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ORIGINAL ARTICLE

Factors affecting intention and behavior of nurses in initial response to radiation accident/disaster

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Abstract: The objective of this paper is to identify factors that affect the intention and behavior of nurses in initial response to radiation accidents/disasters. A questionnaire survey was conducted with nurses working at disaster base hospitals or nuclear emergency core hospitals and nuclear emergency medical cooperation institutions (nuclear hospitals). A significant effect of intention on behavior was observed in both groups. In addition, the determinant factor of nurses for their intention in radiation/nuclear disasters was their disposition towards their expertise, followed by their practical knowledge. However, there was no significant effect of cooperative framework on intention or behavior. Determinants for behavior were intention and expectations from others in both groups. In the disaster base hospital group, on the other hand, uneasiness to radiation exposure affected their intention, and practical knowledge influenced intension and behavior. In contrast, uneasiness to radiation exposure did not affect intention or behavior, and behavior was not affected by practical knowledge in the group from nuclear hospitals. Thus, our results suggest that there are factors affecting intention and behavior which could or could not be overcome by education/training. Measures for a nurse to work with pride as an expert in this field and with social standing are also required for smooth nursing care in radiation emergencies.

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Key words: Radiation disaster; initial response; intention; behavior; nurses.

Introduction

Almost nine years have passed since the nuclear disaster at the Fukushima Daiichi Nuclear Power Plant (NPP) due to the Great East Japan Earthquake on March 11, 2011. In Japan, anti-terrorism measures are now being implemented for the 2020 Tokyo Olympics and Paralympics, and the importance of having countermeasures against radiation terrorism as well as accidents/disasters in place has been emphasized. Today, devices and locations from which an individual could be exposed to, or contaminated with radioactive materials are not scarce; accidental exposure to radiation or contamination with radioactive material may occur not only at NPPs but also at industries and institutes where radiation is used. Therefore, it is prudent to assume that accidental exposure to radiation or contamination might occur anywhere including in public areas. In Japan, disaster base hospitals were designated for medical response to general disasters in all prefectures upon lessons learned during the aftermath of the Hanshin-Awaji Earthquake of 1995, when preventable fatalities occurred due to delays in the initial response of the disaster medical system[1]. Then, because of the experience of the Fukushima accident, the Japanese government revised the response system to radiation accidents at nuclear facilities[2]. In order to provide smooth and timely medical care

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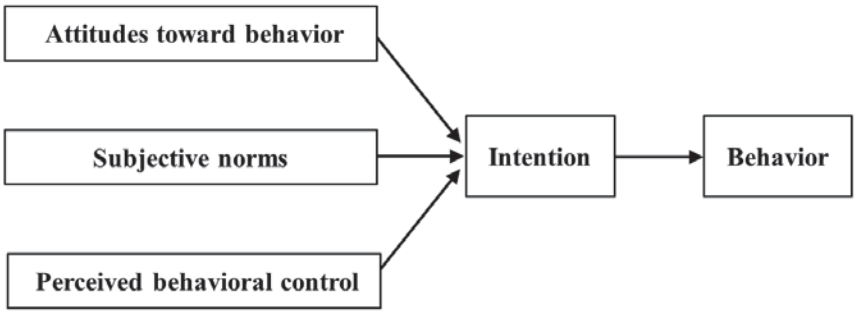

Figure 1 Predicting factors for intention to perform behaviors
Intentions to perform behaviors can be predicted from attitudes toward the behavior, subjective norms, and perceived behavioral control[3].

when a radiation incident has occurred, 19 prefectures with nuclear facilities such as NPPs designated one or two disaster base hospitals as nuclear emergency core hospitals and nominated nuclear emergency medical cooperation institutions. Those prefectures had already run a training/education system on radiation accidents prior to this disaster. However, this comprehensive structure of hospitals and training/education was limited to these 19 prefectures; no nuclear emergency core hospital or nuclear emergency medical cooperation institution has been designated, and no systematic training/education response to radiation incidents has been conducted in the other 28 prefectures without nuclear facilities.

The theory of planned behavior (TPB) was proposed by Ajzen to assist in understanding and predicting social behavior[3]. According to this theory, intention is the immediate antecedent of behavior and is itself a function of attitude toward the behavior, subjective norm, and perceived behavioral control (Fig. 1). Normative expectation of important others influences intention; intention is also affected by the perceived behavioral control of its ability to perform and the presence of control of behavioral performance. When these three components work positively, intention to perform the behavior increases, and the intended behavior becomes easier to perform.

Recently, many studies have pointed out the little time that is devoted to radiation basics and their poor contents in the education and training of nurses[4-7]. Therefore, most nurses have inadequate knowledge about radiation[8-11], and they are uneasy about being exposed to even a low dose while providing nursing care to contaminated patients[11-13]. These reports suggest that nurses who are involved in the task of providing nursing care as part of the initial response to radiation emergencies at disaster base hospitals may be hesitant to participate proactively due to their inadequate knowledge of radiation and an uneasiness concerning exposure. In addition, then, factors other than knowledge and insecurity of radiation may affect the behavior and intention of nurses in the initial response.

To develop a program for nurses to support an initial response system in radiation emergency, in the present study, we tried to clarify the psychological factors affecting the initial response to radiation incidents of nurses who are involved in the response as core staff at disaster base hospitals in prefectures without nuclear facilities.

Materials and Methods

This study was conducted with nurses working at disaster base hospitals, nuclear emergen-

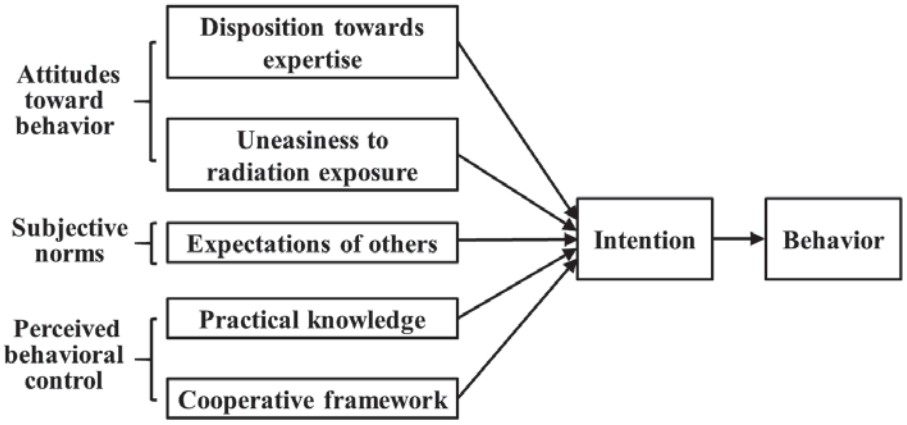

Figure 2 Provisional model constructed in the present study
Based on TPB, 5 factors affecting intention were proposed[14].

cy core hospitals, and nuclear emergency medical cooperation institutions. Thus, the targets of this study were nurses with experience working in radiation/nuclear emergencies or who might be involved in nursing care in the event of nuclear emergencies.

Questionnaires

An anonymous self-administered questionnaire survey was performed in August – September 2018. We sent a research cooperation request form and a set of questionnaires to 567 disaster base hospitals, 36 nuclear emergency core hospitals, and 137 nuclear emergency medical cooperation institutions (740 hospitals in total) and asked the manager of each facility to recommend two nurses who either had experience working during a nuclear emergency or who might be involved in nursing care in a nuclear emergency. When these nurses agreed to our request, they filled out the questionnaire and mailed back both forms in an enclosed envelope. In the questionnaires, we asked whether they had received training in accepting patients who had been exposed to radiation or contaminated with radioactive material, and whether they might be called to join a medical team responding to radiation/nuclear emergencies. In order to study the factors that affect intention and behavior of nurses in the initial response to radiation/nuclear disaster, the three factors of attitude toward the behavior, subjective norms and perceived behavior control were used as constructs[3]. As factors affecting intention and behavior, we chose 5 factors: disposition towards expertise, uneasiness to radiation exposure, expectation of others, practical knowledge, and cooperative framework (Fig. 2).

Nursing as a member of a medical team in a radiation accident/disaster is taken as the behavior, and the plan to carry out the behavior is taken as the intention. However, the behavior of nursing as a member of a medical team had not been carried out at the time of the survey. In the questionnaire, therefore, we asked the following questions: for the intention, "Do you desire/want to be nursing as a member of a medical team in a radiation accident/disaster?" and, for the behavior, "Do you expect to be nursing as a member of a medical team in a radiation disaster?" The question was answered as by 'agree', 'partially agree', 'no opinion', 'partially disagree', or 'disagree' by giving from 1 to 5 points for each of the respective answers, from negative to positive. Among the question items, those with a negative effect on intention

or behavior (such as "I think radiation exposure is scary") have reversed scores. Next, in order to clarify the factors affecting intention and behavior, covariance structure analysis was performed using the five factors and intention and behavior as observation variables, and the hypothetical model was verified. If the initial model was a poor fit, the model was improved by removing and adding effect paths based on a modified index, and a better fit model was adopted.

Analysis

Standardized estimated values were used to evaluate the validity of the model (fitness determination). CMIN means $\chi 2$ (chi-square) value. In this analysis, GFI (goodness of fit index), AGFI (adjusted goodness of fit index), and CFI (comparative fit index) are considered to have higher explanatory power if the value is closer to 1, and 0.9 or more is used as a model selection criterion. The criteria indicate that the smaller the RMSEA (root mean square error of approximation), the higher is the degree of conformity when the value is 0.05 or less, and that the model should not be adopted if the value is 0.1 or more. A higher value indicates a higher influence or affect. Contributions from factors that cannot be explained by this model are shown as error variables e1 and e2. In the present study, IBM SPSS for Windows 25.0J and AMOS25.0J were used as statistical software. The significance level was less than 0.05.

Ethical considerations

This study was carried out with approval by the Certified Review Board of the National Institutes for Quantum and Radiological Science and Technology (approval number: 170107). All participants were explained the objectives and purpose of the study and ensured anonymity, confidentiality and other ethical guarantees in the research cooperation request form, and written informed consent was obtained by replying to the survey form and posting it.

Results

Profiles of participants

We sent 1480 questionnaires to nurses, and we received 362 sets of responses. One set of questionnaires was not completed, so this case was excluded, and 361 valid responses were subjected to data analysis. The effective response rate was 24.4% (Table 1). As for hospital affiliation, 256 nurses (70.9%) worked at disaster base hospitals and 105 (29.1%) at nuclear emergency core hospitals or nuclear emergency medical cooperation institutions.

In the group at disaster base hospitals, less than 30% of the nursing staff was trained for receiving patients exposed to radiation and/or contaminated with radioactive materials. In contrast, 60% of the staff in the nuclear emergency core hospitals or nuclear emergency cooperation institutions (χ 2 = 29.73, df = 1, p < 0.000) had received such training. As for the question regarding the possibility of being called upon for radiation/nuclear incidents, significantly more staff answered positively or were already registered as a member of a team for radiation accident/disaster in the group of nuclear emergency core hospitals or nuclear emergency cooperation institutions (χ 2 = 14.57, df = 3, p < 0.002). There was no difference in the other attributes between these two groups.

Awareness of intention, behavior, and 5 factors in nurses in initial response to radiation accident/disaster

We compared the magnitude in awareness of intention, behavior, and each factor affecting intention/behavior in the groups of disaster base hospitals and nuclear emergency core hospitals or nuclear emergency cooperation institutions (Table 2). These 5 factors were

Table 1. Profiles of participants

		Overall		* Disaster base hospitals (N = 256)		* Nuclear emergency core hospitals/ nuclear emergency cooperation institutes (N = 105)		* p value
		n	%	n	%	n	%	
Age	20s	15	4.2	9	3.5	6	5.7	0.511
	30s	78	21.6	60	23.4	18	17.1	
	40s	146	40.4	100	39.1	46	43.8	
	50s	120	33.2	85	33.2	35	33.3	
	60s	2	0.6	2	0.8	0	0.0	
Years of nursing experience	1-5 years	4	1.1	4	1.6	0	0.0	0.190
	6-10 years	32	8.9	20	7.8	12	11.4	
	11-15 years	40	11.1	34	13.3	6	5.7	
	16-20 years	68	18.8	43	16.8	25	23.8	
	21-25 years	91	25.2	65	25.4	26	24.8	
	26-30 years	60	16.6	42	16.4	18	17.1	
	31 years or longer	66	18.3	48	18.8	18	17.1	
Trained for receiving patients exposed to radiation and/or contaminated with radioactive materials	No	224	61.9	181	70.7	42	40.0	0.000
	Yes	138	38.1	75	29.3	63	60.0	
Called on to join a medical team formed for radiation emergency	Yes	156	43.1	106	41.4	50	47.6	0.002
	No	52	14.4	41	16.0	10	9.5	
	Unknown	130	35.9	99	38.7	31	29.5	
	Already a member of a team	24	6.6	10	3.9	14	13.3	
Certified nurse or certified nurse specialist	No	243	67.3	164	64.1	79	75.2	0.135
	Certified nurse	74	20.5	56	21.9	18	17.1	
	Certified nurse specialist	6	1.7	6	2.3	0	0.0	
	Other	38	10.5	30	11.7	8	7.6	
Affiliated department	General (internal medicine)	31	8.6	21	8.2	10	9.5	0.323
	Emergency	142	39.3	100	39.1	42	40.0	
	Surgery	12	3.3	8	3.1	4	3.8	
	Outpatient	149	41.3	112	43.8	37	35.2	
	Other	27	7.5	15	5.9	12	11.4	
Duration of present affiliated department	Less than 1 year	28	7.8	20	7.8	8	7.6	0.109
	1-5 years	195	54.0	138	53.9	57	54.3	
	6-10 years	93	25.8	60	23.4	33	31.4	
	11-15 years	36	10	32	12.5	4	3.8	
	No answer	9	2.5	6	2.3	3	2.9	

$\chi 2$ goodness-of-fit test
N=361

* Disaster base hospitals and nuclear emergency core hospitals/ nuclear emergency cooperation institutes were compared.

disposition towards expertise, uneasiness to radioactive exposure, expectations of others, practical knowledge, and cooperative framework and we have recently proposed them as those affecting the intention/behavior of nurses in their initial response to radiation/nuclear accident[14]. In this scoring system, a higher score shows more positivity except that of uneasiness to radiation

Table 2. Awareness of intention, behavior, and their affecting factors

	Overall (N = 361)	* Disaster base hospital group (N = 257)	* Nuclear emergency core hospitals/nuclear emergency medical cooperation institutes group (N = 105)	* p values
	M ± SD	M ± SD	M ± SD	
Intention	3.3 ± 1.1	3.2 ± 1.1	3.4 ± 1.1	0.121
Behavior	3.7 ± 1.1	3.6 ± 1.1	3.9 ± 1.1	0.017
Disposition towards expertise	3.7 ± 0.7	3.7 ± 0.7	3.8 ± 0.7	0.379
Uneasiness to radiation exposure	2.3 ± 0.7	2.2 ± 0.7	2.4 ± 0.8	0.012
Expectations of others	3.2 ± 0.9	3.1 ± 0.9	3.3 ± 0.8	0.035
Practical knowledge	2.3 ± 1.1	2.2 ± 1.0	2.7 ± 1.1	0.000
Cooperative framework	2.8 ± 0.9	2.7 ± 0.9	3.1 ± 1.0	0.000

* Results were statistically analyzed by unpaired t-test and presented as mean (M) ± standard deviation (SD). Each item was given 1 to 5 points for each. of the respective answers, from negative to positive. When the item had a negative effect, a reversed score was given.

exposure, where a higher score shows a low magnitude of uneasiness. Scores of behaviors were relatively higher in both groups, with the score being significantly higher in the group of the nuclear emergency core hospital/nuclear emergency cooperation institutions (t = 2.403, p = 0.017). Similar results were obtained in expectations of others in both groups. On the other hand, the group of the disaster base hospitals had significantly lower scores of intention and practical knowledge than that of the nuclear emergency core hospital/nuclear emergency cooperation institutions (t = 2.403, p = 0.017) (t = 3.990, p = 0.000), whereas scores of practical knowledge were relatively lower in both groups. Although scores of intention and disposition towards intention to expertise were relatively high in both groups, there was no significant difference.

Model with goodness-of-fit for all nurses

In order to study the relationship of the factors affecting the intention and behavior of nurses, we constructed the provisional model based on TBP and examined results of 361 questionnaires by a covariance structure analysis in both hospital groups (data not shown). The goodness-of-fit indexes for the model were low: GFI = 0.937, $\chi 2$ value CMIN = 96.188, P = 0.000, AGFI = 0.648, CFI = 0.906, and RMSEA = 0.225. Therefore, we improved the model by deleting/adding relationship of each factor until we could obtain the model with the best goodness-of-fit. This model had the adequate goodness-of-fit indexes of GFI = 0.998, $\chi 2$ value CMIN = 3.024, P = 0.388, AGFI = 0.978, CFI = 1.000, and RMSEA = 0.005 (Fig. 3). In this model, intention affected behavior and the 5 factors influenced one another significantly. Each of disposition towards to expertise, uneasiness to radiation exposure, and practical knowledge affected the intention as the provisional model shown in Fig. 2. In this model, however, affecting factors of expectations of others and practical knowledge did not affect behavior through intention or directly. Moreover, the factor of cooperative framework did not affect intention or behavior.

Model with goodness-of-fit for nurses at disaster base hospitals

To determine whether there was any difference in the effects of these factors between the two groups of the disaster base hospitals and nuclear emergency core hospitals/nuclear emergency medical cooperation institutions, we constructed a model for goodness-of-fit for each

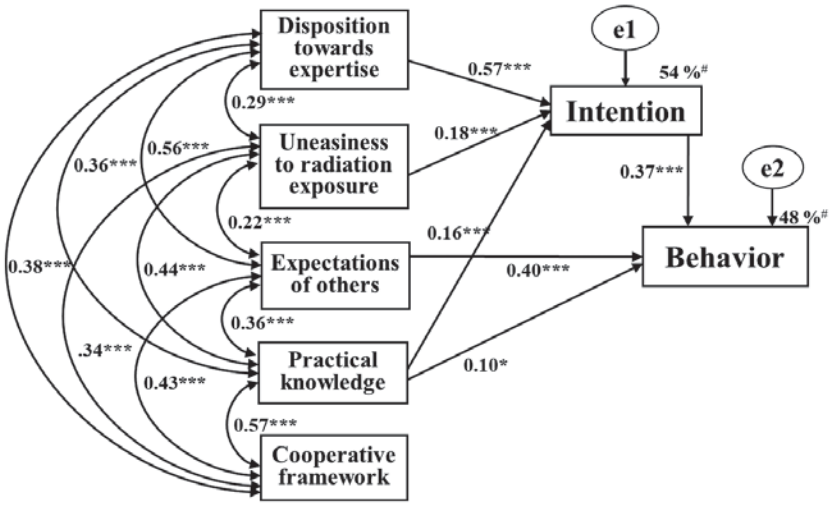

Figure 3 Model with goodness-of-fit for all nurses

Using the results of 361 questionnaires from both hospital groups, the model was constructed. The model was subjected to covariance structure analysis. Only significant effects were presented by arrows. Bidirectional arrows indicate covariant relationships (correlations), and one-way arrows represent causal relationships. Error variables (e) were presented as e1 or e2.

The goodness-of-fit indexes for this model were as follows: GFI = 0.998, χ 2 value CMIN = 3.024, P = 0.388, GFI = 0.998, AGFI = 0.978, CFI = 1.000, RMSEA = 0.005, # coefficient of determination (%)

* p < 0.05, ** p < 0.01, *** p < 0.001

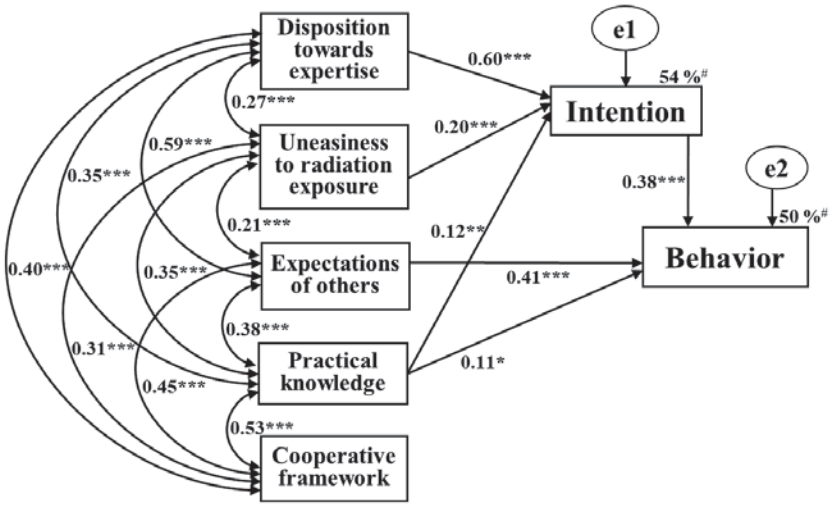

Figure 4 Model with goodness-of-fit for nurses at disaster base hospitals

Using the results of 256 questionnaires from the disaster base hospital group, the model was constructed. The model was subjected to covariance structure analysis. Only significant effects were presented by arrows. Bidirectional arrows indicate covariant relationships (correlations), and one-way arrows represent causal relationships. Error variables (e) were presented as e1 or e2.

The goodness-of-fit indexes for this model were as follows: GFI = 0.994, CMIN = 5.675, P = 0.129, AGFI = 0.942, CFI = 0.996, and RMSEA = 0.059, # coefficient of determination (%)

* p < 0.05, ** p < 0.01, *** p < 0.001

group.

First, we analyzed the results of the questionnaires from 256 nurses at disaster base hospitals by covariance structure analysis. The goodness-of-fit indexes for this model were GFI = 0.994, χ 2 value CMIN = 5.675, P = 0.129, AGFI = 0.942, CFI = 0.996, and RMSEA = 0.059 and had well goodness-of-fit indexes (Fig. 4). In this model, intention also affected behavior significantly (0.38, p < .001). Significant standardized

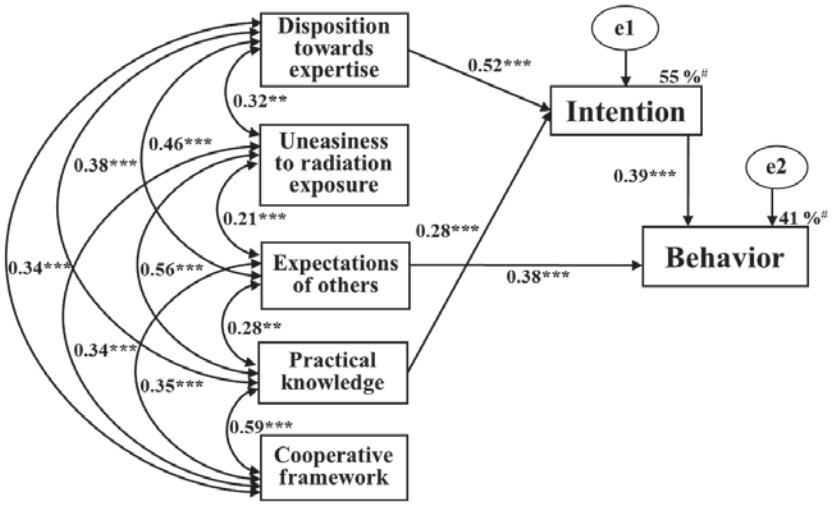

Figure 5 Model with goodness-of-fit for nurses at nuclear emergency core hospitals/nuclear emergency medical cooperation institutions

Using the results of 105 questionnaires of the group from nuclear emergency core hospitals nuclear and emergency medical cooperation institutions, the model was constructed. The model was subjected to a covariance structure analysis. Only significant effects were presented by arrows. Bidirectional arrows indicate covariant relationships (correlations) , and one-way arrows represent causal relationships. Error variables (e) were presented as e1 or e2.

The goodness-of-fit indexes for this model were as follows: GFI = 0.995, GFI = 0.995, χ 2 value CMIN = 1.786, P = 0.618, AGFI = 0.955, CFI = 1.000, and RMSEA = 0.000, # coefficient of determination (%)

* p < 0.05, ** p < 0.01, *** p < 0.001

estimates were obtained among all 5 factors, showing that these factors affected one another significantly. Disposition towards expertise (0.60, p<0.001), uneasiness to radiation exposure (0.20, p<0.001), and practical knowledge (0.12, p< 0.01) affected intention significantly. Furthermore, there were significant effects of expectations of others (0.41, p<0.001) and practical knowledge (0.11, p<0.05) on behavior directly. Approximately 54% of the intention was explained for behavior, disposition towards expertise, uneasiness to radiation exposure, and practical knowledge by the coefficient of determination. Approximately 50% of the behavior was explained for intention, expectations of others, and practical knowledge by the coefficient of determination. There was also no effect of cooperative framework on intention or behavior. Thus, the model for nurses at disaster base hospitals was almost the same as that for all nurses.

Model with goodness-of-fit for nurses at nuclear emergency core hospitals/nuclear emergency medical cooperation institutions

Results of 105 nurses at nuclear emergency core hospitals nuclear or emergency medical cooperation institutions were determined by covariance structure analysis. The high goodness-of-fit was also obtained for this model (GFI = 0.995, χ 2 value CMIN = 1.786, P=0.618, AGFI = 0.955, CFI = 1.000, and RMSEA = 0.000) (Fig. 5). As expected, intention affected behavior significantly (0.39, p<0.001). The 5 factors also influenced one another significantly. Although disposition towards expertise and practical knowledge affected the intention significantly (0.52, p<0.001 and 0.28, p<0.001, respectively), only expectation of others affected behavior directly (0.38, p<0.001). No effect of a factor of cooperative framework was also observed on intention or behavior in this model. Approximately 55% of the intention was explained for disposition toward expertise and practical

knowledge by the coefficient of determination, and approximately 41% of behavior was explained for intention and expectation of others.

Discussion

In TPB, a factor that determines behavior is intention[3]. However, various factors affect intention. When these factors work positively, intention to perform the behavior increases, and the intended behavior becomes easier to perform. Choosing several factors affecting intention, we constructed a provisional model of intention/behavior for nurses in response to radiation accident/disaster. In this model, these factors are thought to affect only intention but not behavior directly. However, the model constructed according to the questionnaires of the nurses of both groups did not fit the provisional one. There were factors that affected behavior directly or did not have effects on intention or behavior. Moreover, there was significant difference in the models between the disaster base hospitals and the nuclear emergency core hospitals and nuclear emergency cooperation institutions.

In the model of the nuclear emergency core hospitals and nuclear emergency cooperation institutions, uneasiness to radiation exposure did not affect intention or behavior, and practical knowledge affected intention but not behavior. In the group of the disaster base hospitals, in contrast, uneasiness to radiation exposure affected intension and effects of practical knowledge were observed on intention and also behavior. Furthermore, uneasiness to radiation exposure was more closely related to practical knowledge, and scores of these two factors were higher in the nuclear emergency core hospitals and nuclear emergency cooperation institutions than in the disaster base hospitals. One of the differences between the two groups of hospitals was education/training in response to radiation/nuclear disaster; the disaster base hospitals included in the present study did not have any education/training system for radiation emergency. Uneasiness to radiation exposure could be reduced if correct knowledge on radiation basics and concept of radiation protection are provided. Moreover, effects of practical knowledge on behavior observed in the model of the disaster base hospitals may be altered by education. In the response to the accident at the Fukushima nuclear power plant, a lack of exact knowledge of radiation and its effects prevented the system for medical care from functioning, and after the accident, demands or requests for training courses have been increasing[15]. Thus, basic knowledge of radiation and its effects has been emphasized for health care providers including nurses. Our results show that opportunities for high-quality education/training are essential.

Disposition towards expertise and practical knowledge affected intention, but no effects of cooperative framework were observed on intention or behavior in the two models. There was also no significant difference in scores of intention and disposition towards expertise in the two groups, although these scores were relatively high. Moreover, expectation of others affected behavior directly, but no effects were observed on intention. Nurses belonging to experts or professionals in the medical field and radiation/nuclear disaster are rare, suggesting that nursing care for radiation emergency is a highly-specialized medical field. Taken together, therefore, these results suggest that enhancement of disposition towards expertise and expectation of others are important for the response of nurses to radiation emergencies. Since education/training may be unable to enhance these factors, measures are required for a nurse to work with pride as an expert in this field and for social standing.

In the present study, we chose five factors that may affect the intention of nurses in re-

sponse to radiation accidents/disasters. However, the factor of a cooperative framework affected neither intention nor behavior in the two groups. The cooperative framework is a system of support from others. We asked whether and how they could receive support from radiation specialists and their affiliated organizations and whether the system is important. These results indicate that human resources are more important than systems, facilities or equipment. Furthermore, coefficients of determination for intension or behavior were not high; factors which we proposed may not necessarily reflect the purpose of our present study. Revision of these factors may be required.

Conflicts of interest

All authors have no conflicts of interest directly relevant to the content of this article.

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