DEVEOPMENT OF THE INDEX OF EFFECTIVE SAFETY IN NUCLEAR DOMAIN OF KOREA

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Abstract

There exists a so-called "experts-lay people" gap in discourses about nuclear safety, because experts and lay people have a different definition of 'safety'. However, it is getting increasingly important for nuclear practitioners to understand the lay people's subjective perception of nuclear safety. We developed the indices of effective safety in nuclear domain of Korea. The index of effective safety indicators (IOES) are based on data of the public survey of local inhabitants. The research results are as follows: Extraction of four sub-factors for effective safety indicators; Communication, Trust, Plant emergency response capability, and Personal emergency coping skills. The IOES was 38.22, which was extremely low. The IOES is a sort of an 'absolute' index and hard to imagine that people feel 'absolutely' safe regarding nuclear power plants. As a more realistic index, we devised a relative index of effective safety (RIOES), which is basically a proportion of residents' IOES to that of the employees of nuclear power plants. RIOES was 56.77, meaning that the level of effective safety of residents was only 56.77 % of that of the employees. The proposed indices can be utilized as an useful communication tool between the local inhabitants and nuclear practitioners.

Keywords: Effective Safety, Risk Perception, Index of Effective Safety, Communication Tool

1. Introduction

The list of Covello shows the differences between the risk perception of lay people and that of domain experts [1]. The communication between lay people and domain expert use different meaning of ‘risk’, there is possibility of the consistent conflict between local inhabitants and employees of nuclear power plant and then the trust between them can be lowered.

Researches on psychological measures of risk perception of nuclear technology have been actively performed. The researches focused to indicate the perception of people on nuclear safety quantitatively. This approach has been applied into other risk technologies as well as nuclear technology. The psychometric researches on nuclear technology can be classified the following three categories.

Firstly, to assess the level of risk using single dimension. The frequent comparison measure is annual death probability or reduction in life expectancy by accident. Secondly, to use the cost-benefit analysis, that uses the concept of acceptable risk or risk acceptability. When the cost from a technology, comparing to the benefit, is too high, people tend to refuse the technology. The nuclear technology shows the biggest unbalance from a view point of cost-benefit analysis. That is, lay people subjectively percept that the cost of nuclear technology is higher than the benefit of that. Thirdly, to find the function of accidents as signals. Likewise a ripple effect, the function as a signal in risk perception for an accident means that people regard an occurrence as a symptom of the same or the severe accident occurrence(s).

The attitude for the risk of nuclear power plant is able to be measured from that of plant construction. Van der Pligt et al. (1986) verified the factors which impact the attitudes of inhabitants, who lived at neighboring area of plant construction. They found that the most predictable factor is the perceived psychological risk. This means that the effective safety impacts as a dominant factor for the attitude of people of nuclear risk. Eiser at al. (1988) reported that people who do not reject the nuclear technology can resist the construction of nuclear plant because it will spoil the nature. Hughey et al. (1985) verified the expectancy model for nuclear technology. The research of van der Pligt(1985) showed that the emotional factors (e.g., fear and anxiety) of lay people prevail the attitudes for the nuclear plant construction. And he reported the implying result that the attitudes and risk perception of a nuclear plant should be understood within a personal attitude network.

The research results, which surveyed the change of people’s risk perception for nuclear power plant after criticality accident of Tokai in 1999, showed that the occurrence of accident did impact to risk perception [6]. This research surveyed three cities (Tokyo, Osaka, Nagoya) before and after the accident. The analysis results found that the trust decreased and the possibility of accident increased after the accident. However, the knowledge level of nuclear power plant did not change.

Recently Choi et al. (2002) developed a tool that is used to measure the attitude for nuclear technology. They also measured the attitude strength. The interesting result of the research is that the attitude strength for nuclear technology goes high in accordance with the ages of people. Though the younger generation has a favorable attitude, the attitude strength is weak. However, the older generation has negative image for nuclear technology and the attitude strength is strong too.

The limitation of risk perception study is the difficulty of communication. It is very effective to describe the attributes of risk perception, but it has limitation to fully express the effective safety of lay people and to address the personal differences. Therefore, it is needed to develop the easy tool, that is, the scale approach that shows the differences of lay people and experts on risk perception in addition to the easy understanding of lay people. So et al. (2001) proposed the concept and necessity of effective safety in nuclear domain, but did not explicitly measure it. We used the scale approach based on the attitude for nuclear safety and the selection method of factors and elements followed the general development procedure of psychometrics.

2. Development of Index of Effective Safety (IOES)

2.1 Development Process of IOES

The index of effective safety (IOES), that we propose, is the level of safety perception of local inhabitants of nuclear power plant, which is based on the statistical method of survey results, not on expert judgment. The development process has four steps. Firstly, we surveyed the previous studies related to the effective safety and derived the preliminary 35 questions. Secondly, we surveyed the 70 local inhabitants using the preliminary questions and chose 5 factors and 21 final questions. Finally, we surveyed the 800 local inhabitants and developed the IOES derived from the 4 factors and 12 questions. The overall development process and respondent characteristics are shown in Figure 1 and Table 1.

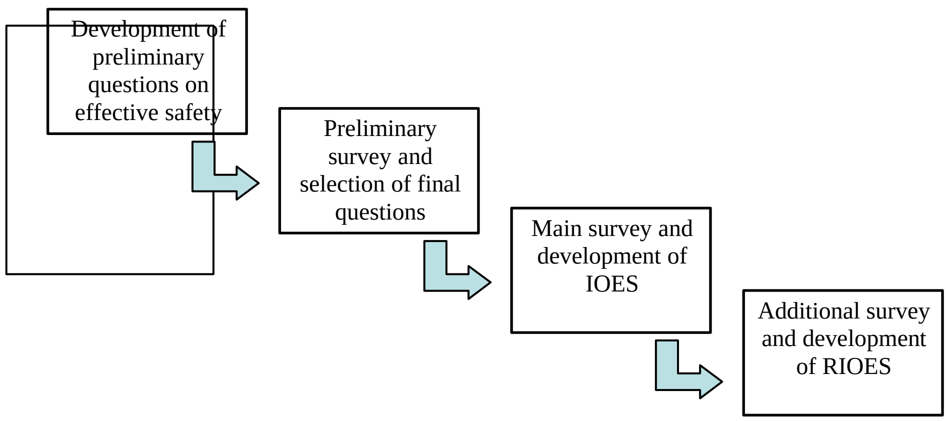

Figure 1. Development process of index of effective safety

Table 1. Respondent characteristics of local inhabitant survey

Index	Contents
Population	Adult aged 20-64 lived around nuclear plant sites
Sample size	800 (200 at each site; Kori, Yonggwang, Ulchin, Wolsong)
Sampling method	Purposive quota sampling
Data collection	Face-to-face personal interview using structured questionnaire
Period	2004. 12. 13 ~ 12. 28

The factor analysis used principal component analysis and varimax rotation. The selection criteria of each factor is the eigenvalue is greater than or equal to 1. The final results are 4 factors with 3 questions per factor. The factors are Communication, Trust, Plant emergency response capability, and Personal emergency coping skills. The total Rsquare of re-analysis with the final 12 questions is 57.4%. The adequacy of IOES was verified by the analysis of correlation with some variables. The correlation coefficients of IOES are as follows: 0.45 for attitude of nuclear technology, 0.25 for 0.31 for satisfaction with nuclear safety, 0.32 for prospect of nuclear safety. All correlation coefficients are statistically meaningful.

2.2 Results of Proposed IOES

In order to verify the impact of each factor to total IOES, we performed regression analysis with total record of questions as a dependent variable and each record of 4 factors as independent variables. The beta coefficients of communication, trust, plant emergency response capability, and personal emergency coping skills are 0.389, 0.361, 0.385, and 0.343 respectively. Therefore, we regard that the impact of each factor to total IOES is same and calculate the IOES from 5-point (1 to 5) response. The value span of IOES is 0 to 100 and high value of IOES means people feel safe more.

The total and factor specific IOES of local inhabitants of nuclear power plants are shown in Figure 2. Total IOES is 38.22 and seems to be very low. The index of 'personal emergency coping skills' is extremely low value of 22.04. Based on this index, we deduce the cause of dissatisfaction of nuclear safety as the ignorance of how to cope with the accident situation.

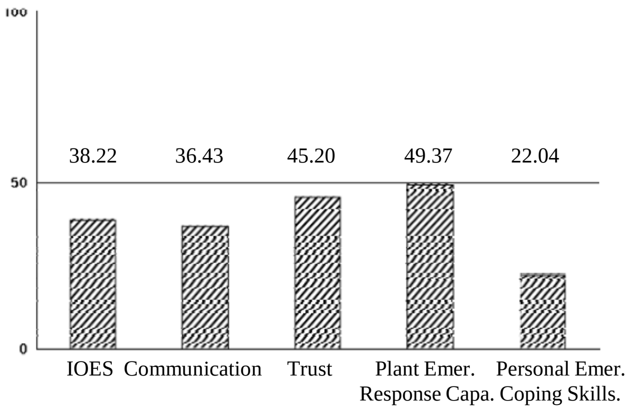

Figure 2. Total and factor-specific IOES

The gender specific IOES of local inhabitants are shown in Figure 3. Total IOES of male and female are 38.14 and 38.29 and there is no statistically meaning. However, factor IOES of plant emergency response capability and personal emergency coping skills show outstanding gender difference. Especially, the female IOES 18.93 of personal emergency coping skills is dangerously low and it is in urgent need of education for coping with the accident situation. On the other hand, the results of site specific IOES show that three sites (i.e., Kori, Wolsong Ulchin) inhabitants have almost same level of effective safety, but the IOES of Yonggwang is lower than the other sites and the difference is statistically meaningful.

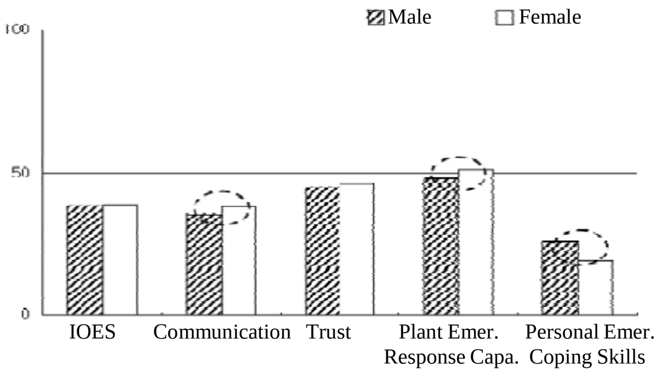

Figure 3. Gender-specific IOES

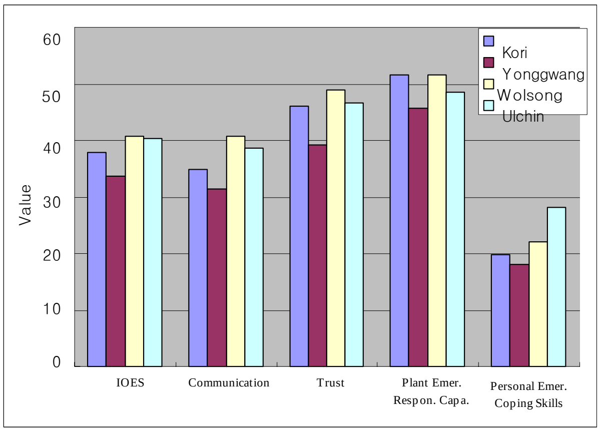

Figure 4. Site-specific IOES

3. Development of Relative Index of Effective Safety (RIOES)

3.1 Development of Relative IOES

The IOES is a sort of 'absolute' index. We assign the perfect IOES of local inhabitants is 100. That means we implicitly assume that the perfect value is achievable and also should be a goal. However, it is not realistic to expect that one can achieve a score of 100 in the IOES because it is hard to imagine that people feel 'absolutely' safe regarding nuclear power plants. Though the absolute index has a clear meaning and is easy to calculate and is a convenient method, it is not a good method. Because when people discuss the risk of nuclear technology, their concern is not absolute but acceptable safety. Because we think the realistic goal is the effective safety of plant employees, we chose the IOES of the employees of nuclear power plant (NPP) as a reference index. Therefore, a more realistic index seems warranted. Therefore, we proposed the IOES as a main index and devised relative IOES (RIOES) as a supportive index, which is basically a proportion of residents' IOES to that of the employees of nuclear power plants and is calculated by the following equation.

$$\text{Relative IOES} = \frac{\text{IOES of local inhabitants}}{\text{IOES of plant employees}} \times 100, \qquad (1)$$

For the RIOES, we surveyed the employees of NPP with the same 12 questions derived from the results of main survey. We also asked them gender, working years, and job position. The questions for effective safety had two aspects; one is for the self agreement type question (e.g., Our plant quickly provides information to inhabitants when an accident happens or plant stops operation.) and the other is for the local inhabitants position (e.g., Our inhabitants think our plant quickly provides information to inhabitants when an accident happens or plant stops operation.). The three questions for plant emergency response capability were asked once as a inhabitants position. So total 21 questions were asked to each plant employee. Table 2 shows respondent characteristics of plant employees of four sites and Table 3 provide the IOES of the plant employees.

Table 2. Respondent characteristics of plant employees survey

Category \ Site		Kori	Yonggwang	Wolsong	Ulchin	Sum
Gender	Male	46	49	38	46	179
	Female	1	1	4	2	8
Working Years	Less than 10	8	14	23	12	57
	From 11 to 20	21	29	8	29	87
	More than 21	18	7	10	8	43

Table 3. Total and factor-specific IOES of plant employees survey

	IOES	Communication	Trust	Plant Emergency Response Capability	Personal Emergency Coping Skills[1)]
Self-viewpoint	67.33	75.18	70.50	79.19	44.59
Inhabitant-viewpoint	53.71	52.13	58.78	59.04	44.59

Note 1) The questions of plant emergency response capability were asked once and the result was same.

3.2 Results of the proposed Relative IOES (RIOES)

The total IOES of plant employees is 67.33. So the total RIOES calculated by using Eq. (1) is 56.77. Though this value seems to show higher effective safety than absolute type IOES of 38.22, but this only means that the effective safety of local inhabitants is the level of 56.77% of plant employees. This value practically expresses the serious gap between inhabitants and employees for plant effective safety, as the Figure 5 shows the difference. The factor level indices shows that personal emergency coping skills and communication are low level. There is no statistical value for RIOES because we just divide IOES of inhabitants by IOES of employees.

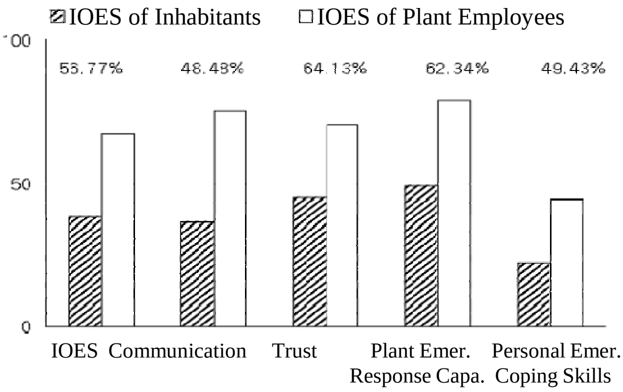

Figure 5. RIOES and Comparison of IOES between Inhabitants and employees

We compare the site-specific total IOES of inhabitants and the total IOES of employees (See Figure 5). We do not use site specific total IOES of employees for RIOES because of the following reasons. Firstly, the sampling number of employees is not big comparing to respondent of inhabitants. Secondly, if we use different criteria of each plant site, then there is a possibility to intentionally modify the effective safety of employees for making higher RIOES. We try to exclude this trial of distorting data and use the average IOES of employees as a reference. Wolsong shows the highest RIOES of 60.67 and Yonggwang the lowest index of 49.96. Yonggwang shows the lowest level both for absolute and relative index, comparing to other plant sites.

4. Discussion on the Results of IOES and RIOES

We proposed an index to measure the effective safety of local inhabitants, which is consisted of four factors including communication, trust, plant emergency response capability, and personal emergency coping skills [9]. The total IOES of inhabitants that shows overall safety perception of the plant are 38.22 shows the need of improvement. The IOES of trust and plant emergency response capability are 49.39 and 45.20 respectively and these are relatively higher than those of other factor's IOES. However, the IOES of communication and personal emergency coping skills are 36.43 and 22.04 respectively. These low values mean two factors are critical to improve the effective safety of inhabitants. Therefore, effective communication between local inhabitants and plant employees and building up the capability of inhabitants for coping with plant accident have priority to other activities. In addition to this priority of activities, other factors of trust and plant emergency response capability seem to be low level from an absolute view point because both indices are less than half of perfect value.

The IOES between male and female inhabitants show significant difference. Especially female has too low perception of own capability for coping with plant accident. So it is needed to consider the gender difference and develop an education program for female's characteristics. On the other hand, site specific IOES also show the difference among plant sites. The IOES of Yonggwang presents striking contrast to IOES of other sites. This research did not contain the searching of cause of site difference. So it is needed to investigate the deep cause of difference and to find the method of improving the effective safety of local inhabitants, tailoring to regional need.

The relative IOES of inhabitants is 56.77% of IOES of plant employees, meaning the effective safety of inhabitants is almost half of that of employees. From a plant employee's viewpoint, they have difficulty in understanding the low level of effective safety of inhabitants and vice versa. This large gap between two groups of people exists. The more serious finding is the big difference of IOES between inhabitants and inhabitants' image of employees. As shown in the data of Figure 2 and Table 3, the guessing IOES of employees for effective safety of inhabitants shows much higher than the actual IOES of inhabitants. These results explain the need of relative IOES.

5. Conclusion

The proposed index of effective safety (IOES) and relative index of effective safety (RIOES) are derived from the survey data of local inhabitants and plant employees. These indices are based on the lay people's subjective perception of nuclear safety, not technical safety level or expert judgment. From the analysis of IOES and RIOES, the effective safety of lay people mainly depends upon the quality of relationship between plant employees and local inhabitants. Therefore, these indices provide the prioritized activity issues and then can be a good communication tool between two groups when nuclear practitioners try to improve the effective safety of local inhabitants. It is desirable to apply two indices into the following activities in order to improve the effective safety of inhabitants:

Firstly, the disclosure and sharing the IOES among inhabitants, plant employees, nuclear practitioners. Secondly, the periodic generation of IOES at least one per year and identification of the IOES trend. Thirdly, Utilization of communication tool between plant employees and inhabitants. Finally, Education of the employees to understand the effective safety level of inhabitants in order to widely accept the plant safety from a lay people's view point.

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