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The Effects of Men's Preference for Metrosexual on Cosmetic Behavior and Narcissistic Tendency

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Abstract

Purpose: *The purpose of this study is to examine the relationship between men's metrosexual preference, Cosmetic Behavior, and narcissistic tendency. Focusing on the effects of metrosexual preference on appearance management and Cosmetic Behavior, this study also considers the role of narcissistic tendency in this process. Through these relationships, this study aims to provide a deeper understanding of the psychological and socio-cultural aspects of men's beauty behavior and to offer basic implications for the men's beauty market.*

Method: *This study conducted a survey targeting adult men in their 20s to 60s. Data were collected using a structured questionnaire, and only valid responses were selected for analysis. The collected data were statistically analyzed using SPSS 25.0. Multiple regression analysis was performed to examine the relationships among variables, and mediation regression analysis was additionally conducted to verify the mediating effects within the research model. The respondents of this study consisted of male participants in their 20s to 60s, classified into X, Y, and Z generations. The analysis of demographic characteristics showed that respondents in their 20s and 30s accounted for the largest proportion of the sample, while office workers and professionals represented a relatively high percentage. In addition, both married and unmarried respondents were evenly distributed, and most participants had a college-level education or higher. These findings suggest that the study reflects the diverse generational and social characteristics of contemporary male consumers.*

Results: *First, metrosexual preference was found to have a positive effect across various sub-dimensions of Cosmetic Behavior. Second, among narcissistic tendencies, other-consciousness showed significant positive effects on most factors of Cosmetic Behavior, whereas self-consciousness had a more limited influence on certain factors. Third, the results of the mediation analysis indicated that narcissistic tendency showed partial mediating effects in the relationship between metrosexual preference and some dimensions of Cosmetic Behavior.*

Conclusion: *This study confirmed that men's metrosexual preference significantly influences Cosmetic Behavior. In particular, higher metrosexual preference was associated with stronger appearance management behaviors. Narcissistic tendency also influenced several dimensions of Cosmetic Behavior, with other-consciousness showing broader effects than self-consciousness. In addition, narcissistic tendency showed partial mediating effects in the relationship between metrosexual preference and some dimensions of Cosmetic Behavior. These findings suggest that men's beauty behavior is shaped by both psychological characteristics and socio-cultural influences, providing meaningful implications for understanding contemporary men's beauty culture and consumer behavior.*

Keywords: ***Metrosexual, Cosmetic Behavior, Narcissistic Tendency, Relationship Variables, Mediating Effect***

1. Introduction

Modern society has increasingly emphasized appearance-oriented values, leading to a tendency for individual identity and social evaluation to be strongly influenced by external image.

In particular, the development of mass media and social networking services (SNS) has contributed to the perception of appearance as a form of competitiveness, and accordingly, appearance management and Cosmetic Behavior are no longer limited to women but have expanded to men as well[1][2]. Within this context, the concept of "metrosexual" has emerged as a representative phenomenon.

A metrosexual refers to a man who actively engages in fashion and appearance management based on an urban sensibility, and this is understood as a socio-cultural reflection of changing masculinity. In recent years, men have become increasingly involved in various beauty-related behaviors such as skincare, makeup, and hairstyling[3], and their interest in appearance is often expressed through Cosmetic Behavior. In fact, previous research targeting men in their 20s to 40s has shown that interest in appearance and levels of self-consciousness have a significant impact on Cosmetic Behavior[4].

As a psychological background of such appearance management behavior, narcissism has been highlighted as an important variable. Narcissism refers to a tendency to maintain a positive self-evaluation and to seek recognition from others, and it is closely related to appearance management and consumption behavior. Prior studies have reported that higher levels of narcissistic tendency are associated with greater interest in appearance and increased beauty-related behaviors[5], showing significant relationships with various forms of appearance management such as makeup, fashion, and cosmetic surgery[6].

Furthermore, narcissism has been identified as an important psychological factor influencing cosmetic consumption and purchase intention[7]. Recent studies emphasize that narcissism extends beyond a simple psychological trait, leading to behaviors that enhance self-expression through appearance and build a positive social image. It has also been reported that individuals with higher levels of narcissistic tendency are more actively engaged in appearance management behaviors, including clothing, cosmetic procedures, and makeup[8][9].

However, existing studies have primarily focused on female-centered beauty behaviors or on the general relationship between narcissism and appearance management. There is still a lack of integrated research examining the structural relationships among men's metrosexual preference, narcissistic tendency, and Cosmetic Behavior. In particular, in-depth analysis of how men's metrosexual preference interacts with narcissistic tendencies and how this interaction influences actual Cosmetic Behavior remains insufficient.

Therefore, this study aims to investigate the effects of men's metrosexual preference on Cosmetic Behavior and narcissistic tendency, and to analyze the relationships among these variables in an integrated manner. Through this, the study seeks to enhance understanding of the evolving characteristics of men's beauty culture and to provide foundational data for future research on the men's beauty industry and consumer behavior.

2. Theoretical Background

2.1 Metrosexual

Metrosexual refers to a concept describing men who are actively engaged in appearance management and self-expression based on urban consumer culture, and it is considered an important socio-cultural term that explains changes in traditional masculinity. It represents a new type of male identity in which men express themselves through fashion, beauty, and consumption[10].

Beyond simple interest in appearance, metrosexual can be understood as part of a strategy for constructing self-identity and managing one's image through consumption. In particular, the

development of mass media and the advertising industry in modern society has played a significant role in normalizing men's appearance management behaviors. As a result, various beauty practices such as the use of cosmetics, skincare, and fashion styling have increasingly spread among men as well[11].

Metrosexual tendency is closely related not only to an individual's interest in appearance but also to the formation of social relationships and the desire for self-expression. It is often manifested as an effort to build a positive image through appearance management behaviors.

These characteristics are linked to changes in male consumers' lifestyles and the growth of the beauty and fashion industries, positioning metrosexual as a key concept in explaining contemporary men's consumer behavior[12].

2.2 Cosmetic Behavior

Cosmetic Behavior refers to actions performed by individuals to improve their appearance and manage their social image, encompassing various beauty-related activities such as the use of cosmetics, skincare, and makeup[13]. These behaviors go beyond simple aesthetic purposes and are understood as a means of self-expression aimed at creating positive impressions and enhancing social evaluation.

Appearance serves as an important criterion in social interactions, and individuals engage in various forms of appearance management to maintain and improve it. In particular, as male consumers' interest in appearance has increased, Cosmetic Behavior has become more common among men. Previous domestic studies have shown that socio-cultural attitudes toward appearance and objectified body consciousness significantly influence men's appearance management behaviors, suggesting that Cosmetic Behavior is also shaped by social factors[14].

Furthermore, men's appearance management behaviors are not merely for aesthetic purposes but function as strategic actions to enhance self-confidence and build a favorable social image. These behaviors extend across various domains, including skincare, hair, and fashion, and are accompanied by increased use of cosmetic products. Personal traits such as vanity and interest in appearance have also been reported to significantly affect appearance management and Cosmetic Behavior[15].

In this regard, Cosmetic Behavior can be understood as a complex form of behavior influenced not only by individual psychological factors but also by socio-cultural environments. In contemporary society, it has become a key component of appearance management regardless of gender [16].

2.3 Narcissistic Tendency

Narcissistic tendency is a personality trait characterized by an excessively positive self-evaluation and a strong desire for recognition from others. It is a psychological characteristic closely associated with maintaining self-esteem and gaining social approval, and has been studied as a key variable influencing individual behavior and consumption patterns.

In particular, narcissistic tendency is closely related to interest in appearance, reinforcing the inclination to manage one's image positively and to stand out to others. This tendency extends beyond appearance management behaviors to include beauty-related consumption such as makeup and fashion[17].

Previous domestic studies have also found that narcissistic tendency is significantly related to appearance management and Cosmetic Behavior. Individuals with higher levels of narcissism tend to show greater interest in their appearance, invest more in managing it, and engage more actively in makeup and fashion consumption behaviors[18].

Furthermore, narcissism is not merely an individual trait but is linked to impression management strategies in social contexts. Through a strong awareness of others' evaluations, it functions as a factor that strengthens appearance-oriented consumption behavior[19].

3. Research Method and Procedures

This study was conducted to examine the effects of metrosexual preference on Cosmetic Behavior and narcissistic tendency among men in their 20s to 60s. The sample was collected through a self-report questionnaire. A total of 800 questionnaires were distributed to men aged between their 20s and 60s, and 765 responses were returned. After excluding incomplete or insincere responses, 750 valid questionnaires were selected for the final analysis.

The variables used in this study consisted of the independent variable (metrosexual preference), the mediating or main psychological variable (narcissistic tendency), and the dependent variable (Cosmetic Behavior). The unit of analysis was the individual level, and all survey items were measured using a 5-point Likert scale. The questionnaire consisted of items measuring metrosexual preference, Cosmetic Behavior, narcissistic tendency, and demographic characteristics, with a total of 60 items used in the final analysis.

Metrosexual preference was adapted from the single-factor scale developed by Woo JY[20]. Cosmetic Behavior was based on previous studies by Choi SK[21], and Choi JS[22], and was categorized into trendiness, subjectivity, conformity, instrumentality, self-esteem, interpersonal orientation, and conspicuousness. Narcissistic tendency was classified into self-consciousness and other-consciousness, based on the studies of Raskin PJ, and Hogan J as well as Kim HJ[23][24].

For data analysis, SPSS 25.0 was used. First, frequency analysis was conducted to identify general characteristics of the sample. Factor analysis and reliability analysis were performed to examine the validity and reliability of the measurement instruments. In addition, descriptive statistics were used to understand the overall distribution of variables. One-way ANOVA was conducted to test differences between groups, and multiple regression analysis was applied to examine the relationships among variables.

3.1 The Effects of Metrosexual Preference on Cosmetic Behavior

The analysis of the effects of metrosexual preference on Cosmetic Behavior is presented in <Table 1>. As shown, the preference factor was found to have a statistically significant positive effect across all sub-dimensions of Cosmetic Behavior. Specifically, significant positive effects at the $p<.001$ level were observed in all sub-factors, including conformity, trendiness, interpersonal orientation, subjectivity, instrumentality, self-esteem, and conspicuousness.

In addition, further significant positive effects were identified in several Cosmetic Behavior factors. Trendiness showed a significant positive effect at the $p<.05$ level, while interpersonal orientation and subjectivity exhibited significant positive effects at the $p<.01$ level. Self-esteem also showed a significant positive effect at the $p<.01$ level, and conspicuousness showed a significant positive effect at the $p<.05$ level.

Overall, these results indicate that higher levels of metrosexual preference are associated with stronger and more positive tendencies across various dimensions of Cosmetic Behavior.

Table 1. The Effects of Metrosexual Preference on Cosmetic Behavior

Dependent Variable		Independent Variable	B	SE	*β*	*t*	*sig.*
Cosmetic Behavior	Conformity	(Constant)	1.773	.256	-	6.935	.000***
		Metrosexual Preference	.447	.042	.388	10.690	.000***
		R=.393 R^2=.155 *F=22.655***					
	Trendiness	(Constant)	.863	.230	-	3.748	.000***
		Metrosexual Preference	.644	.038	.560	17.091	.000***
		R=.559 R^2=.313 *F=56.344***					
	Interpersonal Orientation	(Constant)	.956	.226	-	4.234	.000***
		Metrosexual Preference	.691	.037	.596	18.709	.000***
		R=.591 R^2=.349 *F=66.481***					
	Subjectivity	(Constant)	1.822	.222	-	8.212	.000***
		Metrosexual Preference	.423	.036	.411	11.643	.000***
		R=.447 R^2=.200 *F=30.932***					
	Instrumentality	(Constant)	.636	.258	-	2.468	.014*
		Metrosexual Preference	.621	.042	.500	14.709	.000***
		R=.508 R^2=.258 *F=42.985***					
	Self-Esteem	(Constant)	1.022	.281	-	3.634	.000***
		Metrosexual Preference	.573	.046	.434	12.447	.000***
		R=.468 R^2=.219 *F=34.769***					
	Conspicuousness	(Constant)	1.278	.259	-	4.940	.000***
		Metrosexual Preference	.458	.042	.390	10.825	.000***
		R=.407 R^2=.166 *F=24.632***					

*p<.05, **p<.01, ***p<.001.

3.2 Effects of Narcissistic Tendencies on Cosmetic Behavior

The analysis of the effects of narcissistic tendency on Cosmetic Behavior is presented in <Table 2>. The results show that both self-consciousness and other-consciousness generally have significant positive effects on multiple sub-dimensions of Cosmetic Behavior.

Specifically, other-consciousness demonstrated significant positive effects at the p<.001 level on conformity, trendiness, interpersonal orientation, instrumentality, self-esteem, and conspicuousness. In addition, self-consciousness showed significant positive effects on trendiness (p<.01), interpersonal orientation (p<.001), subjectivity (p<.001), instrumentality (p<.001), and conspicuousness (p<.05).

Notably, in the dimensions of interpersonal orientation and instrumentality, both self-consciousness and other-consciousness showed significant positive effects at the p<.001 level. This indicates that narcissistic tendency plays an important role in Cosmetic Behavior, particularly in terms of social interaction and appearance utilization.

Overall, narcissistic tendency operates as a factor that enhances Cosmetic Behavior through both self-consciousness and other-consciousness, suggesting that it contributes to self-expression through appearance and the formation of a favorable social image<Table 2>.

Table 2. Effects of Narcissistic Tendencies on Cosmetic Behavior

Dependent Variable		Independent Variable	B	SE	*β*	*t*	*sig.*
Cosmetic Behavior	Conformity	(Constant)	1.544	.169	-	9.118	.000***
		Self-Consciousness	.012	.049	.009	.237	.812
		Other-Consciousness	.315	.046	.254	6.878	.000***
		R=.257 R^2=.066 *F=26.399****					
	Trendiness	(Constant)	1.453	.168	-	8.649	.000***
		Self-Consciousness	.149	.048	.113	3.084	.002**
		Other-Consciousness	.283	.045	.229	6.244	.000***
		R=.283 R^2=.080 *F=32.627****					
	Interpersonal Orientation	(Constant)	1.852	.170	-	10.888	.000***
		Self-Consciousness	.224	.049	.169	4.592	.000***
		Other-Consciousness	.198	.046	.159	4.314	.000***
		R=.264 R^2=.070 *F=27.992****					
	Subjectivity	(Constant)	2.842	.154	-	18.484	.000***
		Self-Consciousness	.224	.044	.191	5.073	.000***
		Other-Consciousness	-.046	.042	-.042	-1.116	.265
		R=.183 R^2=.033 *F=12.941****					
	Instrumentality	(Constant)	1.155	.180	-	6.432	.000***
		Self-Consciousness	.256	.052	.181	4.960	.000***
		Other-Consciousness	.267	.049	.200	5.499	.000***
		R=.306 R^2=.094 *F=38.649****					
	Self-Esteem	(Constant)	1.150	.188	-	6.134	.000***
		Self-Consciousness	.001	.054	.001	.023	.982
		Other-Consciousness	.505	.051	.356	9.968	.000***
		R=.356 R^2=.127 *F=54.357****					
	Conspicuousness	(Constant)	1.163	.170	-	6.846	.000***
		Self-Consciousness	.103	.049	.077	2.112	.035*
		Other-Consciousness	.346	.046	.275	7.548	.000***
		R=.257 R^2=.066 *F=8.740****					

*p<.05, **p<.01, ***p<.001.

3.3 The Mediating Effect of Narcissistic Tendency on the Relationship Between Men's Preference for Metrosexual and Cosmetic Behavior

3.3.1 The mediating effect of metrosexual preference on the relationship between narcissistic tendencies and conformity in cosmetic behavior

<Table 3> presents the results of the mediation regression analysis in which metrosexual preference was set as the independent variable and self-consciousness, a component of narcissistic tendency, was introduced as the mediator. The results show that the β value was statistically significant. However, other variables were not found to be significant. Accordingly, self-consciousness showed a limited mediating effect in the relationship between metrosexual preference and conformity.

In addition, when other-consciousness was included as a mediating variable, significant results were found for both metrosexual preference and other-consciousness. This suggests that other-consciousness functions as a mediator in the relationship between these variables and conformity.

Table 3. The Mediating Effect of Narcissistic Tendencies on the Relationship between Metrosexual Preference and Conformity in Cosmetic Behavior

Dependent Variable		Independent Variable	B	SE	*β*	*t*	*sig.*
Conformity	1	(Constant)	1.773	.256	-	6.935	.000***
		Metrosexual Preference	.447	.042	.388	10.690	.000***
		R=.393 R^2=.155 *F=22.655***					
	2	(Constant)	1.735	.256	-	6.782	.000***
		Metrosexual Preference	.434	.042	.377	10.297	.000***
		Self-Consciousness	.119	.058	.090	2.059	.040*
		R=.399 R^2=.159 *F=20.109*** △R^2=.005 △*F=4.240**					
	3	(Constant)	1.384	.263	-	5.266	.000***
		Metrosexual Preference	.403	.042	.350	9.596	.000***
		Other-Consciousness	.222	.044	.179	5.104	.000***
		R=.428 R^2=.183 *F=23.794*** △R^2=.029 △*F=26.048****					

*p<.05, **p<.01, ***p<.001.

3.3.2 The mediating effect of narcissistic tendencies on the relationship between metrosexual preference and trendiness in cosmetic behavior

<Table 4> shows that when metrosexual preference was set as the independent variable and self-consciousness, a component of narcissistic tendency, was included as the mediating variable, the β value was found to be statistically significant. Accordingly, self-consciousness can be interpreted as showing a limited mediating effect conscientiousness in the relationship between metrosexual preference and trendiness.

In addition, when other-consciousness was introduced as a mediating variable, both metrosexual preference and other-consciousness showed statistically significant results. This suggests that other-consciousness also has a mediating effect in the relationship between metrosexual preference and trendiness.

Table 4. The Mediating Effect of Narcissistic Tendencies on the Relationship between Metrosexual Preference and Trendiness in Cosmetic Behavior

Dependent Variable		Independent Variable	B	SE	*β*	*t*	*sig.*
Trendiness	1	(Constant)	.863	.230	-	3.748	.000***
		Metrosexual Preference	.644	.038	.560	17.091	.000***
		R=.559 R^2=.313 *F=56.344***					
	2	(Constant)	.827	.230	-	3.590	.000***
		Metrosexual Preference	.632	.038	.549	16.633	.000***
		Self-Consciousness	.113	.052	.086	2.171	.030*
		R=.563 R^2=.317 *F=49.210*** △R^2=.004 △*F=4.715**					
	3	(Constant)	.526	.237	-	2.220	.027*
		Metrosexual Preference	.606	.038	.527	15.986	.000***
		Other-Consciousness	.192	.039	.156	4.901	.000***
		R=.578 R^2=.334 *F=53.223*** △R^2=.022 △*F=24.020****					

p<.05, **p<.01, ***p<.001.

3.3.3 The mediating effect of narcissistic tendencies on the relationship between metrosexual preference and interpersonal orientation in cosmetic behavior

<Table 5> indicates that when metrosexual preference was set as the independent variable and self-consciousness, a dimension of narcissistic tendency, was introduced as the mediating variable, the β value was found to be statistically significant. This suggests that self-consciousness plays a mediating role in the relationship between metrosexual preference and interpersonal orientation.

Furthermore, in the analysis where other-consciousness was used as the mediator, both metrosexual preference and other-consciousness showed statistically significant results. Accordingly, other-consciousness can also be interpreted as having a mediating effect in the relationship between metrosexual preference and interpersonal orientation.

Table 5. The Mediating Effect of Narcissistic Tendencies on the Relationship Between Metrosexual Preference and Interpersonal Orientation in Cosmetic Behavior

Dependent Variable		Independent Variable	B	SE	*β*	*t*	*sig.*
Interpersonal Orientation	1	(Constant)	.956	.226	-	4.234	.000***
		Metrosexual Preference	.691	.037	.596	18.709	.000***
		R=.591 R^2=.349 *F=66.481****					
	2	(Constant)	.918	.226	-	4.067	.000***
		Metrosexual Preference	.678	.037	.585	18.223	.000***
		Self-Consciousness	.119	.051	.090	2.331	.020*
		R=.595 R^2=.354 *F=58.100*** △R^2=.005 △*F=5.432**					
	3	(Constant)	.734	.234	-	3.133	.002**

		Metrosexual Preference	.666	.037	.574	17.767	.000***
		Other-Consciousness	.126	.039	.102	3.257	.001**
		R=.599 R^2=.358 *F=59.236**** △R^2=.009 △*F=10.607***					

*p<.05, **p<.01, ***p<.001.

3.3.4 The mediating effect of narcissistic tendencies on the relationship between metrosexual preference and subjectivity in cosmetic behavior

<Table 6> shows that when metrosexual preference was set as the independent variable and self-consciousness, a component of narcissistic tendency, was introduced as the mediating variable, the change in significance probability did not reach a statistically meaningful level. Accordingly, no mediating effect was identified.

Similarly, in the analysis where other-consciousness was included as the mediating variable, the change in significance probability was also not statistically significant. Therefore, this result likewise indicates that no mediating effect exists.

Table 6. The Mediating Effect of Narcissistic Tendencies on the Relationship Between Metrosexual Preference and Subjectivity in Cosmetic Behavior

Dependent Variable		Independent Variable	B	SE	*β*	*t*	*sig.*
Subjectivity	1	(Constant)	1.822	.222	-	8.212	.000***
		Metrosexual Preference	.423	.036	.411	11.643	.000***
		R=.447 R^2=.200 *F=30.932****					
	2	(Constant)	1.810	.223	-	8.131	.000***
		Metrosexual Preference	.419	.037	.407	11.400	.000***
		Self-Consciousness	.040	.050	.034	.793	.428
		R=.448 R^2=.201 *F=26.590**** △R^2=.001 △*F=.629*					
	3	(Constant)	1.906	.232	-	8.220	.000***
		Metrosexual Preference	.432	.037	.420	11.654	.000***
		Other-Consciousness	-.047	.038	-.043	-1.236	.217
		R=.449 R^2=.202 *F=26.750**** △R^2=.002 △*F=1.529*					

**p<.01, ***p<.001.

3.3.5 The mediating effect of narcissistic tendencies on the relationship between metrosexual preference and instrumentality in cosmetic behavior

<Table 7> shows that when metrosexual preference was set as the independent variable and self-consciousness, a component of narcissistic tendency, was included as the mediating variable, both metrosexual preference and self-consciousness were found to be statistically significant based on the comparison of β values. This suggests that self-consciousness plays a mediating role in the relationship between metrosexual preference and instrumentality.

In addition, in the analysis where other-consciousness was introduced as the mediating variable, both metrosexual preference and other-consciousness showed statistically significant results. Accordingly, other-consciousness can also be interpreted as having a mediating effect in the relationship between metrosexual preference and instrumentality.

Table 7. The Mediating Effect of Narcissistic Tendencies on the Relationship Between Metrosexual Preference and Instrumentality in Cosmetic Behavior

Dependent Variable		Independent Variable	B	SE	*B*	*t*	*sig.*
Instrumentality	1	(Constant)	.636	.258	-	2.468	.014*
		Metrosexual Preference	.621	.042	.500	14.709	.000***
		R=.508 R^2=.258 *F=42.985***					
	2	(Constant)	.565	.256	-	2.204	.028*
		Metrosexual Preference	.597	.042	.481	14.122	.000***
		Self-Consciousness	.223	.058	.157	3.858	.000***
		R=.522 R^2=.272 *F=39.659*** △R^2=.015 △*F=14.887****					
	3	(Constant)	.297	.266	-	1.116	.265
		Metrosexual Preference	.582	.043	.470	13.677	.000***
		Other-Consciousness	.194	.044	.145	4.394	.000***
		R=.526 R^2=.277 *F=40.510*** △R^2=.019 △*F=19.310****					

*p<.05, ***p<.001.

3.3.6 The mediating effect of narcissistic tendencies on the relationship between metrosexual preference and self-esteem in cosmetic behavior

<Table 8> shows that when other-consciousness was introduced as the mediating variable, both metrosexual preference and other-consciousness showed statistically significant results. This suggests that other-consciousness has a mediating effect in the relationship between metrosexual preference and self-esteem.

Table 8. The Mediating Effect of Narcissistic Tendencies on the Relationship Between Metrosexual Preference and Self-Esteem in Cosmetic Behavior

Dependent Variable		Independent Variable	B	SE	*β*	*t*	*sig.*
Self-Esteem	1	(Constant)	1.022	.281	-	3.634	.000***
		Metrosexual Preference	.573	.046	.434	12.447	.000***
		R=.468 R^2=.219 *F=34.769****					
	2	(Constant)	.997	.282	-	3.536	.000***
		Metrosexual Preference	.565	.047	.428	12.139	.000***
		Self-Consciousness	.078	.064	.052	1.222	.222
		R=.470 R^2=.221 *F=30.035*** △R^2=.002 △*F=1.494*					
	3	(Constant)	.393	.283	-	1.387	.166
		Metrosexual Preference	.502	.045	.381	11.083	.000***
		Other-Consciousness	.359	.047	.254	7.660	.000***
		R=.526 R^2=.276 *F=40.498*** △R^2=.057 △*F=58.677****					

**p<.01, ***p<.001.

3.3.7 The mediating effect of narcissistic tendencies on the relationship between metrosexual preference and conspicuousness in cosmetic behavior

<Table 9> presents the results of the mediation regression analysis in which metrosexual preference was set as the independent variable and self-consciousness, a component of narcissistic tendency, was introduced as the mediating variable. The comparison of β values showed that both metrosexual preference and self-consciousness were statistically significant, indicating that a mediating effect was observed for these variables.

Table 9. The Mediating Effect of Narcissistic Tendencies on the Relationship Between Metrosexual Preference and Conspicuousness in Cosmetic Behavior.

Dependent Variable		Independent Variable	B	SE	*β*	*t*	*sig.*
Conspicuousness	1	(Constant)	1.278	.259	-	4.940	.000***
		Metrosexual Preference	.458	.042	.390	10.825	.000***
		R=.407 R^2=.166 *F=24.632***					
	2	(Constant)	1.214	.257	-	4.714	.000***
		Metrosexual Preference	.437	.042	.372	10.287	.000***
		Self-Consciousness	.198	.058	.148	3.415	.001**
		R=.423 R^2=.179 *F=23.082*** △R^2=.013 △*F=11.660***					
	3	(Constant)	.817	.264	-	3.094	.002**
		Metrosexual Preference	.406	.042	.346	9.616	.000***
		Other-Consciousness	.263	.044	.209	6.008	.000***
		R=.452 R^2=.205 *F=27.268*** △R^2=.039 △*F=36.101***					

*p<.05, **p<.01, ***p<.001

4. Conclusion and Recommendations

This study examined the effects of men's metrosexual preference on Cosmetic Behavior and narcissistic tendency, as well as the mediating role of narcissistic tendency in these relationships. The findings revealed that metrosexual preference had significant positive effects on all sub-dimensions of Cosmetic Behavior, suggesting that a higher preference for metrosexual tendencies is associated with more active appearance management and Cosmetic Behavior.

In addition, narcissistic tendency was found to partially influence Cosmetic Behavior. Specifically, other-consciousness showed significant positive effects across most dimensions of Cosmetic Behavior, while self-consciousness demonstrated significant effects only in certain areas such as trendiness, interpersonal orientation, subjectivity, instrumentality, and conspicuousness. These findings indicate that psychological characteristics related to narcissistic tendency contribute differently depending on the type of Cosmetic Behavior.

The mediation analysis further demonstrated that narcissistic tendency partially mediated the relationship between metrosexual preference and several sub-dimensions of Cosmetic Behavior. In particular, mediation effects were identified in conformity, trendiness, interpersonal orientation, and instrumentality. However, no significant mediating effects were found in subjectivity,

and only limited mediation effects were observed in self-esteem and conspicuousness. This suggests that the mediating role of narcissistic tendency varies according to the characteristics of each Cosmetic Behavior dimension.

Overall, the results indicate that metrosexual preference is an important factor influencing men's Cosmetic Behavior, while narcissistic tendency functions as a selective psychological mechanism within this relationship. Therefore, men's appearance management behaviors can be understood as complex behaviors shaped by both psychological characteristics and sociocultural influences. These findings provide meaningful implications for understanding contemporary men's beauty culture and may serve as foundational data for future studies related to the men's beauty industry and consumer behavior.

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Exploring the Safety Experiences of Multicultural Women During Pregnancy, Childbirth, and the Postpartum Period: A Focus Group Approach

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Abstract

***Purpose**: This study aimed to explore the experiences of pregnancy, childbirth, and the postpartum period among marriage migrant women in South Korea and to provide evidence for culturally sensitive healthcare policies and nursing intervention programs. The study focused on identifying challenges, support systems, and healthcare needs during the maternal health process.*

***Methods**: A qualitative study using focus group interviews was conducted. Participants were 15 marriage migrant women who had experienced pregnancy, childbirth, or postpartum care in South Korea. Data were collected from March 1 to March 30, 2026, through two focus group interviews at a hospital in Seoul. Interviews were audio-recorded, transcribed verbatim, and analyzed using thematic analysis.*

***Results**: Analysis generated 35 codes, 13 subcategories, and four overarching categories. The first category, Difficulties in pregnancy and childbirth, included communication barriers, lack of healthcare information, childcare burden, cultural differences, and childbirth as a means of maintaining life in Korea. The second category, Overcoming challenges with support from others, emphasized the importance of family, social, and healthcare support. The third category, A grateful and meaningful life, reflected emotional fulfillment and gratitude through motherhood. The fourth category, Seeking coping strategies for pregnancy, childbirth, and child-rearing, highlighted the need for interpretation services, systematic education, and culturally tailored healthcare programs.*

***Conclusion**: Marriage migrant women experience various challenges during pregnancy, childbirth, and the postpartum period because of language barriers, insufficient information, and cultural differences. However, emotional and practical support from family members and others helped them adapt and cope with these difficulties. The findings indicate the need for professional interpretation services, multilingual educational resources, and culturally appropriate nursing interventions to improve maternal healthcare experiences and outcomes among marriage migrant women in Korea.*

Keywords: ***Marriage Migrant Women, Pregnancy, Childbirth, Postpartum Period, Multicultural Health***

1. Introduction

1.1 Need for the Study

With globalization and rapid social changes, cross-border mobility has become increasingly common, leading to a steady rise in international marriages worldwide. South Korea is no exception to this trend, as the proportion of international marriages has gradually increased over time. According to the 2019 marriage statistics, out of a total of 239,200 marriages, 23,600 (9.9%) were international marriages. Among these, marriages involving foreign women accounted for 74.8%. As of 2025, the number of marriage migrant women residing in South Korea has reached 137,094[1]. These figures indicate that marriage migrant women have become a significant population group within Korean society.

Marriage migrant women experience a range of complex challenges as they transition into a new society, including language barriers, communication difficulties, cultural adaptation, human rights violations, social prejudice, family conflicts, and limited access to information[2]. In addition, they often face economic instability, difficulties related to child-rearing and education, and legal issues concerning residency status. These multifaceted challenges place them in various vulnerable situations throughout their daily lives and function as significant factors that directly affect marital stability and overall quality of life[3].

In particular, marriage migrant women are reported to give birth to their first child within an average of approximately 15 months after migration[4], indicating that the life events of pregnancy and childbirth often occur concurrently with the process of cultural adaptation. As a result, they experience a dual burden of adjusting to a new society while simultaneously undertaking childbirth and child-rearing responsibilities. This situation may lead to increased anxiety related to parenting and a decline in self-efficacy, which in turn can contribute to psychological withdrawal and heightened parenting stress, ultimately exerting negative effects on parenting attitudes. Indeed, the burden of child-rearing among marriage migrant women has been found to have a significant impact on mental health, and is closely associated with negative emotional outcomes such as decreased self-esteem and depression[5][6].

Although pregnancy and childbirth are normal physiological processes, this period is characterized by significant physical, psychological, and social changes in women, requiring systematic care to ensure the health of both the mother and the fetus. Therefore, it is essential to establish continuous relationships between pregnant women and their families in order to identify potential problems that may arise during pregnancy and childbirth at an early stage, and to provide appropriate education and support[7].

However, marriage migrant women often encounter difficulties in accessing appropriate prenatal care due to various barriers, including communication problems with healthcare providers, limited understanding of medical procedures, financial burden of healthcare costs, low comprehension of medical terminology, and insufficient multicultural sensitivity or experiences of discrimination among healthcare professionals[8]. These factors extend beyond the pregnancy and childbirth process, adversely affecting not only maternal health but also newborn health management and subsequent child-rearing outcomes.

Furthermore, according to the study by Kim[9], reproductive health indicators among marriage migrant women appear to be more vulnerable compared to those of the general female population. The reported rates include 10.9% for spontaneous abortion in early pregnancy, 6.3% for induced abortion, 2.1% for stillbirth, 4.3% for preterm birth, and 4.2% for low birth weight. These findings support the need for more systematic and proactive interventions to improve pregnancy and childbirth health management among marriage migrant women.

Therefore, in order to support marriage migrant women in adapting stably to Korean society, experiencing healthy pregnancy and childbirth, and ultimately ensuring the healthy development of their children, there is a need to develop healthcare policies and practical nursing intervention programs that reflect multicultural characteristics.

Accordingly, this study aims to apply focus group interviews, one of the qualitative research methods[10], to explore in depth the health-related phenomena experienced by marriage migrant women during pregnancy and childbirth, and to describe the essence of these experiences as they are. Through this approach, the study seeks to provide foundational data for the establishment of effective healthcare policies and the development of practical nursing intervention programs that reflect the health management needs of marriage migrant women.

1.2 Purpose of the Study

The purpose of this study is to explore the experiences of pregnancy, childbirth, and the postpartum period among multicultural women. This study aims to generate foundational data that can support multicultural women in adapting to life in Korea and facilitate healthy pregnancy, childbirth, and postpartum experiences.

2. Body

2.1 Research Design

This study is a qualitative study that aims to explore the experiences of pregnancy, childbirth, and the postpartum period among multicultural women through focus group interviews.

Participants were selected in accordance with the criteria of appropriateness and adequacy for qualitative research as suggested by Morse and Field[11]. A combination of purposive sampling and snowball sampling methods was used for recruitment.

To ensure the selection of participants relevant to the purpose and topic of this study, marriage migrant women who had experienced prenatal care, childbirth, or postpartum care at the obstetrics and gynecology outpatient clinic or inpatient wards of S Hospital in Seoul were recruited. The specific inclusion criteria were as follows: women who are married to Korean men and currently residing in Korea, and who possess sufficient Korean language proficiency to adequately express their experiences related to pregnancy, childbirth, marriage, and migration.

Data collection and analysis were conducted concurrently to ensure data adequacy, and data collection continued until saturation was reached, that is, until no new meaningful statements emerged. In addition, when necessary, additional participants were recruited through referrals from initial participants.

A total of 15 marriage migrant women participated in this study. In terms of nationality, 7 participants were from Vietnam and 8 from the Philippines. The participants' ages ranged from 20 to 49 years, with 3 participants aged 20–29 years, 7 aged 30–39 years, and 5 aged 40–49 years. The age difference between participants and their spouses ranged from 6 to 22 years, and the number of children varied from one to four. The length of residence in Korea ranged from 3 to 12 years.

Regarding economic status, most participants reported experiencing financial difficulties, with some relying on government subsidies. In terms of educational background, 4 participants had a college degree, 6 had completed high school, 2 had completed middle school, and 3 had completed elementary school. As for occupation, 8 participants were engaged in manual labor, 3 in office work, and 4 were full-time homemakers.

Data collection was conducted from March 1 to March 30, 2026, through focus group interviews. A total of two focus groups were organized, with each group consisting of 7 to 8 participants. The interviews were held in a meeting room within the hospital, and each session lasted approximately 2 hours and 30 minutes.

Prior to data collection, the purpose and procedures of the study were fully explained to the participants, and written informed consent for voluntary participation was obtained. The interviews were conducted in a comfortable and supportive environment to allow participants to freely express their experiences. As compensation for their participation, a small token of appreciation was provided.

The interviews were conducted using qualitative interviewing techniques as proposed by Kvale[12]. Introductory questions included “What brought you to Korea?” and “What was your life like in your home country?” Follow-up questions such as “What was the most difficult experience for you in Korea?” were also used to facilitate deeper discussion. The main questions included “What were your experiences of pregnancy and childbirth?” and “What difficulties did you encounter during pregnancy and childbirth?” In addition, in-depth questions such as “Please describe in detail how you felt when you first saw your baby after childbirth” were used to explore participants’ experiences more comprehensively.

The moderator facilitated the interviews by appropriately using both direct and indirect questions to deepen participants’ responses, and employed silence techniques when necessary to encourage fuller expression. In addition, the interviews were carefully moderated to ensure that all participants had equal opportunities to share their views.

With the participants’ consent, all interviews were audio-recorded, and no strict time limits were imposed in order to allow sufficient and comprehensive responses. Any unclear or ambiguous statements were immediately clarified during the interview to ensure the accuracy of the data. The collected data were transcribed verbatim, preserving the participants’ original expressions, and subsequently used for data analysis.

2.2 Data Analysis

Data analysis was conducted concurrently with data collection. After each interview, the audio recordings were transcribed by a research assistant, and the researcher verified the accuracy by comparing the transcripts with the original recordings. Immediately following each interview, similarities and differences between groups were identified and reflected in subsequent interviews.

The transcribed data were repeatedly read and listened to in order to extract meaningful statements. Similar contents were compared and contrasted, categorized, and subsequently organized into themes. During the analysis process, the researcher continuously returned to the original data to ensure that participants’ experiences were accurately and sufficiently represented.

To ensure the rigor of the study, the criteria proposed by Lincoln and Guba were applied[13]. Credibility was established through member checking, and transferability was enhanced by including participants with diverse backgrounds. Dependability and confirmability were ensured by providing a detailed description of the research process and presenting participants’ statements. In addition, the researcher made efforts to bracket personal biases and faithfully reflect the participants’ experiences.

3. Results

As a result of analyzing the transcribed data of this study using thematic analysis, a total of 35 codes were identified. These codes were grouped based on similarities in meaning and organized into 13 subcategories. The subcategories were further integrated into four overarching categories.

The four categories derived from the analysis were: ‘Difficulties in pregnancy and childbirth,’ ‘Overcoming challenges with support from others,’ ‘A grateful and meaningful life’ and ‘Seeking coping strategies for pregnancy, childbirth, and child-rearing’ <Table 1>.

3.1 Difficulties in Pregnancy and Childbirth

The category Difficulties in Pregnancy and Childbirth consisted of five subcategories: 'Communication barriers,' 'Lack of information on pregnancy and childbirth,' 'Burden of child-rearing,' 'Cultural differences to be overcome,' and 'Childbirth for maintaining life in Korea.'

3.1.1 Communication barriers

Participants reported experiencing significant difficulties in communication with healthcare providers while undergoing pregnancy and childbirth in a context where they were not yet proficient in the Korean language. They often failed to fully understand explanations provided during medical consultations, and repeatedly encountered situations in which they were unable to obtain sufficient information about prescribed medications. In addition, they expressed frustration at being unable to articulate their questions or concerns despite having them.

In particular, when their husbands did not accompany them, some participants were unable to understand the content of medical consultations at all. Difficulties in reading and limited understanding of medical terminology also hindered their ability to comprehend test results.

"Whenever I go to the hospital for tests, I can't understand anything the doctor says if my husband is not with me." (Participant 5)

"I don't know what kind of medicine is being prescribed, so I always have to go with my husband." (Participants 1, 2)

3.1.2 Lack of information on pregnancy and childbirth

Participants often experienced pregnancy in situations where they lacked basic knowledge related to pregnancy, and some underwent unplanned pregnancies without even having a clear understanding of contraception.

In addition, insufficient prior information about the childbirth process or surgical procedures contributed to significant confusion and fear during delivery. Some participants were unable to recognize the onset of labor or suddenly found themselves in unexpected childbirth situations.

"When I went to the hospital, I found out that I was already six weeks pregnant." (Participants 3, 7)

"I thought I had diarrhea, but the baby came out." (Participants 4, 9)

3.1.3 Burden of child-rearing

Participants experienced difficulties due to a lack of knowledge regarding newborn care following childbirth, and reported simultaneously facing the burden of being first-time caregivers and the anxiety associated with being foreigners. Some participants encountered problems such as infections because they were unfamiliar with proper newborn care methods. In addition, the burden of child-rearing often led to psychological stress, with some participants reporting feelings of depression.

"I didn't know how to take care of the baby, so it was very difficult." (Participants 2, 5)

"Because I am a foreigner, I felt anxious about whether I could raise my child well." (Participants 10, 11)

3.1.4 Cultural differences to be overcome

Participants experienced difficulties arising from cultural differences related to pregnancy, childbirth, and child-rearing. In particular, differences between their home countries and Korea in terms of diet, postpartum care practices, and parenting styles were reported to cause conflict and stress.

Some participants had difficulty obtaining familiar foods from their home countries during morning sickness, while others struggled to adapt to Korean postpartum care practices. In addition, conflicts with mothers-in-law were reported due to differences in child-rearing approaches.

"Seaweed soup didn't suit my taste, so it was very difficult for me." (Participants 5, 12)."

"There were many conflicts because our parenting methods were different." (Participants 3, 13)

3.1.5 Childbirth for maintaining life in Korea

Participants tended to perceive childbirth as an important factor for maintaining a stable life in Korean society. Some participants viewed childbirth as optional in their home countries, but regarded it as necessary in the context of living in Korea.

"I thought that I had to have a child in order to live in Korea." (Participant 6, 14)

3.2 Overcoming Challenges with Support from Others

The category Overcoming Challenges with Support from Others was represented by the subcategory 'Resolving difficulties through family relationships.'

3.2.1 Resolving difficulties through family relationships

Participants reported overcoming challenges during pregnancy, childbirth, and child-rearing with the support of their families. In particular, assistance from their mothers and mothers-in-law played a significant role, and emotional support was also identified as a major source of strength.

In addition, support from other migrant women and acquaintances contributed to participants' psychological stability.

"I was able to endure because my mother and mother-in-law helped me." (Participant 15)

"It gave me strength to have someone who understood how I felt." (Participants 6, 8)

3.3 A Grateful and Meaningful Life

The category A Grateful and Meaningful Life was represented by the subcategory 'Gratitude for having a child.

3.3.1 Gratitude for having a child

Despite the challenges associated with pregnancy and childbirth, participants expressed profound feelings of gratitude and happiness regarding the presence of their children. These experiences were described as emotionally transformative, reinforcing a sense of purpose and contributing to a more positive outlook on life.

In particular, participants reported strong emotional responses, such as being moved to tears upon hearing their baby's heartbeat for the first time. The presence of their child also served as

a meaningful source of motivation, strengthening their commitment to continue living and adapting within Korean society.

"I cried when I heard my baby's heartbeat." (Participant 9)

"Because of my child, I felt that I should continue living in Korea." (Participant 10)

3.4 Seeking Coping Strategies for Pregnancy, Childbirth, and Child-Rearing

The category Seeking Coping Strategies for Pregnancy, Childbirth, and Child-Rearing comprised three subcategories: 'Need for interpretation services during medical examinations and consultations,' 'Need for education and experiential learning on pregnancy, childbirth, and child-rearing,' and 'Development of culturally tailored educational programs for diverse nationalities.'

3.4.1 Need for interpretation services during medical examinations and consultations

Participants emphasized the necessity of professional interpretation services when accessing healthcare. In particular, medical terminology was perceived as difficult to understand, highlighting interpretation support as essential for effective communication and safe care.

3.4.2 Need for education and experiential learning on pregnancy, childbirth, and child-rearing

Participants expressed a need for structured and detailed education regarding explanations of test results, guidance on the childbirth process, and newborn care practices. Experiential, hands-on programs were perceived as especially beneficial in enhancing practical caregiving competencies and confidence in parenting.

3.4.3 Development of culturally tailored educational programs for diverse nationalities

Participants underscored the importance of educational materials provided in multiple languages and emphasized the need for culturally sensitive, tailored education that reflects differences across national backgrounds. Additionally, incorporating information from participants' home countries was perceived as helpful in facilitating understanding and adaptation.

Table 1. Safety Management Experiences during Pregnancy, Childbirth, and the Postpartum Period among Marriage Migrant Women

Categories	Subcategories	Codes
Difficulties in Pregnancy and Childbirth	1.1. Communication Barriers	1.1.1. Unable to understand medical consultations due to communication difficulties
		1.1.2. Unable to identify what medication is being prescribed
		1.1.3. Unable to understand test information due to difficulty reading
		1.1.4. Unable to ask questions due to communication barriers
	1.2. Lack of Information on Pregnancy and Childbirth	1.2.1. Lack of knowledge about pregnancy
		1.2.2. Lack of knowledge about contraception
		1.2.3. Lack of information about delivery
		1.2.4. Lack of information about surgical procedures
	1.3. Burden of Child-Rearing	1.3.1. Lack of knowledge on how to care for a newborn

		1.3.2. Anxiety about ability to raise a child as a foreigner
		1.3.3. Depression due to caregiving burden
	1.4. Cultural Differences to Be Overcome	1.5.1. Need to adapt to different lifestyles and customs
		1.5.2. Missing home-country food during morning sickness
		1.5.3. Differences in postpartum care practices
		1.5.4. Enduring differences in child-rearing culture
	1.5. Childbirth for Maintaining Life in Korea	1.6.1. Perception of childbirth as necessary for maintaining life in Korea
Overcoming Challenges with Support from Others	2.1. Resolving Difficulties through Family Relationships	2.1.1. Enduring with support from natal and in-law families
		2.1.2. Receiving care from mother-in-law during illness
A Grateful and Meaningful Life	3.1. Gratitude for Having a Child	3.1.1. Emotional response (tears) upon hearing the baby's heartbeat
		3.1.2. Feeling gratitude and gaining motivation from having a child
Seeking Coping Strategies for Pregnancy, Childbirth, and Child-Rearing	4-1. Need for Interpretation Services during Medical Examinations and Consultations	4.1.1. Need for professional interpreters in healthcare settings
		4.1.2. Need for interpretation during examinations and consultations
	4-2. Need for Education and Experiential Learning on Pregnancy, Childbirth, and Child-Rearing	4.2.1. Desire for explanations using medical test results
		4.2.2. Need for guidance on labor and delivery process
		4.2.3. Need for guidance on postpartum child-rearing
		4.2.4. Need for education on childbirth and parenting
		4.2.5. Need for hands-on experience in childbirth and parenting
	4-3.Development of Culturally Tailored Educational Programs for Diverse Nationalities	4.3.1. Need for easy-to-understand multilingual educational materials

4. Discussion

This study was conducted to explore the experiences of pregnancy and childbirth among marriage migrant women and to provide foundational data to support their adaptation to Korean society and promote healthy pregnancy and childbirth outcomes.

The findings revealed four major categories— 'Difficulties in pregnancy and childbirth,' 'Overcoming challenges with support from others,' 'A grateful and meaningful life,' and 'Seeking coping strategies for pregnancy, childbirth, and child-rearing'—along with 13 subcategories.

First, within the category 'Difficulties in pregnancy and childbirth,' participants were found to experience high levels of confusion and psychological tension during the pregnancy and childbirth process due to language barriers, cultural differences, and a lack of information. In particular, communication difficulties with healthcare providers and insufficient knowledge related to pregnancy and childbirth were identified as major barriers to accessing appropriate healthcare. In addition, cultural differences in postpartum care practices, diet, and child-rearing approaches were found to exacerbate psychological burden[14]. These findings are consistent with previous

studies reporting that marriage migrant women experience difficulties during pregnancy and childbirth due to limited information and cultural differences[15][16]. This suggests that pregnancy and childbirth management among marriage migrant women should not be regarded solely as an individual-level issue, but rather as an area requiring systemic support within the healthcare system.

Second, within the category 'Overcoming challenges with support from others,' social support from family members and surrounding individuals was identified as a critical protective factor. In particular, both emotional and practical support from family members, including mothers-in-law, played a central role in helping participants cope with the challenges of pregnancy and childbirth. In addition, relationships with other marriage migrant women who shared similar experiences functioned as an important support system. These findings are consistent with previous studies indicating that social support has a positive effect on adaptation to pregnancy and childbirth among marriage migrant women[17]. Therefore, these results underscore the importance of strengthening family- and community-based support systems in promoting the health and well-being of marriage migrant women.

Third, within the category 'A grateful and meaningful life,' participants experienced a sense of meaning in life and emotional fulfillment through childbirth. In particular, the presence of their child served as a significant turning point, strengthening their motivation to settle and continue their lives in Korean society. These findings are consistent with previous research suggesting that childbirth provides marriage migrant women with a renewed sense of purpose and hope[18]. Furthermore, these results indicate that pregnancy and childbirth extend beyond physiological processes and represent critical experiences that contribute to the reconstruction of social identity and life direction.

Fourth, within the category 'Seeking coping strategies for pregnancy, childbirth, and child-rearing,' participants strongly recognized the need for interpretation support, structured educational programs, and culturally tailored services. These findings are consistent with previous studies indicating that multicultural women face limited access to healthcare services due to language barriers and insufficient information[17][18]. In particular, participants expressed a need not only for the provision of information but also for experiential, hands-on education and multilingual, customized materials. This highlights existing limitations within current healthcare services and underscores the need for more accessible and culturally responsive care[19][20].

Therefore, to support healthy pregnancy and childbirth among marriage migrant women, it is necessary to strengthen interpretation services within healthcare institutions, develop multilingual educational materials, and establish nursing intervention programs that reflect cultural characteristics. In addition, there is a need to move beyond individual-centered approaches and develop integrated support systems based on family and community resources[21][22].

The significance of this study lies in its in-depth exploration of the pregnancy and childbirth experiences of marriage migrant women, through which practical health management needs were identified[23]. However, this study included only 15 participants and was limited to marriage migrant women from Vietnam (n=7) and the Philippines (n=8). Therefore, the findings may not fully reflect the experiences of marriage migrant women from other cultural and linguistic backgrounds, and caution is required when generalizing the results to the broader population of marriage migrant women in Korea. In addition, participants were recruited from a single healthcare institution, which may have limited the diversity of experiences represented in the study. Future studies should include participants from a wider range of nationalities and regions and employ mixed-methods or longitudinal approaches to provide more comprehensive and generalizable evidence.

6. Conclusion and Implications

This study is a qualitative investigation that explored the pregnancy and childbirth experiences of marriage migrant women through focus group interviews. The analysis identified four categories—'Difficulties in pregnancy and childbirth,' 'Overcoming challenges with support from others,' 'A grateful and meaningful life,' and 'Seeking coping strategies for pregnancy, childbirth, and child-rearing'—and 13 subcategories.

The findings indicate that marriage migrant women experience various challenges during pregnancy and childbirth, including language and communication barriers, lack of information related to pregnancy and childbirth, burden of child-rearing, and cultural differences. Despite these difficulties, participants were able to cope through emotional and practical support from family members and others. Moreover, childbirth served as a meaningful experience that provided a sense of purpose in life and strengthened their motivation to settle in Korean society. In addition, participants demonstrated an active effort to seek coping strategies, recognizing the need for interpretation support within healthcare settings, structured educational programs, and culturally tailored services that reflect multicultural characteristics.

Based on these findings, to support healthy pregnancy and childbirth among marriage migrant women, it is necessary to establish professional interpretation service systems within healthcare institutions and to develop multilingual education programs on pregnancy, childbirth, and child-rearing. In addition, culturally tailored nursing intervention programs should be implemented, and integrated support systems linked to family and community resources should be strengthened. Furthermore, there is a need to accumulate more in-depth and generalizable evidence through repeated studies and mixed-methods research involving marriage migrant women. Future research should recruit marriage migrant women from diverse countries of origin, including Chinese, Cambodian, Thai, and Central Asian populations, to better understand differences in pregnancy, childbirth, and postpartum experiences according to cultural background. Comparative studies examining nationality-specific needs and healthcare experiences are also recommended to support the development of culturally tailored maternal health policies and nursing intervention programs. Furthermore, multicenter studies involving various healthcare settings and communities are needed to enhance the transferability and applicability of research findings.

In conclusion, promoting healthy pregnancy and childbirth among marriage migrant women requires a multidimensional approach that goes beyond the provision of basic healthcare services, integrating cultural understanding with comprehensive social support.

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A Disastrous World Brought by Humans Who Have Lost Their Humanity: Focusing on *Brave New World*

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Abstract

Purpose: *The 1930s, when Aldous Huxley published Brave New World, saw economic development unparalleled in history due to the explosive economic growth and innovation that was led by the manufacturing industry after the World War I. However, at the same time, individuals were treated like a part used in a factory, and the value of humanity that only a human can have, such as love, emotions, or thoughts, considered efficiency unnecessary and inefficient outweighed by efficiency. This paper explores the question 'Is the world of people living in a world of maximum efficiency and the loss of humanity like love, pain, and insecurity a wonderful world or a disastrous world?', a question asked by Huxley ninety years ago through Brave New World, to reflect on the value of humanity unique to humans and the direction that humans should pursue. In addition, this paper connects Huxley's question to modern protection convergence by examining how the problems of system stability and control in Brave New World are linked to contemporary digital technology, biotechnology, artificial intelligence, and surveillance systems.*

Method: *First, the paper explores the question 'Is love really unnecessary to humans?' in order to find out whether the civilized world, where everyone is born from an artificial insemination for efficiency, not as a result of parental love, like how objects are made in factories to stabilize society and sex is just a play without love which the sole purpose is to satisfy sexual desires, is the development and civilization that we want. Second, the paper sets out the question 'What is the value of pain and insecurity to humans?' to think about the meaning of soma used in the civilized world of Brave New World to make people ignore pain and insecurity, the reason why the states and people of power in the course of history made people look away from pain and insecurities of reality and how they did it, and why we need to face and overcome pain and insecurities. Third, the paper asks the question 'Is Brave New World a disaster or a blessing to humans?' to consider how humans are treated like objects through births and deaths when they have lost humanity, love, pain, and insecurities, for the purpose of social stability and maximization of efficiency and what sacrifices we would have to make to keep our humanity in such a world controlled by advanced digital technology and surveillance.*

Results: *Through John, who was born and raised in the Savage Reservation, where people, who have humanity and are opposite of those in the civilized world that has lost humanity, live, the author calls the people of the civilized world, who only strive to satisfy their sexual desires without love, centaurs, poison, and whores, thereby confirming that a loveless society is not the world humanity should pursue. As John shouts to those of the civilized world to abandon soma and seek freedom, the readers realize that when a state makes its people face away from the insecure and painful reality using soma, in the end, their freedom is seized, and they become mere parts to the society. The book shows John, who tried hard not to become the same as those of the civilized world, a place that is prosperous regardless of losing humanity, is without pain and insecurities, and only strives to satisfy sexual desires, but he gives in to his desires at the end because of the others, committing suicide to protect his pride as a human being and clearly shows that living in the world that resembles the civilized world controlled by artificial intelligence and digital technology in the future would be a disaster.*

Conclusion*: Ninety years ago, Huxley asked a question about which direction humanity should take to us in the present. Thanks to John the Savage, it is clear which road we, who are at the crossroad of choice, standing in*

the middle of the civilized world, the place that has lost humanity filled with people who are like mere objects with beating hearts, and the Savage Reservation, the place that has kept humanity, should take. Therefore, in the face of today's protection convergence issues driven by biotechnology and surveillance, we must find the right direction to protect our true humanity.

Keywords: ***Brave New World, Protection Convergence, Surveillance, Humanity, System Stability***

1. Introduction

The 1930s, when Aldous Huxley announced *Brave New World*, was a time of worldwide turmoil. After World War I, the West experienced explosive economic growth, and the growth and innovation led by manufacturing industries led to the mass production of industrial products to a degree not seen in previous human history. In particular, Ford Motor Company that used a method devised by the American automobile king Henry Ford (1863-1947), in which automobiles were mass produced on assembly lines using conveyor belts, became a symbol of this period. The Ford Model T, for example, was produced at around 1 unit per 24 seconds. This, not only shows that the increase of automobile production, but also shows that other industries in general became significantly developed, so much so that they could handle such rapid production. Thus, society was materially enriched, and new technologies and objects that had never been before were produced continuously.

On the other hand, people were treated like unimportant parts of society. Men were enlisted in the army, factories, construction sites, etc. while women became the angels of the family, bearing and raising children, who were to be used as parts in the future. Then, the Great Depression occurred in 1929, starting with the United States. It hit the world from the late 1920s to the 1930s, causing an economic downturn. A variety of social conflicts arose from massive unemployment as well as financial market turmoil. As the economy collapsed, people experienced racism, skepticism about society, and helplessness. This social background had such a great political and social influence that caused people, who had always pursued freedom, to believe that it was better to be controlled and suppressed by dictators, for example, Adolf Hitler became in charge of Germany and in Italy, Benito Mussolini came to power. This became the background for the World War II, which was the most disastrous war in the human history. During this time of turmoil, Huxley released *Brave New World*. He sneered at the social chaos of the time by adding the word "Brave" to the title. Chu Jae-wook points out that the work calls for a new awakening to the modern mechanical civilization and unethical nature of man experienced before and after World War I, and simultaneously expresses a vision and concern for the future of humanity[1].

Brave New World is a dystopian novel set in a fictional future society at the height of scientific civilization. The term dystopia was first used by the 19th century British philosopher and economist John Stuart Mill (1806-1873) in 1868 when he criticized the British government for oppressing Ireland and is commonly used as the opposite of utopia. A dystopia is a world that looks like a utopia, but the individuals in it are oppressed by society and do not live humane lives. Huxley seems to have thought that although society had grown materially at the time, the humanity of the people had deteriorated due to the Great Depression and the war. Through *Brave New World*, he shows the time of rapid change that humanity has never experienced, people living in the turmoil, and the terrible consequences that the descendants will experience if the society choose to continue as how it has been without thinking or reflecting on the present.

In *Brave New World*, individual states that had borders based on ethnicities and historical backgrounds disappear and become a World State. They profess themselves to be a civilized world. Everyone is born through artificial insemination in a factory, not as the result of their parents' love. At the Central London Hatchery and Conditioning Centre, babies are born in a

factory that produces identical people by making up to ninety-six people from a single egg, just as how cars are produced in the Ford automobile production system. The factory takes Henry Ford as a divine being and takes the production date of the Model T as the basis for their year system, A.F. (After Ford). The upbringing and education of children are the responsibility of the state, and people are thoroughly brainwashed to live in satisfaction with their own class, divided into alpha, beta, gamma, delta, and epsilon classes before they are born. They also give babies the "*brave new world*" style of education to instill an instinctive disgust for pre-A.F. traditions and history. Under the motto of "Everyone belongs to everyone else", the word parent and family itself is taught as dirty and unclean things. People are taught to be satisfied with their classes and their corresponding roles and to be oriented towards the fulfillment of sexual instincts and senses. This is all for the sake of national stability and is taken for granted by the members of society.

Although the world filled with people who are brainwashed with the education appropriate to their classes through conditional reflexes and sleep implications since they were fetuses to make them into efficient parts to be used for the state seems very efficient, it portrays a strange world where human emotions, feelings and thoughts are completely ignored. Love becomes just a sexual play in the book as love between men and women, as well as that of the same sex, become superfluous. Through a medicine called "Soma" which gives the greatest happiness and security that a human being can feel, emotions and feelings, along with pain and anxiety, are removed. In this world, everything else is deemed unnecessary as people only care about the comfort of materials and physical pleasures of soma and sex. Huxley published *Brave New World* about ninety years ago, but it remains appallingly similar to the world that we live in today. Artificial insemination eggs that remove genetic defects, surrogacy of famous celebrities, black market that sells semen and eggs that promote babies with better genes, sex consumed by the general society through music, art, novels, movies, and drugs that are readily available to anyone with money are also prevalent in today's world[2]. As such, *Brave New World* feels like a kind of warning to the inhumane and disastrous world that the author sent to the people of today ninety years ago.

This paper answers the question that Huxley asked us in the present ninety years ago, in the *Brave New World,* the world where efficiency is maximized, where people are mass produced as how cars are mass produced, where people live without insecurities, pain and humanity due to soma. It takes a look at the value of love, sacrifice, pain, insecurity, that is unique to human beings compared to the advanced civilization and social system and the direction that we will pursue.

2. Huxley's First Questions, Is Love Unnecessary to Human?

Every human being in the civilized world is born in a factory that takes A.F., which is the date when the car, Model T, was made by Henry Ford, the person who first devised and implemented factory-based mass production, as the basis of the year notation. Ford, who has implemented the efficiency of production to the extreme, is a god here. Thus pregnancy, the fruit of love is treated as nothing more than a cumbersome process, so much so that all but 30 percent of the female wombs at the factory are injected with male hormones to make them infertile. Also, the humans that are produced at the factory are class-determined from the time they are made: the alpha class of the social leadership, the beta class of the middle class, the lower class of gamma, the delta responsible for simple labor, and the epsilon class[3]. The lower the class, the less oxygen is injected into the brain and skeleton to differentiate the classes.

The birth of man is treated as if it were merely a product from the conveyor belt assembly line factory that is devised by Ford. Just as we produce cheap cars, as well as its opposite, high-

end cars, humans are made divided in different grades at the factory. In this way, human beings are born like goods in factories, not in families made of love and sacrifice. A home is not only unnecessary, but even described as ugly and dirty. Mustapha Mond, one of the ten controllers who rule the World State, describes home to three hundred new humans of the factory as the following:

> A home consists of a few small rooms packed with a man and woman who regularly give birth to a baby, boys and girls different ages. It's like an unsanitary prison where there isn't enough air and space to breath, which is nothing but darkness, disease, and stench. And home is as squalid psychically as physically. Psychically, it is a rabbit hole, a midden, hot with the frictions of tightly paced life, reeking with emotion. (*BNW 77*)[1]

In the civilized world, the days of growing up under parents were educated to be something to be ashamed about, and stories about a person's birth by parental sex were considered dirty and filthy obscenities. When Huxley released *Brave New World*, due to Britain's explosive industrialization, people had a strong perception that the homes of factory workers were places to sleep, eat, and rest for working. The exploding population of the city where all the factories were resulted in a shortage of housing that alienated children from parents who were busy trying to survive[5][6]. As the economy stagnated due to the Great Depression, more people were unable to work. This led to domestic violence, hunger, and illness. The family resembled what Mustapha Mond described as a pre-A.F. family. Huxley made family a dirty and filthy thing in the novel as he expanded his imagination and thought that it would be better to eliminate all love and bond between families for the safety of the factory system and efficient to have humans made by a state, as if objects are made in factories.

In the civilized world, "love," the noble emotion that humans have, is also treated as a play. The pre-A.F. period, which strictly prohibited children's sexual play, is defined as the age of barbarism in which children did not enjoy sexual pleasure, and seven-year-olds are allowed to learn sex through sexual play. People also consider the era of sexual desire to be immoral, the dirty era, and consider a married couple having a monogamous relationship for intercourse as an uncivilized act, saying that "the pathetic human beings before the modern man were wicked, crazy, and miserable(84)." Thus, the people of the civilized world turned the Westminster Minster[2], which was considered sacred by previous times, into a ballroom, where men and women gets tangled, dance, and have orgies in the great music hall[7]. In *Brave New World*, promiscuous intercourse between men and women is depicted not as dirty and ugly, but as a dance in which everyone dances together.

> Everyone put their hands on buttocks of the person dancing in front of them, and they marched in a circle. They shouted the same thing at the same time, stomped their feet to the beat of the music, and tapped the buttocks of the person in front of them with both hands. Twelve pairs of hand tapped like one, and twelve hips pounded like one… I hear him. I hear him coming. (*BNW* 143)

If you substitute the hands in the expression tapping the buttocks with two hands with men's genitals, the expression becomes clearer. Tapping the buttocks with two hands means inserting

[1] The quotations from *Brave New World* are from *Brave New World* (Sodam, 2015; Ahn J, Trans.), and the quotations hereinafter are abbreviated as *BNW* with the page number[4].

[2] Collegiate Church of St. Peter in Westminster is a famous Anglican church in Westminster, London, England. It is used as a site for the British royal coronations and the tombs of royalty and greats, and was inscribed as a UNESCO World Heritage Site in 1987.

a man's penis into a woman's buttocks[8]. Twelve pairs of hands tapping like one, and twelve buttocks making a sound like one expresses the multiple intercourses the men and women are having at the same time. Also, the expression I can hear him can be seen as an expression of orgasm at the peak of intercourse. Thus, in *Brave New World*, orgy is not expressed as strange, dirty, or ugly, but rather as cheerful, peaceful, and liberating to the people of the civilized world (143).

Pornography, which is secretly distributed and consumed in dark in the world that we live in, is also openly consumed by people as "feelies" in *Brave New World*. Feelies are a kind of experiential pornographic film that not only shows sex vividly, but also stimulates the touch and erogenous zones of the skin as if the audience were having real sex and is considered a fun pastime of everyday life by people in the civilized world[9]. Thus, in *Brave New World*, love is not the premise required for sex. Children learn sex like how they learn to play, they consume in openly, find it ugly and dirty to be born through sex that is done only between a couple, and think of such home as something to be ashamed of. The reason for this becomes clear by the words of the controller Mustapha Mond.

> We must seek stability. Without social stability, no civilized world exists, and without personal stability, no society can be stable… As much as we need the wheels on the axis of machines, we need stable, steady, and obedient people who seek stability in the life they are satisfied with. (*BNW* 85-86)

In the end, in order to seek the stability of society, it deprives people of love, turning it into a sex play that spews out instinctive desires through free sex, and makes the existence of a family, which is made of love, a dirty and ugly thing that is like a stumbling block to the stable state, which is the factory system[10].

However, by showing John, who lives in the Savage Reservation that retains the pre-A.F. life, completely different from the civilized world, where there are diseases, where there is a mother breastfeeding her child, where people search each other's head to catch lice, where there is the smell of oil and smoke as they cook, Huxley asks if love really is unnecessary for humans. John was birthed by Linda, who is from a civilized world. Linda lives in the Savage Reservation because she gave birth to John herself. Linda, who enjoys free sex with different men in the Savage Reservation as she has been doing in the civilized world, is treated as a whore in the Reservation and is pointed at. John, on the other hand, is the only one who understands the feelings of love as he reads Shakespeare's book that Linda gave him[11][12]. When he was young, he felt sadness when a man separated him from Linda because the man was trying to take Linda's baby. As the strange man takes away the humane love and stability young John feels from his mother, he even starts to feel rage. John comforts Linda even when she hits him and cries saying, "I am not your mother", "I became a savage", "I birthed like a beast (201-202)", blaming him for becoming a savage and getting shunned from the civilized world[13].

John also sees a tactile film with Lenina when Bernard and Lenina, the people of the civilized world whom he has always admired from his mother, take him to the civilized world, he is shocked that the feelies were only made without the feeling of love to stimulate the tactile and erogenous zones to make people feel sexual satisfaction. He says to Lenina, "I don't think you should watch that, it is an apathetic movie (262)". He thinks the feelies, the movies that the civilized people are crazy about, are pathetic and ridiculous. As John falls in love with Lenina, he genuinely confesses his love to Lenina saying, "You are truly the most noble being in the world" (289) and "I love you above all else in the world" (293); however, Lenina, who does not know the feeling of love, does not understand John's words. She simply wraps her arms around John's neck, kisses him on the lips, undresses herself, approaches him, and seduces him to kiss her passionately[14][15]. Instead, John pushes away Lenina, who, unlike himself, does not know love

and is just full of sexual desires, and says the lines of Shakespeare's King Lear and Othello.

> Not even a weasel or a filthy horse is so eager to jump with such wild greed. The upper side is a woman, but below the waist she is a Centaurus… Ptui, ptui, you are filthy, so filthy!... Oh, you are like a poison, your fragrance is so lovely, beautiful, and sweet that it hurts… Was this wonderful book written to have the word whore in it? (*BNW* 299)

Lenina, who does not understand the emotion of love and enjoys only physical acts to relieve her sexual desires, is no longer the object of love to John, but is filthy. John, who considers the people of the civilized world as barbarians, shows his despise towards her by calling her Centaurus[3], half-human, poison, and prostitute, citing the lines of *King Lear* and *Othello*.

As such, the civilized world, where sex is consumed like a play, is Huxley's critique of post-Depression European society at the end of the explosive industrialization, the time *Brave New World* was released[16]. Huxley depicts sex as a play that enjoys in the civilized world of *Brave New World*, in which men consume women and women consume men, due to the sexual ethics that is different from the past, which makes the feeling of love nothing but an object[17]. By doing so, he makes the readers think about what is the development that we, humans, want and what is civilization. Also he paints a more dramatic picture of the future by focusing on efficiency and destructing the homes made with the premise of love[18]. He depicts the future where people do not know of love and treats the act of love as just a play, as if he is saying that such world should never exist. Through John the Savage in the Savage Reservation, he makes, us, the people in the present, think the acts performed on ourselves or others become just means of desires if they are done without love of feelings.

3. Huxley's Second Question, What is the Value of Pain and Anxiety for Humans?

At the time Huxley published this work, people wanted to escape from reality as they felt depressed, empty, and defeated, because they had lost their jobs and had nothing to do because of the Great Depression that came at the end of the explosive economic growth of the post-World War I era[19]. People consumed things like cannabis, opium, and cocaine to escape from the bitterness of reality through hallucinations. During this time, drugs were mostly supplied by gangs; however, in some cases the state legally supplied them to soldiers to boost the morale of soldiers who were fighting in pain and anxiety during the war. Thousands of years ago, in Homer's *Odyssey*, Helene of Troy gave the medicine "nepenthe" to soldiers to help them get rid of anger and sorrow, and during the American Civil War (1861-1865) "morphine" was given to soldiers. In the World War II, Japanese Kamikaze commandos[4] launched a suicide attack after drinking a drink containing methamphetamine that the Emperor had given them[20].

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[3] **Figure 1.** 18th Century, Paing by P. Batoni

A monster that is a person from the head to the waist, while the rest is a monster in the form of a horse that appears in Greek mythology. Centaurus lives on raw meat and is violent and lustful.

[4] The Kamikaze commandos were Japanese commandos who carried out suicide attacks during World War II by driving bomb-equipped planes. The pilots, considering it an honor to die for the emperor, launched reckless attacks on the Allied fleet with the fuselage. In 1945, more than 1,000 commandos carried out Kamikaze attacks to defend Okinawa.

In *Brave New World*, there is a drug called soma, which is supplied by the civilized world. The drug gives people the ultimate happiness and stability. Soma is described as "A flawless medicine that allows you to escape from reality and rest whenever you want, return to reality without suffering from headaches or vain thoughts, and takes away ten depressive moods with just the amount of 1 cubic meter (102). The people of the civilized world can always receive soma from the state. People can consume soma to relieve themselves from the insecurities and pain of reality[21]. They can even use it to take a short break or have sex. The effects of soma are described as follows.

> The elderly also work and have sex, and they have no time for sitting and refection. They do not have time for anything other than pleasure… The delicacy of soma is always prepared for times like that. You only need to take 1 gram for the weekend, 2 grams for a trip to the East, and 3 grams to enjoy the moon. Once you are back from your break, you can overcome the void and go back to your everyday work, enjoy entertainment, watch feelies, enjoy the girls… (*BNW* 104)

Soma is the last resort to get rid of the emotions that only humans could have-anxiety, pain, depression, and emptiness in the civilized world. Controllers use soma to quell social instability, anxiety, and to forever maintain the social system. This is because taking soma eliminates complaints about reality, and makes people work faithfully like a part in society.

The cases of where things like soma were used to quell social in stability and settle insecurities on behalf of the people can easily be found in the humanity's history[22]. In ancient Rome, Roman citizens who had the right to vote, meaning those who had "Roman citizenship," were given breads enough to feed them for each month and tickets to watch a game at the Colosseum. Rome was in a political and economic crisis due to the incompetence of those in power at the time, and of course the Roman citizens who lived there also suffered. However, the state gave them breads and tickets to the Colosseum games, so that they could settle for reality and turn away from the crisis of the state[23][24]. A satirical poem written around A.D. 100 by the ancient Rome satirical poet Decimus Iunius Iuvenalis (AD 55-140) illustrates the deception suffered by the state by the citizens of Rome at the time.

> The citizens lost interest in state affairs when the right to vote disappeared as Rome was established. The citizens who in the past were sources of authority in all spheres of politics and the military now wait for only two things[25].

Just as the people of the civilized world in *Brave New World* escaped from reality with soma, the Romans fell in love with the bread and entertainment given to them by the state and fled from the unsettling reality, and as a result, Rome was eventually destroyed. There have been similar cases in Korea as well. In 1980, the 5th Republic, where soldiers illegally seized power, pursued the "3S Policy" to divert the attention of the people who aspired to democratization and had criticism towards the brutal suppression of the 5·18 Gwangju Democratization Movement. The state tried to get people's attention off politics through sports, sex, and screen[26]. The state hosted professional baseball, soccer, and wrestling competitions, held beauty competitions, screened erotic films in theaters across the country, distributed pornographic tapes in dark, and turned their heads away from the increase of prostitution. Thus, in order to consolidate the regime, the 5th Republic did not give the people a chance to seriously consider the causes of the insecurity and suffering of the real world.

It is no exaggeration to say that human history has in fact developed due to pain, anxiety, and other emotions that only humans can have. In primitive times, human beings who lived in pain and anxiety caused by the invasion of outside forces and natural dangers, such as natural disasters, created a state to ensure their safety. Those who had suffered by the powerful gathered to

bring about a social transformation like the French Revolution, and those who had suffered by war gathered together to form a peace treaty to escape the danger of war. The development of human society comes from discussions that people, who have reflections on pain and insecurities and have the same will, have together and the resolutions that are derived from them[27]. Developments are made through solidarity between people, and validity for such developments is made to make society better for people. The people who transform society become true citizens. However, soma that the state distributes to deceive the people for the sake of social stability, the bread and the Colosseum games of the Roman era, and those who are domesticated in the 3S policy of Korea's 5th Republic era, are not the masters of society, but merely the parts of society that move according to the intentions of those in power.

Through John, who is from the savage reservation, Huxley tells us not to be exploited by those in power to escape reality, but to overcome pain and anxiety with dignity. After watching a feelie, a film that is made solely for the stimulation of the human touch and erogenous zones, with Lenina, whom he loves, John defines the film as vulgar and tells Lenina that "I don't think you should see things like this (262)", and then shouts at those who are standing in line not to take soma. He tells them that soma is a poison they should be scared of and that they should throw it away, but the people laugh at John the savage as John is a mere savage in their standards. However, John picks up the courage and says:

> Do you not want to be a free and human person? Don't you even understand what humanity and freedom are? Fine. I will liberate you whether you want it or not… Freedom, find freedom… Find freedom! (*BNW* 323-324)

John throws away a handful of soma and creates confusion, but those who have already been addicted to soma for a long time do not understand what John has said. They regain their calm by taking in the thick smoke of soma sprayed by the police. John explains freedom, but for those who have used soma for so long to escape from reality, freedom is a completely unfamiliar concept[28]. Only those who have felt free can know what freedom is, so people do not understand it at all.

Huxley asks the readers whether insecurity and pain are of any value to humans by contrasting John, who grew up on a savage reservation, someone that the people of the civilized world consider dirty and filthy, to the others. Those in power seek to maintain power by making the members of society ignore the pain and insecurity they feel. As we have witnessed, we can easily spot similar things in the present as well as in the Roman period and the history of Korea's 5th Republic. Even today, there are many means such as alcohol, music, games, television that can easily distract us from our insecurities and pain. Bars and convenience stores are flooded with alcohol, and clubs and coffee shops have music that dominates people's emotions. People who have escaped from their tough realities create a world different from reality in online gaming, and on television, dramas, and entertainment programs starring beautiful, handsome, funny celebrities, making us ignore our pain and insecurities.

We can easily consume the present-day somas, like the somas we see in *Brave New World* anytime, as much as we want. However, the moment we get used to soma and simply ignore reality without facing the pain and insecurity within us, our freedom ceases. Then, like the people of the civilized world, society becomes a part of the machine. There are many ways to escape insecurity and pain, we have always faced and overcome them in some way and developed society. Therefore, instead of ignoring our insecurity and pain, we must always be awake to face them with dignity. For freedom is granted only to those who are always awake.

4. Huxley's Last Question, Is Brave New World a Disaster or a Blessing?

The civilized world in *Brave New World* is a society where efficiency is maximized. Ninety-eight people are born from just one egg using a technology developed by the factory, not parents. People believe the education of the pre-A.F. families and schools is inefficient. Everyone grows up in the factory and is brainwashed to praise consumption, and believe it is natural to live according to the class given to them by the factory. They run away from pain and consider their parents and home as terrible and ugly. The savage reservation is described as a disgusting and dirty place, with piles of filth and garbage, dust, dogs, and flies. It makes the people of the civilized world frown (177). For the people of the civilized world, the savage reservation is a place of barbarism where people live, die, grow old and get sick. The civilized world, on the other hand, is portrayed as a beautiful, clean, and prosperous place that is incomparable to the savage reservation. Linda describes the civilized world to John like the following:

> Beautiful music, people playing, delicious food to eat and drink… With everyone who is happy, neither sad nor angry, everyone who belongs to everyone else… Endless happiness, joyful and happy like a summer prom, where you live with people who are not lonely at all… (*BNW* 203)

People of the civilized world live without knowing emotions, such as love, pain, and insecurity, from the moment they are born in the factory. And the death of man in the civilized world is not a sad thing but is treated like an object getting discarded. No human emotion is attached to death. Park Lane Hospital, located in a sixty-story skyscraper, is a place where people who are about to die wait for their deaths. When they die, they are immediately moved to the Slough crematorium. The room is sunlit, spacious, and bright. Delightful music plays out and the television plays from morning to night at the foot of the bed where the people who are about to die are lying. The fragrance (soma) that fills the room is automatically emitted every fifteen minutes [29]. People die in a perfectly refreshing atmosphere, somewhere between the first-class hotel experience and the feelies.

The process is so similar to how we die in the present that it is hard to think that this book was written ninety years ago. Today, we also see elderly people who are done serving their purpose society or who have illnesses that are hard to treat waiting for their deaths in large and small nursing hospitals, just like Park Lane Hospital. They are regularly given toxic painkillers at a set time, and when they die in the hallucination from the drugs, away from the pain, they are moved to the funeral homes or crematoriums next to the nursing hospitals to be buried. Because they are always in a state of hallucination, systematically, they cannot think or reflect on life in-depth. They die just like how objects that have served their purpose die. Enjoying sex play without love, following their instinctive desires, and removing the pain and insecurities of reality using the soma distributed by the state, people become human beings that live in a world where there are no thoughts and feelings[30]. The deaths at Park Lane Hospital that happen as people are reliant on somas, which make them unable to have any remorse or reflection on life are inhumane. They are dealt like how objects, built for the sole purpose of serving the stable society, that were a part of a big machine, society, are handled.

Table 1. Overall Comparison of Brave New World and the Present

	Fertilization	Education	Family	Sexual Desire	Class	Politics	Relief of Insecurity and Pain
Brave New World	Central London Hatchery and conditioning Centre	State	Something that is dirty and filthy	Sexual paly, something that is enjoyed through feelies	Something that is decided at the point of fertilization	Something that is assigned to the elites	Soma

Present	Intercourses between a man and a woman	Homes and schools	The most foundational group for affection	An act in which love is the premise	Something that can be changed through efforts	Something that anyone can do	Some consume alcohol, cigarettes, or drugs but most relieve them through humanistic elements, such as love, reflection, and cooperation

Huxley asks us the last question, Is *Brave New World* a disaster or a blessing to humans? John, the only man of humanity, hides in a lighthouse to wash himself away from the defiled world of the civilized world. Whenever he feels sexual desires, pain, and guilt, he repents by whipping himself, but this is nothing more than a laughing and a good spectacle for the people of the civilized world. John tries to protect his humanity, but eventually gets surrounded by the others, gets high in soma, and joins a frantic sex party. Eventually, he covers his eyes, not being able to stand himself, and cries, "Oh, God! God! (388)". John makes the final choice to protect his pride as a human being, and this is how *Brave New World* ends.

> The lighthouse door was a lightly open. They pushed the door and walked into the darkness… They saw a pair of feet hanging just below the top of the arched corridor… "Mr. Savage!" slowly the two feet turned to the right slowly, pointing north, northeast, east, southeast, and southwest. Then they paused for a moment, and after a few seconds, they turned left again slowly. Southwest, South, Southeast, East… (*BNW* 388)

Although the civilized world is a prosperous and clean place where everyone does their job without any complaints and free from pain and insecurities, thanks to soma, the world is not so brave as they have lost humanity, something that only a human can have, such as thoughts, emotions, and love. Those who have lost their humanity are merely living things that move according to the needs of society. They do not need the dignity that a human has. Therefore, they are not allowed to have any emotions for their deaths. They are disposed as they would dispose of any other objects. John was the only person with humanity in the civilized world, which is full of living objects that cannot be considered human[31]. Here, John realizes that he cannot live protecting his own humanity and shows his last pride as a human being to the living objects by killing himself. This shows that a person who has lost his humanity is just an object with a beating heart, and the world in which such people live is a disaster. Through John's final decision, Huxley shows us that a world of people without humanity can never be a brave new world and makes us think about what kind of world we should pursue and how we should protect our humanity.

5. Conclusion

In 1958, twenty-seven years after the release of *Brave New World* in 1932, Huxley published *Brave New World Revisited*, an analysis of the themes from *Brave New World*. In the introduction, Huxley warns of the dangers posed by our modern society, saying that what he predicted in 1931 has become a reality sooner than he expected.

> The period of blessing that must come between the nightmare of an overly poor order and overly excessive order has yet to begun, and there is no sign of it even

> starting. In Europe, individuals, both men and women, still enjoy a wide range of freedoms. However, even in the countries that have continued the tradition of democracy, freedom and longing for it seem to be declining. In the rest of the world, there are clear signs that individual freedom has already disappeared or will soon disappear (50)[32].

Although things are less serious than it is in *Brave New World*, people today make babies by deliberately eliminating genetic defects, hire surrogate mothers with money to buy and sell babies like objects in order not to suffer the pain of pregnancy and childbirth, and die like zombies while being given painkillers in nursing homes without getting the chance to have a serious reflection and remorse on life before death. Also, just as how life was determined by the status of their birth in the past, most people now live through harsh days working like machines in offices, factories, and fields. People state the legitimacy of class saying that it is natural for a small number of people with money and power to dominate the majority. Things that are equivalent to the present-day soma, such as cigarettes, alcohol, programs playing on television all day long, music that is played everywhere, as well as classic drugs like opium, methamphetamine, and heroin, and hallucinogens like LSD and Yaba, continue to be produced in different forms and names and are available at any time. There are still crimes so cruel that it is hard to believe that humans could do such things taking place all over the world, and wars where people kill each other because of greed. Also, there is prostitution that exists solely to satisfy sexual desires, deprived of the value of love, sexual exploitation of children, and the provocative sexual plays created through arts, such as films and music[33]. These things show that the people in the present also live like those in *Brave New World*, stripped of humanity and freedom, living without any serious reflection on life, relying on soma to escape from reality. Of course, today's society is enriched by an economy that has developed incomparably better than the past and the people in it enjoy humane lives thanks to the society's state system, social security, and education system. Economic prosperity develops culture and art and enriches people's spirits. Great politicians and social activists all over the world suggest ways that are better for society and humanity. Many scholars, writers, painters, and musicians comfort those who are tired of reality. Moreover, there are more countries where the people elect the people who come to power compared to those that do not.

Then is the world we live in today a civilized world filled with heart-beating objects a savage reservation where John the savage was born and lived? In fact, we are standing somewhere in the middle. Today, we stand at the crossroad of choice, at the midpoint between the civilized world, where people have lost humanity but live in a clean and exciting place which is free from unnecessary emotions, pain, and insecurities according to the class given to them at birth, and the savage reservation, which is the complete opposite of the civilized world, looking at both sides to make a choice. Through *Brave New World*, Huxley asked a question on which direction the human race should pursue to us in the present ninety years ago. Now it is our turn to make a milestone about the direction in which our descendants will head in the future. Should we head to the civilized world or to the savage reservation? We already know the answer.

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An Analysis of the Human Rights Promotion and Public Relations Plan for Beginner Executives of the Korean Army

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Abstract

Purpose: *The purpose of this paper is to examine the major factors influencing the application of junior officers, who are the cornerstone of national security in the era of ultra-low birth rates, the necessary tasks, and directions for improving recruitment and publicity to effectively increase the application rate of junior officers in the future. In particular, since the guarantee of the military's judicial independence, the improvement of treatment for junior officers, and education on a human rights-friendly barracks culture are necessary for the improvement of military human rights, this study aims to conduct research on these matters.*

Method: *As a primary research method, considering the characteristics of the study, the Ministry of National Defense and each branch of the military utilized empirical research data centered on literature reviews—such as relevant academic journals and dissertations—and partial case analyses, along with various policy efforts to increase the ap-plication rate of junior officers. Furthermore, the study of military human rights implemented an interdisciplinary approach that strikes a balance between the unique characteristics of the military as a closed organization and the guarantee of basic rights for soldiers.*

Results: *To devise effective measures to induce applications from junior officers, it is necessary to continuously develop diverse promotional strategies based on a thorough understanding of the applicant group. From this perspective, this study examines the factors influencing the entire decision-making process regarding junior officer service for the applicant group. Furthermore, to enhance combat capabilities by reducing the responsibilities and scope of duties of junior officers, excessive administrative burdens must be drastically reduced.*

Conclusion: *The Ministry of National Defense and each branch of the military must actively seek customized policies and measures despite limited budgets and personnel conditions. To expand applications for junior officers in the era of the Fourth Industrial Revolution and foster a technical military, efforts must be made to further subdivide the applicant group and understand the decision-making processes required for their development. In addition, recruitment promotional activities must be approached more actively and persuasively through salary in-creases, improvements in service conditions, and the use of various online and offline media.*

Keywords: ***Era of Low Birth Rates, Junior Officers, Enhancement of Combat Capabilities, Promotional Activities, Improvement of Service Conditions***

1. Introduction

South Korea is a country with an extremely low birth rate, and our military is facing a difficult environment regarding troop supply. Currently, our military maintains a labor-intensive structure, but if the current trend of an extremely low birth rate continues, it will become impossible to maintain the current troop size, making it difficult to maintain a labor-intensive structure. In other words, because the military structure, which makes up the majority of the members, has been maintained for a long time, the Korean military takes on the characteristics of a labor-intensive force that relies on the combat power of soldiers and a small number of officers [1].

Most of the soldiers who enlist in the military under the conscription system are young men aged 19 to under 24. Young men in South Korea serving in the military face a time when they must perform developmental tasks while serving as soldiers or junior officers[2]. With the recent sharp decline in the youth population, the size of the military workforce has shrunk, making structural difficulties in securing military personnel inevitable. In particular, amidst the implementation of a series of policies to improve the conditions of military service, such as shortening the service period, increasing soldiers' salaries, and improving living conditions in barracks, the relative attractiveness of serving as junior officers (officers and non-commissioned officers) is decreasing due to changes in the job perception of young people and improvements in civilian labor market conditions, and the competition rate for applications is also on the decline[3].

A review of major prior studies on the existing military culture for youth in the military reveals the following. Eo Hye-won (2021) emphasized the need for a conceptual shift regarding the impact of stress on career development among late adolescents in South Korea and the stress management experienced by these youths[4]. Choi Kyung-soon (2015) suggested that group counseling and anger control programs need to be provided to late adolescents in the military to reduce and alleviate stress and depression, as the need for autonomy, emotions related to military organizational control, depression, and stress can be causes of deviant behavior in the military[5].

Seo Mi & Jung Ik-joong et al. (2021) presented appropriate psychological and emotional support measures for youths. They noted that youths in the military need assistance in preparing to overcome controlled military life and establishing career plans, as well as social adaptation programs even after discharge[6]. Cho Seo-young and Kang Young-bae (2022) emphasized that personalized structured learning support is necessary for adolescents to adapt to successful career paths in a knowledge-based society[7]. Additionally, Kim Tae-kyun (2021) pointed out that measures to enhance life values and self-confidence are needed to increase social participation among adolescents[8]. In contrast to these existing studies, this paper aims to analyze the concept of junior managers in the era of ultra-low birth rates and to deeply examine support and development strategies, including an analysis of the actual decline in application rates and promotional measures through media.

2. Concept of Junior Officers and the Decline in Application Rates

According to Article 10, Paragraph 2 of the Basic Military Service Act, soldiers are entitled to have their fundamental rights reasonably restricted for all activities related to the conduct or preparation of war. Accordingly, the fundamental rights of soldiers should be restricted only for the purpose of protecting the lives and property of citizens and safeguarding the existence of the state for the sake of 'national security,' but in reality, this is interpreted and applied broadly. Consequently, junior officers are carrying out unreasonable and absurd orders without receiving adequate compensation[9].

In the dictionary definition of the concept of junior officers, junior officers are members with little military experience and refer to non-commissioned officers of the rank of sergeant or higher, and company-level officers of the rank of captain, who serve in units of battalion level or lower as specified in the military leadership level classification. In the dictionary definition of junior officers, junior officers are members with little military experience and refer to company-level officers of the rank of sergeant or higher, who serve in units of battalion level or lower as specified in the military leadership level classification. In the case of officers, they mainly perform the role of commanders who perform command and supervision and staff roles. In the case of non-commissioned officers, they are responsible for small unit combat command and soldier education. In the case of officers, they mainly perform the role of commanders who perform

command and supervision and staff roles. In the case of non-commissioned officers, they are responsible for small unit combat command and soldier education[10].

Junior officers must support the lower part of the military pyramid structure, which maintains the combat power of the unit and, furthermore, inherits and develops the military's traditions. In addition, as leaders of spearhead units to achieve battlefield superiority, they must be responsible for the operation and management of combat equipment so that they can demonstrate combat power. The military is a hierarchical organization, and when conflicts arise between the interests of its members and organizational goals, the absolute nature of the military's organizational goals usually takes precedence[11].

As the distinction between work and life and the importance of personal life are emphasized, the military is making efforts to improve its work environment and keep pace with society; however, limitations such as unannounced tasks, excessive workloads, and rigid work processing methods and culture persist due to the nature of military operations, unit circumstances, and the requirement for constant readiness. According to a survey of junior officers, they cited "performing unannounced tasks (28.4%)" and "excessive workload (25.3%)" as difficulties encountered during work performance, and the percentage of respondents reporting high levels of fatigue from work performance is gradually increasing compared to the previous year (66.7%). In addition, the satisfaction level with systems for personal and family-centered life, such as 'work-family balance policies,' 'utilization of flexible and flexible work systems,' and 'free use of vacation,' is around 40%, indicating that it is not easy to utilize the systems[12][13].

3. Analysis of Factors Affecting Decision-Making for Junior Officer Applications

Korea's MZ generation prefers direct and immediate rewards. Because of this characteristic, the MZ generation makes and carries out decisions to change jobs more boldly and quickly than any other generation to find a workplace that recognizes their abilities. The MZ generation is a generation that is very sensitive to rewards and is very passionate about self-development to improve their skills. Having grown up in a competitive society, they know that they will be left behind if they do not continuously develop themselves. Therefore, they have a strong tendency not to choose jobs where self-development is impossible. Thus, in order to attract the MZ generation as junior officers, the conditions for self-development in the military must not lag behind those of other jobs[14].

To analyze the decision-making process for junior officer service, the Korea Institute for Defense Analyses conducted a mobile survey of junior officer candidates from April 26 to May 12, 2025. Considering the distribution of each military branch and various commissioning types, the target group included 1,760 officer candidates (ROTC/Bachelor's degree) and 900 non-commissioned officer candidates (Civilian/ROTC), and the data from the responses of a total of 2,669 people were analyzed. First, the survey results regarding when they first became interested in applying for junior officer service and when they made their final decision showed that they first became interested at an average age of 17.5, and the time of their final decision to apply was an average age of 19.3, indicating that they made their final decision to apply for junior officer service at the time of fulfilling their military service <Table 1>[15].

Table 1. Analysis of Influencing Factors in Decision-Making for Junior Officer Applications

Division	Total	Officer	NCO
I want to become mentally and physically strong	4.01	3.99	4.06
I have a desire to contribute to the country	3.99	3.99	4.03

My leadership experience as an executive has helped my growth and development.	3.94	4.01	3.86
Access to living facilities (recreational facilities/accommodation/military commissaries) is available.	3.87	3.76	4.10
You can receive housing support benefits, such as official residences.	3.84	3.70	4.13
High job security	3.82	3.61	4.22
You can receive various welfare benefits (support for clothing and meal expenses, medical support, family support, etc.).	3.79	3.67	4.03
I think experience serving as an officer will help me adapt to civilian life (workplace, etc.).	3.77	3.76	3.84
Retirement age is guaranteed for long-term service	3.74	3.55	4.10
Pension can be received upon long-term service.	3.73	3.58	4.08
Family member's military officer service experience had an influence	3.79	3.86	3.92

Lee SM. Directions for Improving Recruitment Promotion to Increase the Application Rate for Junior Officers. Defense Forum, 26(2), p. 6 (2026).

To increase the application rate for junior officers, the 'media' aspect, such as online content and visual materials, is very important. Currently, the Ministry of National Defense and each military branch are pursuing various measures to strengthen recruitment promotion for junior officers. Considering the limited budget, the Ministry of National Defense is promoting non-budgetary promotional projects in collaboration with relevant ministries, and plans for promotional activities that encompass both online and offline, such as producing promotional videos in collaboration with celebrities like YouTubers, distributing card news and short videos via social media, and operating promotional booths at major job fairs. We must continuously seek ways to present abstract concepts such as national identity or enemy identity through concrete situations and stories using visual storytelling, empathy-based model learning, and immersive content, thereby inducing empathy and encouraging participation[16].

By utilizing advanced technology in the era of the Fourth Industrial Revolution, each military branch is implementing various measures such as strengthening online and offline promotion, collaborating with the Military Manpower Administration, and enhancing the professionalism of recruitment promotion officers. This plays an important role in inducing the application rate for junior officers. The use of media utilizing simulation techniques with the latest devices can increase the immersion of young people and increase the importance of mental strength through virtual combat field experiences using immersive content. In practice, the use of media for promotion regarding the improvement of service conditions for junior officers must be actively utilized. A systematic approach is required regarding how to promote the differences in responsibilities and duties between soldiers and junior officers[17].

To elaborate, as of 2026, based on the rank of Sergeant, there is not a significant difference in salary between enlisted soldiers and junior officers such as Staff Sergeants and Second Lieutenants. Some choose to become officers, entrusting them with responsibility and duty, while others choose to serve as enlisted soldiers, experiencing relatively less responsibility and duty. If this situation persists without change, applications for junior officer positions will decline, and the justification for choosing this role will be lost. Consequently, salary increases and publicity regarding them will play the most crucial role in incentivizing junior officer positions. Currently, because officers in our military are not designated as operational civil servants, they do not receive fair compensation even though they work the same hours as police officers or firefighters. Therefore, this is considered an urgent task that must be addressed under the leadership of the Ministry of National Defense from a legal perspective.

4. Key Tasks for Expanding the Application Rate of Junior Officers

First, administrative simplification is necessary. Our military has been pursuing improvements to its administrative and bureaucratic culture on multiple occasions. However, administrative simplification has not been implemented due to the pressure of excessive pending tasks. To enable members to focus on their core duties as soldiers through practical administrative simplification, efforts are required to boldly eliminate unnecessary regulations, assess administrative efficiency, and reduce unnecessary administrative tasks. It is absolutely essential to communicate with the leadership the administrative simplification measures perceived by members of the MZ generation and to actively reflect them. We must find ways to reduce the responsibilities and scope of duties for junior officers. In particular, junior officers perform the mission of operating actual combat elements in the spearhead units of each military branch. In this sense, it is necessary to drastically reduce the administrative burden on junior officers so that they can focus on combat. Enabling junior officers to concentrate on combat elements means that the combat capabilities of our military will be enhanced.

Second, conditions must be provided for junior officers to grow. It was assessed that the current conditions for junior officers to grow are insufficient. The military must become an organization where its members can grow. Increasingly, the military is demanding professionalism and integrated operational capabilities even from small unit commanders. Absolute time and resources must be allocated to junior officers to grow through their military service. There are countless officers who are discharged without possessing any qualifications that are recognized as career experience in society outside of their military service. To provide conditions for junior officers to grow, it will be necessary to equally grant all officers the opportunity for commissioned officer training for 25% of their military service period. Alternatively, for officers who do not wish to receive commissioned officer training, it is necessary to consider paying them an amount equivalent to the tuition as a salary[18][19].

Table 2. Analysis of Contact & Influence of Junior Officer Recruitment Promotion

Division	Contact rate (%)	Influence	Total			
			Officer		NCO	
			Contact rate(%)	Influence	Contact rate(%)	Influence
Official homepage of each military	69.4	3.45	70.5	3.35	67.22	3.65
Official YouTube channels of each military branch	66.64	3.45	68.73	3.34	62.56	3.71
Each military's official SNS	64.7	3.41	67.21	3.3	59.78	3.66
Online advertising (YouTube, Naver)	57.39	3.35	59.01	3.21	54.56	3.62
School visit information session	53.67	3.51	54.35	3.35	52.33	3.82
Military manpower administration website	50.13	3.09	50.25	2.86	49.89	3.55
Advertising for multi-use facilities (posters & banners)	48.85	3.08	52.13	2.93	42.44	3.42
Promotion through events/job fairs	45.72	3.25	47.57	3.06	42.11	3.68

Unit public event	44.14	3.07	48.28	2.85	36	3.55
Recruiting office	32.58	2.8	36.33	2.53	25.22	3.55
On-campus ROTC promotional activities (ROTC)	-	-	66	3.81	80.8	4.0

Lee SM. p. 7 (2026).

Third, it is necessary to examine the unreasonable command measures taken by commanders against junior officers. When serving as a junior officer, one faces the fear of unreasonable command measures taken by commanders. One of the reasons why young people today are reluctant to enlist in the military as officers is that they feel a sense of aversion to the fact that they must follow the commanders' command measures without being able to refuse. Ultimately, it is a structure that inevitably forces officers to work for 'passion pay.' To prevent such situations from occurring, the military must either prepare to pay for the commanders' command measures or be able to restrict the commanders to only the command measures that are absolutely necessary[20].

Fourth, promotional media, such as online and offline recruitment, must be strengthened. Every semester, active promotional activities centered on the campus are being conducted for ROTC officer and non-commissioned officer candidates, and these efforts are proving to be quite effective. Through direct face-to-face contact with applicants, ROTC candidates contribute significantly to stimulating their concerns and motivations for applying. At a time when university students and young adults are contemplating their career paths, face-to-face promotion utilizing the familiar setting of the campus and trustworthy peer mentors is highly persuasive. In addition, direct school visit information sessions contribute to building a genuine consensus by focusing on story-based, case-centered explanations rather than simply providing information on the system. In this regard, incentives such as human and material support should be provided to encourage young people's interest in applying for junior leadership positions and to provide information and management that leads their initial interest to final application through follow-up counseling and information provision <Table 2>[21][22].

5. Conclusion

This study explored the challenges and measures to expand the enlistment of the MZ generation—who have not yet served in the military in the era of low birth rates—into junior officers, and examined ways to expand support through the improvement of service conditions. As South Korea is a nation with an ultra-low birth rate, our military is also facing an environment where troop supply is difficult. As previously emphasized, our military currently maintains a labor-intensive structure; however, if the current trend of ultra-low birth rates continues, it will become impossible to maintain the current troop size, making it difficult to sustain this labor-intensive structure any longer. It is projected that maintaining a force of 400,000 will be impossible after 2035.

Moreover, the difficulty of recruiting junior officers targeting the MZ generation, who are the cornerstone of national security in the era of the Fourth Industrial Revolution, is not merely a matter of personnel recruitment, but a critical task directly linked to the sustainability of future military personnel policies. To increase the application rate for junior officers, the military, led by the Ministry of National Defense, must recognize that one of the biggest reasons young people do not choose the military as an officer is its organizational culture. Therefore, significant efforts must be made to improve the organizational culture. Of course, various promotional

strategies and institutional efforts are currently being implemented to increase the application rate for junior officers. However, it is necessary to fully understand the decision-making process of applicants and listen to their diverse opinions to improve the complex conditions they require. We must continuously explore the major factors that significantly influence young people's application for junior officers and ways to reflect their direct and indirect opinions in the decision-making process[23].

It should also be noted that the factors influencing the motivations for applying for junior officer positions differ. In reality, most officer candidates prioritize leadership and opportunities for self-growth. On the other hand, non-commissioned officer candidates tend to place importance on job security through tangible welfare benefits and opportunities for long-term service. What they share is the goal of establishing a plan for their own growth and security regarding an uncertain future during their service as junior officers, which significantly impacts their career choices after discharge. Consequently, while there are differences in the motivations of MZ generation youths for applying to junior officer positions, they share a common consensus regarding salary increases, improved service conditions, and various educational programs and systems related to future career choices. Considering these aspects, the Ministry of National Defense and the military are required to make continuous efforts to ensure that these points are appropriately reflected in the use of promotional media.

To emphasize, the difficulty of recruiting MZ generation beginner executives, the cornerstone of national security in preparation for future wars in the era of the 4th industrial revolution, is not a simple matter of recruiting manpower. Overall, the decrease in human resources of beginner executives is an important issue that is directly related to the development of strong forces, combat power, and the quality of executives. Efforts to improve the treatment of junior executives and implement policies are considered essential measures to prevent the expansion and departure of executives that form the basis of national security in the era of a rapid population decline and to support an 'elaborated workforce structure.' Therefore, the decline in support for beginner executives should be recognized as a crisis factor that greatly affects combat power and national security, and the Ministry of National Defense and the Korean military should continue to pay attention and seek solutions in terms of institutional and military culture.

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The Effects of SNS Beauty Content Attributes on Consumer Protection Empathy and Human-Centered New Consumption Behavior

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Abstract

Purpose: *This study aims to empirically examine the effects of SNS beauty content attributes on consumer protection empathy and human-centered new consumption behavior. To this end, SNS beauty content attributes were classified into the expertise of information providers, information reliability, information quality, and information accuracy. This study then analyzed how these factors influence consumer protection empathy and human-centered new consumption behavior.*

Methods*: To this end, an online survey was conducted among women in their 20s who had experience watching SNS beauty content, and a total of 575 valid responses were used for the final analysis. The measurement instrument was developed to reflect the sub-factors of SNS beauty content attributes, consumer protection empathy, and human-centered new consumption behavior. The collected data were analyzed using SPSS 29.0, and frequency analysis, factor analysis, reliability analysis, correlation analysis, and multiple regression analysis were conducted.*

Results: *The results showed that SNS beauty content attributes consisted of four factors: expertise of information providers, information reliability, information quality, and information accuracy. Consumer protection empathy was composed of content empathy, empathy with emotional atmosphere, and empathy with situation and content creators. Human-centered new consumption behavior was found to consist of five factors: luxury consumption, green consumption, limited-edition consumption, small luxury consumption, and group-buying consumption. The analysis revealed that SNS beauty content attributes had a significant effect on consumer protection empathy. In particular, information reliability and information quality were identified as important factors in forming consumer protection empathy. In addition, SNS beauty content attributes had partially significant effects on green consumption, small luxury consumption, and group-buying consumption among the sub-factors of human-centered new consumption behavior.*

Conclusion: *These findings indicate that SNS beauty content functions not merely as a means of information delivery but also as an important medium that influences consumers' emotional responses and value-oriented consumption behavior. Therefore, the beauty industry needs to provide highly reliable information and high-quality content that can encourage consumer protection empathy. This study is meaningful in that it provides basic data for understanding the relationship among SNS beauty content, consumer responses, and human-centered new consumption behavior.*

Keywords: ***20's Women, SNS Beauty Content Attributes, Customer Protection Empathy, Human-Centered, New Consumption Behavior***

1. Introduction

The development of information and communication technology and the widespread use of

*This paper is a revised and expanded version of Chaehyun Lee's 2025 doctoral dissertation at Sungshin Women's University entitled "The Effects of SNS Beauty Content Attributes on New Consumption Behavior according to Consumer Empathy and Immersion among Generation Z".

smartphones have brought significant changes to the media environment and consumer behavior. In particular, social networking services(SNS) have become representative digital platforms through which individuals can share information and produce and disseminate various types of content[1][2]. As a result, consumers no longer function merely as passive recipients of information but as active participants who select, interpret, and share content.

Within these changes, beauty content has emerged as one of the most actively consumed types of content on SNS. Beauty content provides information related to personal appearance, including makeup, skin care, and hair care[3]. More recently, it has functioned as a major source of information by delivering product information, user reviews, ingredients, efficacy, and purchase experiences[4]. In addition, by using images, videos, and storytelling, beauty content induces consumers' sensory responses and emotional immersion, thereby becoming an important medium that influences consumers' cognitive judgment and consumption behavior[5][6].

However, because SNS content spreads rapidly and is often distributed by individual content creators, consumers' judgment regarding the reliability, accuracy, and expertise of information is important[7][8]. In particular, since beauty products are applied directly to the skin and body, inaccurate information or exaggerated expressions may cause consumers to misunderstand product efficacy or make inappropriate purchase decisions[9][10]. Therefore, it is necessary to examine SNS beauty content from the perspective of consumer protection.

Meanwhile, since COVID-19, changes in consumers' lifestyles and consumption values have expanded consumption behavior that emphasizes experiential value, emotional satisfaction, and symbolic meaning[11]. Modern consumption behavior has extended beyond simple purchasing to include emotional elements such as symbolism, aesthetics, and entertainment[12]. New consumption behaviors, such as luxury consumption, green consumption, group-buying consumption, small luxury consumption, and limited-edition consumption, have attracted attention as consumption types that reflect consumers' emotional and experiential values as well as their desire for self-realization[13].

In this context, consumer protection empathy can be regarded as an important psychological factor connecting SNS beauty content and human-centered new consumption behavior. In this study, consumer protection empathy is understood as a psychological response in which consumers feel that they can make safe and rational consumption decisions based on the reliability, accuracy, usefulness of information, and the attitude of content creators when encountering SNS beauty content[14]. In addition, human-centered new consumption behavior can be viewed as consumption behavior that goes beyond the simple act of purchasing products and reflects consumers' values, emotions, desire for self-expression, environmental awareness, and sense of social responsibility[15][16][17].

Previous studies have often examined the relationships among SNS content characteristics, consumer empathy, and consumption behavior separately. However, relatively few studies have comprehensively investigated the effects of SNS beauty content attributes on consumer protection empathy and human-centered new consumption behavior. Therefore, this study aims to empirically analyze the effects of SNS beauty content attributes on consumer protection empathy and human-centered new consumption behavior and to provide basic data for understanding safe and rational consumption behavior in the digital beauty content environment.

2. Theoretical Background

2.1 SNS Beauty Content Attributes

Social Network Service(SNS) is understood as an open platform that enables users to form, maintain, and expand relationships with others online, thereby contributing to the formation

of new social connections and the strengthening of existing relationships[1]. Boyd and Ellison(2007) described SNS as a space where individuals create profiles and content, build relationships with other users, and share experiences through information exchange and communication[2]. Ross et al.(2008) viewed SNS as a new communication tool that enables group formation and the expansion of influence through the Internet[18].

Recently, content marketing has been actively developed around SNS platforms. Although the term “content” originally referred to the contents or table of contents of a document, it has recently come to mean information itself delivered through communication networks[19]. It is also understood as an expressive product that combines text, sound, video, and images[20]. In this context, beauty content refers to content that professionally provides information related to personal beauty, such as makeup, skin care, and hair care[3]. It also functions as a major channel through which consumers can obtain in-depth and specialized information on beauty-related products, techniques, and usage methods[5].

Therefore, SNS beauty content can be defined as various types of information and expressive materials related to personal beauty provided through SNS platforms. It can be regarded as important content that provides consumers with specialized information and influences their purchase behavior.

2.2 Consumer Empathy and Consumer Protection Empathy

Recently, in the field of marketing, consumer empathy has attracted attention as an important psychological mechanism for explaining consumer attitudes and behaviors. Consumer empathy is understood as a continuous process of emotional responses that consumers show toward specific marketing stimuli[21], and it is also described as a dynamic process in which individuals accept and become immersed in others’ experiences or emotions from their own perspective. In this sense, consumer empathy can be regarded as an attitude in which consumers understand the situations and emotions presented in content, accept them as if they were their own experiences, and respond accordingly[22][23].

In this study, the concept of consumer empathy is extended from the perspective of consumer protection in the digital consumption environment and discussed as consumer protection empathy. Consumer protection empathy can be understood as an attitude in which consumers emotionally and cognitively judge and respond to whether information related to products or services helps protect their rights and interests, supports safe consumption, and enables rational choices[24][25][26].

In particular, SNS beauty content functions as a major information medium that provides product ingredients, efficacy, usage methods, reviews, and purchase information. However, since SNS content is characterized by rapid dissemination centered on individual creators, consumers decide whether to accept the information based on the reliability, accuracy, and expertise of the content[7][14]. In addition, because beauty products are applied directly to the skin and body, related information has a significant impact on consumer safety and rational decision-making. Therefore, when consumers perceive that SNS beauty content helps protect their consumer rights and interests and supports safe choices, they may form positive empathetic responses toward the content[27][28]. Accordingly, in this study, consumer protection empathy is defined as a psychological response in which consumers perceive the authenticity, usefulness, emotional persuasiveness of information, and relationality with content creators through SNS beauty content, and feel that safe and rational consumption is possible based on these perceptions.

2.3 Human-centered New Consumption Behavior

In modern society, consumption behavior has changed beyond functional utility into a process of meaning-making and communication that satisfies emotional needs such as symbolism, entertainment, and aesthetics[12]. Holbrook and Hirschman(1982) argued that consumption should be understood from experiential aspects such as fantasies, feelings, and fun, while Pine[29], and Gilmore (1998) explained that consumers in the modern economy place greater emphasis on experiential value than on simple products or services[30].

In particular, the changes in lifestyles and values following the COVID-19 pandemic have provided an opportunity to reconstruct the purpose and meaning of consumption[31]. Consumers have come to consider value-oriented factors such as health, safety, eco-friendliness, and naturally derived ingredients[32][33][34]. Accordingly, in the selection of beauty products, health, safety, and environmental values have emerged as important criteria beyond the simple pursuit of beauty. In addition, experiential value, emotional satisfaction, and differentiated meaning obtained through consumption are also regarded as important considerations[29][30].

In this context, new consumption behavior can be viewed as a consumption pattern that combines consumers' emotional and experiential values with social meaning, going beyond simple purchasing behavior. Choi (2019) presented luxury consumption, green consumption, group-buying consumption, small luxury consumption, and limited-edition consumption as representative types of new consumption that emerge in response to social change[35]. Kim (2021) also addressed these types as components of new consumption behavior in the context of cosmetics consumption[13].

In this study, the concept of existing new consumption behavior is reconstructed from the perspectives of the digital beauty consumption environment and consumer protection and is discussed as "human-centered new consumption behavior." Human-centered new consumption behavior refers to consumption behavior that reflects individual values, emotions, self-expression, environmental awareness, and community-based judgment beyond the fulfillment of consumers' functional needs. This concept reflects the idea that beauty product consumption is not limited to simple purchasing or the pursuit of external beauty, but is connected to consumers' safe choices, rational judgment, and value-oriented consumption.

In other words, luxury consumption is a consumption behavior that reflects self-expression and symbolic meaning[36]. Green consumption is a value-oriented consumption behavior that considers environmental awareness and social responsibility[37][38]. Limited-edition consumption can be understood as consumption behavior that pursues scarcity and differentiation, while small luxury consumption can be understood as consumption behavior for emotional satisfaction and self-reward[39][40]. In addition, group-buying consumption can be viewed as consumption behavior based on information sharing and relationship-based judgment in online or SNS environments[41].

3. Research Method and Procedures

3.1 Sample Selection and Data Collection

This study aimed to examine the effects of beauty content attributes on consumer protection empathy and human-centered new consumption behavior among women in their 20s. Accordingly, the following research questions were established, and a total of 575 responses were selected as valid samples for the final analysis.

The variables used in this study included the independent variables of the expertise of information providers, information quality, information reliability, and information accuracy. The dependent variables included empathy with emotional atmosphere, content empathy, empathy with situation and content creators, luxury consumption, green consumption, limited-edition

consumption, group-buying consumption, and small luxury consumption. The questionnaire consisted of items related to SNS beauty content attributes, consumer protection empathy, human-centered new consumption behavior, and demographic variables, comprising a total of 49 items.

The measurement items for SNS beauty content attributes were composed of 15 items based on the studies of Kim et al. (2012) and Park (2020)[42][43]. The measurement items for consumer protection empathy were composed of 13 items based on the studies of Davis (1980), Hoffman (1987), and Kim (2020)[44][45][46]. In addition, the items related to human-centered new consumption behavior were composed of 18 items based on the studies of Yoo (1993), Shin (2010), Park and Wang (2013) and Kim (2020)[13][47][48][49].

SPSS 29.0 was used for data analysis in this study. To identify the demographic characteristics of the research participants, frequency, percentage, and mean values were calculated. Pearson's correlation analysis was conducted to examine the relationships among SNS beauty content attributes, consumer protection empathy, and human-centered new consumption behavior. In addition, stepwise multiple regression analysis was conducted to verify the relationships among demographic variables, SNS beauty content attributes, consumer protection empathy, and human-centered new consumption behavior. The significance level for all analyses was set at $\alpha = .05$.

3.2 Research Questions

This study aims to examine the effects of SNS beauty content attributes among women in their 20s on consumer protection empathy and human-centered new consumption behavior. The specific research questions are as follows.

Research Question 1. This study examines the general characteristics of the participants.

Research Question 2. This study conducts factor analysis and reliability analysis of SNS beauty content attributes, consumer protection empathy, and human-centered new consumption behavior.

Research Question 3. This study examines the causal relationships among the verified variables through correlation analysis of SNS beauty content attributes, consumer protection empathy, and human-centered new consumption behavior.

Research Question 4. This study examines the effects of SNS beauty content attributes on consumer protection empathy.

Research Question 5. This study examines the effects of SNS beauty content attributes on human-centered new consumption behavior.

4. Research Results

4.1 Demographic Characteristics of the Study Subjects

The detailed characteristics of the sample were as follows. In terms of age, participants aged 20 to 24 accounted for the largest proportion at 53.7%, while those aged 25 to 29 accounted for 46.3%. Regarding average monthly income, 35.1% of the participants earned less than 1 million KRW, and 35.7% earned between 2 million and less than 3 million KRW, together accounting for more than half of the sample. In addition, 19.0% earned between 1 million and less than 2 million KRW, while 10.3% earned 3 million KRW or more. In terms of educational background, the largest proportion of participants were enrolled in or had graduated from university, accounting for 84.3%. This was followed by those enrolled in or graduated from high school at

11.0%, and those enrolled in or graduated from graduate school, including master's and doctoral programs, at 4.7%.

4.2 Factor Analysis and Reliability Analysis

To verify the validity of the measurement items used in this study and to identify common factors for use as variables, exploratory factor analysis was conducted using SPSS 29.0. Through reliability analysis and the scale refinement process, several items were removed from the measurement variables, including two items related to SNS beauty content attributes, two items related to consumer protection empathy, and two items related to human-centered new consumption behavior. Principal component analysis was conducted to extract component factors for all measurement variables, and the varimax orthogonal rotation method was adopted to simplify factor loadings. Factor loadings of 0.5 or higher were considered significant.

For the independent variable, SNS beauty content attributes, the cumulative explanatory power was 68.197%. The overall reliability coefficient, Cronbach's α, was 0.881, and the reliability coefficients of each factor were all 0.629 or higher. Four factors were extracted: expertise of information providers (18.319%), information reliability (18.127%), information quality (16.492%), and information accuracy (15.259%) (see <Table 1>).

Table 1. Factor Analysis Results for SNS Beauty Content Attributes

Item		Factor				Communality
		1	2	3	4	
Provider Expertise	The provider of beauty content is perceived to have extensive experience related to the information delivered.	.799	.059	.175	.150	.695
	The provider of beauty content is perceived to be skilled in relation to the information delivered.	.786	.285	.188	.103	.745
	The provider of beauty content is perceived to have competence regarding the information delivered.	.666	.351	.204	.000	.608
	The provider of beauty content is perceived to have expertise regarding the information delivered.	.592	.156	.086	.462	.595
Information Reliability	The provider of beauty content is trustworthy.	.291	.762	.220	.111	.726
	The provider of beauty content is honest.	.294	.760	.115	.148	.700
	The information delivered in beauty content is truthful.	.052	.618	.120	.562	.714
	The information delivered in beauty content is reliable.	.180	.554	.222	.460	.600
Information Quality	The information delivered through beauty content is perceived to be useful.	.164	.169	.814	.111	.730
	The information delivered through beauty content is perceived to be helpful.	.214	.044	.814	.111	.722
	The information delivered through beauty content is perceived to be valuable.	.120	.222	.732	.151	.623
Information Accuracy	The source of information in beauty content can be clearly identified.	.170	.046	.175	.816	.728

	The information provided in beauty content is accurate.	.098	.441	.111	.680	.679
Eigenvalue		2.381	2.356	2.144	1.984	
Variance (%)		18.319	18.127	16.492	15.259	
Cumulative(%)		18.319	36.446	52.938	68.197	
Reliability (Cronbach's α)		.791	.841	.768	.629	
Overall Reliability		.881				
KMO and Bartlett's Test		KMO=.895, χ2=2,966.402 p<.000				

The factor analysis results for the dependent variable, consumer protection empathy, showed that the cumulative explanatory power was 62.517%. The overall reliability coefficient, Cronbach's α, was 0.784, and the reliability coefficients of each factor were all 0.669 or higher. Three factors were extracted: content empathy (29.176%), empathy with emotional atmosphere (19.786%), and empathy with situation and content creators (13.554%).

The factor analysis results for human-centered new consumption behavior showed that the cumulative explanatory power was 67.471%. The overall reliability coefficient, Cronbach's α, was 0.828, and the reliability coefficients of each factor were all 0.651 or higher. Five factors were extracted: luxury consumption (16.757%), green consumption (16.589%), limited-edition consumption (13.100%), small luxury consumption (10.970%), and group-buying consumption (10.054%) (see <Table 2> and <Table 3>).

Table 2. Factor Analysis Results for Consumer Protection Empathy

Item		Factor			Communality
		1	2	3	
Content Empathy	When I watch beauty content, I feel as if I am actually at the place shown in the content.	.855	-.069	.168	.764
	When I watch beauty content, I feel as if I am reliving past experiences.	.807	-.018	.162	.678
	Beauty content helps me forget reality.	.772	-.104	.102	.618
	When I watch beauty content, I feel as if the person in the content represents me.	.732	-.005	.189	.572
	I empathize with emotionally appealing beauty content.	.690	.244	.044	.538
Emotional Atmosphere Empathy	I empathize with informative/useful beauty content.	-.131	.752	.056	.586
	I empathize with beauty content that contains attractive information.	.179	.708	.086	.541
	I empathize with beauty content that contains interesting/fun information.	.150	.708	.144	.545
	I empathize with beauty content that contains the information I want.	-.186	.693	.080	.521
Situational and Poster Empathy	I understand well the situations presented in beauty content.	.141	.141	.870	.798
	I understand well the emotions that the people appearing in beauty content may have felt.	.302	.180	.770	.717

Eigenvalue	3.209	2.176	1.491	
Variance (%)	29.176	19.786	13.554	
Cumulative (%)	29.176	**48.963**	**62.517**	
Reliability (Cronbach's α)	.848	.696	.669	
Overall Reliability	.784			
KMO and Bartlett's Test	KMO=.815, χ^2=2,079.640 p<.000			

Table 3. Factor Analysis Results for Human-Centered New Consumption Behavior

Item		Factor					Communality
		1	2	3	4	5	
Luxury Consumption	I sometimes purchase well-known branded beauty products to show myself off to others.	.812	.137	.164	.130	.010	.723
	When purchasing beauty products, I tend to choose well-known brands.	.767	.111	.063	.043	.043	.608
	I want to express my image through symbolic beauty products.	.743	.142	.165	.040	.035	.603
	I feel good when I purchase well-known branded beauty products.	.711	.032	.064	.191	.121	.562
Green Consumption	I consciously try to purchase eco-friendly beauty products, considering environmental pollution.	.214	.813	.020	-.045	.029	.710
	If a beauty product is environmentally friendly, I am willing to purchase it even if it is relatively expensive.	.132	.805	.077	.098	-.067	.686
	I am willing to replace existing products with eco-friendly beauty products.	.089	.797	.106	.173	.006	.684
	When purchasing beauty products, I try to buy refill products with environmental concerns in mind.	.008	.764	.156	-.014	.092	.617
Limited-Edition Consumption	I sometimes make purchases impulsively because I feel it may be difficult to buy later if I miss the opportunity.	.155	.043	.879	.064	.083	.809
	I feel the need to purchase when I think it will be difficult to buy the product under the same conditions after the available quantity is sold out.	.070	.214	.776	.075	.105	.669
	I feel the need to purchase beauty products quickly when I think they may sell out.	.185	.082	.746	.148	.099	.629
Small Indulgence Consumption	If I find it meaningful, I sometimes spend boldly.	-.049	.039	.126	.833	.057	.717
	I enjoy small luxuries within my means to comfort myself and pursue self-satisfaction.	.218	.055	.094	.735	.124	.615

	Even if they are expensive, I tend to purchase one or two beauty products that provide a satisfying feeling.	.414	.117	.063	.598	.092	.555
Group-Purchase Consumption	I tend to purchase beauty products that are highly recommended within the community.	.043	.031	.142	.061	.884	.808
	I am interested in and want to purchase beauty products that are highly recommended within the community.	.132	.012	.110	.169	.860	.799
Eigenvalue		2.681	2.654	2.096	1.755	1.609	
Variance(%)		16.757	16.589	13.100	10.970	10.054	
Cumulative(%)		16.757	33.347	46.447	57.417	67.471	
Reliability (Cronbach's α)		.800	.824	.780	.651	.751	
Overall Reliability		.828					
KMO and Bartlett's Test		KMO=.806, $\chi 2$=3,076.559 p<.000					

4.3 Correlation Analysis

The results of the correlation analysis showed that SNS beauty content attributes generally had significant positive correlations with consumer protection empathy and human-centered new consumption behavior. In particular, information reliability showed significant relationships with all sub-factors of consumer protection empathy, while information quality showed significant correlations with some factors of human-centered new consumption behavior. In addition, consumer protection empathy generally showed significant positive correlations with human-centered new consumption behavior, confirming the relationships among SNS beauty content attributes, consumer responses, and consumption behavior (see <Table 4>).

Table 4. Results of the Correlation Analysis

		Mean	Standard deviation	SNS Beauty Content Attributes				Consumer Protection Empathy			Human-Centered New Consumption Behavior				
				Provider Expertise	Information Reliability	Information Quality	Information Accuracy	Content Empathy	Emotional Atmosphere Empathy	Situational and Poster Empathy	Luxury Consumption	Green Consumption	Limited-Edition Consumption	Small Indulgence Consumption	Group Purchase Consumption
SNS Beauty Content Attributes	Provider Expertise	3.540	0.639	**1**											
	Information Reliability	3.170	0.598	.587***	1										
	Information Quality	3.944	0.551	.463***	.457***	1									
	Information Accuracy	3.203	0.747	.436***	.618***	.365***	1								
Consumer Protection Empathy	Content Empathy	2.609	0.845	.255***	.406***	.095*	.348***	1							
	Emotional Atmosphere Empathy	3.944	0.503	.356***	.337***	.500***	.217***	.044	**1**						
	Situational and Poster Empathy	3.270	0.743	.248***	.365***	.271***	.271***	.415***	.302***	1					
Human-Centered New Consumption Behavior	Luxury Consumption	3.091	0.884	.148***	.169***	.106*	.147***	.372***	.127**	.263***	1				
	Green Consumption	3.103	0.847	.122**	.235***	.004	.151***	.327***	**.033**	.255***	.291***	1			
	Limited-Edition Consumption	3.325	0.873	.148***	.170***	.103*	.124**	.270***	.147***	.231***	.334***	.267***	1		
	Small Indulgence Consumption	3.680	0.715	.181***	.130**	.259**	.082*	.073	.299***	.209***	.400***	.200***	.295***	1	
	Group Purchase Consumption	3.685	0.765	.263***	.219***	.268***	.200***	.111**	.282***	.224***	.193***	.078	.280***	.275***	1

* p<.05 ** p<.01 *** p<.001.

4.4 The Effects of SNS Beauty Content Attributes on Consumer Protection Empathy

To examine the effects of SNS beauty content attributes on consumer protection empathy, multiple regression analysis was conducted. The results showed that the influential factors differed depending on the type of empathy; however, information reliability and information quality were generally identified as important variables.

For content empathy, information reliability and information accuracy had significant positive effects, with information reliability showing the strongest influence. In contrast, information quality had a negative effect, indicating that an excessively high level of information provision may rather hinder consumer protection empathy.

For empathy with emotional atmosphere, information quality was found to have the strongest positive effect. The expertise of information providers and information reliability also had significant effects. This suggests that the completeness of content and the trustworthiness of information providers play important roles in forming emotional empathy. Lastly, for empathy with situation and content creators, information reliability had the strongest positive effect, while information quality was also found to have a partially significant effect.

These results indicate that information reliability consistently functions as an important influential factor across all types of empathy, whereas information quality has different effects depending on the type of empathy. In particular, when the level of information is too high or excessive, it may hinder the formation of empathy, suggesting the need to adjust the appropriate level of information when constructing content. The results are presented in <Table 5>.

Table 5. The Effects of SNS Beauty Content Attributes on Consumer Protection Empathy

Dependent variable	Independent variable	B	SE	*β*	*t*	*p*
Content Empathy	Provider Expertise	.066	.064	.050	1.033	.302
	Information Reliability	.476	.077	.337	6.187	.000***
	Information Quality	-.222	.068	-.145	-3.286	.001***
	Information Accuracy	.194	.055	.171	3.550	.000***
R^2=.195 adj. R^2=.190 F=34.607 ***						
Emotional Atmosphere Empathy	Provider Expertise	.098	.036	.125	2.720	.007**
	Information Reliability	.091	.043	.108	2.100	.036*
	Information Quality	.376	.038	.412	9.855	.000***
	Information Accuracy	-.037	.031	-.054	-1.188	.235
R^2=.275 adj. R^2=.270 F=54.090 ***						
Situational and Poster Empathy	Provider Expertise	.009	.058	.008	.164	.870
	Information Reliability	.333	.070	.268	4.790	.000***
	Information Quality	.168	.061	.124	2.746	.006**
	Information Accuracy	.057	.049	.057	1.145	.253
R^2=.149 adj. R^2=.143 F=24.954 ***						

*p<.05,**p<.01,***p<.001.

4.5 The Effects of SNS Beauty Content Attributes on Human-centered New Consumption Behavior

To examine the effects of SNS beauty content attributes on human-centered new consumption behavior, multiple regression analysis was conducted. The results showed that, overall, the influence of content attribute factors on human-centered new consumption behavior was limited.

For green consumption, information reliability was found to be a major factor with a significant positive effect, whereas information quality had a negative effect. This indicates that reliable information promotes eco-friendly consumption, while an excessively high level of information may rather hinder consumption.

For small luxury consumption, information quality had a significant positive effect. In group-buying consumption, information quality was also identified as the most important influential factor. In addition, the expertise of information providers had a significant positive effect.

These findings suggest that SNS beauty content attributes partially influence certain types of human-centered new consumption behavior, namely green consumption, small luxury consumption, and group-buying consumption. However, overall, the direct influence of attributes other than information quality was found to be limited. This indicates that even though beauty content is widely exposed to consumers, there are limitations in extending it to human-centered new consumption behavior that reflects individual values and identity. The results are presented in <Table 6>.

Table 6. The Effects of SNS Beauty Content Attributes on Human-Centered New Consumption Behavior

Dependenet variable	Independent variable	B	SE	*β*	*t*	*p*
luxury consumption	Provider Expertise	.089	.073	.064	1.216	.224
	Information Reliability	.129	.088	.087	1.463	.144
	Information Quality	.022	.077	.014	.290	.772
	Information Accuracy	.071	.063	.060	1.139	.255
	R^2=.035 adj. R^2=.028 *F=5.114* ***					
green consumption	Provider Expertise	.018	.069	.014	.261	.794
	Information Reliability	.386	.083	.272	4.648	.000***
	Information Quality	-.210	.073	-.136	-2.873	.004**
	Information Accuracy	.031	.059	.027	.522	.602
	R^2=.069 adj. R^2=.062 *F=10.559* ***					
limited edition consumption	Provider Expertise	.091	.073	.067	1.259	.209
	Information Reliability	.164	.087	.112	1.882	.060
	Information Quality	.021	.077	.013	.275	.784
	Information Accuracy	.024	.062	.020	.382	.703
	R^2=.033 adj. R^2=.026 *F=4.836* ***					

small luxury consumption	Provider Expertise	.107	.058	.095	1.834	.067
	Information Reliability	-.009	.070	-.007	-.128	.898
	Information Quality	.302	.061	.233	4.926	.000***
	Information Accuracy	-.038	.050	-.040	-.773	.440
	R^2=.073 adj. R^2=.067 *F=11.284* ***					
group buying consumption	Provider Expertise	.178	.061	.148	2.899	.004**
	Information Reliability	.018	.074	.014	.247	.805
	Information Quality	.235	.065	.169	3.629	.000***
	Information Accuracy	.066	.052	.065	1.270	.204
	R^2=.100 adj. R^2=.094 *F=15.919* ***					

**p<.01, ***p<.001

5. Conclusion and Recommendations

This study aimed to empirically examine the effects of SNS beauty content attributes on consumer protection empathy and human-centered new consumption behavior among women in their 20s. The results of the study are as follows.

First, the analysis of general characteristics showed that participants aged 20 to 24 accounted for the largest proportion. In terms of average monthly income, those earning less than 1 million KRW and those earning between 2 million and less than 3 million KRW accounted for more than half of the sample. Regarding educational background, the largest proportion of participants were enrolled in or had graduated from university.

Second, the results of factor analysis and reliability analysis of SNS beauty content attributes, consumer protection empathy, and human-centered new consumption behavior showed that all variables had sufficient validity and reliability.

Third, the analysis of the effects of SNS beauty content attributes on consumer protection empathy showed that information reliability and information accuracy had significant positive effects on content empathy, while information quality had a negative effect. The expertise of information providers, information reliability, and information quality had significant positive effects on empathy with emotional atmosphere. In addition, information reliability and information quality had significant positive effects on empathy with situation and content creators.

Fourth, the analysis of the effects of SNS beauty content attributes on human-centered new consumption behavior showed that there were no significant direct effects on luxury consumption and limited-edition consumption. In contrast, information reliability had a significant positive effect on green consumption, while information quality had a negative effect. Information quality had significant positive effects on small luxury consumption and group-buying consumption. In addition, the expertise of information providers was also found to have a significant positive effect on group-buying consumption.

Overall, SNS beauty content attributes can be interpreted as having a more distinct effect on the formation of consumer protection empathy, while exerting partial and selective effects on

human-centered new consumption behavior. In particular, information reliability and information quality were identified as key factors influencing consumer protection empathy and some types of human-centered new consumption behavior. This indicates that SNS beauty content is not merely a means of delivering information but also an important medium that induces consumers' emotional responses and value-oriented consumption behavior.

Based on the above findings, the following suggestions are proposed. First, future studies need to expand the research subjects by including various age groups, genders, and platform types in order to conduct more in-depth verification. Second, since the influencing factors of human-centered new consumption behavior differ depending on the type of consumption, differentiated content strategies are required that reflect the characteristics of each consumption type, such as green consumption, small luxury consumption, and group-buying consumption. Third, although this study conducted exploratory factor analysis and reliability analysis to verify the validity of the measurement instrument, it has a limitation in that it did not conduct measurement model verification through confirmatory factor analysis. Therefore, future studies need to add confirmatory factor analysis to more rigorously verify the convergent validity and discriminant validity of the measurement instrument.

Through these findings, this study is expected to contribute to determining various marketing activities and directions related to SNS content. It is also hoped that this study can provide basic data for understanding the relationship between consumer responses and human-centered new consumption behavior.

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Policy Proposals for Safe Livestock Product Consumption and Zero Waste Realization

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Abstract

Purpose: *This study analyzes the structural limitations of Korea's existing livestock product certification systems and proposes a novel certification framework the Livestock Product Safety Grading System—that comprehensively integrates multi-dimensional sustainability factors, including carbon emissions, animal welfare, food safety, and waste management.*

Method: *A review study was conducted using KCI-indexed journal articles published over the past 15 years on livestock certification, sustainability, and consumer behavior in Korea, along with government policy documents. Data were collected through face validity verification centered on thematic elements and analyzed using an inter-rater agreement method.*

Results: *The existing certification systems, operating under a binary pass/fail structure, fail to provide consumers with integrated, comparable information on food safety, environmental impact, animal welfare, and packaging and waste management. This information gap distorts consumer decision-making and prevents producers who in-vest in sustainability from being adequately rewarded by the market. A 1-to-5 grading framework, bench-marked against the Energy Efficiency Grading System, can substantially improve information resolution com-pared to binary pass/fail certifications and better support consumer-oriented decision-making. Furthermore, the integration of QR code, blockchain, cold-chain data, and packaging information into the grading system can significantly enhance information transparency from the perspectives of food safety protection and public safety.*

Conclusion: *The Livestock Product Safety Grading System proposed in this study should be understood not merely as a labeling tool, but as a protection-oriented certification framework that integrates consumer protection, food safety protection, environmental safety, and public safety. By resolving the structural limitations of the current pass/fail format, the system can support comparative consumer decision-making and incentivize producers to invest continuously in sustainability. Immediate legislative mandates are not recommended; instead, the system should be introduced through phased pilot implementation, followed by evaluation of market acceptance, administrative burden, and producer feasibility before moving toward formal institutionalization.*

Keywords: ***Livestock Product Certification, Sustainability, Zero Waste, Grading System, Consumer Trust***

1. Introduction

Global concern over environmental sustainability and food safety has risen sharply in recent years. The livestock industry, in particular, has been identified as a major contributor to greenhouse gas emissions and waste generation, and is widely regarded as an industry that undermines sustainable development[1]. In Korea, per capita meat consumption continues to grow, and consumers increasingly prefer products that account for environmental impact and animal welfare[2][3]. Yet the current livestock market lacks a structured information system that empowers consumers to make sustainability-informed choices[4]. The challenge of ensuring effective safety regulations extends beyond the food sector to consumer goods more broadly, and

the need for systematic improvement through comparative analysis of international regulatory frameworks has been well documented.

This concern is closely tied to shifting policy landscapes at home and abroad. The European Union has introduced the Farm to Fork strategy to institutionally manage sustainability across the entire food supply chain, incorporating integrated labeling schemes that assess both animal welfare and carbon emissions. Following its 2050 carbon neutrality declaration, the Korean government has developed a greenhouse gas reduction roadmap for the livestock sector and has been expanding animal welfare certification and eco-friendly livestock direct payment programs. However, these individual policies are administered by separate authorities under fragmented certification frameworks, and consequently fail to serve as an integrated information system through which consumers can holistically assess the sustainability of livestock products. When confronted with products bearing multiple, independently affixed certification marks, consumers find it difficult to intuitively compare the meaning and relative rigor of each certification, which ultimately undermines the effectiveness of the certification regime itself[4][5].

The problem with this information structure goes beyond a simple shortage of data. It creates an information gap between producers and consumers, making it difficult for consumers to compare qualitative differences among livestock products. As a result, consumers may rely on price-centered decision making rather than safe-ty, animal welfare, or sustainability-related information. The prevailing livestock certification systems in Korea mostly operate under a binary pass/fail structure and thus fail to resolve this information gap[5]. From the perspective of consumer-oriented information signaling, an effective certification system should clearly communicate the quality and safety level of livestock products to consumers; however, the current pass/fail format pro-vides limited information resolution and does not sufficiently support comparative decision-making.

This This study aims to address these structural deficiencies by designing a quantitative evaluation framework in the form of a multi-dimensional grading system. Specifically, it seeks to answer three research questions. First, what are the structural mechanisms through which existing livestock certifications distort consumer decision-making? Second, how can a multi-grade assessment framework contribute to closing the information gap between producers and consumers and building consumer trust? Third, what policy implications does an integrated certification system encompassing sustainability hold for mitigating environmental impact? By proposing a novel system that combines a quantitative grading scheme with zero waste policies, this study endeavors to compensate for the structural limitations of existing certifications and to advance consumer trust.

2. Research Background

2.1 The Concept of Sustainability and The Livestock Industry

Sustainability, first defined in the 1987 Brundtland Report, refers to development that meets the needs of the present without compromising the ability of future generations to meet their own needs[6]. The concept has evolved to embrace an integrated consideration of economic growth, social equity, and environmental responsibility[7]. The United Nations adopted the Sustainable Development Goals (SDGs) in 2015 to encourage implementation by all member states[8], and corporations have increasingly embraced ESG management practices[9]. Sustainability is commonly discussed across three domains: environmental sustainability[10], social sustainability, and economic sustainability[11].

The livestock industry intersects with all three of these domains. In terms of carbon emissions, the industry is a major source of greenhouse gases. From an animal welfare perspective, factory

farming has raised serious ethical concerns[12][13]. On the food safety front, HACCP certification has been criticized for failing to adequately incorporate sustainability considerations[14]. Existing research has addressed each of these domains in isolation, while studies proposing an integrated certification framework that evaluates all of them in a unified manner remain scarce.

2.2 Current Status and Structural Limitations of Korea's Agricultural and Livestock Certification Systems

As shown in <Figure 1>, Korea's certification system has the following characteristics. The Clean Livestock Farm (CLF) certification assesses farm hygiene management, evaluating factors such as barn cleanliness, quarantine protocols, and wastewater treatment facilities. Free-range Ecological Livestock Farm certification targets farms that raise animals in natural environments, verifying adherence to minimum pasture acreage requirements and nature-cycle husbandry practices. The Environmentally Friendly Livestock Farm certification is granted to farms that minimize environmental burdens during the livestock production process by meeting standards for manure resource recovery, odor reduction, and energy conservation.

Figure 1. Overview of Agricultural and Livestock Certification Systems in Korea

The Animal Welfare certification, operated by the Ministry of Agriculture, Food and Rural Affairs, is awarded to farms that provide housing conditions respectful of animals' innate behaviors while minimizing stress and suffering, with evaluations covering stocking density, natural lighting, and ventilation. HACCP certification systematically manages food safety by analyzing hazards and establishing critical control points across the full process from raw material management through manufacturing, processing, preservation, and distribution. Organic livestock certification is granted to products raised without antibiotics, synthetic hormones, or genetically modified feed, subject to a minimum organic transition period. Finally, Non-Antibiotic certification is awarded to products raised entirely without antibiotic use, introduced in response to growing public concern over antibiotic resistance.

Despite this diversity, the fundamental problem is that each of these certifications operates under a binary (pass/fail) structure, which structurally limits the resolution of information transmitted to consumers[5]. Under a binary scheme, consumers cannot compare qualitative differences between products, and this structural limitation locks in a market in which producers who invest additional costs in sustainability are not adequately rewarded.

The low-carbon agricultural product certification program, operating as a single-dimension assessment focused solely on greenhouse gas reduction, cannot directly evaluate animal welfare or food safety; its low consumer awareness has left it insufficiently activated[15][16]. Animal welfare certification likewise fails to communicate differences in the quality of rearing environments to consumers due to its pass/fail format[17][18], creating a structural anomaly in which farms meeting only the minimum standard receive the same certification as those maintaining far higher welfare conditions. The HACCP system focuses on food safety but does not include

carbon emissions or animal welfare within its scope of evaluation[19][20], resulting in a structural disconnect between the concepts of ‘safety’ and ‘sustainability.’

2.3 Consumer Behavior Theory and The Inevitability of a Grading System

Understanding the effectiveness of certification systems requires an examination of consumer behavior. The livestock market is characterized by a substantial information gap: producers know their rearing environments and sustainability performance, but consumers face significant barriers to accessing this information. From the perspective of consumer-oriented information signaling, certification marks and grade labels serve as signals that convey a producer's quality level to the market. Binary signals communicate only that a minimum thresh-old has been met, without indicating the relative superiority of quality. Multi-grade signals, by contrast, reflect a continuous spectrum of quality, enabling consumers to make comparative judgments..

Furthermore, perceived value—what consumers recognize when selecting a product—is a composite of functional, emotional, and social value. For livestock products, beyond the functional value of food safety, consumers are influenced by the ethical satisfaction derived from animal welfare (emotional value) and the social recognition associated with eco-friendly consumption (social value). Given that existing certifications fail to convey these complex values in an integrated manner, introducing a multi-dimensional grading system can enhance consumers’ perceived value and shape their willingness to pay. The foregoing review supports the conclusion that a grading system is not merely a policy alternative but a structural means of closing the information gap between producers and consumers.

3. Research Methods

This study was conducted as a review study aimed at analyzing the current status and limitations of livestock certification systems and deriving the design framework for a multi-dimensional grading scheme. The primary analytical materials comprised KCI-indexed journal articles published over the past 15 years on livestock certification, sustainability, consumer behavior, eco-friendly packaging, and blockchain-based traceability, supplemented by certification-related policy documents and statistical data from government ministries including the Ministry of Agriculture, Food and Rural Affairs and the Ministry of Environment.

For data collection, the researchers employed a face validity verification method that assigned meaning based on the thematic elements identified in prior studies[4][5]. The literature selected for analysis was coded within a defined scope, and the inter-rater agreement method was applied to the data and analytical results deemed consistent with the research content. Specifically, prior studies on livestock certification, sustainable consumption, eco-friendly packaging, and food safety were classified and reclassified according to analytical scope, with discrepancies between classifications excluded through re-examination. Only materials consistent with the content of this study were ultimately used in the analysis. The analytical approach was grounded in critical synthesis of the prior literature, and the performance and design principles of the Energy Efficiency Grading System were analyzed as a benchmarking case to examine the feasibility of application to the livestock sector.

4. Research Results

4.1 Benchmarking Analysis of the Energy Efficiency Grading System

The Energy Efficiency Grading System, in effect since 1992, is a national-level energy efficiency

management policy that classifies 35 product categories into grades 1 through 5 to support rational consumer choice[21]. The introduction of Minimum Energy Performance Standards (MEPS) drove sub-standard products out of the market, and a gradual decrease in the share of low-efficiency products confirmed a Market Transformation effect[22]. This system went beyond simply disclosing a product's energy efficiency; it functioned as an industrial policy instrument that incentivized manufacturers to invest in energy-saving technologies. In major appliance categories such as refrigerators, air conditioners, and washing machines, the share of Grade 1 products has risen steadily since the system's inception, demonstrating that the grading scheme simultaneously promotes consumer choice and producer-driven technological innovation.

Analyzing the success mechanisms of this system through the lens of signaling theory, the multi-grade framework holds two core advantages over binary certification. First, consumers can compare products based on their relative positions on the 1-to-5 scale. Second, a virtuous cycle emerges in which technological innovation aimed at achieving higher grades becomes the central element of market competition, raising the overall quality standard across the industry. In contrast, because Korea's current livestock certifications operate under a pass/fail format, achieving such a Market Transformation effect is unlikely. Of particular note is the system's dual-coding scheme—combining numbers (1–5) and colors (green to red)—which maximizes intuitive consumer recognition, substantially reducing information-processing costs[23]. This visual signaling framework enables consumers to instantly grasp a product's sustainability level within the brief decision-making window available in a retail setting, providing a solid basis for applying the same principle to the livestock sector.

Moreover, the policy ripple effects of the Energy Efficiency Grading System merit attention for having driven structural transformation of the market itself, extending well beyond consumer information provision. As grading standards were periodically tightened, a standards ratcheting mechanism came into play whereby products once rated Grade 1 were reclassified to Grade 2 or 3 over time[21][22][23], creating a dynamic incentive structure that spurred continuous technological innovation by manufacturers. If a similar dynamic standards framework were introduced for the livestock sector, it could be expected to incentivize livestock operators to make sustained investments in carbon emission reduction, animal welfare improvement, and eco-friendly packaging adoption.

4.2 Design of the Assessment Framework for the Livestock Product Safety Grading System

The Livestock Product Safety Grading System proposed in this study aims to convert the binary information structure of existing certification systems into a multi-grade framework, thereby expanding the basis for consumer comparison and enabling the market to reward producers' differentiated efforts[5]. The assessment comprises four domains, as shown in <Table 1>, each designed to address the specific structural limitations of existing certification systems identified above.

Table 1. Assessment Categories of the Livestock Product Safety Grading System

Category	Assessment Criteria
Carbon emissions	Carbon emissions generated during the production process (gCO_2-eq)
Food safety	HACCP certification status, antibiotic use, compliance with food hygiene regulations
Animal welfare	Compliance with animal welfare standards during the production process
Zero waste	Packaging material usage, waste reduction efforts

Based on a comprehensive integration of these four assessment categories, products are classified into grades 1 through 5, as shown in <Table 2>. This grading framework adapts the classification principles of the Energy Efficiency Grading System and is designed so that consumers can intuitively recognize a product's sustainability level through dual signaling—numerical grades and color differentiation.

Table 2. Grade Classification Criteria for the Livestock Product Safety Grading System

Grade	Criteria
Grade 1	Product meeting the highest standards across all categories
Grade 2	Product meeting passing scores in all categories but falling short of the highest marks
Grade 3	Product requiring improvement in one category
Grade 4	Product requiring improvement in two categories
Grade 5	Product requiring improvement in three or more categories

4.3 Achieving Zero Waste and Carbon Reduction through Eco-friendly Packaging

The Livestock Product Safety Grading System is not merely a certification mark; it functions as a consumer protection mechanism that enables consumers to compare livestock products across multiple dimensions, including food safety, animal welfare, carbon emissions, and packaging and waste management. Food labeling serves as a primary means by which consumers can access and understand product information and exercise informed purchasing judgment, and the credibility of that labeling is directly linked to consumer protection[3][4]. As research shows that environment-friendly consumption behavior is influenced by consumers' environmental concern, altruistic and selfish motivations, and educational experience, graded certification information can play a meaningful role in supporting consumers' value-based purchasing decisions[3]. By converting the current binary pass/fail format into a multidimensional grade, the system enables consumers to identify and select products that align with their own protection-related priorities.

The current food safety framework centered on HACCP is an essential foundation for protecting public health; however, certification status alone does not allow consumers to compare the actual level of safety management across products. As research has emphasized, the effectiveness of HACCP depends not only on certification but also on the rigor of evaluation methods, post-certification monitoring, and the applicability of the system to smaller-scale operators[14][19][20]. The proposed grading system can therefore be expanded beyond HACCP certification status to integrate hygiene management records, antibiotic use histories, inspection out-comes, and distribution traceability into a unified assessment framework, thereby strengthening the food safety protection system[14][20].

The sustainability of livestock products is inseparable from environmental safety concerns, including carbon emissions, livestock waste management, packaging waste, and distribution loss. Carbon footprint assessment and low-carbon agricultural and livestock product certification provide a basis for quantifying environmental information and supporting consumer comparative choice[1][15]. Since eco-friendly livestock production necessarily involves costs related to animal waste treatment and environmental compliance, the grading system must simultaneously account for the producer's burden and the consumer's need for transparent environmental information[12][24][25].

The livestock product certification system has the potential to evolve beyond a tool for individual consumer choice into a public safety governance structure that integrates food safety, environmental safety, animal welfare, and distribution information. Animal welfare policy implementation involves real-world acceptance challenges and ethical tensions at the farm level, which means that a purely regulatory approach is insufficient; instead, information-based and phased institutional design is more appropriate[13][14]. QR code and cold-chain information systems can help consumers access distribution status and safety-relevant product information in real time, thereby further reinforcing the system's role as a protection-oriented governance model[20].

4.4 Achieving Zero Waste and Carbon Reduction through Eco-friendly Packaging and Cold Chain Management

In the food industry, the choice of packaging materials directly affects greenhouse gas emissions and waste generation. Conventional plastic-based packaging offers advantages in preserving freshness but has contributed to rising carbon emissions and environmental pollution[24]. The viability of bio-based packaging and composite resin paper packaging as alternatives has been documented[25], and the adoption of eco-friendly pack-aging by e-commerce companies and the expansion of the EU's Extended Producer Responsibility scheme continue to gain momentum[26][27]. Livestock packaging, in particular, should not be understood simply as reducing or eliminating plastic. Rather, it should be designed as a safety-oriented and environmentally responsible packaging system that considers freshness preservation, recyclability, cold-chain compatibility, and waste reduction[24][25][28][29].

Achieving zero waste is also closely linked to waste management across the entire livestock distribution process. Given the perishable nature of livestock products, food loss and food waste during distribution are substantial and generate additional, unnecessary carbon emissions. Enhancing the efficiency of cold chain systems, diversifying packaging into smaller consumer-tailored portions, and advancing shelf-life management technologies are complementary tasks essential for realizing zero waste in the livestock sector. Accordingly, the proposed grading system incorporates the use of eco-friendly packaging as a core assessment item, aiming to build a full life-cycle sustainability assessment framework that encompasses not only the production stage but also the distribution stage. By quantitatively evaluating factors such as packaging recyclability rates, single-material usage ratios, over-packaging incidence, and bio-based material adoption rates and reflecting these in the grade, the system creates incentives for producers to invest in eco-friendly packaging transitions and establishes an information environment enabling consumers to identify products that contribute to zero waste[24].

4.5 QR Code and Blockchain-Based Information Delivery System

QR codes offer substantially greater data storage capacity and faster information accessibility than conventional barcodes, and their utilization in food supply chain management has been on the rise[30]. When QR codes are integrated with the Livestock Product Safety Grading System, a dual-layer design becomes feasible: the grade label provides summary information (grade 1–5) while the QR code provides detailed information (carbon emissions data, animal welfare scores, HACCP certification, zero waste performance). This dual-layer structure offers the flexibility of enabling rapid judgment based on summary information alone, while also allowing access to detailed information as needed. Specifically, by scanning the QR code, consumers can view granular data including the rearing farm, duration of rearing, feed type, antibiotic use history, slaughter and processing dates, the basis for carbon emission calculations, detailed animal welfare assessment scores, and packaging recyclability grades. This environment empowers consumers to go beyond simply relying on a numerical grade, enabling them to examine individual assessment items in accordance with their own values and priorities when making purchasing decisions.

However, the current livestock traceability system is limited to providing country-of-origin and producer information and does not reflect detailed sustainability factors; moreover, the risk of data falsification persists. This study therefore proposes a traceability system combining QR codes with blockchain technology. Blockchain technology provides a foundation for technically guaranteeing the credibility of grading information by storing data from the production, distribution, and sales processes in a distributed ledger that prevents tampering, and by enabling automated certification through smart contracts[31][32]. In particular, a blockchain-based traceability system can integrate producer-entered rearing environment data, inspection results from third-party certification bodies, and environmental data automatically collected via IoT sensors (barn temperature, humidity, ammonia levels, etc.) into a single immutable record system, thereby ensuring objectivity and transparency in grade determination. Such a technology-grounded trust framework may enhance consumer confidence by improving the traceability and verifiability of sustainability-related information[30][31]. When linked with cold-chain monitoring data, it may also support food safety protection by allowing product quality and distribution conditions to be managed more transparently[32].

5. Conclusion and Recommendations

The current livestock certification systems in Korea, constrained by their binary certification structure, fail to close the information gap between producers and consumers and have entrenched a market in which producers who invest in sustainability are not adequately rewarded. This study proposed the Livestock Product Safety Grading System a multi-grade framework benchmarked against the Energy Efficiency Grading System as a means of addressing these structural deficiencies. This grading system integrates four dimensions—carbon emissions, food safety, animal welfare, and waste management—into a unified assessment, and is characterized by a dual-layer information delivery system combining QR codes and blockchain technology to technically guarantee the credibility of grade signals. The proposed system should be understood not merely as a sustainability label, but as a protection-oriented certification framework that integrates consumer protection, food safety protection, environmental safety, and public safety. By resolving the structural limitations of the current pass/fail format, it can support comparative consumer decision-making and incentivize producers to invest continuously in sustainability.

From a policy standpoint, this study offers the following recommendations. First, the government should con-sider a phased policy approach, beginning with pilot implementation of the Livestock Product Safety Grading System and gradually moving toward institutionalization after evaluating feasibility, administrative burden, producer acceptance, and market acceptance. This includes designing incentives such as tax benefits for higher-graded products[21][23]. Second, at the industry level, the prerequisite is to build infrastructure for the systematic collection and disclosure of quantitative data, including carbon emissions (gCO_2-eq/kg), animal welfare compliance rates, HACCP-based food safety indicators, and packaging recyclability ratios[12][19][20]. Third, at the consumer level, an information environment should be established—through a dual structure combining detailed information access via QR codes and intuitive comparison via grade labels—that enables sustainability-conscious, informed, and assured consumption[30].

Nonetheless, this study, as a review, is limited to proposing a conceptual model and does not include empirical validation for actual implementation. Future research should address the development of specific quantitative indicators for grade assessment criteria, consumer perception surveys and market response analyses, and evaluations of legal and institutional feasibility. Should empirical validation through pilot implementation be undertaken, the viability and effectiveness of the proposed grading system could be more clearly established.

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Reliability Test Framework for EV Power Electronic Modules Based on Recall Case Analysis for Protection Safety

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Abstract

Purpose: *This study aims to analyze global recall cases involving electric vehicle (EV) power electronic modules and propose a structured reliability test framework for improving protection reliability and safety performance. EV power electronic modules, such as OBCs, LDCs, ICCUs, and traction inverters, are essential for charging, voltage conversion, propulsion control, and power distribution. Failures in these modules may cause charging malfunction, low-voltage power loss, propulsion interruption, insulation degradation, or fire hazards. Therefore, this study focuses on reliability assurance for safety-critical automotive power electronic systems.*

Method: *A qualitative analytical approach was applied based on recall case analysis and reliability engineering principles. Publicly available recall cases related to EV power electronic systems were reviewed to identify failure symptoms, affected modules, failure mechanisms, and safety consequences. The identified failures were classified according to major stress factors, including thermal stress, electrical overstress, vibration-induced fatigue, and environmental exposure. Based on this classification, a stepwise framework integrating Highly Accelerated Life Testing (HALT), screening tests, and Design Verification (DV) testing was developed.*

Results: *The analysis indicates that thermal stress, electrical overstress, vibration-induced fatigue, and environmental exposure are major contributors to failures in EV power electronic modules. These stress factors can accelerate degradation in semiconductor devices, solder joints, insulation structures, connectors, and thermal paths. The proposed framework supports early detection of design weaknesses through HALT, removal of latent defects through screening tests, and verification of environmental durability through DV testing.*

Conclusion: *The proposed framework provides a practical methodology for enhancing protection reliability in EV power electronic module development. By integrating HALT, screening tests, and DV testing, the framework supports reliability assurance across design, manufacturing, and validation stages. It can contribute to reducing recall risks, improving protection performance, and strengthening reliability evaluation strategies for next-generation electric mobility systems.*

Keywords: ***Electric Vehicle, Power Electronic Module, Recall Case Analysis, Reliability Test Framework, Protection Reliability***

1. Introduction

The global transition toward electric mobility has accelerated the adoption of electric vehicles (EVs) as a sustainable transportation solution[1][2]. As EV deployment continues to expand worldwide, the reliability of high-voltage power electronic modules has become a critical factor affecting vehicle safety, operational stability, charging availability, and user confidence. Recent studies on EV/HEV power electronic systems have emphasized that reliability assurance is becoming increasingly important because power conversion modules directly influence propulsion control, charging performance, thermal stability, and system-level safety[3][4][5].

Unlike conventional internal combustion engine vehicles, EVs depend heavily on electrical energy conversion, high-voltage power distribution, and electronic control systems. EV power electronic systems include onboard chargers (OBCs), low-voltage DC-DC converters (LDCs), integrated charging control units (ICCUs), and traction inverters. The OBC converts external AC power into DC power suitable for charging the high-voltage battery, while the LDC supplies low-voltage power to auxiliary electrical systems. The ICCU integrates charging control and power conversion functions, and the traction inverter converts DC power from the battery into AC power for motor operation[6][7]. These modules are essential for charging, voltage conversion, propulsion control, and vehicle-level power management.

During vehicle operation, EV power electronic modules are exposed to complex electrical, thermal, mechanical, and environmental stress conditions. High voltage, high current, repetitive switching operation, thermal cycling, vibration, humidity, and environmental exposure can accelerate degradation of semiconductor devices, insulation materials, solder joints, bonding wires, connectors, and control circuits[8][9]. In particular, thermal management is a critical issue in electric-drive vehicle power electronics because increased power density and repeated load variation can intensify junction temperature fluctuation, package degradation, and cooling path deterioration[10]. As a result, failures in these modules may lead to charging malfunction, propulsion interruption, low-voltage power loss, insulation degradation, output limitation, or fire hazards.

Recent global EV recall cases indicate that reliability issues associated with power electronic modules and related high-voltage systems are becoming increasingly important[11]. Recall cases provide practical field-based evidence of failure phenomena that may not be fully identified during conventional design validation. They also reveal how component-level weaknesses can develop into vehicle-level safety risks under actual operating conditions. Representative recall cases with available public sources are summarized in Appendix A. From a protection engineering perspective, these cases should not be treated merely as isolated field failures. Instead, they should be analyzed as risk signals for identifying dominant failure modes, critical stress factors, protection vulnerabilities, and weaknesses in reliability verification procedures.

For safety-critical automotive systems, reliability verification should be closely connected with functional safety and risk assessment principles[12][13]. In EV power electronic modules, protection functions must respond appropriately to abnormal conditions such as overvoltage, overcurrent, overheating, short circuit, insulation degradation, communication faults, and power conversion instability. Therefore, reliability testing should not be limited to confirming normal operation under specified conditions. It should also verify whether protection functions remain effective after repeated exposure to environmental and electrical stresses. This requires a structured framework that links field failure information, failure mechanism analysis, stress factor classification, and design verification test requirements.

The reliability of power electronic modules should also be evaluated based on the relationship between failure mechanisms and operating stress conditions. Previous studies on power module reliability have identified major failure mechanisms such as thermal fatigue, solder joint cracking, bond wire degradation, insulation deterioration, semiconductor device failure, corrosion, dielectric breakdown, and contact degradation[8][9]. These failure mechanisms are often caused by combined stresses rather than by a single stress factor. For example, thermal cycling may accelerate fatigue in solder joints, while vibration and environmental exposure may aggravate connector instability or insulation degradation. Therefore, reliability testing for EV power electronic modules should reflect both individual stress effects and combined stress interactions.

Environmental durability standards and electronics reliability methodologies provide an important basis for designing reliability verification procedures for automotive power electronic

modules[14][15]. Since EV modules operate in harsh vehicle environments, test conditions should consider temperature variation, humidity exposure, vibration loading, mechanical shock, electrical load, and operational cycling. Furthermore, accelerated testing methods can be used to identify design weaknesses and degradation tendencies within a shortened development period[16]. In this context, Highly Accelerated Life Testing (HALT), screening tests, and Design Verification (DV) testing can be integrated into a stepwise reliability evaluation framework.

Therefore, this study aims to analyze global recall cases related to EV power electronic modules and propose a structured reliability test framework for improving protection reliability and safety performance during the development stage. Based on reliability engineering principles, the proposed framework considers the relationship between failure modes, stress factors, test stages, and lifecycle-based reliability assurance[17]. Specifically, this study derives major failure modes and stress factors from recall case analysis and links them with failure mechanisms, protection functions, environmental durability requirements, and design verification procedures. The proposed framework integrates HALT, screening tests, and DV testing to support early detection of design weaknesses, verification of protection functions, and reduction of recall risks in safety-critical EV power electronic systems.

2. Characteristics Of EV Power Electronic Modules

EV power electronic modules are key subsystems that convert, regulate, and distribute electrical energy between the high-voltage battery, traction motor, charging system, and auxiliary electrical loads. Representative modules include onboard chargers (OBCs), low-voltage DC-DC converters (LDCs), integrated charging control units (ICCUs), and traction inverters. These modules play essential roles in charging control, voltage conversion, propulsion power delivery, and vehicle-level power management in electric vehicle architectures[1][6][7].

Compared with conventional electronic devices, EV power electronic modules operate under much higher voltage and current conditions. Modern EV platforms commonly adopt high-voltage architectures such as 400 V and 800 V systems to improve charging speed, power density, and propulsion efficiency. However, these operating conditions increase electrical switching stress, insulation requirements, thermal loading, and protection design complexity. As a result, the reliability of power electronic modules becomes directly related to vehicle safety, charging stability, and operational continuity[3][4][5]. In addition, because latent manufacturing defects may become apparent under repeated environmental and operational stresses, reliability assurance for EV power electronic modules should also consider appropriate screening procedures during the manufacturing and validation stages[18].

EV power electronic modules are also exposed to multiple stress factors during real-world operation. Major stress factors include thermal cycling, electrical overstress, mechanical vibration, humidity exposure, and environmental temperature variation. These stresses are generated by repeated charging and discharging, high-frequency switching behavior, power conversion losses, road-induced vibration, and changes in external driving environments. Since these stresses often occur simultaneously, module degradation is generally influenced by combined stress interactions rather than by a single stress factor[6][8][9][10].

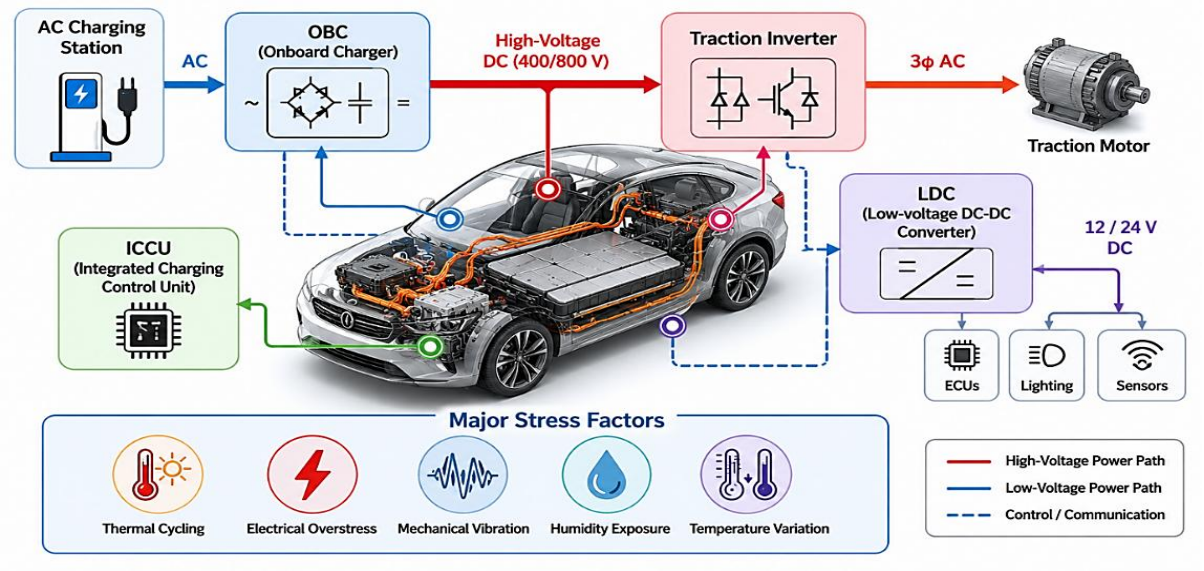
Table 1. Key Characteristics, Dominant Stress Factors, and Failure Consequences of Major EV Power Electronic Modules

Module	Main Function	Major Stress Factors	Possible Failure Consequences
Onboard Charger (OBC)	Converts external AC power into DC power for charging the high-voltage battery	Thermal cycling, high-voltage stress, switching transients, humidity exposure	Charging malfunction, output degradation, insulation degradation, charging interruption

Low-voltage DC-DC Converter (LDC)	Converts high-voltage battery power into low-voltage power for auxiliary electrical systems	Thermal stress, load transients, vibration, electrical noise, humidity exposure	Low-voltage power loss, auxiliary system failure, communication error, system instability
Integrated Charging Control Unit (ICCU)	Integrates charging control and low-voltage power supply functions	Thermal cycling, insulation stress, vibration, electrical transients, humidity exposure	Charging control failure, low-voltage power loss, system reset, propulsion power reduction
Traction Inverter	Converts high-voltage DC power into three-phase AC power for motor driving	High-voltage stress, high current, thermal cycling, vibration, rapid load change	Propulsion interruption, output limitation, motor control abnormality, inverter failure

<Figure 1> illustrates the relationship between major stress factors and failure mechanisms in EV power electronic modules.

Figure 1. Stress Factors and Failure Mechanisms in EV Power Electronic Modules



Thermal stress is one of the most critical factors affecting the reliability of EV power electronic modules. During power conversion, semiconductor devices, solder joints, bonding wires, busbars, and heat dissipation structures experience repetitive temperature rise and cooling cycles. These temperature changes can accelerate thermal fatigue, solder joint cracking, bond wire degradation, and package-level deterioration. In particular, repeated thermal cycling under high-load conditions may lead to progressive degradation of electrical connections and heat transfer paths[6][7][8][9].

Electrical stress is mainly caused by high-voltage operation, high current flow, high-frequency switching, transient surge conditions, and insulation requirements within converter and inverter systems. Abnormal electrical conditions such as overvoltage, overcurrent, short circuit, switching transients, and insulation degradation can cause semiconductor device failure, control circuit malfunction, or protection system activation. Since these failure modes are closely related to the reliability of semiconductor devices and electronic components, relevant reliability test methods and accelerated stress-based evaluation approaches should also be considered when evaluating electrical stress effects[19][20]. Therefore, electrical stress must be considered

not only as a normal operating condition but also as a potential trigger for protection-related failure modes[6][8][9].

Mechanical and environmental stresses also contribute to module degradation. Road-induced vibration and mechanical shock can affect connectors, solder joints, mounting structures, and internal interconnections. Humidity exposure, condensation, contamination, and possible coolant leakage can accelerate insulation degradation, corrosion, leakage current, and dielectric breakdown. These environmental conditions are particularly important for automotive electrical and electronic equipment because EV modules must maintain stable operation under diverse temperature, humidity, vibration, and exposure conditions throughout the vehicle lifetime[14][21][22][23].

The interaction between thermal, electrical, mechanical, and environmental stresses significantly influences the long-term reliability of EV power electronic modules. For example, thermal cycling can weaken solder joints, while vibration can further accelerate crack propagation. Humidity and contamination can reduce insulation resistance, while high-voltage operation can increase the risk of dielectric failure. These combined stress effects make it difficult to evaluate module reliability using only single-condition tests. Therefore, reliability verification should be designed to reflect both individual stress effects and combined stress interactions[3][4][6][8][9].

Understanding the characteristics of EV power electronic modules is essential for developing a protection-oriented reliability test framework. Since failures in OBCs, LDCs, ICCUs, and traction inverters can lead to charging malfunction, low-voltage power loss, propulsion interruption, insulation failure, or fire hazards, reliability testing should verify not only environmental durability but also protection performance under abnormal and degraded conditions. Therefore, a structured reliability test framework should link module characteristics, operating stress factors, failure mechanisms, and protection functions to support early detection of design weaknesses and prevention of recall-related safety risks[1][3][12][20].

3. Screening Theory and Early Failure Mechanisms

3.1 Bathtub Curve Model

Reliability engineering commonly explains product failure behavior over time using the bathtub curve model. This model conceptually divides the failure rate of a product or system into three major regions: infant mortality, random failure, and wear-out failure[14][15]. Although the exact shape of the failure rate curve may vary depending on product type, design maturity, manufacturing quality, component robustness, and operating environment, the bathtub curve remains useful for explaining why early screening is necessary in reliability assurance.

In the context of EV power electronic modules, the bathtub curve is particularly meaningful because these modules operate under high-voltage, high-current, thermally demanding, and mechanically dynamic conditions. A defect that may appear minor during ordinary inspection can develop into a safety-related failure when the module is exposed to electrical load, thermal cycling, vibration, humidity, or combined environmental stress. Therefore, the bathtub curve provides a useful conceptual basis for connecting early failure behavior with screening strategies in EV power electronic module development.

The first region, known as the infant mortality region, is characterized by a relatively high initial failure rate. Failures in this region are mainly associated with manufacturing defects, assembly errors, process variation, weak components, latent material defects, soldering defects, insulation defects, contamination, and hidden structural weaknesses[13][15]. These defects may

not be detected during basic functional inspection because the module can initially operate under normal conditions. However, when exposed to electrical load, thermal cycling, vibration, or humidity, latent defects may rapidly develop into functional failures.

For EV power electronic modules, infant mortality failures are especially critical because early failures may directly affect charging, propulsion, and low-voltage power supply functions. For example, an unstable solder joint may pass initial inspection but fail after repeated thermal cycling. A weak connector may operate normally under static conditions but become unstable under vibration. An insulation defect may remain hidden during normal functional testing but become critical under high-voltage and humidity conditions. Therefore, early-life failure reduction is an essential objective of protection-oriented reliability assurance.

The second region is the random failure region. In this stage, the failure rate becomes relatively stable, and failures occur unpredictably due to accidental overstress, unexpected operating conditions, component variation, abnormal load events, or external disturbances[15]. For EV power electronic modules, random failures may be caused by transient surge events, abnormal load conditions, control instability, intermittent connector contact, thermal fluctuation, or unexpected environmental exposure. Although random failures cannot be completely eliminated through screening, robust design verification, adequate design margin, and protection function validation can reduce their probability and severity.

The third region is the wear-out failure region. In this region, the failure rate increases again as materials and components degrade over long-term operation. Wear-out failures in power electronic modules may be caused by thermal fatigue, solder joint cracking, bond wire degradation, insulation aging, corrosion, dielectric breakdown, connector degradation, and semiconductor device degradation[6][11]. These mechanisms are strongly influenced by repeated thermal, electrical, mechanical, and environmental stresses. Therefore, design verification tests and accelerated life tests are required to evaluate whether modules can maintain performance and protection functions throughout their intended service life.

The failure characteristics of the three bathtub curve regions can be summarized as shown in <Table 2> The table shows that each failure region has different dominant causes, stress triggers, and reliability countermeasures. In particular, infant mortality failures are closely related to latent defects and process variations, while wear-out failures are closely related to long-term degradation mechanisms. This distinction is important because the purpose of screening is not to prove long-term lifetime, but to identify and remove weak units before vehicle integration or field operation.

Table 2. Failure Regions and Screening Strategy Based on the Bathtub Curve Model

Failure Region	Main Failure Characteristics	Typical Causes in EV Power Electronic Modules	Relevant Stress Factors	Reliability Countermeasure
Infant Mortality	High initial failure rate during early operation	Manufacturing defects, assembly errors, weak components, soldering defects, insulation defects, contamination	Thermal cycling, electrical load, vibration, humidity	ESS, burn-in testing, initial functional screening

Random Failure	Relatively constant failure rate during useful life	Unexpected overstress, abnormal load conditions, component variation, intermittent connection, control instability	Surge, load transient, vibration, environmental exposure	Robust design, protection function validation, fault monitoring
Wear-out Failure	Increasing failure rate after long-term degradation	Thermal fatigue, solder joint cracking, bond wire degradation, insulation aging, corrosion, dielectric breakdown	Repeated thermal, electrical, mechanical, and environmental stress	DV testing, accelerated life testing, durability verification

In EV power electronic modules, the infant mortality region is particularly important from a protection safety perspective. These modules operate under high-voltage and high-current conditions and are directly connected to vehicle charging, propulsion, and low-voltage power supply functions. Therefore, early failures may lead to charging malfunction, propulsion interruption, low-voltage power loss, insulation degradation, or protection system activation. Unlike failures in general consumer electronic devices, failures in EV power electronic modules can directly affect vehicle safety and operational stability[6][11].

For this reason, screening processes are essential for eliminating early-life failures before vehicle integration or shipment. Screening tests are intended to expose latent defects by applying controlled environmental or electrical stresses to products during the manufacturing or validation stage. Environmental stress screening is particularly useful for identifying weak components, poor solder joints, unstable connections, insulation weaknesses, and process-induced defects before they develop into field failures[16]. Semiconductor and electronic component reliability test methods also support the identification of early defects and stress-sensitive failure mechanisms[17].

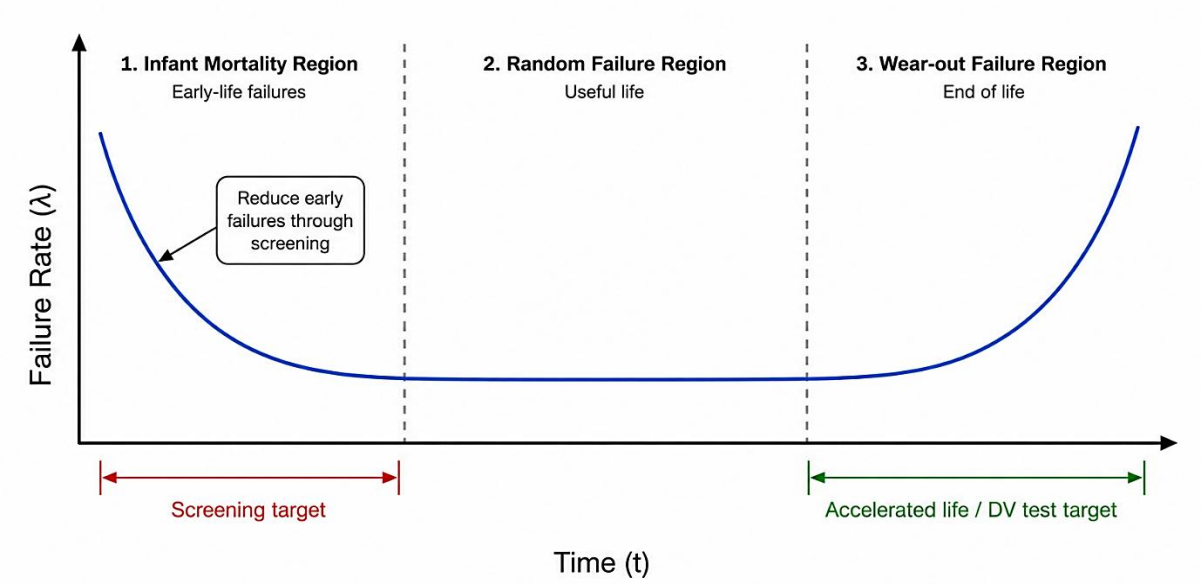
The purpose of screening is not to consume the useful life of the product, but to precipitate latent defects that would otherwise appear during early field operation. In the context of EV power electronic modules, effective screening should be designed based on expected stress conditions and dominant early failure mechanisms. For example, thermal cycling may reveal solder joint or interconnection weaknesses, vibration screening may identify connector or mounting defects, and electrical stress screening may detect insulation or semiconductor-related vulnerabilities. Therefore, screening conditions should be strong enough to activate latent defects but not so excessive that they introduce unrealistic damage into good products.

A protection-oriented screening strategy should also be linked with module-level safety functions. In addition to confirming normal operation after stress exposure, screening should verify whether protection functions such as overvoltage protection, overcurrent protection, overtemperature protection, short-circuit protection, insulation monitoring, and fault detection remain stable. This is particularly important because a module may pass a simple functional test while still having hidden weaknesses in its protection response under abnormal operating conditions.

<Figure 2> illustrates the relationship between the bathtub curve model and the screening strategy for EV power electronic modules. In this figure, the early failure region is associated with latent defects and process-induced weaknesses, while screening tests are positioned as a reliability assurance activity for reducing early-life failures. The useful life region is associated with stable operation and protection monitoring, whereas the wear-out region is associated with long-term degradation and durability verification. This conceptual relationship supports

the role of screening as an intermediate reliability assurance step between design improvement and field reliability.

Figure 2. Screening Strategy for Reducing Infant Mortality Failures in EV Power Electronic Modules Based on the Bathtub Curve Model



The figure conceptually illustrates how screening tests reduce early-life failures by identifying latent defects before shipment or vehicle integration.

Therefore, the bathtub curve model provides a theoretical basis for applying screening tests to EV power electronic modules. By reducing the number of defective units in the infant mortality region, screening can improve long-term reliability, reduce early field failures, and lower recall risk. When combined with Highly Accelerated Life Testing (HALT) and Design Verification (DV) testing, screening can serve as an intermediate reliability assurance step that connects design weakness discovery with production-level defect removal.

In this study, the bathtub curve model is used not only as a general reliability concept but also as a basis for structuring a protection-oriented reliability test framework. HALT is applied to identify design weaknesses and operational margins during the early development stage. Screening tests are applied to remove latent defects and infant mortality failures before shipment. DV testing is applied to verify environmental durability and protection performance under representative operating conditions. Accordingly, the bathtub curve model supports the logical integration of HALT, screening, and DV testing within the proposed reliability evaluation framework.

3.2 HALT Test Methodology

Highly Accelerated Life Testing (HALT) is a reliability engineering methodology used to identify design weaknesses and operational margins by applying environmental and operational stresses beyond normal use conditions[17]. Unlike conventional qualification tests, which are generally designed to verify whether a product satisfies predefined specification limits, HALT is intended to expose hidden design vulnerabilities by progressively increasing stress levels until functional degradation, intermittent malfunction, or physical failure occurs. Therefore, HALT is not primarily a pass-or-fail test, but a discovery-oriented engineering process for improving product robustness during the early development stage.

The basic principle of HALT is to apply stepwise stress conditions to the test sample and observe how the product responds as the stress level increases. Typical HALT stress factors include low temperature, high temperature, rapid thermal transition, vibration, electrical load variation,

power cycling, and combined thermal-vibration stress. Through this process, lower operating limits, upper operating limits, destruct limits, functional margins, and dominant weak points can be identified. These results provide useful engineering feedback for improving design robustness before formal validation or mass production[17].

For EV power electronic modules, HALT is particularly useful because these modules operate under severe electrical, thermal, mechanical, and environmental conditions. OBCs, LDCs, ICCUs, and traction inverters are continuously exposed to high voltage, high current, repetitive switching, thermal cycling, vibration, humidity, and transient electrical disturbances during vehicle operation. These operating conditions can accelerate degradation in semiconductor devices, solder joints, bonding wires, insulation structures, connectors, busbars, printed circuit board assemblies, thermal interface materials, and cooling paths[6][8][9]. Therefore, HALT can reveal structural and functional weaknesses that may not be detected through ordinary functional inspection or limited environmental testing.

In a typical HALT procedure for EV power electronic modules, the test begins with baseline functional verification under normal operating conditions. This initial verification confirms whether the module satisfies normal output performance, communication response, insulation performance, thermal behavior, and protection function requirements before stress application. After the baseline check, the module is exposed to gradually increasing thermal stress, such as stepwise low-temperature and high-temperature conditions. At each stress level, electrical operation, output stability, temperature response, communication status, insulation performance, and protection function behavior should be monitored. If the module shows abnormal operation, temporary malfunction, output instability, protection triggering, communication error, or insulation degradation, the stress level and failure symptoms are recorded to determine the operating margin and potential weakness.

After thermal step-stress testing, vibration stress may be applied to identify mechanically sensitive defects. Vibration stress can reveal weaknesses associated with solder joints, connectors, busbars, mounting structures, heavy components, PCB assemblies, and internal interconnections. For EV power electronic modules, vibration-induced defects are especially important because vehicles are continuously exposed to road-induced vibration, mechanical shock, and structural resonance during operation. Weak connections or marginal solder joints may not fail under static conditions, but they can become unstable when vibration and thermal cycling are combined.

Combined stress testing is a critical part of HALT because real vehicle environments rarely impose only one stress factor at a time. In actual EV operation, power electronic modules may experience simultaneous thermal loading, electrical operation, vibration, and environmental exposure. Therefore, combined thermal-vibration or thermal-electrical stress can be used to accelerate the discovery of interaction-related weaknesses. For example, thermal expansion and contraction may weaken solder joints, while vibration may accelerate crack propagation. Similarly, repeated temperature changes can affect insulation materials, and electrical stress can increase the severity of insulation degradation. These combined stress effects are important for identifying failure mechanisms that may later appear in field operation.

For EV power electronic modules, HALT should also include protection-oriented monitoring. Since these modules perform safety-critical functions, it is not sufficient to observe only whether the module continues to operate. The test should also verify whether protection functions respond properly under abnormal or near-limit conditions. Important monitoring items may include overvoltage protection, overcurrent protection, overtemperature protection, short-circuit protection, insulation monitoring, fault detection, derating control, shutdown behavior, fail-safe response, and recovery characteristics after stress exposure. If a protection function operates too late, operates incorrectly, or fails to activate under stress conditions, the module

may have a protection reliability weakness even if the main power conversion function appears to operate normally.

The major HALT stress factors and expected weakness detection items for EV power electronic modules are summarized in <Table 3>.

Table 3. HALT Stress Factors and Expected Weakness Detection Items

HALT Stress Factor	Test Purpose	Expected Weakness Detection	Related Module Area
Low-temperature step stress	Identify low-temperature operating limit	Startup failure, communication delay, insulation weakness, control instability	Control circuit, insulation structure, PCB assembly
High-temperature step stress	Identify high-temperature operating limit	Thermal shutdown, output instability, semiconductor degradation, thermal path weakness	Power semiconductor, solder joint, thermal interface
Rapid thermal transition	Detect thermal expansion mismatch	Solder joint cracking, package fatigue, connector instability	Solder joint, package, connector
Vibration step stress	Identify mechanically sensitive defects	Loose connector, PCB crack, mounting weakness, intermittent contact	Connector, busbar, PCB, mounting structure
Electrical load variation	Evaluate load response and protection behavior	Output fluctuation, overcurrent triggering, derating error, control malfunction	Converter, inverter, protection circuit
Combined thermal-vibration stress	Detect interaction-related weaknesses	Accelerated crack propagation, intermittent failure, insulation degradation	Power module, PCB, interconnection
Protection function monitoring	Verify safety response under stress	Delayed fault detection, abnormal shutdown, fail-safe malfunction	Protection circuit, control software

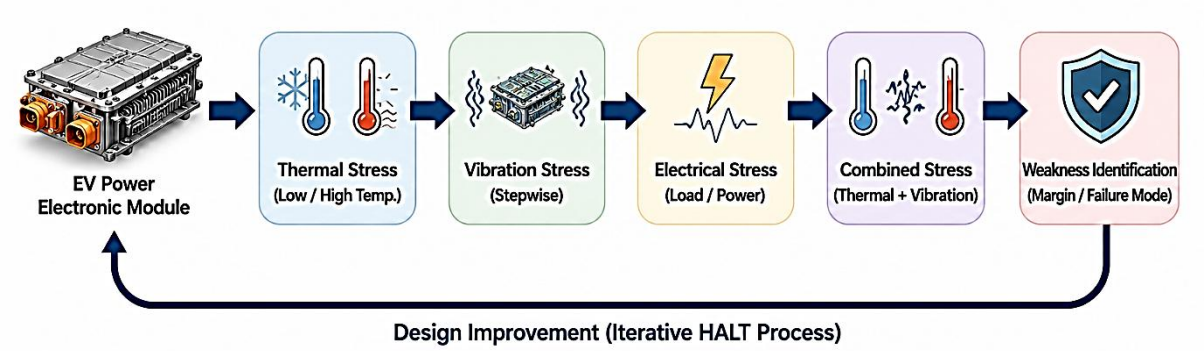
The results obtained from HALT can be used to improve the design before formal validation or production screening. Identified weaknesses may lead to design improvements such as strengthening solder joints, improving PCB layout, modifying thermal paths, enhancing insulation distances, reinforcing connectors, improving mechanical fixation, adjusting protection thresholds, or improving control algorithms. After corrective actions are implemented, the HALT process can be repeated to confirm whether the design margin has improved. In this way, HALT supports iterative design improvement rather than simple product qualification.

In the development of EV power electronic modules, HALT can serve as an early-stage reliability discovery tool that precedes screening tests and Design Verification (DV) testing. HALT identifies design weaknesses and operational margins, screening tests remove latent manufacturing defects, and DV testing verifies whether the final design satisfies environmental durability and performance requirements. Therefore, HALT plays an important role in linking failure mechanism analysis with protection-oriented reliability verification.

Overall, HALT contributes to improving design robustness and reducing the likelihood of safety-related failures in electric mobility systems. By exposing latent structural and functional weaknesses during early development, HALT helps prevent failures that could otherwise appear

as field failures or recall issues after vehicle deployment. For this reason, HALT should be incorporated as a key step in a structured reliability test framework for EV power electronic modules.

Figure 3. HALT-Based Design Weakness Identification Process for EV Power Electronic Modules



The figure illustrates how HALT identifies design weaknesses by applying stepwise thermal, vibration, electrical, and combined stress conditions before formal validation and production screening.

3.3 Environmental Stress Screening

Environmental Stress Screening (ESS) and burn-in testing are representative reliability screening techniques applied during the manufacturing and pre-shipment stages to remove latent defects before products are delivered to customers[18][19]. While HALT is mainly used during the development stage to identify design weaknesses and operational margins, ESS and burn-in testing are primarily used to detect and eliminate early-life failures caused by manufacturing variation, assembly defects, weak components, and process-induced imperfections. Therefore, these screening methods play a critical role in reducing infant mortality failures and improving the long-term reliability of EV power electronic modules. The fundamental concept of ESS is to expose products to controlled environmental and operational stresses so that latent defects can be precipitated before field operation[18]. Latent defects may remain hidden under normal inspection conditions because the product may initially satisfy basic functional requirements. However, when the module is exposed to temperature cycling, electrical loading, vibration, or combined stress conditions, weak solder joints, unstable connectors, poor insulation, marginal semiconductor devices, and process-related defects may become observable. In this sense, ESS is intended to separate weak units from robust units by accelerating the manifestation of early failure mechanisms.

Burn-in testing is another important screening method that applies electrical and thermal stress for a specified period to detect early failures in electronic products and semiconductor-based systems[19]. In burn-in testing, the product is generally operated under elevated temperature and electrical load conditions to accelerate defects related to weak components, marginal circuits, poor interconnections, or early semiconductor degradation. For EV power electronic modules, burn-in testing can be useful for identifying unstable power conversion behavior, abnormal temperature rise, intermittent output fluctuation, communication instability, and protection-related abnormalities under powered operating conditions.

In EV power electronic modules, ESS procedures may include temperature cycling, thermal shock, vibration exposure, electrical loading, power cycling, and functional operation under stress conditions[18][19]. Temperature cycling is used to reveal defects associated with solder joints, bonding interfaces, PCB assemblies, and thermal expansion mismatch. Vibration exposure is used to identify weaknesses in connectors, mounting structures, heavy components, busbars, and internal interconnections. Electrical loading and power cycling are used to detect mar-

ginal semiconductor devices, unstable control circuits, insulation weaknesses, and power conversion abnormalities. These screening conditions should be selected based on expected field stresses, product characteristics, and dominant early failure mechanisms.

The application of ESS is particularly important for EV power electronic modules because these modules operate under high-voltage, high-current, and thermally demanding conditions. Even minor manufacturing defects can develop into safety-critical failures when the module is exposed to repeated electrical and environmental stress during vehicle operation. For example, a marginal solder joint may pass initial functional inspection but fail after repeated thermal cycling. A weak connector may operate normally under static conditions but become unstable under vibration. An insulation defect may remain undetected at low stress levels but become critical under high-voltage and humidity conditions. Therefore, ESS provides an effective method for identifying these latent defects before vehicle integration or customer use.

From a failure mechanism perspective, ESS is closely related to the infant mortality region of the bathtub curve. Early failures are commonly associated with defects introduced during material selection, component production, PCB assembly, soldering, bonding, insulation processing, connector assembly, or final module integration. ESS does not fundamentally improve the design itself; rather, it removes units that contain latent defects and verifies process stability. Therefore, ESS should be understood as a manufacturing-stage reliability assurance tool, whereas HALT should be understood as a development-stage design improvement tool.

The effectiveness of ESS depends on the appropriateness of screening stress levels. If the screening stress is too weak, latent defects may not be precipitated, and defective units may escape into the field. On the other hand, if the screening stress is excessively severe, it may damage good products or consume part of the useful life of the module. Therefore, ESS conditions should be carefully designed to activate early failure mechanisms without introducing unrealistic damage. Screening parameters such as temperature range, temperature transition rate, dwell time, vibration level, electrical load, operating duration, and acceptance criteria should be determined based on field stress profiles, reliability requirements, and protection performance criteria[18][19].

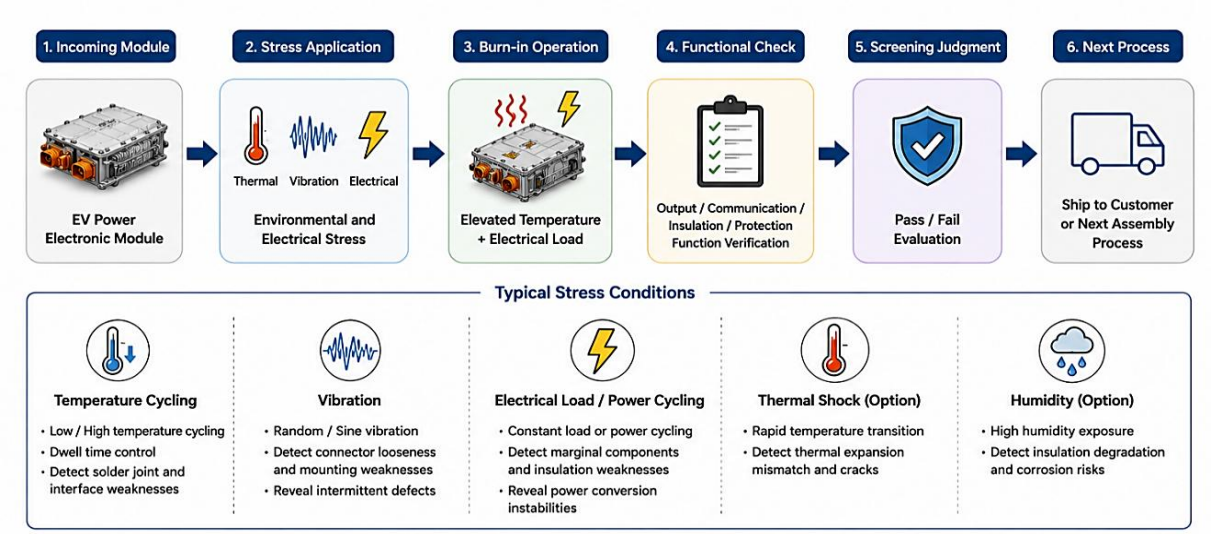
For EV power electronic modules, screening should also include protection-function verification. Since OBCs, LDCs, ICCUs, and traction inverters perform safety-critical functions, the screening process should not only confirm normal operation after stress exposure but also verify whether protection functions remain stable. Key protection-related items may include overvoltage protection, overcurrent protection, overtemperature protection, short-circuit protection, insulation monitoring, fault detection, derating control, shutdown behavior, and fail-safe response. A module that passes basic output performance testing may still have hidden weaknesses in its protection response under abnormal conditions. Therefore, protection-oriented screening is necessary for reducing recall-related safety risks.

In addition, ESS results can provide useful feedback for manufacturing process control. If repeated failures are observed during screening, the failure information can be used to identify process weaknesses such as soldering instability, component handling problems, insufficient insulation control, connector assembly variation, thermal interface defects, or PCB manufacturing variation. Therefore, ESS should not be treated merely as a final inspection process. Instead, it should be integrated with failure analysis, process improvement, and reliability monitoring activities to continuously improve production quality.

Screening techniques are also complementary to component qualification methods such as automotive-grade stress testing. For example, semiconductor and electronic component reliability test methods are useful for evaluating component-level robustness, while module-level ESS evaluates whether assembled systems remain stable under combined environmental and

electrical stress conditions[19][21]. In EV power electronic systems, this distinction is important because module failures may arise not only from individual component defects but also from interactions among semiconductor devices, PCB assemblies, connectors, cooling structures, insulation systems, and control circuits.

Figure 4. Environmental Stress Screening Process for EV Power Electronic Modules



The figure illustrates how environmental and electrical stress screening identifies latent defects and removes weak units before shipment or vehicle integration.

To clarify the role of each screening method, <Table 4> summarizes the major screening techniques applicable to EV power electronic modules. The table shows that ESS, burn-in testing, and functional screening have different purposes but can be integrated to reduce early-life failures and improve field reliability.

Table 4. Screening Methods for EV Power Electronic Modules

Screening Method	Main Purpose	Applied Stress Condition	Expected Detection	Reliability Contribution
Environmental Stress Screening (ESS)	Removal of latent manufacturing defects	Temperature cycling, vibration, electrical loading, combined stress	Weak solder joints, unstable connectors, insulation defects, process variation	Reduces infant mortality failures before shipment
Burn-in Testing	Detection of early electrical and thermal failures	Elevated temperature and powered operation	Weak components, marginal circuits, early semiconductor degradation	Improves operational stability under powered conditions
Functional Screening after Stress	Verification of normal operation after stress exposure	Output check, communication check, insulation check, protection response check	Output instability, communication error, insulation weakness, abnormal protection behavior	Confirms module stability after environmental or electrical stress
Protection-Oriented Screening	Verification of safety-related response	Overvoltage, overcurrent, overtemperature, short-circuit, insulation monitoring	Delayed fault detection, derating error, fail-safe malfunction	Supports protection reliability and recall-risk reduction

Therefore, ESS and burn-in testing serve as essential screening processes for reducing early-life failures in EV power electronic modules. By precipitating latent manufacturing defects before shipment, these methods help reduce infant mortality failures, improve field reliability, and decrease the probability of safety-critical failures during vehicle operation. When combined with HALT and Design Verification (DV) testing, ESS provides an intermediate reliability assurance step between design weakness discovery and final validation.

Based on these screening principles and early failure mechanisms, this study proposes a structured reliability evaluation framework that integrates HALT, screening processes, and DV testing. In the proposed framework, HALT is used to identify design weaknesses and operational margins during early development, ESS and burn-in testing are used to remove latent manufacturing defects before shipment, and DV testing is used to verify environmental durability and protection performance under representative operating conditions. This stepwise approach supports systematic reliability assurance for EV power electronic modules and contributes to reducing recall risks in electric mobility systems.

4. Proposed Reliability Test Framework for Protection Performance

This study proposes a stepwise reliability evaluation framework to improve protection performance in EV power electronic modules. The proposed framework consists of three major test stages: Highly Accelerated Life Testing (HALT), screening testing, and Design Verification (DV) testing. Each stage has a distinct purpose within the product development and manufacturing lifecycle. HALT is used to identify structural and design weaknesses during early development, screening testing is used to remove latent manufacturing defects before shipment, and DV testing is used to validate environmental durability and protection performance under representative operating conditions.

The proposed framework is designed to address reliability risks from both design and manufacturing perspectives. In EV power electronic modules, failures may originate from insufficient design margins, weak component selection, thermal design limitations, insulation weakness, solder joint vulnerability, connector instability, or process-induced defects. Therefore, a single reliability test method is not sufficient to identify all potential failure risks. A lifecycle-based evaluation structure is required to connect design weakness discovery, manufacturing defect removal, and final durability verification. In this context, the integration of HALT, screening testing, and DV testing provides a systematic approach for improving protection reliability before large-scale vehicle deployment.

The proposed framework is based on the premise that failures in EV power electronic modules are caused not only by individual component defects but also by complex interactions among thermal, electrical, mechanical, and environmental stress factors. In particular, OBCs, LDCs, ICCUs, and traction inverters operate under high-voltage and high-current conditions and are exposed to repeated thermal cycling, electrical overstress, vibration, humidity, and other environmental factors. These stress conditions can lead to degradation of semiconductor devices, solder joints, insulation structures, connectors, printed circuit board assemblies, and cooling paths[6][11][13].

Recent global recall cases summarized in Appendix A indicate that reliability problems in EV power electronic modules are closely associated with thermal stress, electrical overstress, vibration-induced fatigue, and environmental exposure. The dominant environmental stress factors affecting EV power electronic module reliability are summarized in Table B1 of Appendix B and provide the technical basis for selecting appropriate test conditions in the proposed reliability evaluation framework. Therefore, the proposed framework links recall-derived failure

modes with failure mechanisms, stress factors, protection functions, and reliability verification procedures.

Table 5. Structure of the Proposed Reliability Test Framework for EV Power Electronic Modules

Stage	Main Objective	Test Type	Major Stress Factors	Expected Detection	Main Output
HALT testing	Identification of structural design weaknesses and operating margins	Step-stress temperature, vibration, electrical load, combined stress	Thermal stress, electrical overstress, vibration stress	Latent design weaknesses, weak structures, insufficient margins	Design margin improvement and design correction
Screening testing	Removal of infant mortality failures before shipment	Burn-in testing, Environmental Stress Screening (ESS)	Temperature cycling, electrical loading, vibration exposure	Manufacturing defects, process variations, weak components	Early failure removal and process quality improvement
DV testing	Validation of environmental durability and protection performance	Environmental durability test based on automotive test profiles	Thermal cycling, humidity, vibration, mechanical shock, electrical load	Field reliability risks, degradation behavior, protection weakness	Qualification evidence and reliability validation

HALT testing is applied during the early development stage to identify design weaknesses under accelerated stress conditions. Unlike conventional qualification tests, HALT is not primarily intended to determine pass-or-fail compliance. Instead, it is used to expose potential weaknesses by applying stress levels beyond normal operating limits. Typical HALT stress conditions include low temperature, high temperature, rapid thermal transition, vibration, electrical load variation, and combined thermal-vibration stress[20]. For EV power electronic modules, HALT can reveal vulnerabilities in semiconductor devices, solder interconnections, insulation structures, PCB assemblies, connectors, and thermal paths[8][9]. The results of HALT provide engineering feedback for design improvement before mass production and contribute to strengthening protection reliability.

In the proposed framework, HALT serves as the first stage of reliability discovery. It is especially useful for determining whether the module has sufficient design margin against severe thermal, electrical, and mechanical stress conditions. If abnormal output, communication instability, insulation degradation, overtemperature response, or protection malfunction occurs during HALT, the failure symptom can be analyzed to identify the weak design element. The identified weakness may lead to corrective actions such as improving thermal paths, reinforcing solder joints, modifying PCB layout, increasing insulation distance, strengthening connector fixation, adjusting protection thresholds, or improving control logic. Therefore, HALT supports design improvement before the product proceeds to formal validation or production screening.

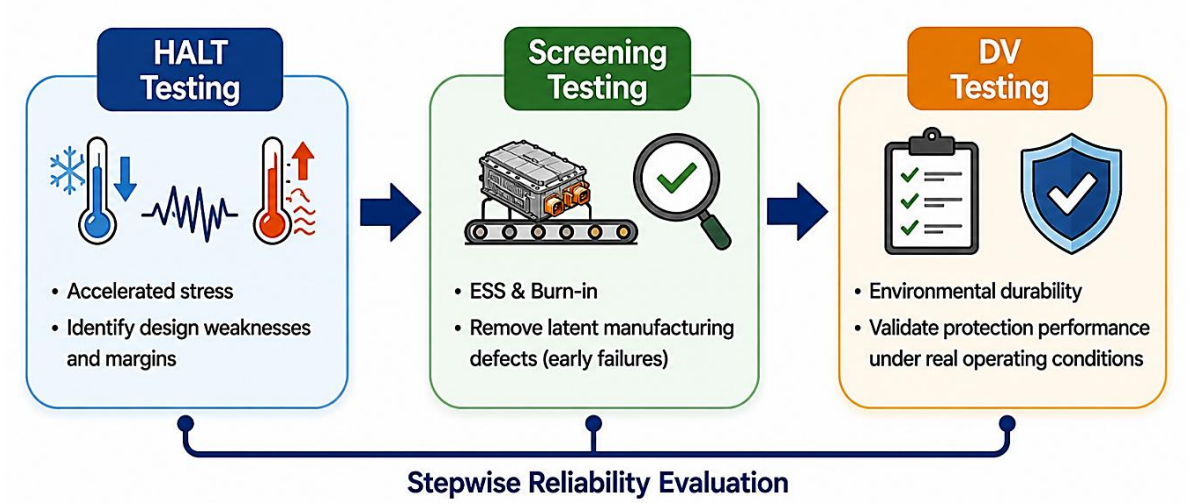
Screening testing is performed after design improvement and during the manufacturing stage. Its primary purpose is to remove infant mortality failures caused by latent defects, weak components, assembly errors, and process variations. Environmental Stress Screening (ESS) and burn-in testing are representative screening methods used for this purpose[18][19]. In EV power electronic modules, screening procedures may include temperature cycling, electrical loading, vibration exposure, and powered operation under stress conditions. These tests help precipitate early-life failures associated with poor solder joints, unstable connectors, marginal semiconductor devices, insulation weaknesses, and process-induced defects[18][21]. As a result, screening testing reduces the probability of unexpected failures during vehicle operation and improves field reliability.

Screening testing functions as a manufacturing-stage reliability filter. Even when design weaknesses are improved through HALT, production variation may still introduce latent defects into individual modules. For example, soldering instability, component handling damage, insufficient insulation control, connector assembly variation, thermal interface defects, or PCB manufacturing variation may not be detected by ordinary visual inspection or basic functional testing. By applying controlled environmental and electrical stresses, screening testing can identify weak units before shipment or vehicle integration. Therefore, screening testing contributes not only to early failure removal but also to manufacturing process stabilization and quality improvement.

DV testing is applied to validate whether the final design satisfies environmental durability and protection performance requirements under representative operating conditions. DV testing typically includes temperature cycling, high-temperature operation, low-temperature operation, humidity exposure, vibration loading, mechanical shock, water protection, and electrical performance verification. These test conditions are selected to reflect environmental stresses encountered in real vehicle operation[22][23]. Representative DV test conditions corresponding to the dominant environmental stress factors are summarized in Appendix C. Since these conditions are closely related to the degradation factors summarized in Appendix B, DV testing provides evidence that the module can maintain its required performance and protection functions under expected service environments[14][22].

In the proposed framework, DV testing serves as the final validation stage. While HALT intentionally applies stress levels beyond normal operating limits to identify design weaknesses, DV testing evaluates whether the finalized design satisfies defined reliability and environmental durability requirements. Therefore, DV testing should verify not only output performance but also protection behavior after environmental exposure. Protection-related verification items may include overvoltage protection, overcurrent protection, overtemperature protection, insulation monitoring, short-circuit response, derating control, shutdown behavior, fail-safe response, and recovery characteristics after stress exposure. These verification items are important because EV power electronic modules must maintain safe operation even under abnormal or degraded conditions.

Figure 5. Stepwise Reliability Test Framework for Protection Performance of EV Power Electronic Modules



The figure illustrates the stepwise relationship among HALT testing, screening testing, and DV testing. HALT identifies design weaknesses, screening removes latent manufacturing defects, and DV testing validates environmental durability and protection performance under representative vehicle operating conditions.

The three test stages are complementary rather than redundant. HALT identifies design weaknesses and operating margins, screening removes manufacturing-related latent defects, and DV testing verifies environmental durability and protection performance of the finalized design. In

this sense, the proposed framework provides a lifecycle-based reliability evaluation structure that connects development, manufacturing, and validation activities. The framework also clarifies which type of reliability risk should be addressed at each stage. Design-related weaknesses should be addressed through HALT and design correction, manufacturing-related latent defects should be addressed through screening, and field durability risks should be addressed through DV testing.

From a protection performance perspective, the proposed framework should verify not only normal operating performance but also abnormal-condition response. EV power electronic modules must respond appropriately to overvoltage, overcurrent, overtemperature, short-circuit conditions, insulation degradation, communication errors, and output instability. Therefore, protection functions should be monitored throughout HALT, screening, and DV testing. This includes verification of fault detection, derating control, shutdown behavior, insulation monitoring, fail-safe response, and recovery characteristics after stress exposure. If protection functions are not verified under stress conditions, a module may pass normal operation tests while still having hidden safety vulnerabilities.

The integration of HALT testing, screening testing, and DV testing enables systematic identification of failure mechanisms across the product lifecycle[16][20]. This structured reliability evaluation framework supports early detection of design weaknesses, removal of early-life manufacturing defects, and validation of environmental durability under representative vehicle operating conditions. Consequently, the proposed framework contributes to improving protection reliability, reducing recall risks, and enhancing the safety performance of EV power electronic modules in electric mobility systems[3][12].

Overall, the proposed framework provides a practical method for linking recall-derived failure modes with reliability verification activities. Recall cases provide evidence of actual field failures, while failure mechanism analysis explains how such failures occur under specific stress conditions. By connecting these two elements with HALT, screening, and DV testing, the framework supports a more systematic and protection-oriented reliability evaluation process. This approach is particularly useful for EV power electronic modules because their failures can directly influence vehicle safety, charging stability, propulsion continuity, and customer confidence.

5. Applicability Analysis of the Proposed Framework

The applicability of the proposed reliability test framework was evaluated by analyzing its consistency with dominant failure mechanisms identified from global recall cases and established environmental stress conditions affecting EV power electronic modules[6][8][9]. Since EV power electronic modules operate under high-voltage, high-current, thermally demanding, and mechanically dynamic conditions, their reliability cannot be sufficiently evaluated using a single test method. Instead, a lifecycle-based reliability evaluation approach is required to address design weaknesses, manufacturing defects, and long-term environmental durability risks. From this perspective, the proposed framework integrates HALT testing, screening testing, and DV testing to systematically address reliability risks across different product lifecycle stages[15][17][18][22].

5.1 Applicability to Design Weakness Identification

The first applicability aspect is related to the use of HALT testing for early identification of design weaknesses. HALT testing enables the discovery of structural and functional vulnerabilities associated with semiconductor devices, insulation structures, solder interconnections, PCB assemblies, connectors, thermal interfaces, and control circuits[20]. In EV power electronic modules, these weak points may not be detected during ordinary functional inspection because

the module may initially operate normally under standard conditions. However, when exposed to stepwise temperature stress, vibration stress, electrical load variation, and combined stress conditions, hidden design vulnerabilities can become observable.

As shown in Appendix A, representative recall cases were related to battery manufacturing defects, ICCU MOSFET damage, low-voltage charging failure, propulsion loss, and charging function abnormalities[24][25][26][27][28]. These failure symptoms indicate that weaknesses in battery systems, charging control units, and power conversion modules can develop into safety-related vehicle-level problems when they are exposed to actual operating environments. Therefore, HALT testing is applicable as an early-stage engineering tool for identifying operating margins and improving design robustness before mass production.

In practical development environments, HALT results can be used to support design review and corrective action. If abnormal output, communication instability, insulation degradation, overtemperature response, or protection malfunction occurs during HALT, the failure symptom can be analyzed to identify the weak design element. Corrective actions may include improving thermal paths, reinforcing solder joints, modifying PCB layout, increasing insulation distance, strengthening connector fixation, adjusting protection thresholds, or improving control logic. In this regard, HALT testing supports effective mitigation of design-related vulnerabilities before the module proceeds to formal validation, production preparation, or vehicle integration.

5.2 Applicability to Manufacturing Defect Screening

The second applicability aspect concerns the role of screening testing in improving manufacturing reliability. Even when the design has been improved through HALT, early-life failures may still occur due to manufacturing variation, assembly defects, weak components, poor solder joints, unstable connectors, insufficient insulation control, contamination, or process-induced imperfections. These failures are closely related to the infant mortality region of the bathtub curve and may appear during early vehicle operation if they are not removed before shipment[16][18].

Environmental Stress Screening (ESS) and burn-in testing are widely used in electronics production environments to detect latent defects and process variations[18][19]. In EV power electronic modules, screening testing is applicable because modules are exposed to repeated thermal, electrical, and mechanical stresses during vehicle operation. For example, temperature cycling may reveal solder joint weakness or thermal expansion mismatch. Electrical loading and powered operation may detect marginal semiconductor devices, unstable control circuits, or power conversion abnormalities. Vibration exposure may identify connector looseness, mounting weakness, or intermittent contact defects.

These screening procedures correspond to the early-life failure mechanisms summarized in Appendix B and contribute to reducing unexpected failures during vehicle operation[14][18][19]. Therefore, screening testing serves as a manufacturing-stage reliability filter that removes weak units before they reach customers or are integrated into vehicles. In addition, screening results can be used to identify repeated manufacturing weaknesses, improve process control, and stabilize production quality. This makes screening testing not only a defect removal process but also a feedback mechanism for manufacturing reliability improvement.

5.3 Applicability to Environmental Durability Validation

The third applicability aspect is related to DV testing, which ensures environmental durability under representative vehicle operating conditions[21][22][25][26]. DV testing is applied after design improvement and manufacturing control to verify whether the finalized module design satisfies reliability, durability, and protection performance requirements. Temperature cycling,

humidity exposure, vibration loading, mechanical shock, water protection, and electrical performance verification are typical DV test items for automotive electrical and electronic equipment.

DV testing is particularly important because EV power electronic modules must maintain stable performance throughout the intended vehicle lifetime. Thermal cycling can accelerate solder fatigue and package degradation, while humidity exposure can reduce insulation resistance and increase leakage current. Vibration and mechanical shock can affect connectors, busbars, mounting structures, and internal interconnections. Electrical load variation can cause output instability or trigger protection functions. These stress conditions are consistent with international automotive environmental reliability standards such as ISO 16750 and ISO 19453[21][25].

In the proposed framework, DV testing provides qualification evidence that the final design can maintain required electrical performance, insulation performance, environmental durability, and protection functions under representative vehicle operating conditions. Unlike HALT, which intentionally applies stress levels beyond normal operating limits to reveal weaknesses, DV testing evaluates whether the finalized design satisfies defined reliability requirements. Therefore, DV testing is suitable for validating field durability risks and confirming that the module can maintain stable operation under realistic environmental stress conditions.

5.4 Applicability to Protection Performance Improvement

The proposed framework also provides a structured relationship between failure mechanisms, environmental stress factors, and reliability verification procedures[12][15][16]. Global recall cases provide practical evidence of field failure symptoms, but recall information alone does not directly provide test conditions or engineering countermeasures. Therefore, recall-derived failure symptoms should be interpreted through failure mechanism analysis and stress factor classification. By integrating recall-case-based failure analysis with reliability engineering principles, the proposed framework supports systematic selection of appropriate stress conditions for protection-oriented reliability evaluation.

The framework is also applicable because the three test stages are complementary rather than redundant. HALT testing addresses design-related weaknesses by exposing modules to accelerated stress conditions beyond normal limits. Screening testing addresses manufacturing-related latent defects by removing weak units before shipment. DV testing addresses field durability risks by validating the final design under representative environmental and operating conditions. Therefore, each test stage has a distinct role within the product development lifecycle. The integration of these stages allows reliability evaluation to cover design, production, and validation perspectives in a systematic manner.

From a protection performance perspective, the proposed framework can also be applied to verify abnormal-condition response. EV power electronic modules should respond appropriately to overvoltage, overcurrent, overtemperature, short-circuit conditions, insulation degradation, communication faults, and output instability. If protection functions are not verified under stress conditions, a module may pass normal operating tests while still having hidden vulnerabilities under abnormal or degraded conditions. Therefore, monitoring protection functions throughout HALT, screening, and DV testing is necessary to improve protection reliability and reduce safety-related recall risks.

In practical development environments, the proposed framework can support decision-making during design review, process control, and validation planning. HALT results can be used to determine whether design margins are sufficient. Screening results can be used to identify manufacturing process weaknesses and improve production quality. DV test results can be used as qualification evidence for environmental durability and protection performance. In this way, the

framework does not merely provide a list of test items; rather, it provides a structured evaluation logic that links field failure evidence, stress factors, failure mechanisms, test methods, and protection requirements.

Therefore, the proposed reliability test framework can be effectively applied to EV power electronic module development processes to improve protection performance and reduce safety-related recall risks in electric mobility systems[1][3][20]. By connecting recall case analysis with HALT testing, screening testing, and DV testing, the framework supports early detection of design weaknesses, removal of early-life manufacturing defects, and validation of environmental durability under representative vehicle operating conditions. Consequently, it provides a practical methodology for strengthening reliability assurance in safety-critical automotive power electronic systems.

6. Conclusion

This study proposed a structured reliability test framework to improve protection performance in EV power electronic modules based on global recall case analysis and reliability engineering principles. As electric mobility systems increasingly depend on high-voltage power electronic modules such as OBCs, LDCs, ICCUs, and traction inverters, ensuring their reliability has become essential for maintaining vehicle safety, charging stability, and operational continuity[3][8].

The analysis of representative recall cases showed that major failure mechanisms in EV power electronic modules are closely associated with thermal stress, electrical overstress, vibration-induced fatigue, and environmental exposure[6][11][13]. These dominant degradation factors were reflected in the proposed reliability evaluation framework, which integrates HALT testing, screening testing, and DV testing.

The proposed framework enables early identification of structural design weaknesses through HALT testing, removal of manufacturing-induced infant mortality failures through screening testing, and verification of environmental durability under representative vehicle operating conditions through DV testing. The integration of these test stages supports systematic identification of failure mechanisms across different product lifecycle stages and strengthens protection-oriented reliability verification.

Furthermore, the applicability of the framework was confirmed through its consistency with recall-case-derived failure mechanisms and environmental stress conditions summarized in Appendices A and B. The structured relationship between stress factors, detection methods, and reliability verification procedures demonstrates that the proposed framework can effectively support reliability assurance in EV power electronic module development environments.

In particular, thermal cycling and power cycling are important reliability concerns for power electronic modules because repeated temperature stress can accelerate wear-out mechanisms and influence lifetime prediction results[29][30]. Therefore, the proposed framework should be further validated using empirical test data obtained from HALT, screening, DV testing, and accelerated power cycling tests. Such validation would make it possible to quantitatively evaluate the relationship between stress conditions, degradation behavior, protection response, and field reliability performance.

Therefore, the proposed reliability test framework provides practical guidance for improving protection performance and reducing safety-related recall risks in automotive power electronic applications. The results of this study are expected to contribute to the establishment of systematic reliability evaluation strategies for next-generation electric mobility systems. Further

empirical validation using actual HALT, screening, DV test, and power cycling test data is required in future studies.

<Appendix A> EV Recall Cases Related to Power Electronic System Failures

OEM	Vehicle Model	Major Failure Cause	Impact	Recall Scale	Source
GM	Bolt EV	Battery cell manufacturing defect	Fire risk	Approx. 140,000 units	[24][25]
Hyundai	Ioniq5 / Ioniq6 / GV60	ICCU MOSFET damage	12V charging failure, propulsion loss	Approx. 140,000 units	[26][27][31]
Kia	EV6	Power electronic control system malfunction	Charging function abnormality	Approx. 60,000 units	[28][32]

Representative recall cases with available public sources are summarized in Appendix A.

This appendix summarizes the major environmental stress factors affecting reliability degradation and failure mechanisms in EV power electronic modules. These stress factors were identified based on the recall case analysis presented in Appendix A and established reliability engineering principles. They represent the primary physical contributors to protection-related failures in automotive power electronic systems.

EV power electronic modules operate under combined thermal, electrical, mechanical, and environmental stress conditions during vehicle operation. These stress factors directly influence early failure occurrence and long-term degradation behavior in semiconductor devices, interconnections, insulation structures, and packaging materials. Therefore, systematic consideration of these stress environments is essential when establishing protection-oriented reliability evaluation frameworks.

The dominant environmental stress factors affecting EV power electronic module reliability are summarized in <Appendix B>.

<Appendix B> Major Environmental Stress Factors Affecting EV Power Electronic Module Reliability

Stress Category	Stress Factor	Description	Typical Impact on Modules
Thermal Stress	Junction temperature variation	Repetitive temperature rise due to switching operation	Semiconductor degradation, solder fatigue
Thermal Stress	Ambient temperature cycling	Temperature fluctuation during vehicle operation and parking	Package fatigue, PCB warpage
Thermal Stress	Rapid thermal transition	Fast heating and cooling during charging/discharging	Material expansion mismatch failures
Electrical Stress	High-voltage switching	High-frequency switching in inverter and converter circuits	Insulation degradation, semiconductor overstress
Electrical Stress	Overcurrent conditions	Load transient and abnormal operating states	Device overheating, conductor damage
Electrical Stress	Power cycling stress	Repeated ON/OFF operation of power modules	Bond wire fatigue, solder crack propagation

Mechanical Stress	Random vibration	Road-induced vibration during vehicle driving	Connector loosening, PCB cracking
Mechanical Stress	Mechanical shock	Sudden impact from road irregularities	Structural displacement, fastening failure
Mechanical Stress	Resonance excitation	Structural resonance during operation	Amplified stress on mounted components
Environmental Stress	Humidity exposure	Moisture penetration under high humidity environments	Corrosion, insulation resistance reduction
Environmental Stress	Condensation	Rapid temperature drop causing moisture condensation	Short circuit risk, insulation degradation
Environmental Stress	Salt spray exposure	Coastal or winter road environments	Corrosion of terminals and connectors
Environmental Stress	Dust contamination	Particle ingress into module enclosure	Cooling degradation, insulation failure

Sources: Summarized based on reliability engineering literature, automotive environmental standards, and publicly available recall information

<Appendix C> Representative DV Test Conditions

Test Type	Typical Test Condition	Test Objective
Temperature test	−40°C to 105°C	Thermal reliability verification
Vibration test	5–2000 Hz, 3 Grms	Vehicle vibration durability verification
Humidity test	85°C / 85% RH	Insulation performance verification
Shock test	30 G, 11 ms	Mechanical shock resistance verification
Water protection test	IPX5 / IPX7 Ingress protection verification	-

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The Effects of Social Comparison Orientation on Turnover Intention among Beauty Professionals: The Role of Job Stress

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Abstract

Purpose: *This study aims to examine the effects of social comparison orientation on job stress and turnover intention among beauty workers, and to verify the mediating effect of job stress. In particular, this study focuses on psychological protection and emotional labor issues experienced by beauty workers in highly competitive organizational environments. As the beauty industry is characterized by emotional labor, customer interaction, and performance-based evaluation, workers are frequently exposed to psychological pressure and stress. Therefore, this study seeks to provide foundational data for establishing psychologically safe and sustainable work environments in the beauty industry.*

Method: *A survey was conducted among beauty workers, and a total of 200 questionnaires were used for the final analysis. The questionnaire consisted of social comparison orientation, job stress, turnover intention, and demographic variables, and all items were measured using a 5-point Likert scale. Data analysis was performed using the SPSS 29.0 program, including factor analysis, reliability analysis, correlation analysis, multiple regression analysis, and mediation regression analysis. In addition, this study attempted to identify the relationship between social comparison behavior and psychological stress in the workplace environment of beauty workers.*

Results: *First, among the sub-factors of social comparison orientation, upward comparison was found to influence task-related stress. Second, regarding the effect of social comparison orientation on turnover intention, downward comparison tended to decrease turnover intention, whereas upward comparison tended to increase turnover intention. Third, job stress was found to influence turnover intention. Fourth, the mediating effect of job stress was generally not significant. The findings indicate that excessive upward comparison may negatively affect psychological stability and emotional well-being among beauty workers working in competitive organizational environments.*

Conclusion: *The findings of this study suggest that, in a competitive environment such as the beauty industry, social comparison orientation can influence workers' job stress and turnover intention. Therefore, at the organizational level, it is necessary to establish fair evaluation systems and foster a positive organizational culture, as well as to implement management strategies to reduce job stress. Furthermore, psychological protection systems and emotional labor management strategies should be strengthened to improve psychological safety and sustainable working conditions for beauty workers. These findings suggest that organizational strategies for reducing job stress are necessary not only for turnover prevention but also for the protection of workers' mental health and psychological safety. Future research should expand by including diverse groups and additional variables related to emotional labor protection and organizational safety.*

Keywords: ***Social Comparison Orientation, Job Stress, Emotional Labor, Turnover Intention, Psychological Safety***

1. Introduction

In modern society, workplace competition has become increasingly intensified, and individuals tend to compare themselves with others in order to evaluate their abilities and performance. Such comparison processes significantly influence individuals' psychological states and behaviors, and this tendency is conceptualized as social comparison orientation. According to social comparison theory, individuals are inclined to compare themselves with others to evaluate their abilities and opinions, and these comparisons can have various effects on their emotions and behaviors[1][2].

The beauty industry is a continuously growing sector driven by increasing interest in personal appearance management. It is characterized as a labor-intensive field with a high dependence on human resources, where the skills and expertise of practitioners play a crucial role in determining service outcomes. In particular, as a service-oriented industry, technical competence, customer satisfaction, and physical appearance function as key evaluation criteria[3].

The beauty industry, in particular, is a service-oriented sector in which technical skills, customer satisfaction, and external appearance serve as key evaluation criteria. Due to these characteristics, beauty workers are required to perform multiple roles, including responding to diverse customer demands and engaging in emotional labor[4]. Such work environments may threaten workers' psychological safety and increase emotional exhaustion and mental stress. In particular, beauty workers are frequently exposed to emotional labor, performance pressure, and interpersonal comparison within competitive organizational environments. Therefore, the protection of mental health and emotional labor among beauty workers has recently emerged as an important issue in protection-convergence research.

Within such work environments, beauty workers are frequently exposed to situations in which they compare their abilities and performance with those of colleagues or competitors, often based on factors such as skill level, customer responses, and job performance. These social comparisons may lead to negative emotions, including psychological burden and stress[5].

Meanwhile, beauty workers often experience emotional exhaustion and job stress due to various factors such as long working hours, emotional labor, customer interactions, and competitive work environments[6]. Job stress has been reported to negatively affect job satisfaction, organizational commitment, and job performance. In particular, when job stress accumulates over time, it is more likely to lead to turnover intention, which is recognized as a critical issue in organizational human resource management[7].

However, previous studies have mainly focused on general employees or workers in various industries, and there is a relative lack of research that comprehensively examines the relationships among social comparison orientation, job stress, and turnover intention specifically among beauty industry workers. Considering the unique characteristics of the beauty industry, it is necessary to investigate how social comparison behaviors influence job stress and turnover intention.

Therefore, this study aims to examine the effect of social comparison orientation on turnover intention among beauty workers and to analyze the role of job stress in this relationship. Through this, the study seeks to provide fundamental data for reducing turnover intention and improving organizational management in the beauty industry.

2. Theoretical Background

2.1 Social Comparison Orientation

Social comparison orientation refers to individual differences in the tendency to compare one's abilities or opinions with those of others[8]. Social comparison theory, proposed by Festinger (1954), suggests that individuals have a tendency to compare themselves with others in order to evaluate their abilities and opinions more accurately. When objective standards are available, individuals can assess themselves based on those criteria; however, when such standards are unclear or unavailable, they rely on social information—such as others' abilities or opinions—to evaluate their own position or status. Depending on the level of the comparison target, social comparison can be categorized into upward comparison, lateral comparison, and downward comparison[9].

Social comparison orientation may lead to negative emotions such as envy or feelings of inferiority when individuals compare their abilities or performance with others. In particular, social comparison in the workplace often evokes emotions such as envy and influences individuals' psychological states and behaviors[10]. These negative emotions can be interpreted as leading to individuals' stress responses, and stress has been identified as a significant factor influencing psychological burden[11].

2.2 Job Stress

Job stress refers to the negative psychological and physiological responses experienced by individuals during the process of performing their job. Cooper and Marshall (1976) defined job stress as negative environmental factors related to work[12], while Schuler (1980) described it as a dynamic phenomenon that arises from individuals' perceptions of organizational demands, opportunities, and constraints[13]. In addition, Beehr and Newman (1978) conceptualized job stress as individuals' physical responses to specific organizational demands, noting that such responses may manifest in either positive or negative forms[14].

In domestic studies, job stress has been defined as the negative physical and psychological responses perceived by individuals as a result of discrepancies arising from interactions with the external work environment[15], and as a phenomenon resulting from the imbalance between organizational goals and employees' needs[16]. These perspectives suggest that job stress is not merely an external stimulus, but rather an interactive concept formed through the relationship between the organization and the individual.

Meanwhile, job stress has negative effects on both individuals and organizations. Stress arising from work can lead to various problems in physical, behavioral, and organizational aspects, and is considered a major cause of health issues, decreased productivity, and increased human error. Furthermore, such effects may result in higher turnover rates and reduced job performance, ultimately leading to negative outcomes for organizational effectiveness[17].

In addition, previous studies on beauty industry workers have shown that job stress negatively affects job satisfaction and plays a mediating role in the relationship between professionalism and job satisfaction, thereby further influencing organizational efficiency[18]. Furthermore, job stress can be reduced by factors such as reference groups, autonomy, and service beliefs, while social support has been shown to moderate these relationships[19].

2.3. Turnover Intention

Turnover intention refers to the psychological state and behavioral intention of organizational members to leave their current organization, and it has been conceptualized by various scholars. Price (1977) defined turnover as the movement of individuals across organizational boundaries within a social system, including employment, withdrawal, transfer, and promotion[20]. Meyer and Allen (1984) described turnover intention as the opposite of the degree to which employees wish to remain as members of an organization, representing an attitudinal tendency that has not yet manifested as actual turnover behavior[21].

Furthermore, Tett and Meyer (1993) conceptualized turnover intention as a deliberate cognitive process of thinking about leaving the organization rather than a simple behavior[22], while Vandenberg and Nelson (1999) defined it as an individual's subjective estimation of the likelihood of permanently leaving the organization in the near future[23]. These perspectives emphasize that turnover intention is a significant predictor that precedes actual turnover behavior.

Turnover intention is a complex phenomenon formed through the interaction of internal psychological factors and external environmental factors. It is influenced not only by organizational factors such as job stress, low compensation, lack of promotion opportunities, and conflicts with supervisors or colleagues, but also by external factors such as labor market opportunities and socio-economic conditions[24]. Moreover, turnover intention extends beyond the mere intention to leave and affects overall job attitudes and organizational behaviors. Employees with high turnover intention are more likely to exhibit low job involvement, reduced performance, and passive attitudes, which can ultimately have negative impacts on overall organizational effectiveness[25]. In particular, in service occupations, emotional labor and job stress have been identified as key factors that increase turnover intention[26].

3. Research Method and Procedures

3.1 Sample Selection and Data Collection

This study was conducted to examine the effect of social comparison orientation on turnover intention among beauty workers, with job stress as a mediating variable. The research subjects consisted of beauty industry workers, and the survey was conducted over a two-week period from July 1 to July 15, 2025. A total of 200 questionnaires were used for the final statistical analysis.

Data for this study were collected using a self-report questionnaire, and the survey items were constructed based on previous studies for empirical analysis. The questionnaire consisted of a total of 34 items, including 9 items on general characteristics, 15 items on social comparison orientation, 6 items on job stress, and 4 items on turnover intention. All items were measured using a 5-point Likert scale. The measurement items for social comparison orientation were developed based on the studies of Park (2016), Delery and Doty (1996), and Ramamoorthy and Carroll (1998)[27][28][29]. Job stress was measured using instruments adapted from the studies of Jung (2015), Lee (2014), and Kim (2017)[30][31][32]. Turnover intention was measured based on the studies of Bluedorn (1982), Price and Muller (1981), and Hwangbo (2023)[33][34][35].

Data analysis was conducted using SPSS 29.0. Frequency analysis, percentages, and means were calculated to examine the demographic characteristics of the respondents. Pearson's correlation analysis was performed to examine the relationships among variables. In addition, mediation regression analysis was conducted to test the mediating effect of job stress on the relationship between social comparison orientation and turnover intention. The significance level for all statistical analyses was set at $\alpha = .05$.

3.2 Research Questions

This study aims to examine the effect of social comparison orientation on turnover intention among beauty workers, with job stress considered as a mediating variable. The specific research questions are as follows. The research model is presented in <Figure 1>.

Research Question 1. To examine the demographic characteristics of the respondents.

Research Question 2. To conduct factor analysis and reliability analysis of social comparison orientation, job stress, and turnover intention.

Research Question 3. To analyze the correlations among social comparison orientation, job stress, and turnover intention.

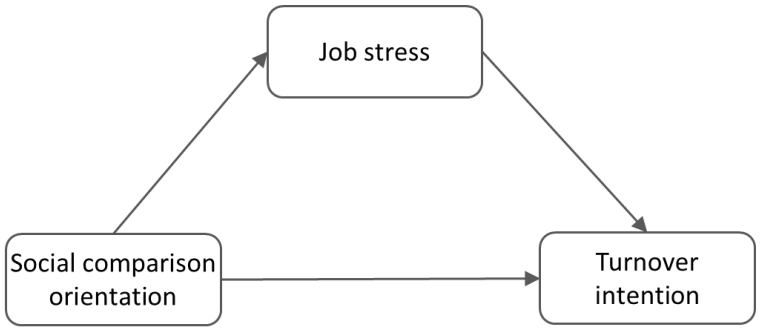
Research Question 4. To examine the effect of social comparison orientation on job stress.

Research Question 5. To examine the effect of social comparison orientation on turnover intention.

Research Question 6. To examine the effect of job stress on turnover intention.

Research Question 7. To examine the mediating effect of job stress in the relationship between social comparison orientation and turnover intention.

Figure 1. Research Model



4. Research Results

4.1 Demographic Characteristics of the Respondents

Examining the demographic characteristics of the respondents, females accounted for the majority (89.5%). In terms of occupational field, the largest group was in skincare (45.0%), followed by makeup, nail, and hair.

Regarding position, owners represented the highest proportion, followed by staff and managers. In terms of work experience, most respondents had between 5 and less than 10 years (59.5%).

With respect to marital status, the majority were unmarried (57.5%). In terms of education, most respondents had a junior college degree or lower (56.0%), and respondents in their 30s formed the largest age group (34.5%).

Regarding employment type, most were full-time employees (66.0%), and the most common monthly income range was between 2 million and less than 3 million KRW (34.5%).

4.2 Factor Analysis and Reliability Analysis

Exploratory factor analysis (EFA) was conducted to verify the validity of the measurement items used in this study and to identify common factors for use as variables. During the process of reliability analysis and scale purification, some items were removed (one item from social comparison orientation and one item from job stress).

All measurement variables were analyzed using principal component analysis (PCA) to extract underlying factors, and varimax rotation was applied to simplify the factor structure. Factor

loadings of 0.5 or higher were considered significant. The results of the factor analysis indicated that both independent and dependent variables were grouped into factors with eigenvalues greater than 1.

For the independent variable, social comparison orientation, the cumulative variance explained was 76.908%. The overall reliability coefficient (Cronbach's α) was 0.937, and the reliability coefficients for all factors were above 0.896. Three factors were extracted for social comparison orientation: lateral comparison (29.371%), downward comparison (29.154%), and upward comparison (18.384%) (see <Table 1>).

Table 1. Results of the Factor Analysis for Social Comparison Orientation

Item		Factor			Communality
		1	2	3	
Lateral Comparison	I think about the level of ability of people who are similar to me.	.873	.127	.125	.795
	I compare what I have achieved in life with people who are similar to me.	.852	.108	.261	.805
	I often compare myself with people who are similar to me.	.832	.222	.250	.804
	I compare the results of what I have done with what similar people have accomplished.	.787	.148	.266	.711
	I compare myself with people who are similar to me in order to evaluate myself.	.774	.183	.363	.765
Downward Comparison	Seeing people who are worse off than me is comforting.	.169	.879	.145	.822
	Seeing people who are worse off than me makes me feel relieved about my own life.	.209	.847	.168	.790
	Seeing people who are worse off than me makes me feel proud of myself.	.145	.843	.223	.781
	Seeing people who are worse off than me makes me feel happier.	.114	.821	.297	.774
	Seeing people who are worse off than me makes me think that things will get better for me.	.119	.745	.281	.649
Upward Comparison	I compare myself with others when I see people's activities (e.g., travel, hobbies).	.306	.283	.794	.804
	I compare myself with others when I see people living happy daily lives.	.384	.322	.730	.784
	I compare myself with others when I see people owning nice possessions (e.g., clothes, bags).	.437	.373	.640	.740
	I compare myself with others when I see people with superior physical appearance or physical conditions	.401	.443	.621	.742
Eigenvalue		4.112	4.082	2.574	
Variance (%)		29.371	29.154	18.384	
Cumulative (%)		29.371	58.524	76.908	
Reliability (Cronbach's α)		.925	.920	.896	
Overall Reliability		.937			
KMO and Bartlett's Test		KMO=.931 χ^2=2,213.916 p<.000			

For the mediating variable, job stress, the results of the factor analysis indicated that the cumulative variance explained was 81.445%. The overall reliability coefficient (Cronbach's α) was 0.798, and the reliability coefficients for each factor were found to be above 0.830.

Two factors were extracted for job stress: fairness-related stress (45.335%) and task-related stress (36.110%).

Table 2. Results of the Factor Analysis for Job Stress

Item		Factor		Communality
		1	2	
Fairness-related Stress	I am dissatisfied with my pay relative to my performance.	.851	.222	.845
	I am dissatisfied with my pay relative to my career experience.	.842	.105	.816
Job-related Stress	I work in a constantly tense state.	-.052	.952	.858
	I sometimes feel frustrated with my work.	.131	.834	.825
	My current workload feels overwhelming.	.332	.723	.735
Eigenvalue		2.266	1.725	
Variance (%)		45.335	36.110	
Cumulative (%)		45.335	81.445	
Reliability (Cronbach's α)		.850	.830	
Overall Reliability		.798		
KMO and Bartlett's Test		KMO=.650 χ^2=540.55 p<.000		

For the dependent variable, turnover intention, the results of the factor analysis showed that the cumulative variance explained was 78.775%. The overall reliability coefficient (Cronbach's α) was 0.915, indicating a very high level of reliability.

Only one factor was extracted for turnover intention, accounting for 78.775% of the variance (see <Table 3>).

Table 3. Results of Factor Analysis for Turnover Intention

Item		Factor	Communality
		1	
Turnover Intention	I would like to work at another organization.	.912	.824
	I often think about quitting my current job.	.885	.875
	I would leave my current job if I had a good opportunity to do so.	.872	.795
	I am ready to change jobs at any time.	.855	.784
Eigenvalue		3.243	
Variance (%)		78.775	
Overall Reliability		.915	
KMO and Bartlett's Test		KMO=.830 χ^2=540.458 p<.000	

4.3. Correlation analysis

Descriptive statistics indicated that the mean values of the sub-factors of the independent variable, social comparison orientation—lateral comparison (M = 3.246, SD = 1.006), downward comparison (M = 2.497, SD = 1.031), and upward comparison (M = 2.983, SD = 1.070)—were generally around the midpoint of the scale. For the mediating variables, fairness-related stress (M = 3.003, SD = 1.118) and task-related stress (M = 2.960, SD = 0.870) were found to be at similar or slightly lower levels. The dependent variable, turnover intention (M = 3.059, SD = 1.106), was observed to be at a moderate level slightly above 3. The results of the correlation analysis showed that lateral comparison had significant positive correlations with downward comparison (r = .411, p < .001), upward comparison (r = .712, p < .001), fairness-related stress (r = .235, p < .01), task-related stress (r = .374, p < .001), and turnover intention (r = .306, p < .001). Downward comparison showed significant positive correlations with upward comparison (r = .663, p < .001), fairness-related stress (r = .164, p < .05), and task-related stress (r = .197, p < .01), but no significant correlation with turnover intention (r = .072, p > .05). Upward comparison was significantly positively correlated with fairness-related stress (r = .270, p < .001), task-related stress (r = .406, p < .001), and turnover intention (r = .308, p < .001). In addition, among the mediating variables, fairness-related stress showed strong positive correlations with task-related stress (r = .376, p < .001) and turnover intention (r = .509, p < .001), while task-related stress was also significantly positively correlated with turnover intention (r = .388, p < .001), as shown in <Table 4>.

Table 4. Results of the Correlation Analysis

Item	Correlation Analysis							
	Mean	Standard Deviation	1	2	3	4	5	6
1. Independent Variable: Lateral Comparison	3.246	1.006	1					
2. Independent Variable: Downward Comparison	2.497	1.031	.411***	1				
3. Independent Variable: Upward Comparison	2.983	1.070	.712***	.663***	1			
4. Mediating Variable: Fairness-related Stress	3.003	1.118	.235**	.164*	.270***	1		
5. Mediating Variable: Job-related Stress	2.960	0.870	.374***	.197**	.406***	.376***	1	
6. Dependent Variable: Turnover Intention	3.059	1.106	.306***	.072	.308***	.509***	.388***	1

* p<.05, ** p<.01, *** p<.001.

4.4 Mediating Effect of Job Stress between Social Comparison Orientation and Turnover Intention

This study conducted a multiple regression analysis to examine the effect of social comparison orientation on job stress, and the results are presented in <Table 5>. First, the regression analysis for the dependent variable, fairness-related stress, showed that the overall model was significant (F(3,196)=5.431, p<.001), with an explanatory power of 7.7% (R^2=.077). However, the sub-factors of social comparison orientation—similar comparison, downward comparison, and upward comparison—did not show a significant effect on fairness-related stress. Next, the regression analysis for the dependent variable, task-related stress, indicated that the overall model was significant (F(3,196)=14.968, p<.001), with an explanatory power of 18.6% (R^2=.186). Among the sub-factors, upward comparison was found to have an effect on task-related stress, whereas similar comparison and downward comparison did not show significant effects. Overall, upward comparison was found to increase task-related stress.

Table 5. The effect of social comparison orientation on job stress

Dependent Variable		Independent Variable	B	se	β	t	p
	Fairness-related Stress	Constant	2.056	.275		7.472	.000***
		Lateral Comparison	.094	.109	.084	0.857	.393
		Downward Comparison	-.020	.100	-.018	-0.196	.845
		Upward Comparison	.232	.125	.222	1.849	.066
		R^2= .077, $F(3,196)=5.431^{***}$					
	Job-related Stress	Constant	1.861	.201		9.253	.000***
		Lateral Comparison	.136	.080	.157	1.700	.091
		Downward Comparison	-.095	.073	-.113	-1.299	.196
		Upward Comparison	.300	.092	.369	3.275	.001**
		R^2= .186, $F(3,196)=14.968^{***}$					

* p<.05, ** p<.01, *** p<.001.

This study conducted a multiple regression analysis to examine the effect of social comparison orientation on turnover intention, and the results are presented in <Table 6>. The overall model was found to be significant (F(3,196)=10.341, p<.001), with an explanatory power of 13.7% (R^2=.137). Among the independent variables, downward comparison was found to have a negative effect on turnover intention, while upward comparison had a positive effect on turnover intention. In contrast, similar comparison did not show a significant effect on turnover intention. Overall, the results indicate that among the sub-factors of social comparison orientation, downward comparison decreases turnover intention, whereas upward comparison increases turnover intention.

Table 6. The Effect of Social Comparison Orientation on Turnover Intention

Dependent Variable	Independent Variable	B	se	β	t	p
Turnover Intention	Constant	2.043	.263		7.758	.000***
	Lateral Comparison	.164	.105	.149	1.562	.120
	Downward Comparison	-.235	.096	-.219	-2.451	.015*
	Upward Comparison	.359	.120	.347	2.993	.003**
	R^2= .137, $F(3,196)=10.341^{***}$					

* p<.05, ** p<.01, *** p<.001.

This study conducted a multiple regression analysis to examine the effect of job stress on turnover intention, and the results are presented in <Table 7>. The overall model was found to be significant (F(3,196)=43.078, p<.001), with an explanatory power of 30.4% (R^2=.304). Among the independent variables, fairness-related stress had a positive effect on turnover intention, and task-related stress also had a positive effect on turnover intention. Overall, the results indicate that both fairness-related stress and task-related stress, as sub-factors of job stress, increase turnover intention.

Table 7. The Effects of Job Stress on Turnover Intention

Dependent Variable	Independent Variable	B	se	β	t	p
Turnover Intention	Constant	.940	.253		3.709	.000
	Fairness-related Stress	.419	.063	.423	6.596	.000
	Job-related Stress	.291	.082	.229	3.570	.000
	R^2= .304, $F(3,196)=43.078^{***}$					

* p<.05, ** p<.01, *** p<.001.

4.5 Mediating Effect of Job Stress between Social Comparison Orientation and Turnover Intention

This study conducted a mediation regression analysis using Model 4 of the SPSS Process Macro Ver. 4.2 (Hayes, 2018) to examine the mediating effect of fairness-related stress on the relationship between similar comparison and turnover intention, and the results are presented in <Table 8>. The results of the path analysis showed that similar comparison did not have a significant effect on fairness-related stress or turnover intention, whereas fairness-related stress had a positive effect on turnover intention. To test the significance of the indirect effect, bootstrapping (5,000 resamples) was conducted, and the indirect effect of similar comparison on turnover intention through fairness-related stress was B=0.038, with a 95% confidence interval [BootLLCI=-0.061, BootULCI=0.140], which included zero, indicating that the indirect effect was not significant. Overall, fairness-related stress did not significantly mediate the relationship between lateral comparison and turnover intention.

Table 8. Results of the Mediating Effect Analysis among Similar Comparison, Fairness-Related Stress, and Turnover Intention

Path	B	se	t	LLCI	ULCI
Lateral Comparison →Fairness-related Stress	.094	.109	.857	.393	-.122
Lateral Comparison →Turnover Intention	.098	.093	1.063	.289	-.084
Fairness-related Stress →Turnover Intention	.402	.063	6.406	.000	.278

Independent Variable	Parameter	Dependent Variable	B	BootSE	BootLLCI	BootULCI
Lateral Comparison	Fairness-related Stress	Turnover Intention	.038	.050	-.061	.140

* p<.05, ** p<.01, *** p<.001.

This study examined the mediating effect of fairness-related stress on the relationship between downward comparison and turnover intention, and the results are presented in <Table 9>. The results of the path analysis showed that downward comparison did not have a significant effect on fairness-related stress, whereas it had a negative effect on turnover intention. In contrast, fairness-related stress had a positive effect on turnover intention. To test the significance of the indirect effect, bootstrapping (5,000 resamples) was conducted, and the indirect effect of downward comparison on turnover intention through fairness-related stress was B=0.093, with a 95% confidence interval [BootLLCI=-0.015, BootULCI=0.208], which included zero, indicating that the indirect effect was not significant. Overall, the results indicate that the mediating effect of fairness-related stress in the relationship between downward comparison and turnover intention was not significant.

Table 9. Results of the Mediating Effect of Fairness-Related Stress on the Relationship between Downward Comparison and Turnover Intention

Path	B	se	t	LLCI	ULCI
Downward Comparison → Fairness-related Stress	-.020	.100	-.196	.845	-.217
Downward Comparison → Turnover Intention	-.208	.084	-2.462	.015	-.374
Fairness-related Stress → Turnover Intention	.402	.063	6.406	.000	.278

Independent Variable	Parameter	Dependent Variable	B	BootSE	BootLLCI	BootULCI
Downward Comparison	Fairness-related Stress	Turnover Intention	.093	.057	-.015	.208

* p<.05, ** p<.01, *** p<.001.

This study examined the mediating effect of fairness-related stress on the relationship between upward comparison and turnover intention, and the results are presented in <Table 10>. The results of the path analysis showed that upward comparison did not have a significant effect on fairness-related stress or turnover intention, whereas fairness-related stress had a positive effect on turnover intention. To test the significance of the indirect effect, bootstrapping (5,000 resamples) was conducted, and the indirect effect of upward comparison on turnover intention through fairness-related stress was B=0.093, with a 95% confidence interval [BootLLCI=-0.015, BootULCI=0.208], which included zero, indicating that the indirect effect was not significant. Overall, the results indicate that the mediating effect of fairness-related stress in the relationship between upward comparison and turnover intention was not significant.

Table 10. Results of the Mediating Effect of Fairness-Related Stress on the Relationship between Upward Comparison and Turnover Intention

Path	B	se	t	LLCI	ULCI
Upward Comparison →Fairness-related Stress	.232	.125	1.849	.066	-.015
Upward Comparison →Turnover Intention	.205	.108	1.894	.060	-.008
Fairness-related Stress →Turnover Intention	.402	.063	6.406	.000	.278

Independent Variable	Parameter	Dependent Variable	B	BootSE	BootLLCI	BootULCI
Upward Comparison	Fairness-related Stress	Turnover Intention	.093	.057	-.015	.208

* p<.05, ** p<.01, *** p<.001.

This study examined the mediating effect of task-related stress on the relationship between similar comparison and turnover intention, and the results are presented in <Table 11>. The results of the path analysis showed that similar comparison did not have a significant effect on task-related stress or turnover intention, whereas task-related stress had a positive effect on turnover intention. To test the significance of the indirect effect, bootstrapping (5,000 resamples) was conducted, and the indirect effect of similar comparison on turnover intention through task-related stress was B=0.038, with a 95% confidence interval [BootLLCI=-0.061, BootULCI=0.140], which included zero, indicating that the indirect effect was not significant. Overall, the results indicate that the mediating effect of task-related stress in the relationship between similar comparison and turnover intention was not significant.

Table 11. Results of the Mediating Effect of Task-Related Stress on the Relationship between Similar Comparison and Turnover Intention

Path	B	se	t	LLCI	ULCI
Lateral Comparison → Job-related Stress	.094	.109	.857	.393	-.122
Lateral Comparison → Turnover Intention	.098	.093	1.063	.289	-.084
Job-related Stress → Turnover Intention	.402	.063	6.406	.000	.278

Independent Variable	Parameter	Dependent Variable	B	BootSE	BootLLCI	BootULCI
Lateral Comparison	Job-related Stress	Turnover Intention	.038	.050	-.061	.140

* p<.05, ** p<.01, *** p<.001.

This study examined the mediating effect of task-related stress on the relationship between downward comparison and turnover intention, and the results are presented in <Table 12>. The results of the path analysis showed that downward comparison did not have a significant effect on task-related stress, whereas it had a negative effect on turnover intention. In contrast, task-related stress had a positive effect on turnover intention. To test the significance of the indirect effect, bootstrapping (5,000 resamples) was conducted, and the indirect effect of downward comparison on turnover intention through task-related stress was B=0.093, with a 95% confidence interval [BootLLCI=-0.015, BootULCI=0.208], which included zero, indicating that the indirect effect was not significant. Overall, the results indicate that the mediating effect of task-related stress in the relationship between downward comparison and turnover intention was not significant.

Table 12. Results of the Mediating Effect of Task-Related Stress on the Relationship between Downward Comparison and Turnover Intention

Path	B	se	t	LLCI	ULCI
Downward Comparison →Job-related Stress	-.020	.100	-.196	.845	-.217
Downward Comparison →Turnover Intention	-.208	.084	-2.462	.015	-.374
Job-related Stress →Turnover Intention	.402	.063	6.406	.000	.278

Independent Variable	Parameter	Dependent Variable	B	BootSE	BootLLCI	BootULCI
Downward Comparison	Job-related Stress	Turnover Intention	.093	.057	-.015	.208

* p<.05, ** p<.01, *** p<.001.

This study examined the mediating effect of task-related stress on the relationship between upward comparison and turnover intention, and the results are presented in <Table 13>. The path analysis indicated that upward comparison did not have a significant effect on task-related stress or turnover intention. In contrast, task-related stress had a positive effect on turnover intention. To examine the significance of the indirect effect, bootstrapping with 5,000 resamples was conducted. The indirect effect of upward comparison on turnover intention through task-related stress was B=0.093, with a 95% confidence interval [BootLLCI=-0.015, BootULCI=0.208], which included zero, indicating that the indirect effect was not significant. Overall, these results

suggest that task-related stress does not mediate the relationship between upward comparison and turnover intention.

Table 13. Results of the Mediating Effect of Task-Related Stress on the Relationship between Upward Comparison and Turnover Intention

Path	B	se	t	LLCI	ULCI
Upward Comparison →Job-related Stress	.232	.125	1.849	.066	-.015
Upward Comparison →Turnover Intention	.205	.108	1.894	.060	-.008
Job-related Stress →Turnover Intention	.402	.063	6.406	.000	.278

Independent Variable	Parameter	Dependent Variable	B	BootSE	BootLLCI	BootULCI
Upward Comparison	Job-related Stress	Turnover Intention	.093	.057	-.015	.208

* p<.05, ** p<.01, *** p<.001.

5. Conclusion and Recommendations

This study aimed to examine the effect of social comparison orientation on turnover intention through job stress among beauty workers, and the results are as follows.

First, the analysis of the demographic characteristics showed that the proportion of females was high, and the largest group was engaged in the skincare field. In addition, the group with 5 to less than 10 years of work experience accounted for the highest proportion.

Second, the results of factor analysis and reliability analysis for social comparison orientation, job stress, and turnover intention indicated that all variables had sufficient validity and reliability.

Third, the results of the correlation analysis revealed significant relationships among social comparison orientation, job stress, and turnover intention.

Fourth, the analysis of the effect of social comparison orientation on job stress showed that upward comparison had an influence on task-related stress.

Fifth, the analysis of the effect of social comparison orientation on turnover intention indicated that downward comparison had a tendency to reduce turnover intention, whereas upward comparison had a tendency to increase turnover intention.

Sixth, the analysis of the effect of job stress on turnover intention showed that both fairness-related stress and task-related stress had an influence on turnover intention.

Seventh, the analysis of the mediating effect of job stress in the relationship between social comparison orientation and turnover intention showed that job stress influenced turnover intention; however, its mediating role in the relationship between social comparison orientation and turnover intention was limited.

Overall, the findings suggest that social comparison orientation is an important factor influencing job stress and turnover intention in the work environment of beauty workers. In particular, upward comparison tends to increase task-related stress and turnover intention, whereas downward comparison tends to reduce turnover intention. In addition, job stress was identified as a key factor affecting turnover intention.

These findings indicate that social comparison affects the psychological states and job attitudes of beauty workers in competitive work environments. Therefore, it is necessary for organizations to establish fair evaluation systems and foster a positive organizational culture, as well as to implement strategies to reduce job stress. In particular, psychological protection systems and emotional labor management strategies should be strengthened to improve psychological safety and sustainable working conditions for beauty workers. These findings suggest that organizational strategies for reducing job stress are necessary not only for turnover prevention but also for the protection of workers' mental health and psychological safety.

Future research should expand the scope by including diverse groups and additional variables related to emotional labor protection, mental health protection, and organizational safety within the beauty industry.

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A Study on the Establishment Approaches for a National Intelligence Community

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Abstract

Purpose: *The purpose of this study is to present policy measures for establishing a "future-oriented national intelligence community" that can effectively respond to rapidly evolving new security threats by overcoming the limitations of the current NIS-centered intelligence system. To this end, the study analyzes cases of intelligence reform in major advanced nations and critically examines the deep-seated bureaucratic rivalries and factors hindering intelligence sharing among South Korean intelligence agencies. Moving beyond political logic, this research focuses on the core value of national security to derive fundamental institutional reform plans, including the evolutionary restructuring of the NIS. Ultimately, it seeks to propose a mid-to-long-term development model for a Korean-style intelligence community that can safeguard national interests and public safety through a systematic mechanism for organic cooperation.*

Method: *Due to the inherent secrecy and closed nature of intelligence agencies, which limit empirical surveys, this study employs a "reflexive literature review" focusing on previous research and policy documents. Leveraging the researcher's 30 years of practitioner experience, the study uses the gap between field reality and theory as an analytical starting point, cross-validating these insights with literature and normative standards. Methodologically, rather than analyzing correlations between variables, it adopts a normative approach combined with case studies to diagnose the limitations of the current system. By conducting a comparative analysis of intelligence community models in major advanced nations—such as the U.S., the U.K., and Japan—this research derives implications tailored to the South Korean context. Ultimately, these multifaceted analyses are synthesized to propose practical and strategic policy measures for establishing a future-oriented Korean intelligence community.*

Results: *This research argues that the establishment of a "National Intelligence Office" (tentative name) by separating the NIS's planning and coordination functions, alongside the creation of a highly capable, advanced intelligence community is critical to overcome South Korea's structural intelligence limitations. To achieve this, a phased roadmap was established; Phase 1 involves a "Preparatory Task Force" led by the NIS to lay the legal and technical foundations, while Phase 2 features a "Promotion Task Force" led by the National Security Office to finalize government-wide integrated governance.*

Conclusion: *This study concludes that Establishing a future-oriented Korean intelligence community requires a long-term roadmap and unified leadership from the legislative and executive branches to ensure consistent reform regardless of government changes. A national commission should be formed for a rigorous diagnosis, focusing on strengthening the National Security Office's coordination and fostering a trust-based community culture. To secure democratic legitimacy, a multifaceted oversight system and strategic public communication must be established. Lastly, improving the declassification system and fostering academia-practitioner collaboration are essential to create a research ecosystem that ensures the continuous evolution of national intelligence capabilities.*

Keywords: ***National Security, Intelligence Reform, National Intelligence Community, Intelligence Sharing, Intelligence Integration***

*This paper is a revised and expanded version of the first author, Yoonseok Lee's 2025 doctoral thesis from Kyongwoon University, "A Study on the Establishment Approaches for a National Intelligence Community -Focusing on the Intelligence Community".

1. Introduction

The 21st-century international landscape demands a fundamental paradigm shift in national security. Since the September 11 attacks, the emergence of non-traditional security threats—characterized by invisibility, uncertainty, and global reach—has elevated national intelligence as a core pillar of national interest. While advanced nations like the United States, the United Kingdom, and Japan have aggressively pursued intelligence integration to mitigate these threats, South Korea's intelligence reforms have remained predominantly politically driven [1][2].

Recent reforms in Korea focus narrowly on the National Intelligence Service (NIS) to ensure political neutrality, often neglecting functional excellence. Despite its global economic and military standing, Korea's intelligence capabilities are hampered by chronic bureaucratic rivalry and "silo effects" between the NIS and various departmental agencies. The 2020 revision of the NIS Act failed to foster a competitive, integrated system, focusing instead on reducing domestic mandates. Consequently, there is an urgent need for a future-oriented "National Intelligence Community" (IC) that prioritizes professional synergy and national survival over partisan political logic.

The primary objective of this study is to propose a strategic policy framework for a Korean-style IC that departs from the current NIS-centric centralized model. By critically reviewing the Korean intelligence landscape through the lens of advanced international models, this research aims to derive actionable, phased measures for a "dramatic overhaul." This study seeks to bridge the gap between academic theory and operational reality, utilizing the researcher's 30 years of professional experience to offer a pragmatic, security-first roadmap for reform.

The scope of this research encompasses two primary areas: the intelligence communities of advanced nations and the current state of the Korean intelligence apparatus. For comparative analysis, the United States, the United Kingdom, and Japan were selected due to their political similarities and established integration mechanisms. The temporal focus is set from the post-9/11 era to the present, a period defined by the global prioritization of "intelligence sharing and integration." The study specifically examines the legal foundations and inter-agency cooperation frameworks within these contexts.

Due to the inherent secrecy of intelligence operations, this study adopts a "Reflexive Literature Review" based on scholarly research and policy documents. The researcher acknowledges a unique "positionality," transitioning from a three-decade career as an intelligence practitioner to an academic. This background provides a specialized lens for cross-verifying theoretical frameworks against the practical constraints and operational failures observed in the field. This methodological approach ensures that the proposed policy recommendations are both academically rigorous and operationally viable.

2. Comprehensive Review of Previous Studies

A comprehensive review of previous studies on the development of the national intelligence system, including the establishment of a Korean-style intelligence community, as well as intelligence sharing and integration, reveals several common academic trends. First, following the 9/11 attacks in 2001, as the complexity and diversity of the international security environment have increased and the pace of change has accelerated, there is a deep consensus that strengthening national intelligence capabilities is a core task for national security in modern society, where traditional and emerging security threats intersect. Furthermore, although the South Korean intelligence community operates with the National Intelligence Service (NIS) at its center, critical perceptions prevail that the NIS is failing to properly perform its pivotal role of intelli-

gence sharing, coordination, and integration due to frequent politically motivated organizational reshuffles and functional reductions. Consequently, the majority of studies have utilized the intelligence sharing and integration-centric reform cases pursued by the U.S. intelligence community post-9/11 as a primary reference model. Through this, these studies have attempted to derive implications for the development of South Korea's national intelligence across various dimensions, ranging from legal and institutional foundations to organizational structures, technological infrastructure, and intelligence culture.

However, despite the meaningful contributions of these previous studies, they expose distinct limitations in driving practical innovation within the national intelligence system. The most prominent issue is the bias in research areas. The majority of discussions are concentrated solely on macroscopic legal and institutional reforms and organizational structures, resulting in an absolute lack of balanced, in-depth research on the practical operating principles of the intelligence community, such as advanced technology, analytical capabilities, organizational culture, cooperative mechanisms, and measures to ensure security and transparency. Even though the structural contradictions of the current NIS-centric system are continuously raised, most studies remain confined to deriving micro-level improvements while maintaining the framework of the existing system, making it difficult to preemptively respond to rapidly changing, comprehensive security threats. In addition, although various discourses for the future development of national intelligence have been formed since the mid-2000s, most arguments stop at presenting declarative directions or remain at the level of rough ideas, failing to guarantee the specificity and execution capability required for actual policy implementation.

Based on the critical awareness of the existing literature, this study seeks to clearly differentiate itself from previous research by expanding the horizon of the discussion and presenting effective alternatives. First, breaking away from the narrow perspective confined to law and organizational structure, this study presents a multidimensional direction for national intelligence development that encompasses top-level leadership, micro-institutional design, technological infrastructure for data integration, an intelligence culture that overcomes exclusivity, and the areas of security and transparency for democratic control. Second, this study proactively proposes a new form of a "Separated-Integrated" national intelligence system that completely departs from the current NIS-centric structure. This is a fundamental structural reform designed to respond to the diversification of security threats, fundamentally prevent the monopolization of power by intelligence agencies, and restore public trust. Third, to ensure that the research results can be utilized in actual policy fields, this study derives practical implementation plans by designing a phased roadmap for building a new Korean-style intelligence community. Finally, rather than blindly adopting the operational cases of intelligence communities in major advanced countries, this study focuses on building a customized intelligence community model that best fits South Korea's unique security reality by thoroughly analyzing the implications of overseas cases in connection with the inherent political and structural problems of current South Korean intelligence agencies.

3. Intelligence Reform Initiatives in the USA, UK, and Japan after 9.11 Attacks

3.1 Progress of Intelligence Reform: USA, UK, and Japan

The purpose of this paper is to provide a critical evaluation of South Korea's intelligence community and to present future-oriented alternatives. Therefore, this paper examines the case of the United States, which has pursued intelligence reform on a zero-base foundation since the 9/11 terrorist attacks. At the same time, since the United States intelligence community differs from Korea in various aspects such as scale, this paper also examines the cases of the United

Kingdom and Japan, which pursued intelligence reform under the influence of the United States, thereby deriving the characteristics and implications of each country's intelligence reform.

Following the 9/11 terrorist attacks, the United States established the 9/11 Commission to diagnose problems in the intelligence sector. Based on this diagnosis, the United States enacted the Intelligence Reform and Terrorism Prevention Act (IRTPA) in 2004 and established the position of Director of National Intelligence (DNI) based on this legislation, thereby pursuing systematic and rapid intelligence reform with emphasis on intelligence sharing and intelligence integration. The U.S. intelligence community consists of a total of 18 agencies and departments centered on the Office of the Director of National Intelligence (ODNI), of which ODNI and the CIA are independent agencies, while the remaining 16 agencies are subordinate to departments such as the Department of War[3].

To strengthen intelligence sharing, the United States established legal and institutional foundations. Based on IRTPA, the United States created the position of DNI and enabled ODNI to lead the intelligence community. In 2008, it announced the IC Information Sharing Strategy to present a new information sharing model. Additionally, by establishing the National Intelligence University under ODNI in 2021, the United States built cooperative systems among intelligence community members through joint education. To promote an IT-based intelligence community, the United States presented the ICITE vision and developed A-Space, the Analysis Resource Catalog (ARC), and Analyst Rolodex (AYG) to facilitate analyst cooperation in cyberspace. In particular, the United States adopted Intellipedia, which was developed bybenchmarking Wikipedia, to activate information sharing among analysts[4].

To integrate intelligence agencies, core leadership including the President, Congress, and the DNI led the implementation of various policies and systems at both legislative and administrative levels. Essential roles and authority to oversee national intelligence were granted to the DNI, and threat-specific intelligence integration centers were established within ODNI to integrate the capabilities of intelligence agencies. Additionally, the Analytic Transformation program was implemented in 2008, and subsequently, intelligence community collaboration was strengthened through programs such as civilian joint service programs within the intelligence community.

The United Kingdom's intelligence community is centered on the Joint Intelligence Committee (JIC) under the Prime Minister's Office and its operational organization, the Joint Intelligence Organisation (JIO). It comprises the Secret Intelligence Service (SIS) and Government Communications Headquarters (GCHQ) under the Foreign Office, the Security Service (SS), which handles domestic intelligence, under the Home Office, and Defence Intelligence (DI) under the Ministry of Defence[5].

The United Kingdom pursued intelligence reform in response not only to the 9/11 terrorist attacks but also to significant events such as the 2003 Iraq War and the July 7, 2005 London terrorist attacks. To strengthen the legal basis for intelligence activities, the United Kingdom expanded the scope of intelligence agency activities and provided clear legal grounds for intelligence operations through a series of legislation including the Justice and Security Act (2013), the Investigatory Powers Act (2016), and the National Security Act (2023). Additionally, by establishing the NSC in 2010 and creating the position of Deputy National Security Advisor within the NSC, the United Kingdom granted authority to directly coordinate the strategic intelligence requirements and priorities of the intelligence community. The United Kingdom strengthened counterterrorism capabilities by establishing the Joint Terror Attack Center, comprising representatives from 16 agencies, and, like the United States, pursued the ROSA Project to establish a single network enabling the entire intelligence community to handle classified information. By installing search programs on this network, the United Kingdom enhanced the IT-based intelligence community working environment[6].

Japan's intelligence community is centered on the Cabinet Intelligence and Research Office (CIRO) and comprises 4 core agencies and 4 additional agencies. CIRO, which reports directly to the Prime Minister's Office, serves as the central coordinating body for the intelligence community. The core agencies include the Defence Intelligence Headquarters (DIH) under the Ministry of Defence, the Intelligence and Analysis Service (IAS) under the Ministry of Foreign Affairs, the Public Security Intelligence Agency (PSIA) under the Ministry of Justice, and the Security Bureau (SB) under the National Police Agency. In 2008, the Financial Services Agency, Ministry of Finance, Ministry of Economy, Trade and Industry, and Japan Coast Guard were incorporated as additional agencies[7].

Japan's intelligence reform was undertaken in earnest through the Policy Program to Enhance Intelligence Capabilities of the Prime Minister's Office and the Cabinet (2008). This policy reflected comprehensive measures for national intelligence capacity development, including the establishment of an expanded intelligence community to strengthen intelligence analysis capabilities and securing direct reporting routes from individual intelligence agencies to the Prime Minister. Subsequently, Japan maintained the momentum of intelligence reform through the establishment of Japan's first National Security Council (2013) and the announcement of the National Security Strategy, thereby strengthening the linkage between intelligence and policy lines at the national level. In 2013, Japan enacted the Designated State Secrets Law, which legalized the classification system and strengthened norms related to information sharing and protection. This legislation has been evaluated as improving Japan's comprehensive counterintelligence capabilities and enhancing information sharing with foreign intelligence agencies[8].

3.2 Characteristics of Intelligence Reform: USA, UK, and Japan

Based on a comparative analysis of intelligence reform measures related to intelligence sharing and integration in the United States, the United Kingdom, and Japan, several key characteristics emerge. First of all, The success of intelligence reform initiatives has been substantially influenced by the commitment and consistency of political leaders across all three nations. In the United States, the Bush administration led intelligence reform through executive orders following the 9/11 terrorist attacks, but subsequent administrations witnessed a gradual weakening of reform momentum[9]. The United Kingdom implemented intelligence reform policies and established the National Security Council in response to evolving security threats, yet the consistency of these policies deteriorated as different prime ministers prioritized reform differently. Japan experienced active intelligence reforms under Prime Minister Abe's tenure, including the establishment of the NSC and enactment of intelligence-related legislation, but reform momentum could not be sustained thereafter. All three countries demonstrate that sustained political leadership is essential for maintaining intelligence reform initiatives.

Second, All three countries have established intelligence communities through horizontal separation of intelligence agencies combined with vertical coordination and integration mechanisms. The Office of the Director of National Intelligence (ODNI) in the United States, the Joint Intelligence Organisation (JIO) in the United Kingdom, and the Cabinet Intelligence and Research Office (CIRO) in Japan serve as primary coordinating bodies. This structure effectively preserves the specialized expertise and independence of individual agencies while achieving integrated intelligence analysis. Notably, the ODNI exercises personnel and budgetary authority over subordinate agencies, whereas the JIO and CIRO primarily focus on integrated analysis without equivalent administrative authority.

Third, To support the efficient decision-making of senior policy makers, all three countries have strengthened interactions between intelligence coordinating organizations and policy bodies such as the National Security Council. The ODNI functions as an NSC member in the United States, while the JIO maintains cooperative relationships with the National Security Secretariat (NSS) in the United Kingdom, and CIRO coordinates similarly with the NSS in Japan. Furthermore,

Direct reporting channels have been established enabling intelligence leaders and agency heads to brief the president or prime minister directly, ensuring that integrated intelligence reaches senior decision-makers efficiently.

Fourth, All three countries have developed comprehensive legal frameworks to provide statutory legitimacy for intelligence communities and activities. The United States enacted the Intelligence Reform and Terrorism Prevention Act, USA PATRIOT Act, and Foreign Intelligence Surveillance Act Amendments Act following 9/11. The United Kingdom implemented the Justice and Security Act, Investigatory Powers Act, and National Security Act, while Japan introduced the Act on the Protection of Specially Designated Secrets and the Cybersecurity Basic Law. These legislative measures have enhanced the efficiency and transparency of intelligence operations.

Fifth, Joint organizational structures have been created to improve intelligence sharing and integration. The United States established joint task forces within the ODNI covering counterterrorism, counterintelligence, and counterproliferation. The United Kingdom created the Joint Terrorism Analysis Centre (JTAC) under the Security Service, and Japan established joint counterterrorism and counterintelligence units within the CIRO. These structures enable critical intelligence collected by each agencies to be shared and integrated at the intelligence community level, facilitating timely production of tailored intelligence and fostering collaborative work cultures.

Lastly, All three countries have invested in unified information technology environments to support intelligence community operations. The United States enhanced the Intellink system with differentiated security classifications for controlled unclassified and classified information intelligence, creating networked environments for collaborative analysis. The United Kingdom, following initial attempts in the mid-2000s, successfully established the "ROSA" classified network in the mid-2010s, enabling personnel to freely search and utilize necessary intelligence for analytical purposes. These technological infrastructures have become essential to modern intelligence operations.

3.3 Implications

The intelligence reform cases of the United States, the United Kingdom, and Japan offer significant implications for the future development of South Korea's national intelligence system. First, leadership from core national leaders is a prerequisite for effective reform. To substantially improve national intelligence capabilities, leadership must remain steadfast regardless of political leanings or regime changes. It is crucial to objectively evaluate intelligence capabilities through independent diagnostic bodies and establish a comprehensive reform plan. Furthermore, the executive and legislative branches must take the lead in creating a conducive environment for reform, regularly evaluating implementation, and establishing effective oversight system to ensure sustainability of intelligence reform.

Second, intelligence reform must comprehensively consider diverse elements, including organizational culture, expertise, and trust. Beyond legal and structural changes, the national intelligence system should be viewed as an integrated network. While maintaining the separated structure among intelligence agencies, both horizontal cooperation and vertical integration mechanisms must be established. Recognizing that fostering a culture of trust and cooperation among intelligence agencies is the core of practical reform is essential.

Third, the national intelligence system must be designed to be future-oriented and resilient. To effectively respond to emerging security environments such as climate change, AI, and cyber threats, the system must move away from rigid structures and adapt to international trends and technological advancements. This approach aims to build the capacity to preemptively address new threats rather than merely solving current problems.

Fourth, establishing an effective coordination and integration mechanism at the national level is vital. Following the models of the U.S. ODNI, the U.K. JIO, and Japan's CIRO, South Korea needs a system that synthesizes individual agency assessments for policymakers. As the current National Intelligence Service (NIS) is often evaluated as underperforming in its integration role, a new "Korean-style Intelligence Community" should be created. Additionally, cooperation between intelligence and policy lines—specifically among the Office of the National Security, NSC, and various intelligence agencies—must be strengthened.

Fifth, strengthening specific intelligence capabilities is essential. Since 9/11, major powers have continuously expanded their capabilities in counterintelligence, cyber, space, and technical intelligence. South Korea urgently needs to restore its human intelligence (HUMINT) capabilities and secure counterintelligence expertise against emerging threats. Regarding technical intelligence, large-scale investment in signals (SIGINT) and imagery (IMINT) is required, and the potential integration of capabilities currently dispersed between the NIS and the military should be examined for efficiency[10].

Finally, proactive measures must be prepared for challenges such as the dilemma between intelligence sharing and security, organizational resistance, and political controversy. A new paradigm is needed to maximize synergy through intelligence sharing, moving away from traditional security-centric thinking. Simultaneously, comprehensive security measures, including stricter vetting and penalties for leaks, must be improved. Preparation for cultural challenges, such as bureaucratic inertia and the politicization of intelligence, is vital to ensure the continuity of reform.

4. Current Problems of the Korean National Intelligence Community

4.1 The Discrepancy Between the Centralized Structure and Actual Leadership

Although the current South Korean national intelligence system ostensibly adopts a 'centralized' model with the National Intelligence Service (NIS) at its apex, its practical operation harbors a structural contradiction characterized by a lack of organic integration between the NIS and various departmental intelligence agencies. This fragmented intelligence governance serves as a critical factor severely undermining the national-level intelligence capabilities required to respond agilely to the rapidly evolving modern security environment and transnational, multifaceted threats[11].

The South Korean intelligence community suffers from a fundamental problem: a severe discrepancy between its legally designed centralized framework and its actual operational leadership. Under current legislation, the National Intelligence Service (NIS) is vested with the authority to plan and coordinate national intelligence and security affairs, designating it as the control tower of the intelligence community. In reality, however, the leadership of the NIS fails to exert a practical integrative force commensurate with its statutory authority. This limitation arises because the NIS's intelligence coordination authority is constrained by the vague and restrictive legal caveat of acting "within a necessary and reasonable scope," making it difficult to exercise comprehensive enforcement power over other agencies. In particular, effective control and coordination mechanisms are virtually non-existent regarding departmental intelligence agencies equipped with independent collection assets and extensive analytical capabilities, such as the Korea Defense Intelligence Command (DIC) and the 777 Command under the Korea Defense Intelligence Agency (KDIA).

A more critical issue is that, rather than focusing on its macroscopic role of coordination and integration as the supreme national intelligence agency, the NIS engages in direct intelligence collection functions—such as human intelligence (HUMINT) and signals intelligence (SIGINT)—

overlapping with agencies under the Ministry of National Defense. This creates a structural contradiction akin to the NIS acting simultaneously as both "referee" and "player" within the arena of the intelligence community. Consequently, it provokes unnecessary inter-agency competition and conflict, leading to the inefficient allocation of the national budget and resources. Furthermore, the repeated organizational downsizing and abrupt personnel reshuffling driven by political motives during every transition of political power severely undermine the inherent professionalism and operational continuity of the intelligence agencies. Such political instability fundamentally obstructs the formulation of a consistent, mid-to-long-term development strategy encompassing the entire intelligence community. It also weakens the NIS's institutional grip over departmental intelligence agencies, ultimately resulting in the degradation of the nation's overall intelligence capabilities.

4.2 The Void in the Legal and Institutional Infrastructure Governing the IC

This limitation in leadership is further exacerbated by the inadequacy of the legal and institutional infrastructure that should support the intelligence community. In the case of the United States, following the 9/11 attacks, the legal entity of the intelligence community was clearly defined, and robust intelligence integration mechanisms were established through legislation such as the Intelligence Reform and Terrorism Prevention Act (IRTPA). In contrast, South Korea currently lacks a foundational law capable of comprehensively governing and controlling the entire intelligence community. Current inter-agency intelligence sharing relies merely on presidential decrees or memorandums of understanding (MOUs) centered around specific issues like counterintelligence and cybersecurity, resulting in a severe lack of legal binding force to mandate comprehensive and continuous intelligence sharing[12].

Due to the absence of clear obligations and procedures for intelligence sharing stipulated in higher-level laws, a strong "silo effect" emerges in the field, where intelligence is treated as the exclusive asset of individual agencies. In other words, while there are absolutely no institutional incentives for sharing intelligence with other agencies, the security responsibilities borne in the event of a leak are excessively heavy, naturally leading each agency to maintain a passive attitude toward sharing. The lack of communication and discrepancies in intelligence assessments among agencies—starkly revealed during grave national crises such as North Korea's sinking of the ROKS Cheonan and the bombardment of Yeonpyeong Island—serve as prime examples demonstrating that such institutional flaws can lead to fatal vacuums in actual national security[13]. Furthermore, with the exception of limited fields such as cybersecurity, there is a complete lack of legal basis for utilizing advanced private-sector expertise or sharing intelligence between the public and private sectors. Consequently, the system fails to effectively respond to emerging security threats closely linked to the private domain, such as economic security and the prevention of high-tech leaks. Moreover, democratic control mechanisms—such as the activities of the National Assembly's Intelligence Committee, which should monitor intelligence agency operations, and independent internal audits—remain merely perfunctory. This exposes a fundamental limitation in the intelligence agencies' ability to secure public trust and support.

4.3 The Limitations of a Closed Culture and Technological Interoperability

Alongside the institutional void, the deeply rooted closed organizational culture among intelligence agencies and their stagnant technological infrastructure also act as massive barriers hindering the substantive integration of the intelligence community. South Korean intelligence agencies remain excessively entrenched in the "Need to Know" principle, a relic of the Cold War era, and show a strong tendency to perceive intelligence not as a public good of the state, but as the power and exclusive asset of a specific organization. In a situation where there is no objective evaluation and reward system that recognizes not only the production but also the "sharing" of intelligence as a core achievement of the organization and the individual, sharing intelligence with other agencies is regarded solely as a potential risk factor for security incidents.

Consequently, this creates a vicious cycle that further solidifies the barriers between agencies[11].

Additionally, a severe lag is evident in the infrastructure keeping pace with the advancement of information and communication technologies (ICT). While the intelligence communities of advanced nations like the United States have technologically realized global, real-time intelligence sharing by building sophisticated integrated networks and cloud computing systems, South Korea's networks—such as the NIS network, the Ministry of National Defense's Military Intelligence Management System (MIMS), and the internal police network, and so on—are strictly physically disconnected and operated individually without policy-level linkage. Because of this, timely and automated intelligence sharing through electronic systems is virtually impossible. Furthermore, there is absolutely no technological standardization of the vast amounts of data collected and held by each intelligence agency, which fundamentally blocks fusion analysis utilizing artificial intelligence (AI) or big data analytics. This is a serious obstacle that directly contradicts the developmental trajectory of modern intelligence agencies, which must acquire analytical accuracy and predictive power by integrating the cutting-edge technologies of the Fourth Industrial Revolution into national intelligence operations.

4.4 The Demand for Redesigning National Intelligence Governance to Respond to Complex Security Threats

Synthesizing the above discussions, the current South Korean intelligence community can be diagnosed as a state where individual intelligence organizations corresponding to "hardware" exist, but the "cooperative mechanisms" (the software) and the "laws and institutions" (the operating system) required to organically connect and operate them have fallen into complete dysfunction. The current centralized system centered around the NIS may have had some validity in responding to the linear, military threats from North Korea during the past Cold War era. However, it must be viewed as having reached the end of its structural lifespan in handling modern complex security threats, where transnational and non-military threats are multi-layered and intertwined.

In particular, as the control tower function—which fuses information from diverse sources and makes comprehensive intelligence judgments at the national level—fails to operate normally, there is a persistent risk that narrow-minded assessments based on fragmented information collected by individual agencies will be reported unfiltered to top policymakers. Ultimately, this heightens the probability of causing severe confusion in national policy and fatal intelligence failures. Therefore, the overarching problems currently facing the South Korean intelligence community can never be resolved through mere operational improvements at the working level or superficial memorandums of understanding between agencies. To overcome this, a fundamental redesign of the national intelligence system's governance is essential. A comprehensive, national-level innovation is urgently required. This must include the enactment of a foundational law that strongly mandates intelligence sharing and integration while simultaneously protecting intelligence sources; the construction of a cloud-based integrated intelligence platform that perfectly ensures technological interoperability; and a monumental cultural shift that breaks down the closed secrecy of the past and moves toward a "Responsibility to Provide."

5. Strategies for Establishing a Korean-style National Intelligence Community

5.1 The Paradigm Shift toward a Korean-Style Intelligence Community

For a prolonged period, South Korea's national intelligence system has maintained a centralized structure, predominantly relying on an operational model centered around the National

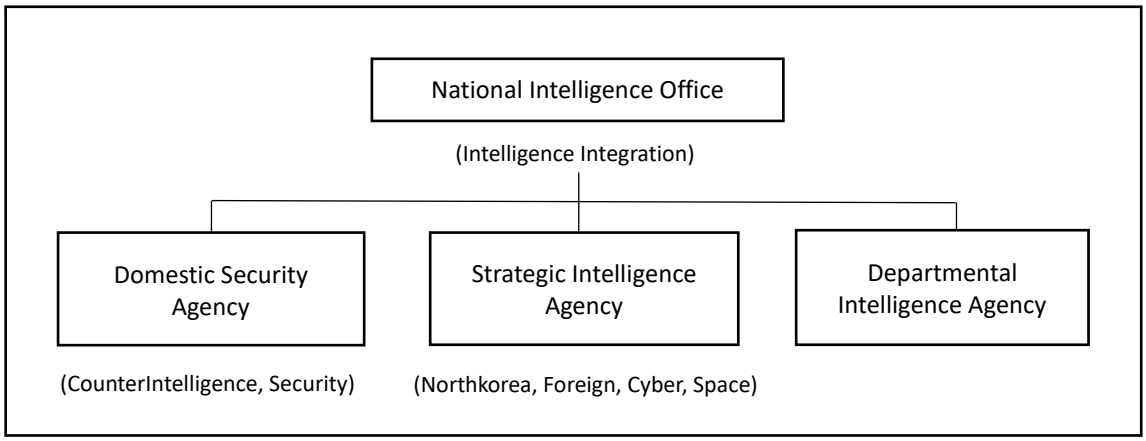
Intelligence Service (NIS). While this system historically played a certain role in responding to past political environments and domestic and international security situations, it has recently exposed its limitations in meeting the demands of a rapidly changing security environment and democratic expectations. Major democratic nations, such as the United States, the United Kingdom, and Japan, already operate decentralized-integrated or decentralized-coordinated intelligence communities. By strengthening the expertise of each agency and effectively integrating and managing intelligence, they safeguard national security and public safety more efficiently. In contrast, South Korea has focused primarily on NIS-centric reforms, continuously exposing structural vulnerabilities such as the dispersion of intelligence capabilities, operational inefficiencies, and a decline in public trust due to political fluctuations.

The time has come for South Korea's national intelligence system to transition into a new paradigm—one that guarantees the independence and expertise of individual intelligence agencies while integrating and coordinating intelligence capabilities at the national level. Achieving this necessitates the establishment of a robust legal and institutional foundation, organizational restructuring, the advancement of intelligence-sharing systems, the construction of cutting-edge technological infrastructure, and the enhancement of transparency to restore public trust.

5.2 Structural Innovation and Functional Separation

The first cornerstone of building a Korean-style intelligence community is structural innovation and the separation of functions. The upper and lower functions of the NIS must be decoupled: the planning and coordination functions should be transferred to a newly established integrated body, tentatively named the National Intelligence Office (NIO). Meanwhile, the intelligence collection and analysis functions should be reorganized by sector and duty into specialized entities, such as a Strategic Intelligence Agency and a Domestic Security Agency, thereby reinforcing the expertise and independence of each institution. The NIO must exercise core authorities—including budget, personnel, and policy coordination—to ensure the cohesiveness of the entire intelligence community. Figure 1 below summarizes the above discussion

Figure 1. The New Korean-Style Intelligence Community(Created by the author)



To facilitate this, a phased approach is required. In the short term, a "Preparatory Task Force" aimed at strengthening the foundation for intelligence sharing and cooperation should be operated under the control of the NIS Director. In the mid-to-long term, this should be expanded and transitioned into a "Promotion Task Force" led by the Office of National Security (ONS). Additionally, an independent diagnostic commission must be formed to analyze the current system's flaws and derive practical improvement measures.

5.3 Legal Foundations and Technological Integration

Strengthening the legal and institutional basis for the intelligence-sharing system is paramount[14]. Through the enactment of general laws, such as a proposed Framework Act on Intelligence Sharing, and the amendment of sector-specific regulations, the principles, procedures, responsibilities, and mandatory clauses of intelligence sharing must be clearly defined. Concurrently, the establishment of an intelligence-sharing platform, the introduction of evaluation and incentive systems, and the implementation of security measures commensurate with technological advancements must be pursued.

The adoption of cutting-edge technology and the balanced expansion of intelligence capabilities are equally critical. Building an intelligence analysis and integration platform based on IT-ABC (AI, Big Data, and Cloud) technologies will determine the future competitiveness of the intelligence community[15]. This must be accompanied by a scientific diagnosis and balanced expansion of each agency's collection and analytical capabilities, rigorous data quality management, and the reinforcement of privacy protection and ethical standards. A delicate balance between technology and security must be struck to ensure that enhanced intelligence sharing harmonizes with the protection of classified information.

5.4 Cultivating Trust and Normalizing Intelligence Budgets

The success of an intelligence community hinges on inter-agency cooperation and a culture of trust[16]. Various cooperative mechanisms must be institutionalized, including joint operations and training, regular workshops and conferences, and the operation of joint project teams. By establishing personnel exchange programs, joint performance recognition, and comprehensive reward and evaluation systems, agencies can foster voluntary cooperation and solidify a shared community identity.

Furthermore, public trust is the bedrock for the sustainable development of the intelligence community. The transparency and political neutrality of intelligence agencies must be secured by strengthening public communication (e.g., expanding open channels like websites, unclassified reports, and podcasts), supporting public-private partnerships and academic research, and reinforcing internal and external oversight mechanisms, such as a National Assembly Intelligence Advisory Committee and an Independent Inspector General system for the intelligence community[17].

In particular, resolving the transparency issues related to the budget management of intelligence agencies is an imperative task for enhancing trust and efficiency. While the budget used by the NIS officially includes "security expenditures" reviewed by the National Assembly's Intelligence Committee, in practice, a significant portion of reserve funds—which can be utilized merely by a resolution of the government—has been spent under the pretext of Basic National Security Expenses. This has led to persistent allegations of illegality and opacity in budget execution. This budgeting practice, rooted in the Act on Special Cases Concerning Budget and Accounts enacted more than 60 years ago during the establishment of the Korean Central Intelligence Agency (KCIA), is criticized for failing to meet contemporary standards. While the original intent was to prevent the exposure of state secrets by hiding the total intelligence budget within reserve funds, today, this opacity and lack of control only deepen public distrust. Therefore, the normalization of the national intelligence budget must be pursued in tandem with the establishment of the new intelligence community[17].

6. Conclusions

6.1 Summary

Modern South Korean intelligence agencies face a complex array of comprehensive security threats, ranging from traditional military provocations to international terrorism, cyberattacks, and socio-economic instability. Internally, the 2020 revision of the National Intelligence Service (NIS) Act fundamentally altered the intelligence apparatus by abolishing the NIS's domestic intelligence duties and transferring its anti-communist investigative authority. Despite this critical turning point for redefining national intelligence, practical state-level efforts to innovate the system remain insufficient. Furthermore, academic discourse has largely been confined to conceptual discussions, exposing limitations in driving actual policy improvements.

To address this gap, this study established a framework for "building a Korean-style national intelligence community" by analyzing advanced nations like the United States, the United Kingdom, and Japan. Recognizing intelligence as a core element of national competitiveness, these countries successfully pursued post-9/11 intelligence reforms under strong executive leadership. They established robust legal foundations, optimal cooperative structures, technology-based intelligence environments, and strict democratic control systems. Conversely, South Korea's current intelligence agencies exhibit distinct structural limitations: the absence of a legal mandate for intelligence sharing, a dysfunctional national intelligence integration mechanism, lagging technological infrastructure for cloud-based integration, and a lack of social trust due to insufficient democratic oversight.

Consequently, this study proposes the creation of a tentatively named "National Intelligence Office (NIO)" to comprehensively coordinate and integrate national intelligence capabilities. This involves separating the NIS's upper functions (planning and coordination) from its lower functions (collection and analysis). To realize this, the study outlines a two-phase roadmap; initially forming a "Korean-style Intelligence Community Preparation Task Force" under the NIS Director to establish a legal foundation for intelligence sharing, and subsequently elevating it to a "Promotion Task Force" led by the Office of National Security to complete mid-to-long-term governance and cultural integration

6.2 Policy Recommendations

The establishment of the proposed Korean-style national intelligence community cannot be achieved through short-term organizational reshuffling or declarative measures. It requires a fundamental redesign of the NIS-centric system entrenched since 1961. Above all, bipartisan and integrated leadership encompassing both the legislative and executive branches is essential. Intelligence reform must be elevated to a core national agenda, supported by strong authorizing legislation, and sustained according to a consistent roadmap independent of political transitions. Furthermore, an optimized intelligence delivery mechanism must be established. The intelligence coordination function within the Office of National Security must be significantly reinforced so that the President is provided with fused, high-quality intelligence without delay. However, structural reorganization alone is insufficient; achieving true "chemical integration" requires fostering an intelligence community-specific culture of trust to help inherently closed agencies overcome departmental egoism. This cultural shift must be supported by software-driven innovations, such as integrated training and incentive systems for intelligence sharing. Equally important is the establishment of democratic control and transparency. Since an intelligence agency cannot survive without public support, it is imperative to fundamentally block the abuse of power by enhancing the practical oversight authority of the National Assembly Intelligence Committee, establishing control bodies within the executive branch, and building independent internal audit systems.

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Effects of Hydrogen-ionized Silica Intake on Blood Biomarkers in Adults: Multinational Exploratory Study of Korea, Japan, Thailand, and Taiwan

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Abstract

Purpose: *Oxidative stress and chronic inflammation have recently been recognized as major underlying mechanisms of various chronic diseases, leading to growing interest in antioxidant materials capable of modulating these processes. Although hydrogen and silica have individually been reported to exhibit antioxidant and physiological effects, human studies investigating Hydrogen-ionized Silica, a combined aqueous formulation of these substances, remain limited. Therefore, this study aimed to investigate the effects of Hydrogen-ionized Silica intake on physiological blood biomarkers in adults and to explore potential metabolic and physiological responses, including differences according to country.*

Method: *This study employed a single-group pre–post intervention design involving adults from South Korea, Japan, Taiwan, and Thailand. A total of 32 participants consumed Hydrogen-ionized Silica for 6 weeks. Pre- and post-intervention blood test results were analyzed to assess hematological parameters, immune and inflammatory markers, liver and renal function markers, and metabolic and lipid-related indicators. Data were analyzed using the Wilcoxon signed-rank test, Mann–Whitney U test, and Kruskal–Wallis test following normality testing.*

Results: *The findings indicated that most blood biomarkers did not show significant pre–post changes following Hydrogen-ionized Silica intake. However, significant changes were observed in fasting glucose and eosinophil levels. In addition, analyses according to sex, age, and country demonstrated no significant differences for most variables.*

Conclusion: *Hydrogen-ionized Silica intake appeared to demonstrate limited changes in specific metabolic and immune-related biomarkers rather than broad effects across overall blood biochemical parameters. These findings provide exploratory baseline evidence regarding the physiological effects of Hydrogen-ionized Silica and may serve as preliminary data for future systematic investigations.*

Keywords: ***Hydrogen-ionized Silic, Blood Glucos, Blood Biomarkers, Antioxidants, Oxidative Stress***

1. Introduction

Changes in modern lifestyles and the westernization of dietary patterns have been associated with excessive production of reactive oxygen species (ROS) in the human body, and the resulting oxidative stress is recognized as a major factor contributing to cellular damage and chronic inflammatory responses[1]. In particular, irregular lifestyle habits, diets centered on processed

foods, environmental pollution, psychological stress, alcohol consumption, and smoking may disrupt the balance between oxidative and antioxidative systems, thereby inducing metabolic abnormalities and impaired immune function. These factors have also been reported to be closely associated with cardiovascular diseases, metabolic disorders, and neurological diseases. Accordingly, growing attention has recently been directed toward functional materials capable of regulating oxidative stress and chronic inflammatory responses in the fields of medicine and nutrition, and studies investigating the physiological effects of antioxidant-based interventions are continuously being conducted[2][3].

Recently, hydrogen has attracted considerable attention as a functional bioactive substance related to the regulation of oxidative and inflammatory responses. Hydrogen is a small molecular substance characterized by high diffusibility and selective reductive properties, and it has been suggested to selectively react with highly cytotoxic hydroxyl radicals (•OH) and peroxynitrite (ONOO–), thereby potentially alleviating oxidative stress[4]. In addition, several studies utilizing hydrogen-rich water or hydrogen gas have reported possible associations with fatigue recovery, improved post-exercise recovery, maintenance of metabolic homeostasis, and modulation of inflammatory responses[5][6]. Based on these findings, hydrogen has been investigated not only for its antioxidant properties but also for its potential anti-inflammatory and metabolic regulatory effects.

Meanwhile, silica (SiO_2) is an inorganic mineral substance containing silicon and is known to be involved in maintaining the structural stability of connective tissues, collagen synthesis, and bone metabolism. Silica has also been associated with maintaining the elasticity of tissues such as the skin, hair, and blood vessels, and several studies have suggested its potential relationship with mineral metabolism and antioxidant responses. More recently, silica has been reported to potentially interact with bile acids, thereby influencing lipid absorption and metabolic processes, and its possible association with blood lipid concentrations and circulatory health has also been discussed[7][8][9]. These previous findings suggest that silica may play diverse roles related to the maintenance of physiological homeostasis beyond serving merely as a structural mineral.

Taken together, hydrogen and silica have individually been suggested to possess functions related to oxidative stress regulation and physiological stability, and a combined formulation of these substances may offer new possibilities in terms of antioxidant and metabolic regulation. However, studies applying Hydrogen-ionized Silica, a formulation combining hydrogen and silica, to human subjects remain limited. In particular, studies investigating physiological changes based on blood biochemical markers are still insufficient. Although several preclinical and cellular-level studies have suggested the potential physiological effects of Hydrogen-ionized Silica related to oxidative stress and inflammatory responses[10], objective verification through human studies remains inadequate.

Therefore, the present study aimed to analyze changes in hematological parameters, immune and inflammatory markers, liver and renal function indicators, and metabolic-related biomarkers by examining blood biochemical changes before and after Hydrogen-ionized Silica intake. Furthermore, by applying the same research procedures to adults from South Korea, Japan, Taiwan, and Thailand, this study also sought to explore physiological response patterns according to differences in lifestyle environments and cultural backgrounds among countries. Through this approach, the study intended to provide preliminary evidence regarding the physiological response potential of Hydrogen-ionized Silica and to establish foundational data for its possible application in the fields of functional materials and healthcare.

2. Background of the Study

2.1 Concept of Hydrogen Ion

Hydrogen ions (H^+) are positively charged forms of hydrogen atoms that have lost an electron and are considered important factors involved in maintaining redox balance and pH homeostasis in biological systems. Because free H^+ is highly unstable, it generally exists in aqueous environments in the form of hydronium ions (H_3O^+). Variations in hydrogen ion concentration are closely associated with intracellular enzymatic activity and the regulation of physiological homeostasis[11][12].

Hydrogen ions (H^+) are also known to play an important role in cellular energy production. In the mitochondrial electron transport chain, a proton (H^+) gradient is formed, which is involved in the activation of ATP synthase and the production of ATP[13]. This process is considered one of the major mechanisms associated with cellular energy metabolism, and the balance of H^+ has been reported to be related to the maintenance of normal metabolic function. However, during energy metabolism, a portion of oxygen is converted into reactive oxygen species (ROS), and highly reactive oxidative substances such as hydroxyl radicals (•OH) are known to contribute to damage to cellular membranes, proteins, and DNA[14][15][16]. Recently, increasing attention has been directed toward hydrogen-related substances because of their potential to selectively reduce specific reactive oxygen species and alleviate oxidative damage[17]. These findings suggest that hydrogen ions may function not merely as regulators of acidity but also as factors associated with the maintenance of intracellular redox environments and energy metabolism.

2.2 Components and Functions of Silica

Silica (SiO_2) is an inorganic compound composed of silicon (Si) and oxygen and has been widely utilized in the fields of food, cosmetics, pharmaceuticals, and biomaterials because of its chemical stability and biocompatibility[18]. Although silicon exists in trace amounts within the human body, it is known to be involved in physiological functions related to connective tissue maintenance and bone metabolism.

In biological systems, silicon primarily exists in the form of orthosilicic acid ($Si(OH)_4$) and is associated with maintaining the structural stability of connective tissues such as the skin, cartilage, bone, and blood vessels[19]. Orthosilicic acid-based silicon formulations have been reported to exhibit favorable bioavailability and oral safety profiles[20]. In addition, several studies have suggested that silicon may participate in collagen and elastin synthesis and interact with glycosaminoglycan metabolism, thereby potentially influencing tissue elasticity and regeneration processes. Furthermore, its potential association with the metabolism of minerals such as calcium, magnesium, and zinc has also been reported, and its possible role in bone metabolism and physiological homeostasis has therefore been discussed[21]. Silicon is generally obtained through dietary intake from cereals, vegetables, and drinking water[22][23], and recent studies have actively investigated high-purity silica extraction technologies based on plant-derived materials[24][25]. Moreover, silica-based materials have attracted attention for their biocompatibility and structural stability and have been suggested to possess potential applicability in drug delivery systems and biomaterial fields[26][27].

2.3 Potential Composite Effects of Hydrogen-ionized Silica

Hydrogen-ionized Silica is a composite material in which hydrogen ions (H^+) or hydrogen-related components are incorporated into a silica-based structure and has been proposed as a concept intended to utilize both the antioxidant properties of hydrogen and the stable delivery characteristics of silica[28]. Conventional hydrogen-rich water (HRW) or hydrogen gas-based materials have been reported to have limitations associated with their short retention time in the body because of the high diffusibility and volatility of hydrogen. Accordingly, various approaches have been explored to improve the stability and delivery efficiency of hydrogen.

In particular, silica-based structures possess porous characteristics that enable the capture or protection of ions and molecules, and several studies have suggested that hydrogen may be

stabilized in the form of Si–H_x within silicon- and silica-based structures and gradually released over time[29][30]. These properties may be associated with reducing the rapid loss of hydrogen and establishing a more sustained delivery environment.

In addition, studies utilizing silica-based hydrogen composites have suggested potential associations with enhanced antioxidant enzyme activity, cellular protection, and tissue recovery[31][32][33]. Furthermore, hydrogen-generating silica materials have been reported to alleviate ultraviolet-induced oxidative damage and may be associated with activation of the Nrf2/HO-1 signaling pathway[34]. Moreover, silicon nanostructures have also been proposed as potential platforms for hydrogen storage and release[30], supporting the possibility that silica-based structures may function as mediators for hydrogen delivery.

Taken together, Hydrogen-ionized Silica may be understood as a composite material capable of compensating for the low stability and short retention time of hydrogen by providing a more stable delivery environment through silica-based structures. In addition, the combined actions of the antioxidant properties of hydrogen and the biocompatibility of silica suggest its potential association with the regulation of oxidative stress and the maintenance of physiological homeostasis.

3. Research Methods

3.1 Selection of Study Participants

This study was conducted in accordance with the guidelines for human application trials and efficacy evaluation established by the Ministry of Food and Drug Safety (MFDS)[35]. Participants were recruited from South Korea, Japan, Taiwan, and Thailand through open recruitment, and adults who voluntarily expressed willingness to participate were screened according to predefined inclusion criteria. Individuals who satisfied the eligibility criteria were selected as final study participants. In addition, convenience sampling, a non-probability sampling method, was applied considering the feasibility of participant recruitment across multinational settings. The inclusion criteria were as follows:

① Adults aged between 40 and 70 years
② Individuals who had not been diagnosed with any major acute or chronic disease within the previous 6 months
③ Individuals who had not consumed vitamins, antioxidants, functional supplements, or health functional foods within the previous 4 weeks
④ Individuals capable of maintaining regular dietary habits, sleep patterns, and lifestyle routines during the study period
⑤ Individuals classified within the normal or overweight range
⑥ Individuals who fully understood the purpose and procedures of the study and voluntarily provided written informed consent
⑦ Individuals without excessive alcohol consumption or smoking habits and who were able to comply with the researchers' instructions
⑧ Individuals without a history of allergies or hypersensitivity reactions to the study product (Hydrogen-ionized Silica)
⑨ Women who were not pregnant or breastfeeding and who had no plans for pregnancy during the study period
⑩ Individuals considered suitable for participation in human application testing by the researchers

All participants underwent screening procedures to confirm their baseline physiological and health status. After receiving a sufficient explanation regarding the study objectives and procedures, all participants voluntarily submitted written informed consent forms. In addition, participants' personal and biological information was anonymized through the assignment of research identification codes, and all collected data were managed to ensure that they were used exclusively for research purposes. This study was conducted as a non-invasive exploratory preliminary investigation based on oral intake observations. All participants voluntarily provided written informed consent after receiving sufficient explanations regarding the study purpose and procedures. In addition, personal information was anonymized and managed exclusively for research purposes in accordance with ethical research principles.

A total of 32 participants were enrolled in this study, with 8 participants (25.0%) recruited from each of South Korea, Japan, Taiwan, and Thailand. Participants in their 40s accounted for the largest proportion of the sample (n = 12, 37.5%). The study population consisted of 12 males (37.5%) and 20 females (62.5%). The mean height and body weight were 162.9 ± 8.88 cm and 64.4 ± 15.80 kg, respectively.

Regarding lifestyle-related characteristics, non-smokers accounted for 25 participants (78.1%), and non-drinkers accounted for 18 participants (56.3%). The most common exercise frequency was no regular exercise, reported by 14 participants (43.8%). The average sleep duration was 6.18 ± 1.49 hours per day.

With respect to health-related characteristics, participants with and without prior experience of taking health supplements were equally distributed, with 16 participants (50.0%) in each group. Participants without prior experience of consuming hydrogen- or silica-related products accounted for the majority of the sample (n = 23, 71.9%). Regarding recent body weight changes, the largest proportion of participants reported no noticeable weight change (n = 20, 64.5%). The general characteristics of the participants are presented in <Table 1>.

Table 1. General Characteristics of Participants

Category	Variable	Classification	n (%) / M ± SD
Demographic characteristics	Country	South Korea	8 (25.0)
		Japan	8 (25.0)
		Taiwan	8 (25.0)
		Thailand	8 (25.0)
	Age	40s	12 (37.5)
		50s	10 (31.3)
		60s	10 (31.3)
	Sex	Male	12 (37.5)
		Female	20 (62.5)
	Marital status	Married	23 (71.9)
		Unmarried	9 (28.1)
	Occupation	Office worker	12 (37.5)
		Self-employed	15 (46.9)
		Homemaker	4 (12.5)
		Unemployed/Retired	1 (3.1)
Anthropometric characteristics	Height (cm)	Mean	162.9 ± 8.88
	Weight (kg)	Mean	64.4 ± 15.80

Lifestyle characteristics	Smoking status	Yes	7 (21.9)
		No	25 (78.1)
	Alcohol consumption	Yes	14 (43.7)
		No	18 (56.3)
	Exercise frequency	None	14 (43.8)
		1–2 times/week	11 (34.4)
		3–4 times/week	3 (9.4)
		≥5 times/week	3 (9.4)
	Sleep duration	Mean	6.18 ± 1.49
Health-related characteristics	Experience of health supplement intake	Yes	16 (50.0)
		No	16 (50.0)
	Experience of hydrogen/silica intake	Yes	9 (28.1)
		No	23 (71.9)
	Recent weight change	No change	20 (64.5)
		Increased	7 (22.6)
		Decreased	4 (12.9)

3.2 Experimental Materials

The test material used in this study was Hydrogen-ionized Silica, which was provided in the form of a semi-translucent milky liquid aqueous solution <Figure 1>. The test material was supplied by ARV CO., LTD., Japan. The formulation was manufactured for human oral consumption and was provided in sealed 50 mL containers to prevent deterioration caused by external environmental exposure. The test material was stored at room temperature (20–25°C) away from direct sunlight. Participants were instructed to dilute 1.4 g of Hydrogen-ionized Silica solution in 100 mL of purified water and consume it twice daily, once in the morning and once in the evening. Accordingly, the total daily intake was set at 2.8 g. Participants were advised to maintain consistent intake times throughout the study period. Even when adjustments to intake timing were necessary because of personal schedules, participants were instructed to maintain the same total daily intake amount.

Figure 1. Hydrogen-ionized Silica

3.3 Measurement Tools

In this study, blood tests were conducted to evaluate physiological changes before and after Hydrogen-ionized Silica intake. Blood test data was collected based on test results from medical institutions performed by study participants, and to ensure consistency in comparisons between countries, only test items commonly performed in the four countries of Korea, Japan, Thailand, and Taiwan were selected and used for analysis.

The selected blood biomarkers were classified into five categories according to the physiological functions and clinical characteristics reflected by each marker, based on existing clinical blood test classification systems and previous studies: hematological indicators, immune and inflammatory markers, liver function markers, metabolic and lipid-related markers, and renal function markers[36]. This classification was based on the premise that blood tests are representative biomarkers reflecting the overall physiological condition of the human body and can be utilized to comprehensively evaluate changes across multiple physiological systems rather than a single specific function[37].

Hematological indicators included red blood cell count (RBC), hemoglobin (Hb), hematocrit (Hct), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and mean corpuscular hemoglobin concentration (MCHC). These indicators are key biomarkers reflecting oxygen transport capacity and the fundamental physiological status of blood and are commonly utilized to evaluate the maintenance of physiological homeostasis[38]. Immune and inflammatory markers included white blood cell count (WBC), neutrophils, lymphocytes, monocytes, eosinophils, and platelets. These markers are representative indicators reflecting immune responses and inflammatory status within the body and are widely used to assess defensive and regulatory responses to external stimuli and physiological changes[39].

Liver function markers included aspartate aminotransferase (AST) and alanine aminotransferase (ALT). As the liver is a central organ involved in detoxification and metabolic processes, liver enzyme levels are commonly used as important indicators reflecting hepatocellular injury and liver functional status[40]. Metabolic and lipid-related markers included blood glucose, total cholesterol, high-density lipoprotein (HDL), low-density lipoprotein (LDL), and triglycerides. These indicators reflect energy metabolism and lipid metabolic status and are widely utilized in the evaluation of cardiovascular health and metabolic balance[41]. Renal function markers included blood urea nitrogen (BUN) and creatinine. These indicators are representative biomarkers reflecting renal function and waste excretion capacity and are commonly used to evaluate the body's ability to process metabolic byproducts[42]. The measured blood biomarkers were not intended for the diagnosis of specific diseases or evaluation of clinical normal ranges but were utilized to identify relative patterns of change before and after Hydrogen-ionized Silica intake.

3.4 Research Procedure

This study was conducted in the following sequence: baseline assessment, intake of the test material, post-intervention assessment, and data analysis. Prior to the initiation of the study, baseline conditions of all participants were assessed, and pre-intervention data were obtained by collecting blood test results conducted at medical institutions. Research data were collected from participants in South Korea, Japan, Thailand, and Taiwan. Considering language differences among countries, study instructions and data collection procedures were conducted according to the linguistic environment of each country. In addition, to ensure consistency in multinational comparisons, only blood test items that were commonly performed across the four countries were selected for analysis.

Subsequently, participants were instructed to consume Hydrogen-ionized Silica for a total of 6 weeks, from October 15 to November 26, 2025, and were advised to maintain similar lifestyle

conditions throughout the study period. Compliance with intake was monitored through intake logs. Participants were also requested to restrict additional intake of antioxidants, health functional foods, and functional beverages and to minimize abrupt changes in lifestyle habits during the study period. Pre- and post-intervention assessments were conducted under conditions that were as similar as possible, and efforts were made to minimize differences in testing environments between assessment time points. After completion of the intervention, post-intervention blood test results were collected using the same procedures, and changes before and after Hydrogen-ionized Silica intake were comparatively analyzed.

3.5 Data Analysis

The data collected in this study were analyzed using SPSS version 25.0 (IBM Corp., Armonk, NY, USA). The Shapiro–Wilk test was conducted to assess the normality of each variable, and normality was determined based on the results of this test considering the relatively small sample size of the study. The results of the normality test indicated that the assumption of normality was not satisfied for the majority of variables except for several measures; therefore, non-parametric statistical methods were applied.

The Wilcoxon signed-rank test was used to compare pre- and post-intervention changes. The Mann–Whitney U test was applied to analyze differences according to sex, and the Kruskal–Wallis test was conducted to examine differences according to age and country. Statistical significance was set at $p < .05$ for all analyses.

4. Results

4.1 Normality Test

As presented in <Table 2>, the results of the normality test indicated that the assumption of normality was not satisfied for the majority of variables except for several measures. In particular, normality was confirmed for several variables, including hemoglobin (Hb), red blood cell count (RBC), total cholesterol, and creatinine ($p > .05$). However, major physiological indicators such as white blood cell count (WBC), alanine aminotransferase (ALT), blood glucose, high-density lipoprotein (HDL), low-density lipoprotein (LDL), triglycerides, blood urea nitrogen (BUN), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), and mean corpuscular volume (MCV) did not satisfy the assumption of normality ($p < .05$). Accordingly, non-parametric statistical methods were applied.

Table 2. Results of the Normality Test on Changes in Physiological Indicators

Category	Variable (Change Score)	W	p-value
Hematological indicators	Hb	0.950	.141
	Hct	0.931	.043
	RBC	0.958	.250
	MCH	0.635	< .001
	MCHC	0.188	< .001
	MCV	0.259	< .001
Immune and inflammatory markers	WBC	0.793	< .001
	Neutrophils	0.878	.002
	Lymphocytes	0.901	.006
	Monocytes	0.957	.226

	Eosinophils	0.883	.002
	Platelets	0.685	< .001
Liver function markers	AST	0.918	.019
	ALT	0.843	< .001
Metabolic and lipid-related markers	Blood glucose	0.524	< .001
	Total cholesterol	0.949	.135
	HDL	0.679	< .001
	LDL	0.883	.002
	Triglycerides	0.861	.001
Renal function markers	Creatinine	0.940	.073
	BUN	0.786	< .001

4.2 Analysis of Blood Biomarkers according to Pre–Post Changes

In this study, the Wilcoxon signed-rank test was conducted to examine changes in physiological indicators before and after Hydrogen-ionized Silica intake. As presented in <Table 3>, the results indicated that most blood biomarkers did not show statistically significant pre–post changes ($p > .05$). Specifically, no significant differences were observed in hematological indicators (Hb, Hct, RBC, MCH, MCHC, and MCV); immune and inflammatory markers (WBC, neutrophils, lymphocytes, monocytes, and platelets); liver function markers (AST and ALT); metabolic and lipid-related markers (total cholesterol, HDL, LDL, and triglycerides); or renal function markers (BUN and creatinine).

In contrast, statistically significant changes were identified in several specific biomarkers. Among the immune and inflammatory markers, eosinophils showed a significant change ($Z = -2.111$, $p = .035$). In addition, blood glucose, a metabolic marker, also demonstrated a significant change ($Z = -2.295$, $p = .022$). These findings suggest that Hydrogen-ionized Silica intake may exert partial effects on certain biomarkers; however, consistent changes were not observed across overall physiological indicators .

Table 3. Comparison of Changes in Blood Indicators Before and After Hydrogen Ion Silica Intake

Category	Variable	Z	p-value
Hematological indicators	Hb	-0.763	.445
	Hct	-0.108	.914
	RBC	-0.563	.573
	MCH	-0.992	.321
	MCHC	-1.297	.195
	MCV	-0.432	.666
Immune and inflammatory markers	WBC	-0.049	.961
	Neutrophils	-0.168	.866
	Lymphocytes	-0.037	.970
	Monocytes	-0.309	.758
	Eosinophils	-2.111	.035*
	Platelets	-0.916	.359

Liver function markers	AST	-0.993	.321
	ALT	-1.324	.186
Metabolic and lipid-related markers	Blood glucose	-2.295	.022*
	Total cholesterol	-0.451	.652
	HDL	-0.350	.727
	LDL	-0.271	.786
	Triglycerides	-0.019	.985
Renal function markers	BUN	-0.617	.537
	Creatinine	-1.237	.216

*p<.05.

4.3 Comparison of Changes in Physiological Indicators According to Demographic Characteristics

To examine differences in physiological changes according to demographic characteristics, analyses were conducted based on the change scores of each variable. First, the Mann–Whitney U test was performed to investigate differences according to sex, and no statistically significant differences were observed in any variables (p > .05). These findings indicate that the physiological changes observed in this study were not limited to a specific sex and appeared to show similar patterns across male and female participants.

Next, the Kruskal–Wallis test was conducted to examine differences according to age group (40s, 50s, and 60s). The results showed no statistically significant differences in any physiological indicators (p > .05). Despite potential physiological differences associated with age, these findings suggest that the patterns of change following the intervention may have appeared relatively consistent across age groups.

In addition, differences according to country were analyzed, and no significant differences were observed in most variables (p > .05). However, among the liver function markers, AST showed a statistically significant difference according to country (H = 10.142, p = .017). Nevertheless, because no significant difference was identified in ALT, another liver function marker within the same category, and significance was observed in only a single variable, caution is warranted in interpreting this finding as indicating a consistent physiological difference among countries.

Taken together, the physiological changes observed in this study appeared to show generally similar patterns rather than being distinctly differentiated according to demographic characteristics such as sex, age, and country. These findings suggest that the response patterns associated with the intervention may not have been limited to a specific subgroup and may have occurred in relatively similar directions across participants. The detailed results are presented in <Table 4>.

Table 4. Comparison of Changes in Physiological Indicators according to Demographic Characteristics

Category	Variable	Sex (U)	P	Age (H)	P	Country (H)	P
Hematological indicators	Hb	0.770	.380	0.600	.741	3.212	.360
	Hct	0.803	.370	0.480	.787	2.255	.521
	RBC	0.055	.815	1.027	.598	4.097	.251
	MCH	1.070	.301	0.466	.792	0.519	.915
	MCHC	0.055	.815	0.685	.710	2.449	.484

	MCV	1.602	.206	1.266	.531	2.056	.561
Immune and inflammatory markers	WBC	1.651	.199	1.175	.556	2.048	.563
	Neutrophils	0.702	.402	0.694	.707	4.108	.250
	Lymphocytes	1.066	.302	0.213	.899	2.836	.418
	Monocytes	0.768	.381	0.168	.920	4.012	.260
	Eosinophils	0.951	.329	1.672	.433	7.047	.070
	Platelets	2.247	.134	0.096	.953	2.619	.454
Liver function markers	AST	0.110	.740	0.539	.764	10.142	.017*
	ALT	1.283	.257	1.347	.510	1.288	.732
Metabolic and lipid-related markers	Blood glucose	0.002	.969	0.767	.682	3.095	.377
	Total cholesterol	1.026	.311	0.789	.674	1.428	.699
	HDL	0.438	.508	5.143	.076	3.950	.267
	LDL	1.753	.185	3.061	.216	1.320	.724
	Triglycerides	0.838	.360	1.927	.382	4.493	.213
Renal function markers	Creatinine	1.031	.310	2.920	.232	1.710	.635
	BUN	2.134	.144	0.112	.946	1.554	.670

*$p < .05$.

5. Discussion

Recently, hydrogen has attracted considerable attention as a functional material associated with metabolic health and physiological homeostasis because of its potential selective antioxidant effects and regulatory role in oxidative stress[17]. Likewise, silica has also been suggested to have possible associations with metabolic and physiological regulation as a bioavailable source of silicon[21]. Several previous studies have reported that hydrogen- or silica-based materials may partially influence blood glucose, oxidative stress, and inflammatory responses; however, findings remain inconsistent, and different outcomes have been observed depending on the formulation type and administration method. Furthermore, studies investigating changes in human blood biomarkers using liquid water-soluble composite formulations combining hydrogen and silica remain extremely limited. Accordingly, the present study aimed to examine changes in blood biomarkers following intake of Hydrogen-ionized Silica, a liquid water-soluble formulation combining hydrogen and silica. The results showed significant changes in blood glucose and eosinophils, whereas most hematological indicators, lipid metabolic markers, and liver and renal function markers did not show statistically significant changes.

In particular, the significant change observed in blood glucose may indicate a possible association between Hydrogen-ionized Silica intake and metabolic responses. This finding appears to show partial similarity to the metabolic-related findings reported in previous hydrogen-rich water (HRW)-based studies. Kajiyama et al. reported possible improvements in glucose and lipid metabolism following HRW intake in individuals with type 2 diabetes mellitus and impaired glucose tolerance[43], while Liang et al. also suggested the possibility of reduced fasting blood glucose levels in subjects with impaired fasting glucose[44]. In addition, Vaquero et al. recently investigated the potential metabolic physiological responses associated with postprandial triglyceride and insulin responses in a human study using diatomaceous earth-based silicon[45]. In the present study, the significant change observed in blood glucose may therefore indicate a possible connection with the general direction of previous findings.

Nevertheless, the present findings do not completely correspond with previous studies. Some earlier investigations reported potential changes in lipid metabolic markers such as LDL and triglycerides and suggested possible alterations in insulin responses following silica intake. In contrast, the present study did not identify statistically significant changes in lipid-related biomarkers, including total cholesterol, HDL, LDL, and triglycerides. Moreover, Nakao et al. reported changes in antioxidant status but did not observe significant changes in fasting blood glucose[43][46]. These discrepancies suggest that the physiological responses associated with hydrogen- or silica-based materials may not occur uniformly across all metabolic markers and may vary depending on participants' health conditions, intake period, formulation characteristics, bioavailability, and lifestyle-related factors.

Importantly, the present study differs from conventional hydrogen-rich water (HRW)-based studies in terms of the applied formulation and material characteristics. Most previous studies primarily focused on molecular hydrogen or HRW alone, whereas the present study applied Hydrogen-ionized Silica in a liquid water-soluble composite formulation combining hydrogen and silica. In addition, many previous silica-related studies utilized engineered silica materials such as mesoporous silica, silica nanoparticles, or diatomaceous earth-based silicon[45][47]. In contrast, the test material used in the present study was a liquid water-soluble composite formulation intended for oral human consumption. Therefore, it may be difficult to directly compare findings such as HbA1c or triglyceride changes reported in previous silica-based studies with the results of the present study using identical interpretative criteria.

Nevertheless, it is noteworthy that previous hydrogen- and silica-related studies have repeatedly suggested possible associations with oxidative stress regulation, metabolic responses, and inflammation-related physiological changes. Ohsawa et al. proposed the selective antioxidant potential of molecular hydrogen[17], and subsequently Ohta summarized the possible associations between hydrogen-based approaches, oxidative stress, and metabolic disorders[13]. In addition, silicon is known to exist in the body in the form of orthosilicic acid and has continuously been discussed in relation to connective tissue maintenance and metabolic physiological functions[48]. More recently, Dudek et al. also suggested that silicon-based materials may partially influence oxidative stress and metabolism-related responses[49]. Considering these research trends, the blood glucose changes observed in the present study may also be partially associated with metabolic responses related to hydrogen- and silica-based materials. However, because oxidative stress-related biomarkers were not directly measured in this study, caution is required in interpreting these findings.

Meanwhile, a significant change was observed in eosinophils. Eosinophils are known to be indicators associated with allergic reactions, immune status, and inflammatory responses; however, studies directly investigating the relationship between hydrogen-ionized silica and eosinophil changes remain limited. Some silica nanoparticle studies have suggested the possibility of alterations in oxidative stress, inflammatory responses, and pro-inflammatory cytokine expression[50]. However, most of these studies were conducted at the cellular level or based on nanoparticle models, which limits direct comparison with the findings of the present study. Therefore, the eosinophil changes observed in this study may be interpreted as preliminary findings suggesting a potential association with immune and inflammatory responses.

In addition, no statistically significant differences were identified in most blood biomarker changes according to sex, age, or country. These findings suggest that the observed patterns of change following Hydrogen-ionized Silica intake may not have been restricted to specific demographic groups and may have appeared relatively similar across participants. However, among the country-based comparisons, statistical significance was observed only for AST, whereas no consistent differences were identified in other liver function markers, including ALT. Therefore, this finding should be interpreted cautiously while considering possible influences from dietary

patterns, lifestyle factors, testing environments, and individual physiological variability among countries.

The present study is differentiated from previous HRW- or silica-related studies in that it applied a liquid oral formulation of Hydrogen-ionized Silica combining hydrogen and silica to human participants and comprehensively evaluated various blood biomarkers. In particular, hematological indicators, immune and inflammatory markers, liver function markers, metabolic and lipid-related markers, and renal function markers were simultaneously analyzed. Furthermore, because the study was conducted within a multinational setting including South Korea, Japan, Taiwan, and Thailand, the findings may serve as preliminary reference data for future related studies.

In addition, the present study may have exploratory implications from the perspective of protection-oriented convergence healthcare research. Recently, increasing attention has been directed toward preventive healthcare approaches focusing on oxidative stress regulation, metabolic homeostasis, and early physiological monitoring. In this context, the present findings may provide preliminary reference data regarding the possible applicability of Hydrogen-ionized Silica as a convergence functional material associated with preventive healthcare and health protection. Furthermore, the simultaneous application of hydrogen- and silica-based materials together with blood biomarker monitoring in a multinational setting may suggest the potential expandability of convergence healthcare research integrating functional biomaterials, metabolic health management, and preventive health monitoring approaches.

However, several limitations should be considered because this investigation was conducted as an exploratory preliminary study. First, the sample size was relatively small, and external variables such as diet, exercise, sleep, medication use, and fasting conditions were not sufficiently controlled. In addition, no control group was included, and factors such as hydrogen concentration stability, silica structure, and bioavailability were not rigorously standardized. Therefore, although the observed changes in blood glucose and eosinophils may be interpreted as preliminary findings, caution is required in generalizing these results as definitive physiological responses. Because this study employed a single-group pre–post exploratory design without a control group, direct causal relationships between Hydrogen-ionized Silica intake and the observed biomarker changes cannot be established. Therefore, the findings should be interpreted as preliminary exploratory observations rather than definitive physiological effects. In addition, because this study was conducted as a multinational exploratory preliminary investigation based on non-invasive oral intake observations, institutional bioethical review procedures could not be fully implemented during the research process. Therefore, future studies should incorporate more systematic ethical review procedures and methodological supplementation in accordance with institutional bioethics and human research guidelines.

6. Conclusion and recommendations

This study analyzed changes in blood biomarkers following the intake of Hydrogen-ionized Silica, a liquid water-soluble formulation combining hydrogen and silica, using a multinational sample. The results showed statistically significant changes in blood glucose and eosinophils, whereas most hematological indicators, lipid metabolic markers, and liver and renal function markers did not show significant changes. In addition, no statistically significant differences were identified in most blood biomarker changes according to sex, age, or country.

In particular, the significant change observed in blood glucose may reflect a possible association with metabolic-related responses associated with Hydrogen-ionized Silica intake. However, caution is required in interpreting these findings because this study had limitations related to sample size and the absence of a control group, and external variables such as diet, exercise,

and lifestyle habits were not sufficiently controlled. Future studies should include randomized controlled trials and long-term follow-up studies involving hydrogen-only, silica-only, and combined intervention groups to more specifically explore the associations between formulation characteristics and physiological responses.

7. References

7.1 Journal Articles

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