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Nurse Administrators' Roles for Nurse Retention when Radioactive Disaster occurs: Findings from Nurses' Evacuation Consideration and Evacuation after the Fukushima Daiichi Nuclear Power Plant accident

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Abstract

Background: In 2011, a nuclear accident severely affected many hospitals in Fukushima. Many nurses faced a dilemma of whether to evacuate voluntarily or keep working. This study examined the voluntary evacuation and returning of nurses and then suggested how nurse administrators can prepare for such situations.

Methods: The study was conducted from July through September 2018. Eight hundred nurses who had been working prior to the incident in three hospitals in Koriyama and Aizuwakamatsu participated. Although both cities had higher-than-normal terrestrial radiation levels, Koriyama's level was three times higher. An anonymous questionnaire was administered, and individual interviews were conducted with participants. For statistical analyses, SPSS Statistics for Windows, version 25.0, was used.

Results: Ultimately, 723 questionnaires were collected. The proportions of those who considered evacuating (33.1%) and who evacuated (8.1%) were significantly higher in Koriyama. The characteristics of the group who considered evacuation were being pregnant, living with an adult cohabitant, and/or living with small child (ren). The evacuated nurses were all female and had similar characteristics as the group that considered evacuating; however, the age of their children was not related. Four out of six interviewees contacted nurse administrators and/or colleagues and overcame their feelings of guilt when their superiors and colleagues welcomed them back to work.

Conclusion: Nurse administrators should understand that, when a radioactive disaster occurs, individuals who are more likely to consider evacuation have conflicts between their personal life and professional responsibilities. Nursing departments should inform nurses of their policies in advance and respect individuals' decision to leave, supporting them when they return to work. Departments should also have a plan in place for managing with a temporarily reduced workforce.

Introduction

Nurses comprise the largest healthcare workforce and their turnover leads to a shortage in

the clinical workforce; consequently, management of nurse retention has been studied in many countries¹⁻⁴. When large-scale disasters occur, such

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nurse shortages are more problematic. In 2011 the Great East Japan Earthquake (GEJE) affected many hospitals in three prefectures: Iwate, Miyagi, and Fukushima. The Fukushima Daiichi Nuclear Power Plant (FDNPP) accident brought more severe damage to hospitals not only in the coastal area near the plant, but also in inland areas. Maehara⁵ reported that, in the 44 hospitals in Fukushima, 5.2% of staff left the workplace immediately after the accident due to fear of radiation exposure.

FDNPP affected mostly coastal areas; however, inland areas also had much higher-than-normal terrestrial radiation levels and accepted many evacuated patients from coastal areas. In 2013, Sato et al.⁶ reported that 44.6% of nurses at the inland Fukushima Medical University Hospital, 63 km northwest of FDNPP, intended to leave after the accident. The first researcher was working for an inland general hospital in Koriyama City (Koriyama); some colleagues who evacuated voluntarily resigned while others returned to their wards afterward. Ota⁷ who worked at a hospital on the coast described hospital staff's evacuation dilemma.

Nurse administrators must understand nurses' situation to maximize nurse retention. Suggestions for maintaining staff retention include strengthening the hospital's business continuity plan (PCB) to provide the necessary health services to community members when disasters occur.

This study aimed to understand nurses' voluntary evacuation and return in order to suggest ways nurse administrators can prepare for radiation disasters to support both evacuated nurses willing to return and nurses who remain. The researchers considered nurses in two areas: Koriyama, 58 km west of FDNPP, which had the highest terrestrial radiation (8.26 microsievert per hour [$\mu\text{S}/\text{h}$]) three days after the accident and faced electricity, water, and logistics shortages⁸, and Aizuwakamatsu (Aizu), 98 km west, which had 2.57 $\mu\text{S}/\text{h}$ three days after the accident and faced logistics challenges⁸. Both cities' regular terrestrial radiation level was approximately 0.5–0.7 $\mu\text{S}/\text{h}$ ⁸.

Method

Target population: Eight hundred nurses who were working prior to the FDNPP incident in three

general hospitals in Koriyama (500 nurses) and Aizu (300 nurses) each.

Questionnaire: An anonymous questionnaire was developed to understand nurses' personal attributes, nursing position, family structure, presence or absence of pregnancy, intention to leave the workplace, voluntary evacuation/reasons for evacuating or not, conditions of contact with nurse administrators during evacuation and return, at the time of the accident. These items were selected based on Sato's article⁶ and Toho Area Research Institute's report⁹. They were informed to submit the anonymous questionnaire if they agreed to participate. The questionnaires with envelopes were delivered to nursing department directors in six hospitals; boxes to collect the sealed envelopes were set up during the study period.

Interview: The researchers asked nursing directors to recommend nurses who had voluntarily evacuated and then returned to the workplace. Only nurses who agreed to an individual interview with the researcher and signed the informed consent participated. Interviews focused on how and who decided about evacuation, contacts with nursing administrators and colleagues during evacuation, and decisions to return to workplaces.

Study period: July 17 through September 28, 2018.

Data analysis: Microsoft Excel, for Mac version 16.18.2018 (Washington, USA), was used for the simple calculations of numbers and percentages. For some statistical analyses, SPSS Statistics for Windows, version 25.0 (IBM Corp., NY, USA), was used. To test the normal distribution of age, the Kolmogorov-Smirnov test was used and the Mann-Whitney's U test was applied to test differences between age distributions in two cities. To determine the proportion difference between two cities and within Koriyama, a chi-square test or multiple comparison test with Bonferroni correction was applied. For all tests, a *p*-value of less than .05 was applied.

Results

1. Response number and rate

Koriyama nurses returned 460 questionnaires (92.0%); Aizu nurses returned 264 questionnaires

(90.5%). One questionnaire from Koriyama with incomplete responses was removed, resulting in 723 responses for analysis (valid response rate: 90.4%).

2. Participants' personal attributes

Table 1 summarizes participants' age, gender,

position, and pregnancy condition. The only difference between the two cities was age distribution; Koriyama's nurses were significantly younger than Aizu's.

Table 1. Comparison of nurses' personal attributes between two cities

Category	Sub-category	Koriyama	Aizu	p-value
Age*	Median (range)	33.0 (20-60)	40.0 (21-62)	<0.001
Gender**	Female	421 (91.7%)	251 (95.1%)	0.142
	Male	35 (7.6%)	12 (4.5%)	
Position**	Staff	370 (81.5%)	214 (82.0%)	0.949
	Administrator	84 (18.5%)	47 (18.0%)	
Pregnancy**	Presence	31 (7.7%)	11 (5.4%)	0.368
	Absence	372 (92.3%)	194 (94.6%)	

*: Mann-Whitney's U test

** : Pearson's chi-square test

3. Nurses considering evacuation

Of the 723 participants, 33.1% of Koriyama nurses considered voluntary evacuation, which was significantly higher than in Aizu (Table 2).

Table 2. Comparison of nurses who considered voluntary evacuation in two cities

Category	Koriyama	Aizu	p-value
Considered	152 (33.1%)	424 (9.1%)	<0.001
Not considered	307 (66.9%)	240 (90.9%)	

*Pearson's chi-square test

The reasons for considering evacuation were the same in both cities: fears about their children's health, fears about their own health, and family members' suggestion to evacuate. Among nurses with no children, fears about their own health ranked first. Meanwhile, the reasons for not evacuating differed in the two cities. The majority of Koriyama nurses answered "responsibilities as nurses" while those in Aizu indicated the "low terrestrial radiation level."

Table 3 compares nurses in the two cities who considered voluntary evacuation based on gender, position, pregnancy condition, and having child (ren). All females—whether nurses/nurse administrators, pregnant/not pregnant, and having child (ren)/having no child—had higher proportions in Koriyama than Aizu. Males showed no differences.

Table 3. Comparisons of nurses who considered voluntary evacuation in two areas

Category	Subcategory		Koriyama	Aizu	p-value
Female*		Considered	139 (33.0%)	22 (8.8%)	<0.001
		Not considered	282 (67.0%)	229 (91.2%)	
Male**		Considered	13 (37.1%)	2 (16.7%)	0.288
		Not considered	22 (62.9%)	10 (83.3%)	
Staff nurse*		Considered	130 (35.1%)	22 (10.3%)	<0.001
		Not considered	240 (63.9%)	192 (89.7%)	

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Nurse administrator*		Considered	20 (23.8%)	1 (2.1%)	0.001
		Not considered	64 (76.2%)	46 (97.9%)	
Pregnancy	presence**	Considered	20 (64.5%)	2 (18.2%)	0.013
		Not considered	11 (35.5%)	9 (81.8%)	
	absence*	Considered	115 (30.9%)	12 (6.2%)	<0.001
		Not considered	257 (69.1%)	182 (93.8%)	
Child(ren)	presence*	Considered	97 (46.0%)	19 (10.9%)	<0.001
		Not considered	114 (54.0%)	155 (89.1)	
	absence*	Considered	55 (22.4%)	5 (5.7%)	<0.001
		Not considered	191 (77.6%)	83 (94.3%)	

*: Pearson's chi-square test

**: Fisher exact test

4. Evacuated nurses

Thirty-seven evacuated in Koriyama, which was

Table 4 indicates the number of evacuees among those who considered evacuation in both cities.

significantly higher than in Aizu.

Table 4. Comparison of proportions of evacuated nurses in two cities (n=253)

Category	Koriyama	Aizu	p-value
Evacuated	37 (24.3%)	1 (4.2%)	<0.028
Evacuation considered but not evacuated	115 (75.5%)	23 (95.8%)	

*Fisher exact test

5. Characteristics of Koriyama participants who considered evacuation

Koriyama was faced higher radiation levels and had higher rates of nursing staff who considered

evacuating and who evacuated than Aizu. Therefore, the characteristics of Koriyama's nurses were examined. Table 5 shows that being a staff nurse, being pregnant, and having child(ren) were more common in the group considering evacuation than the other group.

Table 5. Comparisons of Koriyama participants who considered voluntary evacuation (n=456, except pregnancy n=326 [under 45 years old])

Category		Female	Male	p-value
Gender*	Considered	139 (33.0%)	13 (37.1%)	0.619
	Not considered	282 (67.0%)	22 (62.9%)	
Category		Staff nurse	Nurse administrator	p-value
Position*	Considered	130 (35.1%)	20 (23.8%)	0.046
	Not considered	240 (64.9%)	64 (76.2%)	
Category		Presence	Absence	p-value
Pregnancy*	Considered	19 (67.9%)	94 (31.5%)	<0.001
	Not considered	9 (32.1%)	204 (68.5%)	
Category		Presence	Absence	p-value
Adult family member(s)**	Considered	37 (27.4%)	0	0.006
	Not considered	98 (72.6%)	17 (100%)	
Category		Presence	Absence	p-value
Child(ren)*	Considered	97 (46.0%)	55 (22.4%)	<0.001
	Not considered	114 (54.0%)	191 (77.6%)	

*: Pearson's chi-square test

**: Fisher's exact test

Table 6 compares voluntary evacuation considering four family structures (adults and children). Those who lived with adult family member(s) and child(ren) were more likely to consider evacuation than other family structures

($p < 0.05$). In addition, a chi-square test showed that those who lived with adult family member(s) had a significantly higher evacuation rate than those without adult family members ($p < 0.001$).

Table 6. Relationship between voluntary evacuation consideration and four family structures in Koriyama (n=457)

Voluntary evacuation consideration	Lived alone		Lived with adult family member(s) but no child		Lived with no adult family member(s) but with child(ren)		Lived with adult family member(s) and child(ren)		Total
	n	%	n	%	n	%	n	%	
Presence	17 _a	18.7	38 _a	24.5	<5 _a	77	96 _b	48.5	152
Absence	74 _a	81.3	117 _a	75.5	12 _a	92.3	102 _b	51.5	305

* Multiple comparison: the same subscript alphabet means no difference * $p < 0.05$

The relationship between voluntary evacuation consideration and the youngest child's age was examined. Age groups were categorized as under seven years old (preschooler), 7–12 years old (primary school), 13–15 years old (junior high school), and over 15 years old (high school or older). In multiple comparisons, the greatest difference emerged between nurses with preschoolers (more

likely to consider evacuation) and those with children older than 15 years old (less likely; Table 7). The test between preschoolers and over six years old shows that the preschooler group had the higher rate (chi-square test, $p < 0.001$). Similarly, the test between under 13 years old and 13 years old and over showed the former had a higher rate of voluntary evacuation consideration (chi-square test, $p < 0.001$).

Table 7. Relationship between voluntary evacuation consideration and youngest child's age (Koriyama n=211)

Voluntary evacuation consideration	Preschooler (under seven years old)		7–12 years old		13–15 years old		Over 15 years old		Total	
	n	%	n	%	n	%	n	%	n	%
Presence	61 _a	56.5	26 _{a,b}	44.8	4 _{a,b}	30.8	6 _b	18.8	97	46.0
Absence	47 _a	43.5	32 _{a,b}	55.2	9 _{a,b}	69.2	26 _b	81.3	114	54.0

* Multiple comparison: the same subscript alphabet means no difference * $p < 0.05$

6. Characteristics of evacuees in Koriyama

Thirty-seven nurses in Koriyama evacuated. Although there was an evacuee in Aizu, in order to maintain confidentiality, no description of that nurse was provided. The 37 Koriyama evacuees accounted for 8.1% of all Koriyama participants; they were all females between 27 and 54 years old. The characteristics of the 37 evacuees were compared with

those of the 115 non-evacuees, focusing on pregnancy, family structures, and the youngest child's age. The relationship between pregnancy and voluntary evacuation was tested using a chi-square test among 113 nurses who were under 45 years old: 31 evacuees and 82 non-evacuees (Table 8). The pregnant nurses were more likely to evacuate ($p < 0.001$).

Table 8. Relationship between pregnancy and evacuation in those under 45 years old (n=113)

		Evacuated	Not evacuated	p-value
Pregnancy	Presence	11 (35.5%)	8 (9.8%)	<0.001
	Absence	20 (64.5%)	74 (90.2%)	

*Fisher's exact test

Table 9 shows that those who lived with adult family member(s) and child(ren) evacuated more than those who lived alone. The chi-square test indicated that those who lived with adult family member(s) had a significantly higher evacuation rate than those who did not ($p=0.006$). Table 10 indicates that the youngest

child's age did not influence evacuation decisions. A chi-square test between the preschooler group and over six years old group found no difference. The chi-square test also compared the under seven years old group to the over 13 years old group, with no difference found.

Table 9. Relationship between evacuation and four family structures in Koriyama (n=152)

Evacuation	Lived alone		Lived with adult family member(s) but no child		Lived with no adult family member(s) but with child(ren)		Lived with adult family member(s) and child(ren)		Total
	n	%	n	%	n	%	n	%	
Presence	0 _a	0	7 _{a,b}	18.4	<5 _{a,b}	0	30 _b	31.3	37
Absence	17 _a	100	31 _{a,b}	81.6	<5 _{a,b}	-	66 _b	68.8	115

* Multiple comparison: the same subscript alphabet means no difference * $p<0.05$

Table 10. Relationship between evacuation and youngest child's age groups in Koriyama (n=85)

Evacuation	Preschooler (under seven years old)		7-12 years old		13-15 years old		Over 15 years old		Total	
	n	%	n	%	N	%	n	%	n	%
Presence	22 _a	39.3	6 _a	26.1	<5 _a	-	<5 _a	-	29	34.1
Absence	34 _a	60.7	17 _a	73.9	<5 _a	-	<5 _a	-	56	65.9

* Multiple comparison: the same subscript alphabet means no difference * $p<0.05$

7. Interview results

Six nurses participated in the individual interviews. Three decided to evacuate on their own due to their concern about their children's health. The other three were encouraged to make this decision by an obstetrician or parents/relatives.

Four interviewees remained in contact with their nursing director or head nurse. One director offered to exchange phone numbers with an evacuated nurse to stay in contact. Three were in contact with colleagues. Two had no contact with any co-workers.

Two had calls from nursing administrators requesting them to return to work. Four decided to

return on their own. One was confronted by in-laws regarding her return. Some were afraid of colleagues' reactions when they returned to work because they did not share the heavy burden of the nurses who remained; however, they found no critical atmosphere when they returned. Almost of evacuees were gone for fewer than 10 days.

Discussion

1. Influence of FDNPP accident on nurses' voluntary evacuation in two cities

Although the two groups were similar in terms of personal attributes (except for the younger age of Koriyama nurses), the Koriyama group had

much higher proportions of those who considered voluntarily evacuating and who evacuated than Aizu. The sole definitive difference between the two cities was that Koriyama had higher radiation levels than Aizu and Koriyama issued tap water restrictions after detecting 150Bq/kg of radioactive iodine in a water purification plant¹⁰. Consequently, Koriyama residents had greater awareness of the reality of radiation exposure, leading and Koriyama nurses to consider evacuating and evacuate more than Aizu nurses.

2. Characteristics of nurses who considered voluntary evacuation

Koriyama nurses who considered voluntary evacuation were pregnant, lived with adult(s) and child(ren) under 13 years old (especially preschoolers), and were staff nurses. These characteristics might also have been related to their younger age than nurses in Aizu. Adult cohabitant(s) might have influenced nurses' evacuation decisions, discussion of possible future radiation health effects, and so on.

Meanwhile, no differences in considering evacuation emerged due to gender. Of the 35 male nurses, 13 considered voluntary evacuation, along none evacuated; this finding might be a gender issue in terms of prioritizing job responsibilities over family ones, although any choice is justified.

3. Characteristics of voluntarily evacuated nurses

Characteristics of voluntarily evacuated nurses were similar to those who considered voluntary evacuation, but the youngest child's age was not related to the evacuation decision. Although the evacuees in this study were small in number and the decisive factors were complex and multidimensional, the findings of this study suggested that one possible factor was female nurses with adult cohabitants. All 37 evacuees were female, lived with an adult cohabitant, lived with child(ren), and/or had been pregnant. Female nurses seemed to prioritize their children over themselves.

Moreover, a family with multiple adults had advantages such as being able to discuss issues among adults, collect information (e.g., place to evacuate), access transportation, and access affordable resources. Financial affordability was important because, unlike

people officially ordered to evacuate, voluntary evacuees had to pay for all of their own expenses in almost all cases. Financial issues were the most difficult experience of voluntary evacuees during the evacuation period in all Fukushima prefectures⁹.

Evacuees might have faced workplace and community conflicts when they decided to evacuate. Matsunaga¹¹ reported that voluntarily evacuated mothers were strongly stressed by sensing different values related to radiation exposure risk compared to family members or neighbors. Yonemoto¹² also indicated that the same stress was found among voluntarily evacuated nurses with colleagues.

4. Implications for nursing management

Considering these results, preparing to respond as a nursing department during large-scale radioactive disasters would be beneficial, especially as such an emergency could happen in anywhere around the globe. The researchers suggest that nursing departments educate staff about policies related to leaving and returning to the workplace before an incident occurs. It is important to build an effective working environment that does not disrespect evacuated colleagues. Emergencies happen, and nurses face conflicts between their professional responsibilities and personal roles. Especially in the case of a radioactive disaster, it is important that the nursing department respects individuals' decision to leave and ensures that all nurses know to respect such decisions. The nursing department should remind nurses who remain to respect their evacuated colleagues as well. Policies that promote respect for and the importance of all nurses can help avoid negative impacts on both evacuated nurses and nurses who remain.

The nursing department's willingness to return when the resignation or temporal leave is reported and their supportive contact during evacuation are also very important. As the interviewees described, those who had contact with their superiors seemed to have a lower hurdle to return to work and join their colleagues. Nursing administrators should know that, when radiation levels go down, many nurses are likely to come back. Morioka et al.¹³ reported that ratios of nurses per thousand individuals in the general population in three GEJE-affected prefectures dropped in 2011 compared to the 2020

ratios; however, they increased in 2013, except in the most severely damaged areas. Maehara⁵ indicated that 5.2% of all hospital staff left immediately after the accident, with 71% of them eventually returning and the final resignation rate being only 1.5%.

In addition to departmental policies, nursing administrators' support of both the nurses who evacuate and those who remain is indispensable for maintaining robust nursing manpower. Majeed and Jamsheed¹⁴ reported that nurse leaders' emotional intelligence is needed to reduce nurses' turnover intentions. Nursing administrators should treat their staff nurses as being irreplaceable. Arbon et al.¹⁵ reported that willingness to attend work during a disaster was affected by many competing factors that impacted both work and home environments.

Conclusion

Nursing administrators should thoroughly prepare to protect their nurses when a disaster damages their facility and function. The radiation disaster in Fukushima affected many nurses. In emergency situations, nursing departments must equally respect personal decisions to leave or remain and be welcoming of those returning, which should be announced. BCP, including how to manage nursing services with a smaller number of nurses, should be prepared simultaneously.

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