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Development and assessment of an instrument measuring environmental health perception and behavior toward reproductive health of female adolescents

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Abstract

Aim: This study is aimed to develop and test the measurement of environmental health perceptions and behavior concerning female adolescents' reproductive health.

Methods: The scales constructed through literature review, in -depth interview, and factor analysis based on the protection motivation theory. The sample comprised 384 female adolescents for exploratory factor analysis, aged 18-22 years, and recruited in September-November 2019 in South Korea. The construct was validated using factor analysis, convergent validity, and known-group comparisons. Reliability was examined using Cronbach's alpha for internal consistency and half-split reliability.

Results: The environmental health perception for female adolescents (EHP-FA) comprises "Sensitivity," "Susceptibility," "Response efficacy," and "Self-efficacy." The environmental health behavior for female adolescents (EHB-FA), based on principal component analysis, yielded 19 items with five factors, including "Chemical reduction," "Electromagnetic reduction," "Food selection," "Cosmetic selection," "Dust & Gas reduction," and explained 62.6% of the variance (Cronbach's $\alpha = .93$).

Conclusion: The utility of EHP-FA and EHB-FA recommend assessment of female youth's environmental attention and health behavior in the community. Nursing professionals can use the scales to promote female adolescents' reproductive health.

KEYWORDS
adolescent, behavior, environment, female, measurement

1 | INTRODUCTION

The global ecosystem has been perforated by hazardous chemical impacts that have also been a source of convenience for human beings for several decades. Microplastics in the water, environmental hormones in the food, micro-dust in the air, radiation from soil and cell phones are widespread, ubiquitous, and oblivious in daily life (Sutton, Giudice, Conry, & Woodruff, 2016). Environmental pollution imposes adverse effects on the body and increases economic burden. The annual economic burden produced by endocrine disruptors (EDCs) amounts to €157 billion for the European Union (Trasande et al., 2015). Reproductive health problems—such as uterus myoma (11.8%), endometriosis (41.3%), benign ovarian tumor (31.9%), and non-inflammatory ovarian problems (24.0%)—among girls/women aged 10–29 in Korea steeply increased, along with industrialization, from 2008 to 2017 (Statistics Korea, 2019).

Environmental toxins are defined as EDCs and cancer-causing chemicals that can harm human health by disrupting sensitive biological systems (Giulivo, de Alda, Capri, & Barceló, 2016). Consequentially, long-term exposure to environmental toxins adversely affects the human body. Emerging scientific evidence highlights the existence of reproductive disorders caused by environmental toxins, indicating that female young adulthood is a critical window for reproductive organs due to proliferating tissue and the plasticity of reproductive development (Ho et al., 2017). Exogenous estrogen (Xenoestrogen) can gradually alter the female reproductive system, causing problems such as abnormal puberty, irregular cyclicity, reduced fertility, polycystic ovarian syndrome (PCOS), endometriosis, and hormone-sensitive cancer (Gore et al., 2015).

Nevertheless, the long-term effects of environmental toxins that increase the risk of reproductive health problems can be dampened through environmental toxin reduction efforts. Recently, several studies explored the effects of diminishing environmental toxicants on adolescents' health. For instance, the Health and Environmental Research on Make-up of Salinas Adolescents (HERMOSA) project resulted in lowering exposure to EDCs (Harley et al., 2016). Adolescents are highly susceptible to external stimuli, and are willing to accept new behaviors to follow a healthy lifestyle (Gwon & Jeong, 2018). To achieve female adolescents' environmental health, further multi-strategy studies should be performed to reduce adolescents' exposure to environmental toxicants (Zota et al., 2017) through scientific measurements.

However, there is a lack of chemical risk reduction behavior assessment when compared to the increasing chemical pollution sensitivity worldwide (Whaley et al., 2016). The existing assessment tools for measuring environmental health perception and behavior that target female adolescents are scales for urban youth's environmental understanding of chemicals in personal care products (Bogar et al., 2017) and female college students' environmental health literacy regarding EDCs in personal care products (Chan, Chalupka, & Barrett, 2015). Eliciting and deciphering further behavioral information is imperative. Moreover, validated assessment tools can lead to meaningful activation of environmental health promotion and policy change to catalyze the development of eco-friendly societies for the benefit of female youth's reproductive health.

2 | BACKGROUND

The protection motivation theory (PMT) (Rogers, 1975) was used as the conceptual framework for this study (Figure 1). PTM focuses on individual fear appraisal and motivation toward health behaviors to cope with threatening events. Risky life conditions such as environmental diseases are increasing among Korean female adolescents. For example, breast cancer incidence and prevalence rates per 100,000 persons increased by 500 and 166% respectively in those aged 15–19, and 126 and 108.8% respectively in those aged 20–24 from 2007 to 2017 (Statistics Korea, 2019). In this study, PMT explained the perceptions of female adolescents regarding environmental risks, its effects on their reproductive health, behavioral efficacy, and self-efficacy. The four perception domains used in this study were: perceived

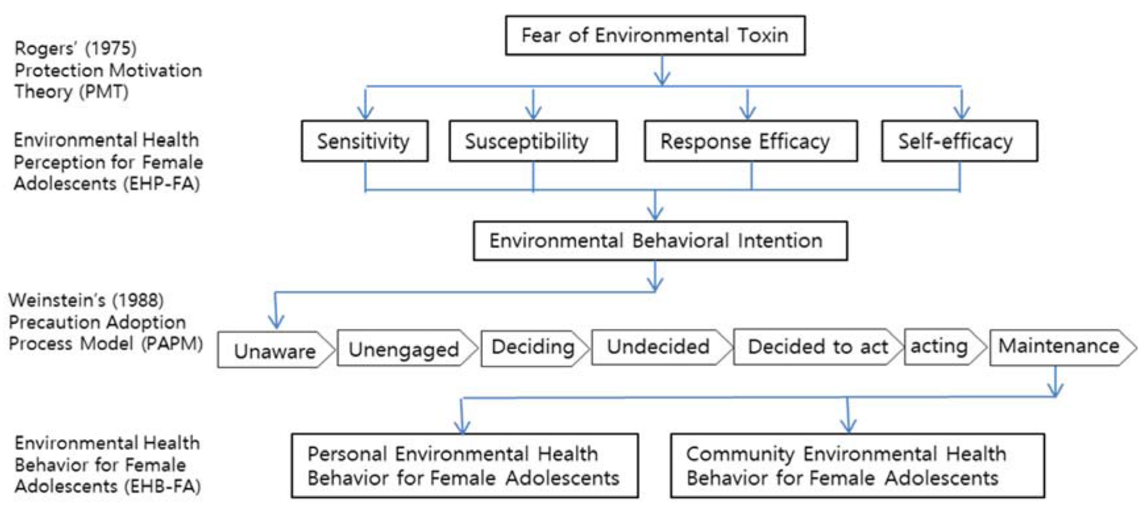

FIGURE 1 Conceptual framework of scales

sensitivity, perceived susceptibility, perceived response efficacy, and self-efficacy. Sensitivity is defined as the fear of risks from chemical exposure among female adolescents. Susceptibility is the damage caused by hazards through the facilitation of disease. Response efficacy is defined as the perception of actions as useful for health. Self-efficacy refers to prevention efficacy and protection efficacy, and represents the subjects' confidence in themselves.

This study used Weinstein's (1988) precaution adoption process model (PAPM) to create a staging algorithm, measure the behavioral intention degree, and analyze the known-group validity. Behavioral intention toward environmental action was gradually built, step by step, and staged as follows: unaware, unengaged, deciding, undecided, decided against, decided to act, acting, and maintenance stage. This study utilizes the intention stage to evaluate female adolescents' intention of environmental action states (Figure 1). The female adolescents' environmental health behavior was explored on two aspects—community behavior and personal behavior. The responsible, normative, altruistic, and conscious actions of the ecosystem form the community environmental health behavior (Cavaliere et al., 2018; Wong et al., 2018). On the other hand, personal environmental health behavior is an inherent action that protects female adolescents' reproductive health by decreasing exposure to EDCs, chemicals, heavy metals, electromagnetic radiation, and light pollution (Zota et al., 2017). Personal health behavior is characterized through attributes such as disease prevention, health protection, and wellness promotion for oneself (Glanz, Rimer, & Viswanath, 2015), while environmental health behavior comprises sustainable behavior in order to minimize adverse effects on nature through personal actions propagating environmental promotion (Cavaliere, Marchi, & Banterle, 2018).

Recently, a few experimental studies were conducted to examine the educational intervention impact on the changes to environmental health perception, affection, and behaviors. It was found that the pro-environmental program, such as energy preservation and recycling, was effective among adolescents (Krettenauer, 2017). Health promotion behavior and quality of life are mediated via environmental satisfaction concerning air, water, and hygiene (Wong, Yang, Yuen, Chang, & Wong, 2018). Chemical exposure reduction intervention is proven effective in targeting specific behavioral changes (Zota, Singla, Adamkiewicz, Mitro, & Dodson, 2017). Furthermore, dietary health behavior has proved useful for mothers having daughters (Lion et al., 2018), and maternal concern about phthalate, phenol, or plastics was directly associated with the level of EDCs (Pell et al., 2017). The bisphenol A (BPA) contact intervention reduced the BPA level through education of appropriate skin contact and hand washing techniques (Ndaw, Remy, Jargot, & Robert, 2016).

There are environmental assessment scales for measuring the knowledge, attitude, behavior, and self-efficacy of university students (Richards, Brown, Williams, & Eggett, 2017). For example, the environmental health literacy scale was developed for measuring knowledge, attitude, and behavior (Lichtveld et al., 2019), while the Agency of Toxic Substances and Disease Registry (ATSDR, 2015) can measure environmental exposure by means of an exposure survey, and by probing on work history and environmental history. Kim (2017) developed pro-environmental behavior for women's health having attributes as a protective, preventive, altruistic, and alternative behavior. They can be utilized for various target populations in domains of perceptions and behaviors; however, an adequate assessment scale for female adolescents' reproductive health has yet to be developed.

3 | PURPOSE

To develop and test the measurement of environmental health perceptions and behavior concerning female adolescents' reproductive health.

4 | METHODS

4.1 | Preliminary items

The environmental health perception and behavior for female adolescents (EHP-FA and EHB-FA) were developed based on DeVellis' methodology (2017). Item generation and scale development were comprised of two stages. The first stage involved item formation through a literature review and in-depth interviews of participants using research questions based on the PMT. The collected items were then categorized and defined in order to construct categories based on the PMT (Rogers, 1975). The second stage involved statistical analysis and finding the underlying latent variables using a categorized item pool through exploratory factor analysis.

A literature review was conducted to extract environmental health concepts and behaviors for female adolescents' reproductive health through systemic review methods according to Cochrane Collaboration, Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) (Higgins & Green, 2011), in March–May 2019. Keywords in the title and abstract, namely "adolescent or youth", "reproductive or female health", "environment", and "toxin or endocrine disrupt" were entered using the advanced search option in CINAHL, PsychINFO, PubMed, ERIC, SCOPUS, Google Scholar, and RISS to yield articles from journals published until 2019. After removing unrelated articles from the search engine, one out of 706, one out of 11, 10 out of 899, 0 out of 24, zero out of 640, three out of 936, and two out of 804 articles remained, respectively. The databases yielded 17 studies on environmental concept and behavior, adding five articles through bibliographic search operations. Finally, preliminary items were extracted—encompassing 35 perception items and 39 behavioral items from 22 records.

In-depth interviews were performed at the researcher's office from June–July 2019. Participants were three female university students and two female high school students recruited by convenience and snowball sampling methodologies. This qualitative study was based on Giorgi's (2009) phenomenological theory. The semi-structured interviews were conducted, transcribed, and recorded after obtaining consent from the participants during 1–2 hr sessions in the school seminar room. Theoretical sampling and interpreted meaning by thematic extraction (Denzin & Lincoln, 2018) were employed. The research questions based on PMT included: "Which environment can harm your reproductive health?", "What reproductive health problems can occur?", "Which behaviors can affect your reproductive health?", "Can you perform health behaviors for yourself?", "What are you doing for the environment?", and "What are you doing for your environmental health?" Preliminary items were extracted from the interviews, and comprised of 38 perception items and 40 behavioral items. In total, 53 perception items and 42 behavioral items remained after the removal of redundancies through the literature review and interviews.

4.2 | Content validity

Four female health nursing professors and one environmental engineering professor tested items through email. In the first round, the item-content validity index (I-CVI) for each item was determined in August 2019 using a five-point Likert type scale ranging from 1 "not proper at all" to 5 "very proper." The I-CVI is computed by dividing the number of experts giving a rating by the total number of experts. Thereafter, the means of each item are divided by five and valued into I-CVI. After the deletion of defective items, 48 out of 53 perception items and 39 out of 43 behavioral items with an I-CVI of over 0.80 were retained. Qualitative feedback was obtained in the blank box provided in the content validity questionnaire, along with reasons for low I-CVI and information about low inter-rater inconsistency. In the second round, the scale-content validity index (S-CVI) of 95.38 was obtained in the perception scale and 90.25 in the behavioral scale (Polit, Beck, & Owen, 2007).

Extracted items tested the reading difficulty level of 10 participants in August 2019 using a four-point Likert type scale ranging from 1 "very difficult to understand" to 4 "very easy to understand." The mean difficulty level was 0.96 and one item about BPA was easily corrected. A pilot study was conducted with the same dataset to confirm the layout of the questionnaire.

4.3 | Participants

The participants recruited through convenience sampling were from three universities and two high schools, selected from the top three provinces in terms of air pollution in South Korea. Air pollution contains particulate matter 10 (PM10) and fine particles (PM2.5) (dust diameter under 10 and 2.5 μm) (Korea Ministry of Environment, 2019). A researcher and two research assistants collected the data in September–November 2019. Further, a researcher requested professors from three universities and teachers from two schools for permission, after which questionnaires were distributed by the researcher and research assistants. The research assistants were trained regarding the protocol for obtaining research consent, possibility of rejection or withdrawal, and rights of the subjects. The inclusion criteria were: female, late adolescents (aged 18–22), ability to understand the survey questions, and agreeing to participate in the study. The exclusion criteria were: having acute illness, academic relationship, and having any conflict of interest with the researcher or research assistants. The sample size of 390 was calculated based on 10 times the number of the preliminary behavioral items (39), because DeVellis (2017) recommended a sample size of 5–10 times the number of items, or over 300 cases. In total, 389 of the 390 self-reported questionnaires were returned, and 384 completed questionnaires were analyzed for construct validity through exploratory factor analysis.

4.4 | Instruments

The questionnaire included demographic characteristics (age, menarche, menstrual period, income, education, environmental education experience, environmental influence, and reproductive health problem), environmental intention (one item), sensitivity (20 items), susceptibility (eight items), response efficacy (10 items), self-efficacy (10 items), Personal EHB-FA (24 items), Community EHB-FA (15 items), and Environmental Health Engagement Profile (EHEP) (44 items). These were categorized according to PTM (Rogers, 1975) and PAPM (Weinstein, 1988). A four-point Likert type scale was used (1 = never, 2 = sometimes, 3 = often, and 4 = always) to generate items on EHP-FA and a 10-point (0 = never do, 10 = absolutely do) scale was used for EHB-FA as behavioral items need to be delicately assessed. Income was defined as the median monthly gross income in Korea with regard to demographic characteristics.

4.5 | Convergent validity

The convergent validity was established using the Korean version of EHEP (Dixon, Hendrickson, Ercolano, Quackenbush, & Dixon, 2009). The self-report EHEP is comprised of 44 items in five subscales, where each item was scored on a Likert scale ranging 0–10, with higher scores implying greater environmental engagement. Internal consistency was reported as "Pollution Sensitivity Scale (α=.91)", "Pollution-Causes-Illness Scale (α=.84)", "Pollution Acceptance Scale (α=.67")', "Community Environment Action Scale (α=.79)", and "Personal Environmental Action Scale (α=.63)" (Dixon et al., 2009), and each scale's Cronbach's α values were .95, .94, .82, .89, and .74 in this study.

TABLE 1 Participants' characteristics (*N* = 384)

Categories	Subcategories	Total
Age, years		20.31 (2.29)
Menarche, year		12.57 (8.11)
Menstrual period, days		31.74 (1.51)
House income	Low (<50% of median income)	35 (9.1)
(economic status)	Medium (50–150% of median income)	330 (85.9)
	High (>150% of median income)	19 (4.9)
Environmental education		1.36 (1.08)
Significant other	Family	149 (38.9)
	Media	101 (26.3)
	Friend	65 (16.9)
	Teacher	64 (16.7)
	Gym trainer	5 (1.3)
Reproductive disease	Vaginitis	20 (5.2)
	Polycystic ovarian syndrome	12 (3.1)
	Irregular menstruation	26 (2.6)
	Dysmenorrhea	4 (1.0)
	Endometriosis	1 (0.3)

4.6 | Ethical considerations

This study was approved by the institutional review board of the primary researcher's affiliated university (KNU-IRB-2019-25). Written informed consent was obtained from all participants. They were provided information about the research purpose, content, contribution, dissemination of results, interview or survey duration, procedure, right of withdrawal from the study, and the provision of anonymity, privacy, and confidentiality. After completion of the interview, the participants were rewarded stationery gifts worth $5–10.

4.7 | Statistical analyses

Participants' characteristics were analyzed with descriptive statistics. Construct validity was analyzed through item-total correlations, exploratory factor analysis using principal component analysis (PCA) with Oblimin rotation, Kaiser Meyer Olkin (KMO), χ^2 through Bartlette's test of sphericity, and subtotal–total correlations. Convergent validity was examined using Pearson's correlation coefficients with the EHEP. Known-group validation was analyzed using *t*-tests for comparison among behavioral intention stages. Reliability was analyzed for internal consistency using Cronbach's α and split-half reliability using Spearman Brown's coefficients. The statistical analyses were performed with SPSS v.25.0.

5 | RESULTS

5.1 | In-depth interview

The following themes were extracted from interviews of 11 female participants aged 18–22 years: (a) worry about reproductive health in the future, (b) sensitivity to chemicals and micro-dust, (c) protective behavior from the hazard, and (d) responsible behavior for the environment.

5.2 | Sample characteristics

The mean age of the 384 participants was 20.31 years (*SD* = 2.29), while the mean age of menarche was 12.57 (*SD* = 8.11), and the mean menstrual period was 31.74

TABLE 2 Exploratory factor analysis of the environmental health perception and behavior for female adolescents (EHP-FA and EHB-FA) scales ($N = 384$)

Scales	Subscales	Factors	Items	Factor loading	Item-total γ
EHP-FA[a]	Sensitivity	1. Endocrine disruptor	12 pesticides	.91	.55
			13 herbicides	.90	.55
			14 antiseptic	.82	.57
			11 disinfectant	.79	.38
			15 petroleum	.53	.62
			16 tar	.52	.59
		2. Goods	20 cellular phone	.78	.64
			18 plastic product	.76	.61
			19 night lighting	.73	.66
			17 new furniture	.62	.64
		3. Cosmetics	8 perfume	.85	.71
			9 nail polish	.75	.62
			10 personal product	.67	.66
		4. Dust	5 micro-dust	.88	.45
			6 exhaust gas	.87	.49
		5. Fat	1 meat and dairy	.91	.45
			2 big fish	.85	.41
Eigenvalue = 3.61 ~ 1.66 variance = 11.1 ~ 24.1% cumulate variance = 69.2% Cronbach's α = .94					
	Susceptibility	(Environmental pollution cause ...)	4 uterine disease.	.91	.79
			7 infertility.	.89	.78
			5 female cancer.	.86	.76
			2 menstrual problems.	.85	.75
			1 ovarian disease.	.84	.73
			8 fetal malformation.	.83	.72
			6 miscarriage.	.82	.72
			3 precocious puberty.	.76	.67
Eigenvalue = 5.74 variance % = 71.8% cumulate variance % = 71.8% Cronbach's α = .95					
	Response efficacy	(...is helping my reproductive health.)	5 avoid electric wave	.81	.79
			9 thorough hygiene	.81	.79
			7 avoid micro-dust	.76	.74
			2 drinking clean water	.75	.72
			10 interest to environment	.74	.74
			1 avoid chemicals	.70	.68
			3 avoid instant food	.65	.64
			6 avoid night light	.57	.60
			4 eating vegetable	.54	.60
Eigenvalue = 4.54 variance = 50.4% cumulate variance = 50.4% Cronbach's α = .88					
	Self-efficacy	1. Prevention efficacy (I can...)	4 choose useful health behavior.	.82	.58
			3 manage my reproductive health.	.81	.37
			5 identify harmful environmental.	.71	.37
			2 learn about environmental toxins.	.70	.32
			1 prevent reproductive problems from hazard environment.	.60	.42

TABLE 2 (Continued)

Scales	Subscales	Factors	Items	Factor loading	Item-total γ
		2. Protection efficacy (I can defend against environmental toxins)	9 through my skin.	.89	.76
			10 via the soil.	.87	.78
			8 via the food.	.81	.63
			6 via the air.	.56	.50
Eigenvalue = 3.14 ~ 2.83 variance = 34.9 ~ 31.5% cumulate variance = 66.4% Cronbach's α = .90					
EHB-FA[b]	Personal EHB-FA	Chemical reduction	16 I reduced antiseptic use.	.67	.53
			18 I reduced plastic product use.	.62	.57
			15 I reduced the use of detergent.	.61	.65
			14 I use a low chemical personal product.	.53	.66
			19 I use a bisphenol-free product.	.52	.49
		Electromagnetic reduction	24 I avoid exposure to light at night.	.81	.63
			23 I keep away from the cell phone.	.77	.67
			22 I avoid electromagnetic waves.	.63	.67
			21 I avoid radiation.	.47	.67
		Food selection	1 I reduce meat-eating.	.79	.42
			2 I eat low-fat diet.	.78	.52
			4 I reduce food additives.	.56	.58
		Cosmetic selection	11 I avoid perfume.	.81	.40
			10 I avoid air fresheners.	.80	.49
			12 I avoid antiseptic cosmetics.	.53	.64
			13 I avoid nail polish.	.51	.46
		Dust and gas reduction	6 I avoid tobacco smoke.	.77	.43
			7 I avoid car exhaust.	.76	.54
			8 I avoid micro-dust	.74	.55
Eigenvalue = 1.76 ~ 2.84 variance = 7.8 ~ 12.3% cumulate variance = 62.6% Cronbach's α = .93					
EHB-FA	Community EHB-FA	Reduction	8 I reduce plastic use.	.79	.76
			7 I reduce wastes.	.78	.79
			5 I reduce detergent use.	.76	.74
			6 I reduce disposables.	.76	.77
			4 I minimize personal use.	.71	.74
		Reuse	3 I reuse products.	.74	.75
			1 I reduce electricity use.	.72	.71
			2 I reuse water.	.71	.77
		Recycle	9 I separate waste collection.	.76	.56
			11 I separate battery waste.	.70	.68
			10 I separate drug waste.	.67	.68
		Response	14 I participate in environmental activities.	.79	.50
			15 I have an interest in environmental issues.	.74	.51
Eigenvalue = 1.65 ~ 3.01 variance % = 11.8 ~ 21.9% cumulate variance % = 68.8% Cronbach's α = .91					

[a]Environmental Health Perception for Female Adolescents
[b]Environmental Health Behavior for Female Adolescents

TABLE 3 Subtotal–total correlations of the environmental health perception and behavior for female adolescents (EHP-FA and EHB-FA) scales ($N = 384$)

	Sensitivity	Susceptibility	Response efficacy	Self-efficacy	Personal EHB-FA[a]	Community EHB-FA[a]
	r (p)					
Total EHP-FA[b]	.73 (<.001) ***	.64 (<.001) ***	.71 (<.001) ***	.53 (<.001) ***	.19 (.003) **	.27 (<.001) ***
Total EHB-FA[a]	.33 (<.001) ***	.25 (.001) ***	.22 (.001) ***	.33 (<.001) ***	.94 (<.001) ***	.88 (<.001) ***

[a]Environmental Health Behavior for Female Adolescents;
[b]Environmental Health Perception for Female Adolescents.
***$p < .001$; **$p < .01$.

TABLE 4 Correlations between environmental health behavior for female adolescents (EHB-FA) and environmental health engagement profile ($N = 384$)

Variables	r (p)
Sensitivity – pollution sensitivity	.25 (.010) *
Susceptibility – pollution causes illness	.36 (< .001) ***
Response efficacy – pollution acceptance	-.26 (.029) *
Personal EHB-FA[a] – personal environmental action	.51 (< .001) ***
Community EHB-FA – community environment action	.46 (< .001) ***

[a]Environmental Health Behavior for Female Adolescents.
***$p < .001$; *$p < .05$.

($SD = 1.51$). Further, 85.9% of the participants had moderate household income, the mean score for environmental education was 1.36 ($SD = 1.08$), and participants' environmental influencers were family (38.9%), media (26.3%), and others. Participants had reproductive diseases, including vaginitis (5.2%), PCOS (3.1%), and others (Table 1).

5.3 | Validity

5.3.1 | Item-total analysis

The corrected item-total correlation coefficients ranged from .32–.79 among the 384 subjects; 48 perception and 39 behavioral items significantly correlated with the total score ($p < .001$). Three items with Pearson's correlation coefficients of under .30 were removed (Table 2).

5.3.2 | Exploratory factor analysis

1 Factor analysis of the 384 subjects through PCA with direct Oblimin rotation resulted in "Sensitivity in EHP-FA" items, yielding KMO = .867 and $\chi^2 = 1,935.66$ ($p < .001$). Three items (smoke, food additives, and genetically modified organism) were deleted because of low correlation with subtotal score (r = .21–26, $p < .001$). Factors with eigenvalues greater than 1.0 contributed to 69.2% of the total variance. Finally, the five factors yielded 17 items: Endocrine disruptor (six items), Goods (four items), Cosmetics (three items), Dust (two items), and Fat (two items) (Table 2).
2 Factor analysis resulted in "Susceptibility in EHP-FA" items, yielding KMO = .899 and $\chi^2 = 1,689.1$ ($p < .001$). The one factor (eight items) explained 71.8% of the total. All preliminary items were adopted.
3 Factor analysis resulted in "Response Efficacy in EHP-FA" items, yielding KMO = .899 and $\chi^2 = 895.83$ ($p < .001$). The one factor (nine items) explained 50.4% of the total. One item was deleted because of high correlation with subtotal score (r = .86, $p < .001$).
4 Factor analysis resulted in "Self-efficacy in EHP-FA" items, yielding KMO = .858 and $\chi^2 = 1,053.79$ ($p < .001$). The two factors (nine items) explained 66.4% of the total: prevention efficacy (five items) and protection efficacy (four items). One item was deleted because of high correlation with subtotal score (r = .89, $p < .001$).
5 Factor analysis was performed with "Personal EHB-FA" items, yielding KMO = .835 and $\chi^2 = 2079.87$ ($p < .001$). Five factors (19 items) contributed to 62.6% of the total variance: Chemical reduction (five items), Electromagnetic reduction (four items), Food selection (three items), Cosmetic selection (four items), and Dust & Gas reduction (three items). Two items were deleted because of a low correlation with subtotal score (r = .24–29).
6 Factor analysis was performed with "Community EHB-FA" items, yielding KMO = .890 and $\chi^2 = 1944.04$ ($p < .001$). Four factors (13 items) contributed to 68.8% of the total variance: Reduce (five items), Reuse (three items), Recycle (three items), and Response (two items). Two items were deleted because of high correlation with subtotal score (r = .82, $p < .001$) (Table 2).

TABLE 5 Differences in the environmental health behavior for female adolescents (EHB-FA) scores by behavioral intention stages ($N = 384$)

	Behavioral intention stage	Mean ± *SD*	F (*p*)	Scheffé test (*p*)
Personal EHB-FA[a]	Unaware	0.00 (0.00)	2.84 (.025)	b > a (.049)*
	Unengaged	62.57 (20.28)[b]		
	Deciding	82.33 (28.00)		
	Undecided	86.00 (2.01)		
	Decided against	0.00 (0.00)		
	Acting	90.16 (29.81)		
	Maintenance	105.00 (35.91)[b]		
Community EHB-FA[a]	Unaware	0.00 (0.00)	4.03 (.004)	c > a,b (.009)*
	Unengaged	54.00 (5.56)[b]		
	Deciding	54.43 (28.42)[b]		
	Undecided	71.99 (19.67)		
	Decided against	0.00 (0.00)		
	Acting	75.91 (22.14)		
	Maintenance	95.13 (14.66)[b]		

[a]Environmental Health Behavior for Female Adolescents.
[b]Except for analysis.
*$p < .05$.

5.3.3 | Subtotal–total correlations

The subscale-to-total correlations examined for the total EHP-FA with four domains were .73 (sensitivity), .64 (susceptibility), .71 (response efficacy), and .53 (self-efficacy), and for the total EHB-FA with the two domains were .94 (Personal EHB-FA) and .88 (Community EHB-FA) ($p < .001$) (Table 3).

5.3.4 | Convergent validity

The correlation between developed scales and EHEP was valid: "Sensitivity and Pollution Sensitivity" ($r = .25$, $p = .001$), "Susceptibility and Pollution-Causes-Illness Scale" ($r = .36$, $p < .001$), "Response efficacy and Pollution Acceptance" ($r = -.26$, $p = .029$), "Personal EHB-FA and Personal Environmental Action" ($r = .51$, $p < .001$), and, "Community EHB-FA and Community Environment Action" ($r = .46$, $p < .001$) (Table 4).

5.3.5 | Known-group validity

The five stages of behavioral intention were compared with the scores based on PAPM. Personal behavioral scores were different among stages (F = 2.84, $p = .025$) and community scores (F = 4.03, $p = .004$). The Scheffé test showed that in each stage, the 7th score was significantly greater than the others (Table 5).

5.4 | Reliability

Items that lowered the subtotal internal consistency were deleted—three Personal EHB-FA items. Final internal consistency was good, as evidenced by Cronbach's α of sensitivity (.94), susceptibility (.95), response efficacy (.88), self-efficacy (.90), Personal EHB-FA (.93), and Community EHB-FA (.91) using 384 subjects for the scale. The split-half reliabilities of behavioral scales were .84 and .84 in the randomized split sample using Spearman Brown correlation (Table 2).

6 | DISCUSSION

The purpose of this study was to develop a multidimensional scale that reflects female adolescents' thoughts and behaviors regarding their reproductive health and environmental pollution. This instrument includes 43 environmental perception items and 32 behavioral items, obtained using factor analysis. The psychometrically sound scales were derived and systemized into sensitivity (17 items), susceptibility (eight items), response efficacy (nine items), self-efficacy (nine items), personal behavior (19 items), and community behavior (13 items).

The findings revealed that female adolescents have environmental literacy and concern regarding the impact of environmental toxins, as well as sensitivity toward the causation of reproductive diseases. Although experience of environmental education occurred only for a mean of 1.36 times and some participants received health-related information from their families (38.9%), the study's subjects had the perception that environmental health behaviors could alleviate environmental toxins. Therefore, in the mentioned context, the meaning of developed subscales was explained.

Sensitivity in EHP-FA was perceived as risk of chemicals and physical refusal response from EDCs, household goods, personal care products, dust, or fat in food. The scope of environmental risk consisted of broad aspects including chemical pollutants, electromagnetic field, and climate. A precautionary approach should be followed regardless of the cause and effects being scientifically unknown (Sutton et al., 2016), because pollutants are widespread in the water, soil, air, and food, as well as in homes and schools. Sensitivity in EHP-FA can be a useful scale for the assessment of perception of environmental toxin exposure and potential hazard among female youth.

In this study, susceptibility in EHP-FA covered uterine disease, ovarian disease, precocious puberty, menstrual problems, female cancer, infertility, miscarriage, and fetal malformation. Moreover, the present study found that adolescents had environmental health literacy and understanding of the link between biological plausibility and disease. Environmental pollutants such as phthalate, BPA, pesticide, and tobacco induce premature ovarian insufficiency through changes in gene expression and cell apoptosis. It has also been shown that polluted rivers affect necessary developmental change, such as sexual maturity abnormality, fetal death, low fertility, low birth weight babies, and newborn anomalies (Grossman & Slusky, 2017). Pollutant exposure was most harmful during young adulthood than in other life stages, because the female subject's lifestyle affects two subsequent generations (Vabre et al., 2017).

Response efficacy in EHP-FA investigated the avoidance capability of micro-dust, electric waves, light pollution, unhealthy diets, hygiene, clean water drinking, and consumption of vegetables. Belief in behavioral impact prompts actionability and motivation toward environmental health behavior. Higher confidence in the positive health effects of a behavior increases the likelihood of that health behavior to be performed (Glanz et al., 2015). Healthcare providers can focus on this scale to access participants' degree of perception and preparation about environmental health behaviors. Plastic-free lifestyle interventions affected paraben, phthalate, phenol, and triclosan content in urine among girls aged 14–18 years through chemical use restrictions, such as toothpaste, sunscreen creams, perfumes, cosmetics, and hair products (Harley et al., 2016).

Self-efficacy in the EHP-FA scale consisted of prevention efficacy and protection efficacy, representing the subjects' confidence in themselves. The prevention efficacy had items related to the capabilities of health management, behavioral choice, identification and discrimination of hazards, learning about the environment, and prevention of reproductive health problems by oneself. The protection efficacy items had self-appraisal about defense and cutting pollutants via air, soil, water, food, and skin contact. Health care professionals may use this scale to evaluate youths' willingness to perform environmentally oriented health retention strategies because self-efficacy is a substantial factor in changing health behavior (Glanz et al., 2015). Self-efficacy, knowledge, and attitudes toward environmental health behavior also affected the eating of canned food among college students (Richards et al., 2017).

Personal EHB-FA scale assessed behaviors concerning chemical reduction, electromagnetic reduction, food selection, cosmetic selection, and dust and gas reduction. In China, young adults from air-polluted cities, aged 16–36 years, have actively engaged in more exercise, healthy diets, clean water drinking, and mask-wearing behavior. Thus, there is more awareness and perception of the environment's psychological impacts, such as depression, anxiety, and aggressiveness (Rajpa, Ullah, & Li, 2019). Focusing on environmental health may improve female health outcomes, because environmental toxins and reproductive health problems have a cause and effect relationship, as validated in previous researches (Ho et al., 2017; Zota et al., 2017).

Community EHB-FA scale consisted of reducing, reusing, recycling, and responding that were conscious behaviors minimizing the adverse effects on the environment. The common characteristics among the constituents are that they are future-oriented, lifestyle changing, and ask for a sacrifice to achieve prospective benefits (Cavaliere et al., 2018). Pro-environmentalism could motivate adolescents' moral development toward energy conservation and recycling because adolescence corresponds to the ethics formation stage in the aspects of moral awareness, emotion, and judgment (Krettenauer, 2017). The satisfaction with air, noise, water, light, hygiene, and environmental protection could enhance the psychological quality of life (Wong et al., 2018). Otherwise, female adolescents—the most vulnerable population—would suffer from various reproductive health problems due to the excessive consumption of modern society.

In this study, subjects adopted more health-promoting behaviors when they resided in micro-dust air-polluted areas. It is known that environmental education impacts lifestyle change; therefore, nurses should raise awareness regarding the environmental risks for female youth reproductive health (Cavaliere et al., 2018). Adolescents can be educated to accept new perspectives through collaborative and interdisciplinary approaches initiated by schools and communities (Gwon & Jeong, 2018). The ecological perspectives integrated for the EHP-FA and EHB-FA should involve environmental policies to minimize the negative influence on adolescents' reproductive health. The future intervention specified through the EHP-FA and EHB-FA can enhance environmental consciousness, reduce environmental risks, and effectively prevent reproductive diseases.

7 | LIMITATIONS OF THE STUDY

Although participants were female adolescents living in high air pollution areas, the sample is not representative of all the female adolescents who live in polluted areas. Another limitation was that this study was based on questionnaires. Therefore, opinions may have been ignored owing to response bias. Future studies should focus on a transcultural sample and validate the developed scales on various adolescent groups.

8 | CONCLUSION

The validated instrument developed in this study contributes toward evaluating the environmental perceptions and behaviors of female adolescents. Environmental health behaviors are increasingly being recognized as important, and emphasize the need for reliable and valid measures to adequately assess such behaviors. Facing an ecological threat, the four factors' environmental perception and two factors' behavioral scales were developed based on PTM. The 11 qualitative and 384 quantitative samples comprised of 18–22-year-old Korean females who participated in the development of EHP-FA and EHB-FA scales. Nurses have a responsibility to reduce adolescents' reproductive health problems resulting from climate change and pollution through partnership with the adolescents. Healthcare professionals should, therefore, pay special attention to accessibility and provide environmental health information for female adolescents. The use of the measurement validated through various approaches may contribute toward the monitoring of perceptions and behaviors regarding reproductive health problems among a broad population of female adolescents.

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CONFLICT OF INTEREST

The author has not stated any conflicts of interest.

AUTHOR RESPONSIBILITY

The sole author is responsible for all aspects of research and manuscript development.

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