior, self-efficacy, and self-efficacy in the specialty of projects), and environmental characteristics (organizational personality, organizational effectiveness, and protective environment against harmful effects of radiation) (Table 1).

2.3 Method of Data Analysis

The collected data were analyzed by using the SPSS 15.0 and AMOS 7.0. The key features of analysis are as follows:

1. The Pearson's correlation coefficient was used to verify the relationship between the variables that affect the protective behavior.
2. A stepwise multiple regression method was applied to determine the factors that affect the protective behavior.
3. A path analysis was used to investigate the paths of the factors that are expected to affect the protective behavior.

The verification of the goodness-of-fit of the hypothetical model used in this study was performed by using χ^2 statistics, goodness-of-fit index (GFI), adjusted goodness-of-fit Index (AGFI), root mean square error of approximation (RMSEA), comparative fit index (CFI), and tuker lewis index (TLI).

3. RESULTS

3.1 Relationship between the Variables that Affect the Protective Behavior

The protective behaviors are relative to the subvariables of the personal characteristics, such as expectation of the protective behavior, protection knowledge, protective attitude in radiological technologists themselves, protective attitude, self-efficacy in the speciality of projects, and the subvariables of the environmental characteristics, such as protective environment against harmful effects of radiation, organizational personality, position structure, individual autonomy, support, reward orientation, organizational effectiveness, job satisfaction, and organization commitment.

The protective environment showed the highest correlation r=0.637 ($p<0.01$). The correlations in the protective environment for the patients and guardians, radiological technologists themselves, and general protective behavior showed high values, r=0.564 ($p<0.01$), r=0.573 ($p<0.01$), and r=0.556 ($p<0.01$), respectively.

The subvariables of the personal characteristics, such as expectation of the protective behavior, protective attitude, protective attitude against radiation in patients and guardians, protective attitude in radiological technologists themselves, and protective attitude, represented as r=0.490, r=0.381, r=0.374, r=0.345, and r=0.350, respectively, with the high relations to the self-efficacy in the specialty of projects. Also, the self-efficacy showed high relations r=0.302, and job satisfaction, r=0.302 (Table 2).

3.2 Factors that Affect the Protective Behavior

This study used a stepwise multiple regression process by applying the scores of the protective behavior as dependent variables and the subvariables of the environmental characteristics, such as protective environment, organizational personality, and organizational effectiveness, the subvariables of the personal characteristics, such as protection knowledge, expectation of the protective knowledge, protective attitude, self-efficacy in the specialty of projects, self-efficacy, and the general characteristics, such as age, the period of wearing a personal dosimeter, daily working hours, daily imaging time, number of the education sessions related to the protection, number of patients taken a day and number of radiological technologists as independent variables. The

Table 2. Correlation Matrix Using the Variables that Affect Protective Behavior. $^{*}p<0.05$, $^{**}p<0.01$

Item	Protective behavior	Protective behaviors in patients and guardians	Protective behaviors in themselves	General protective behavior	Behavior expectation	Protective knowledge	Protective environment	Protective attitude	Protective attitudes in patients and guardians	Protective attitudes in themselves	General protective attitude	Self-efficacy in the specialty of projects	Self-efficacy	Organization personality	Position structure	Individual autonomy	Support	Reward orientation	Organizational effectiveness	Job satisfaction	Organization commitment
Protective behavior	1																				
Protective behaviors in patients and guardians	.922**	1																			
Protective behaviors in themselves	.869**	.656**	1																		
General protective behavior	.838**	.650**	.683**	1																	
Behavior expectation	.477**	.417**	.402**	.464**	1																
Protective knowledge	.100**	.095**	.100**	.077**	.127**	1															
Protective environment	.637**	.564**	.573**	.556**	.422**	.198**	1														
Protective attitude	.505**	.462**	.450**	.388**	.323**	.164**	.454**	1													
Attitudes in patients and guardians	.488**	.474**	.405**	.348**	.302**	.157**	.431**	.961**	1												
Protective attitude in oneself	.465**	.398**	.465**	.354**	.304**	.158**	.430**	.930**	.821**	1											
General protective attitude	.446**	.379**	.396**	.404**	.311**	.146**	.399**	.893**	.775**	.818**	1										
Self-efficacy in the specialty of projects	.536**	.480**	.463**	.494**	.490**	.093**	.469**	.381**	.374**	.345**	.350**	1									
Self-efficacy	.386**	.357**	.339**	.320**	.239**	.115**	.265**	.344**	.332**	.324**	.286**	.453**	1								
Organizational personality	.292**	.236**	.271**	.321**	.291**	.017	.359**	.140**	.131**	.141**	.122**	.332**	.226**	1							
Position structure	.074*	.039	.116**	.084**	.016	.026	.145**	-.021	-.016	.001	-.049	.094**	.229**	.530**	1						
Individual autonomy	.194**	.124**	.198**	.257**	.218**	-.027	.211**	.075**	.073*	.050	.083**	.292**	.051	.644**	.083**	1					
Support	.296**	.258**	.264**	.295**	.284**	.050	.345**	.219**	.211**	.218**	.182**	.318**	.302**	.848**	.419**	.370**	1				
Reward orientation	.257**	.225**	.205**	.280**	.272**	.006	.320**	.095**	.081**	.100**	.104**	.244**	.076**	.819**	.124**	.467**	.596**	1			
Organizational effectiveness	.373**	.310**	.346**	.364**	.360**	.038	.437**	.280**	.266**	.256**	.262**	.452**	.284**	.642**	.223**	.381**	.605**	.567**	1		
Job Satisfaction	.390**	.325**	.368**	.376**	.361**	.033	.428**	.295**	.278**	.274**	.277**	.479**	.302**	.605**	.222**	.377**	.575**	.522**	.936**	1	
Organization commitment	.310**	.256**	.283**	.308**	.319**	.042	.394**	.228**	.217**	.206**	.218**	.376**	.235**	.604**	.211**	.344**	.566**	.543**	.945**	.768**	1

variables that were selected as the factors, affecting the protective behavior were presented as the environmental characteristics, such as protective environment, the personal characteristics, such as protective expectation, self-efficacy, and protective attitude, and the general characteristics, such as daily imaging time, and number of the education sessions related to the protection. 59% of the total variation in protective behavior is explained by those factors. The protective environment showed the highest Beta, 0.456, and the imaging time showed an inverse proportion (Table 3).

3.3 Protective Behavior Model for Harmful Effects of Radiation by Using a Path Analysis

It was obvious that the protective behavior model directly affects the protective behavior based on the results of the path analysis were presented in the environmental characteristics, such as protective environment 0.405 ($p<0.01$), and the personal characteristics, such as protective attitude 0.171 ($p<0.01$), self-efficacy 0.122 ($p<0.01$), expectation of the protective behavior 0.16 ($p<0.01$), and self-efficacy in the specialty of projects 0.154 ($p<0.01$). The protective environment 0.463 ($p<0.01$) and protective attitude 0.06 ($p<0.05$) directly affected the protective attitude. It was recognized that the protective knowledge indirectly affected the protective behavior. In addition, there was a correlation between the self-efficacy and the expectation of the protective behavior, 0.213 ($p<0.01$), the protective environment and the self-efficacy, 0.272 ($p<0.01$), the self-efficacy and the self-efficacy in the specialty of projects, 0.445 ($p<0.01$), the expectation of the protective behavior and the self-efficacy in the specialty of projects, 0.474 ($p<0.01$), the protective environment and the self-efficacy in the specialty of projects, 0.473 ($p<0.01$), and the protective environment and the expectation of the protective behavior, 0.406 ($p<0.01$).

In the goodness-of-fit of the model, the Goodness-of-Fit Index (GFI), which is an absolute goodness-of-fit index, and Comparative Fit Index (CFI) were 0.969 and 0.943, respectively. The values of χ^2 and df were 118.878 and 37, respectively. The index of χ^2/df that represents the goodness-of-fit of the model was 3.213 and that was presented in its criteria. Adjusted Goodness-of-Fit Index (AGFI), which is a CFI, and Tuker Lewis Index (TLI), which is a non-standard goodness-of-fit index, were 0.890 and 0.852, respectively, and those can be considered as excellent scales in the goodness-of-fit index in actual applications. Furthermore, it can be regarded that the model proposed in this study satisfied the goodness-of-fit of the model through considering these two aspects, such as the explanatory property and these various indices, which evaluate the goodness-of-fit index of model (Fig. 1 and Table 4).

Table 3. Factors on Protective Behavior.

Model	Non-standard factor		Standard factor	t(p-value)
	B	Standard error	Beta	
(Constant)	14.630	3.201		4.570(0.000)
Protective environment	0.384	0.031	0.456	12.542(0.000)
Expectation of protective behavior	0.142	0.021	0.228	6.896(0.000)
Self-efficacy	0.127	0.028	0.142	4.567(0.000)
Protective attitude	0.190	0.037	0.178	5.071(0.000)
Daily imaging times	-1.057	0.276	-0.112	-3.833(0.000)
Number of education session related to protection of harmful effects of radiation	0.670	0.269	0.074	2.495(0.013)
F(p-value)	118.996(0.000)			
$R^2 = 0.601$, $R^2_{adj} = 0.596$				

Table 4. Verification of Goodness-of-Fit of Protective Behavior Model (Fig. 1).

Constitutional Concept	GFI	AGFI	TLI	CFI	RMSEA	χ^2	df	P
Behavior	0.969	0.890	0.852	0.943	0.117	118.878	37	0.000

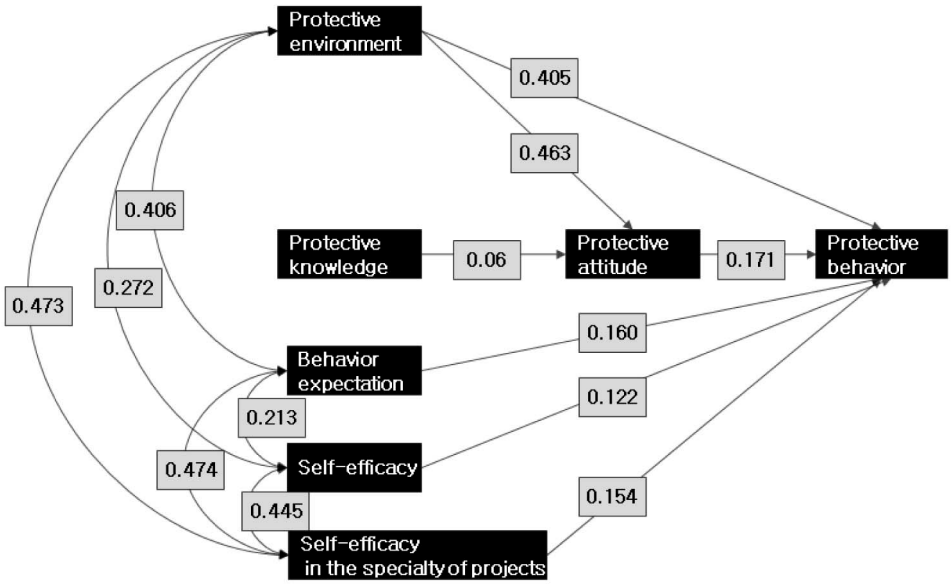

Fig. 1. Protective behavior model through a path analysis.

4. CONCLUSION

There are many ways to reduce the exposure to patients without any interferences in medical centers. It is important to recognize the protective behaviors to achieve the goal. This study investigated the variables that affect the protective behaviors in medical centers. The conclusions of this study are summarized as follows:

First, the selected variables that affect the protective behavior were the environmental characteristics, such as protective environment, the personal characteristics, such as expectation of the protective behavior, self-efficacy, and protective attitude, and the general characteristics, such as daily imaging time and the number of education session related to the protective behavior explained 59.6% of the total variation. The protective environment showed the highest relation, r=0.637 ($p<0.01$), and the daily imaging time showed an inverse proportion. Thus, it can be seen that it is necessary to improve the level of the protective environment for improving the protective behavior. It is necessary to limit the present daily imaging time.

Second, it was obvious that the model for the protective behavior directly affected the protective behaviors in the environmental characteristics, such as protective environment and the personal characteristics, such as protective attitude, self-efficacy, expectation of the protective behavior, and self-efficacy in the specialty of projects. In the goodness-of-fit of the model, the values of GFI and CFI were 0.969 and 0.943, respectively, and those are very excellent levels. The value of χ^2/df was 3.213 which satisfied the criteria. The values of AGFI and TLI were 0.890 and 0.852, respectively, and those showed reasonable scales in the goodness-of-fit of the model in practical applications.

It is necessary to continuously improve protective behaviors by developing the environmental characteristics, such as protective environment, and the personal characteristics, such as protective attitude, expectation of the protective behavior, self-efficacy, and the self-efficacy in the specialty of projects. In order to improve the level of the protective behavior as the same idea as the social recognition theory in which the human behavior can be determined by the continuous interaction between personal, behavioral, and environmental characteristics [11-15]. The protective environment should be improved in advance in order to increase the protective behaviors. It is necessary to establish various and distinctive intervention strategies by considering the characteristics of related variables used in this study and the characteristics between other groups that represent different levels of behavior. The results of this study can be a basis for establishing effective ways improving the protective behaviors in the management of medical exposures, which affect national health.

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