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Relationship among Public's Risk Characteristics, Risk Severity, Risk Perception and Risk Acceptability of Human Stem Cell Technology

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공중의 체세포복제기술에 대한 위험특성, 위험심각성, 위험인식 및 위험수용의 관계

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Abstract The purpose of this study was to examine the relationship among public's risk characteristics, risk severity, risk perception and risk acceptability of human stem cell technology. The subjects were 300 Koreans selected. The data were analyzed by the exploratory factor analysis, confirmatory factor analysis, correlation analysis and structural equation modeing analysis. The results were as followed. First, public's risk characteristics on human stem cell technology influenced positively on risk severity. Second, public's risk characteristics on human stem cell technology influenced positively on risk perception. Third, public's risk severity on human stem cell technology influenced positively on risk perception. Fourth, public's risk characteristics on human stem cell technology influenced negatively on risk acceptability. Fifth, public's risk severity on human stem cell technology influenced not significantly on risk acceptability. Sixth, public's risk perception on human stem cell technology influenced not significantly on risk acceptability. These results will contribute to develop the risk communication strategy on the acceptability of human stem cell technology

Key Words : Risk Characteristics, Risk severity, Risk Perception, Risk Acceptability, Human Stem Cell Technology

요 약 본 연구는 공중의 체세포복제기술에 대한 위험특성, 위험심각성, 위험인식 및 위험수용의 관계를 살펴보기 위하여 서울에 거주하는 한국인 300명을 대상으로 IBM SPSS 21 프로그램과 IBM AMOS 21 프로그램을 활용하여 탐색적 요인분석과 확인적 요인분석, 상관관계 분석, 구조모형분석을 수행하였다. 주요결과를 요약 제시하면 다음과 같다. 첫째, 공중의 체세포복제기술에 대한 위험특성은 위험심각성에 통계적으로 유의한 정적 영향을 미치는 것으로 나타났다. 둘째, 공중의 체세포복제기술에 대한 위험특성은 위험인식에 통계적으로 유의한 정적 영향을 미치는 것으로 나타났다. 셋째, 공중의 체세포복제기술에 대한 위험심각성은 위험인식에 통계적으로 유의한 정적 영향을 미치는 것으로 나타났다. 넷째, 공중의 체세포복제기술에 대한 위험특성은 위험수용에 통계적으로 유의한 부적 영향을 미치는 것으로 나타났다. 다섯째, 공중의 체세포복제기술에 대한 위험심각성은 위험수용에 통계적으로 유의한 영향을 미치지 못하였다. 여섯째, 공중의 체세포복제기술에 대한 위험인식은 위험수용에 통계적으로 유의한 영향을 미치지 못하였다.

주제어 : 위험특성, 위험심각성, 위험인식, 위험수용, 체세포복제기술

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1. Introduction

Human stem cell technology is rife with ethical and safety issues. This was seen most vividly in April 2007 when the National Bioethics Committee of Korea conditionally approved a study involving human embryos for stem cell technology, re-igniting then dormant disputes over the safety and ethical issues surrounding it.

There are in general two main points of contention in human stem cell technology: economic and ethic. The economic argues for medical and economic benefits such as infertility treatment, rare incurable disease treatment, increased understanding of genetic disorders/diseases, and healthcare cost reduction incurred from efficient health management both at individual and national levels. The ethical typically points to the questions on the onset of human personhood - is an embryo a person with the same moral status as an adult? -, or medical risks involved in oocyte retrieval, or rather dubiously grounded fear over the possibility of human clones. No country where stem cell technology has ever been carried out has been exempt from stakeholders sharply divided and polarized over these issues. As such, human stem cell technology is marked by high uncertainty, rendering tenuous effective analysis and evaluation of its future risk.

Uncertainty can be attributed to increased complexity incurred from insufficient knowledge or conflicting information[1], and technologies with high uncertainty such as human stem cell technology tend to generate sharply divisive risk contention with varying opinions. Some researchers recently argued in a Nature article that there is a high risk related to genome-editing of embryos that scientists should pause and actively engage in discussions involving the public, experts, and academics[2]. As a novel and scientifically evolving technology, human stem cell technology as yet leaves a lot of potential future risks unanswered.

With this background, it is of import to understand how the public perceives risks regarding human stem cell technology. Because of the high levels of scientific uncertainty of it, risk judgments of diverse groups of stakeholders such as policy makers and experts exhibit significant divergence, a potential fodder for increased conflicts among them. These conflicts are the direct results of the application of different judgments criteria adopted by stakeholders.

Moreover, the public tends to resort to experts for knowledge about specialized technologies such as human stem cell technology; hence, disputes among experts in human stem cell technology regarding its danger or safety will inevitably lead to confusion of the public.

Experts employ scientific evaluation for risk assessment, whereas the public use subjective risk perception for the evaluation of risk acceptability[3,4.5].

Risk itself is perceived and often defies quantification and frequency measurement, and heavily depends on personal backgrounds, such as education, experience, fear, that individuals employ subjective risk perception, resulting in varying risk judgment and perception[6]. Scientific uncertainty of human stem cell technology, however, makes a risk assessment of even experts, including the public,—tenuous. Policy makers also need to take into consideration the risk evaluation and perception of the public in policy making and execution processes. Hence, the present study considers it significant to examine perceived risk characteristics of the public, and identify factors and inherent relations in them, which may inform the public acceptability of human stem cell technology.

However, few studies have been directed to human stem cell technology towards these goals that would elucidate the public perception of risk characteristics and identify relations resident among risk severity, risk perception, and risk acceptability. This study thus aims to provide insights into the landscape of risk acceptability of the public for human stem cell technology.

2. Theoretical Background

Risk falls into two categories: objective and subjective[7]. Objective risk relates to risk evaluation formed by objective data such as mortality rate, fatality rate, property damages, all of which can be substantiated by experts, whereas the subjective risk is related to risk evaluation employed by the public affected by risk perception and evaluation of individuals. The psychometric paradigm emphasizes the difference in risk perception between experts and the public, who employ dissimilar risk evaluation criteria, making evident the necessity for closer investigation of the mechanisms involved in subjective risk perception[8]. Moreover, since scientific uncertainty increases diversity in risk assessment among experts in human stem cell technology, it is important for policymakers to consider the public perception of risk in the process of policy making and execution.

According to the psychometric paradigm, the public perceives hazards subjectively rather than in objective manners and use various heuristics employing psychological factors of individuals. The psychometric paradigm is a model in which risk is assumed to be inherently subjective, and consists of multi-dimensional factors which characterize risk, informing and affecting risk perception[9,10]. That is, the individual perception of a risk is by nature subjective and much depends on the value estimation of the individual who assesses the entailing benefits and harms related to the risk.

Hence, individual perception of risk varies based on factors such as controllability, fatality, scientific knowledgeability, and voluntariness of the risk. If a risk is voluntary, controllable, non-fatal, and scientifically known, it is perceived as less risky than involuntary, artificial (man-made), fatal, less scientifically known risks[11]. The risk is measured by factors such as its voluntariness, familiarity, scientific knowledge, and controllability, which provide valuable insights in determining how public perception of risk is established[12]. Studies employing the psychometric paradigm have used various measures such as voluntariness, controllability, dread, familiarity, scientific knowledge, and individual knowledge, which in combination can distinguish dread risk from unknown risk, and which affect the individual perception of risk[13,14,15].

Contrary to the experts, the public tends to depend upon risk severity formed by perceived harm of the risk[16,17]. That is, individuals perceive and evaluate a risk based on its potential risk outcomes. Risk severity perceived by the public is formed by risk characteristics as well as dread: the higher the perceived levels of risk characteristics and dread, the more elevated the perception of risk severity.

The public does not assess risk quantitatively but rather subjectively, which enables individuals to perceive risk by dread or fear[18]. Dobbie & Brown[19] argue for the necessity of emotions in risk perception of the public, and Sjöberg[20] accepts the direct effects of knowledge, trust, and emotion-driven dread or fear in risk perception.

Though; in light of risk communication, dread or fear can be considered an effective means to bring attention to risk factors in society[21], undue dread or fear, however, may cause unexpected reactions such as social unrest[22]. These studies have demonstrated that perception of risk severity is closely linked with risk characteristics and/or emotion-driven dread or fear.

Meanwhile, risk severity increases when one faces uncertainty, which exacerbates as information about the risk is deemed untrustworthy, incomplete, and confusing. Conflicts in data or arguments provided by experts also raise uncertainty[23,24]. Therefore, risk perception for highly uncertain technologies such as human stem cell technology is very likely to be determined by future possibilities of negative and unwanted events, and resulting severity of the outcomes[25], and one study[26] shows the positive correlation of risk severity and risk perception.

Especially, the acceptance of technology by the public is formed by the evaluation of its potential benefit, costs, or risk[27], the acceptance by the public of human stem cell technology can be very much likely to be determined by risk severity. Likewise, considering that risk perception is taken to be the deciding factor for risk acceptability in the psychometric paradigm[28,29], risk perception exerts a significant role in determining acceptance by the public of human stem cell technology. Drawing upon these findings, the present study formulated its research model and hypotheses as follows:

Hypothesis 1. Risk characteristics of human stem cell perceived by the public will be positively associated with risk severity.

Hypothesis 2. Risk characteristics of human stem cell perceived by the public will be positively associated with risk perception.

Hypothesis 3. Risk severity of human stem cell perceived by the public will be positively associated with risk perception.

Hypothesis 4. Risk characteristics of human stem cell perceived by the public will be negatively associated with risk acceptability.

Hypothesis 5. Risk severity of human stem cell perceived by the public will be negatively associated with risk acceptability.

Hypothesis 6. Risk perception of human stem cell perceived by the public will be negatively associated with risk acceptability.

3. Method

3.1 Study Population

This study used a survey targeted for 300 Korean adults residing in Seoul, Korea in May, 2015, to examine the relations among risk characteristics, risk severity, risk perception, and risk acceptability of the public regarding human stem cell technology based on the psychometric paradigm. Data from a sample of 300 home-dwellers were gathered to test our hypotheses. Some key demographic characteristics of the sample population are shown in <Table 1>.

<Table 1> Statistics of some demographic characteristics of the sample population

	Description	Frequency(%)
Gender	Male	157(52.3%)
	Female	143(47.7%)
Age (years)	<41	106(35.3%)
	41-50	118(39.3%)
	<51	76(25.4%)
Education	Vocational college	100(33.3%)
	Under graduate	110(36.7%)
	Graduate	90(30.0%)

3.2 Measurements

3.2.1 Risk Characteristics

Drawing upon the risk characteristics proposed by studies of the psychometric paradigm[10,14,15], the present study employed and measured six risk characteristics: Familiarity, scientific knowledge, individual knowledge, voluntariness, controllability, and dread. Each of which is represented by a five-point Likert scale: voluntariness(1: very voluntary, 5: very involuntary), controllability(1: very controllable, 5: very uncontrollable), dread(1: not very dreadful, 5: very dreadful), familiarity(1: very familiar, 5: very unfamiliar), scientific knowledge(1: very scientifically known, 5: not very scientifically known), and individual knowledge(1: risk level known precisely, 5: risk level not known).

3.2.2 Risk severity

Risk severity measures how individuals subjectively assess risks posed by human stem cell technology, and the authors adapted the characteristic used by Slovic, Fischhoff, & Lichtenstein[15] with an 11-point Likert scale(0: certainly not fatal, 10: certainly fatal)

3.2.3 Risk perception

Risk perception is measured by two item proposed by Song[21], designed to measure how risks are perceived risks to the society as a whole and perceived risks to you and your family. Each characteristic is represented by an 11-point Likert scale(0: not risk, 10: extreme risk).

3.2.4 Risk acceptability

Risk acceptability is measured by the two items proposed by Poortinga & Pidgeon[30]: the extent to which the given hazard is acceptable, and the benefits and risks involved in the hazard. The former is measured on a five-point Likert scale(1: very unacceptable, 5: very acceptable), and the latter in the same scale(1: the risks far outweigh the benefits, 5: the benefits far weigh the risks)

3.3 Statistical analysis

For the exploratory factor analysis, this study used principal component analysis and varimax rotation; and for the confirmatory factor analysis Kaiser-Meyer-Olkin(KMO), Bartlett's test of sphericity χ^2, and significance(p) were used. To determine how well the proposed model fits the data collected, χ^2 and, root mean square residual(RMR), a goodness of fit index(GFI), incremental fit index(IFI), and comparative fit index(CFI) were used. The adequacy of the proposed model is indicated by a non-significant χ^2, RMR≦0.06, and ≧0.90 for GFI, IFI, and CFI. For the sample-size sensitive χ^2, when items were not suitable for inclusion, other indices were cross-checked for a final decision of item inclusion. Through the exploratory factor analysis and the confirmatory factor analysis, risk severity, risk perception, and risk acceptability were not included. Descriptive statistical analysis, correlation analysis, and reliability analysis were carried out for the risk characteristics, risk severity, risk perception and risk acceptability.

4. Results

4.1 Exploratory and confirmatory factor analysis

The exploratory factor analysis for risk characteristics validated two characteristics: Unknown risk, and dread risk with the factor loadings of 0.51 to 0.87 and cumulative variance of 64.54%. The exploratory factor analysis showed KMO = 0.71, Bartlett's test χ^2=482.85, df=15, and p<0.001.

<Table 2> Results of exploratory factor analysis

		Factor Loading	Eigen value	Variance
Unknown risk (α=0.71)	*Familiarity	.86	2.78	46.46%
	Individual knowledge	.85		
	Scientific knowledge	.64		
Dread risk (α=0.69)	Controllability	.87	1.08	18.97%
	Voluntariness	.81		
	Dread	.61		

* excluded from confirmatory factor analysis

The initial results of confirmatory factor analysis showed χ^2=55.04 (df=8, p<0.001), RMR=0.07, GFI=0.94, NFI=0.88, IFI=0,90, CFI=0.90, with χ^2, RMR and NFI failing model fit test. To establish a satisfactory model fit, several modified indices were subsequently applied, and with 'familiarity' excluded, the subsequent confirmatory factor analysis showed χ^2=17.89 (df=4, p<0.01), RMR=0.04, GFI=0.97, NFI=0.94, IFI=0,95, CFI=0.95, suggesting a satisfactory model fit. The Cronbach's α values for the unknown risk and dread risk were 0.71 and 0.69, respectively. Cronbach's α coefficients for the risk perception and risk acceptability were 0.83 and 0.72. The risk severity which was measured by the single item was excluded from the reliability analysis.

<Table 3> Results of confirmatory factor analysis

	β	S.E.	t
individual knowledge ← unknown risk	.71	-	-
scientific knowledge ← unknown risk	.62	.13	5.81***
dread ← perceived dread	.53	-	-
voluntariness ← perceived dread	.67	.19	7.17***
controllability ← perceived dread	.78	.21	7.47***

*** p<.001

4.2 Correlation analysis

The correlations between the risk characteristics, risk severity, risk perception, and risk acceptability are shown in <Table 4>. 'Unknown risk' and 'Dread risk' have positive correlations with 'risk severity' and 'risk perception', respectively, but negative correlation with 'risk acceptability'. 'Risk severity' has a positive correlation with 'risk perception', but negative correlation with 'risk acceptability', and 'risk perception' has a negative correlation with 'risk acceptability'.

<Table 4> Correlation analysis

Measures	1	2	3	4
1. unknown risk	-			
2. Perceived dread	.45**	-		
3. Risk severity	.26**	.24**	-	
4. Risk perception	.28**	.31**	.74**	-
5. Risk acceptability	-.29**	-.21**	-.13*	-.15**

** p<.01

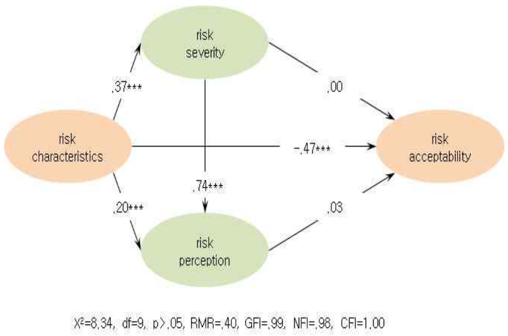
4.3 Results of structural equation modeling analysis

Structural equation modeling analysis was performed to consider directed dependencies between the risk characteristics, risk severity, risk perception, and risk acceptability. <Table 5> shows that the risk characteristics positively affect risk severity(β=0.37, t=4.67, p<0.001) and risk perception (β=0.20, t=3.46, p<0.001). Risk severity also positively affects risk perception(β=0.74, t=15.67, p<0.001). And the risk characteristics negatively affect risk acceptability(β =-0.47, t=-3.71, p<0.001). However, risk severity do not significantly influence risk acceptability(β=0.00, t=0.01, p>0.05), nor does risk perception significantly influence risk acceptability(β=0.03, t=0.23, p>0.05).). These results validate the significance of the risk characteristics as predictors of risk severity, perception, and risk acceptability. Risk severity is also a significant variable for predicting risk perception. Hence, the public perception of the risk characteristics may be used as a determiner of risk severity, perception, acceptability in human stem cell technology.

<Table 5> Results of structural equation modeling analysis

	β	S.E.	t
risk severity ← risk characteristics	.37	.28	4.67***
risk perception ← risk characteristics	.20	.20	3.46***
risk perception ← risk severity	.74	.04	15.67***
acceptability ← risk characteristics	-.47	.19	-3.71***
acceptability ← risk severity	.00	.05	.01
acceptability ← risk perception	.03	.06	.23

*** p<.001



[Fig. 1] Results of structural equation modeling analysis

5. Discussion and Conclusion

This study has investigated risk characteristics of the public, and explored the role of the risk characteristics towards risk severity, perception, and acceptability. The findings of the study can be summarized as follows:

First, risk characteristics are classified into two factors: unknown risk(individual knowledge and scientific knowledge), and dread risk (controllability, voluntariness, and dread), all of which have a significantly positive impact on risk severity. The public more keenly perceives risk about human stem cell technology when it is individually and scientifically unknown, uncontrollable, involuntary, and dreadful. In short, the current results indicate that the risk characteristics are key predictors of risk severity, and in the presence of scientific uncertainty, individual and scientific knowledge, as well as their ensuing emotional dread and fear, may play significant roles in assessing risk severity.

Second, the risk characteristics influence positively on risk perception, which exacerbates as individuals perceive the technology, human stem cell, as an unknown or dreadful risk. That is, risk perception for a scientifically uncertain hazard can vary according to perceived risk characteristics of the public, implying the significant impacts on risk perception of emotional factors such as dread and established knowledge. Therefore, it is important that the public is provided with sufficient knowledge and information to increase the levels of awareness when faced with highly uncertain scientific technologies such as human stem cell technology.

The psychometric paradigm infers the relationship between risk characteristics and risk perceptions on the level of most individual risk characteristics[25], and the risk characteristics are an important clue in risk perception and evaluation of the public[12]. Therefore, our study results prove that risk characteristics are an important factor in predicting risk perception[10,13,15], since the level of perception of risk characteristics determines risk perception.

Third, risk severity influences positively on risk perception of the public: the more severely the public feel of the risk, the more increased perception of it. This result implies that in the public's risk perception, the possibility of risk occurrence or the risk severity attached to potentially negative results when the risk is accepted may play a role in risk perception [16,25], and also shows that risk severity is also an important determining precursor in risk perception.

Fourth, the risk characteristics have a significantly negative impact on risk acceptability: the more unknown and dreadful the risk is, the less acceptable it becomes to the public. The public will less likely accept a risk when it is scientifically uncertain and is presented with insufficient amounts of data, which will eventually lead to dread or fear.

Due to the unpredictability of the future outcomes of a highly uncertain technology, and uncontrollability of its future danger, the pubic are vulnerable to high levels of fear and anxiety[15, 31, 32, 33]. Especially, unknown danger creates assumed risk, which generates high levels of signal effects, compared to those related to known risk, and is regarded as more dangerous than known risk[11]. Therefore, our results may be taken to show that apprehension related to future danger and potential risk uncontrollability of human stem cell technology creates unwarranted fear and anxiety, further increasing negative effects on the risk acceptability of the public. Lastly, neither risk severity nor risk perception has a significant impact on risk acceptability. Though our results contradict the hypothesis of the psychometric paradigm that risk severity or risk perception is a determining predictor for risk acceptability, it may be that it may not be the case in dealing with such highly uncertain technologies as human stem cell technology. In other words, the public determines risk acceptability according to knowledge, social trust, a possibility of risk occurrence, risk severity of negative results[25] or benefits that can be brought about by accepting a risk, and others.

The public lack in sufficient knowledge or data and experts are divided over potential risk or safety of human stem cell technology, leading to further inability of the public to predict risk severity of negative results, and hampering their risk perception. Therefore, they do not have solid criteria by which to decide whether they should accept or reject human stem cell technology, which demands a more careful investigation to understand the public's risk acceptability when dealing with highly uncertain technology.

Also, risk perception is affected by psychological, social, systemic, and cultural factors[25], and wide national differences also exist. These studies should be all taken into consideration in understanding the results presented in the study.

Human stem cell technology involves highly uncertain technologies, and as such, it will be of little value in a generalization of our findings to other areas. However, it will be beneficial in the future to cross-compare the current findings with other highly uncertain technologies such as nanotechnologies. Second, future research should be performed to elucidate differences and similarities in risk perception between the public and experts.

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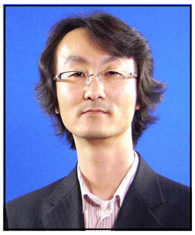

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