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ORIGINAL RESEARCH

Development of Emerging Infectious Diseases Preventive Health Behavior (EID-PHB) Scale and Validation of the Complex Models

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Introduction: Emerging Infectious Diseases are one of the world's leading causes of death, and preventive measures must be implemented to minimize human casualties. Research on preventive behavior relies on the preventive behavior scale and it has an impact on the findings.

Purpose: This study aimed to develop an Emerging Infectious Diseases Preventive Health Behavior (EID-PHB) Scale and verify the validity and reliability of the complex models.

Methods: Initial items were generated through a literature review and interviews, based on the proposed conceptual framework of transmission-based precautions. 14 experts reviewed the preliminary items for content validity and 20 adults for face validity. Data were collected online by a research company from April 28 to May 3, 2023. A total of 533 participants completed the survey, and subjects were assigned through simple random sampling. The first sample (n = 330) was used for item analysis and Exploratory Factor Analysis (EFA), and the second sample (n = 203) was used for Confirmatory Factor Analysis (CFA), convergent validity, discriminant validity, criterion validity, and reliability. The test-retest reliability was assessed in 34 adults.

Results: The final instrument derived six components (droplet, contact, airborne, bloodborne, environmental prevention, and psychological coping), nine indicators, and 34 items. The CFA indicated that all the complex models had a good fit and the integrated factors were confirmed through validity tests. The Cronbach's alpha for the 34 items was 0.92, and the criterion validity was verified (r = 0.85, $p < 0.001$).

Conclusion: The EID-PHB is a valid and reliable tool that can be used to determine preventive behaviors against emerging infectious diseases. This tool is expected to provide a conceptual framework for future research, contribute to the clinical practice and education, and establish strategies and policies for improving individual and public health.

Keywords: emerging infectious disease, health behavior, primary prevention, validation studies as topic

Introduction

Since the turn of the 21st century, the world has been exposed to a wide range of emerging infectious diseases. An emerging infectious disease poses the threat of increased human incidence in the near future as a new, previously unknown pathogen spreading geographically or expanding its influence.[1] Such infections caused by biofilm-forming pathogens affect both human and animals but the host immune system finds it difficult to eradicate these infections, and the prevalence of antimicrobial resistance is rising globally. These challenges pose a serious public health threat.[2] Despite ongoing attempts to develop adequate preventive and quarantine measures, infectious diseases continue to be one of the world's major leading causes of death, accounting for millions of casualties annually.[3] The mortality rates of recently emerging infectious diseases were SARS 9.5%, MERS 34.4%, and Ebola VIrus 63.0%.[4] Therefore, non-pharmacological preventive efforts to avoid human deaths have become crucial quarantine measures from a public health perspective before identifying a novel infectious disease and developing a remedy.

Preventive health behaviors are a series of actions performed by asymptomatic individuals who perceive themselves as healthy to prevent or identify disease in an asymptomatic state.[5] In order to successfully carry out preventive health behaviors,

understanding the factors that affect preventive health behaviors in a pandemic crisis as well as tracking compliance with preventive practice guidelines have been key aims in the field of social science research.[6,7] Such studies rely on instruments that ensure validity and reliability,[7] and these tools significantly impact the research findings. Due to the lack of standardized scales, different approaches exist to quantify preventive behaviors against emerging infectious diseases. Some survey questions directly reflect government regulations,[6,8] apply tools used in previous studies,[9,10] or exclusively assess particular behaviors, such as wearing masks, washing hands, and coughing etiquette.[11] However, standardized measurement tools that enable accurate communication via theory verification studies, repeated research, and cross-study comparisons are needed, rather than using non-standardized measuring tools that rely on subjective assessment.[12]

Assessing preventive behavior is challenging until a novel infectious disease's lesions, symptoms, and infection routes are identified. Research on preventive behavior against novel infectious diseases is insufficient until the government announces specific guidelines for preventive behaviors. Consequently, very little research focuses on establishing a standardized novel infectious disease preventive behavior scale for the general public. Previous research on emerging infectious disease prevention practices has generally focused on medical professionals[13] and nursing students,[14] applying isolation and standard precautions[15,16] to prevent infection. As public awareness has grown through the recent widespread promotion of quarantine guidelines, research on COVID-19 among the general public is progressing.[6–10] Hence, this study aimed to develop a standardized prevention behavior scale for emerging infectious diseases for the general public in preparation for future outbreaks of novel infectious diseases. Its scope is to minimize the future damage caused by emerging infectious diseases and aid local governments in developing policies and regulations by strengthening research on preventive behavior compliance or identifying factors affecting preventive behaviors.

Materials and Methods
Research Design
This methodological study aimed to develop a preventive behavior scale for emerging infectious diseases and evaluate its validity and reliability following the eight-step tool development guidelines presented by Devellis (Figure 1).[17]

Development of the Scale
Conceptual Framework
The proposed conceptual framework was built by extracting concepts related to preventive behaviors and infection transmission through a literature review, and then constructing specific factors based on the infection transmission route through a mixed process of deductive and inductive methods. An infection spreads through the sources of infectious agents, susceptible hosts, and modes of transmission. However, since controlling the source of infectious agents that harbor microorganisms infiltrating the human body, objects, and surrounding environment, as well as susceptible hosts infected by these infectious agents, may be challenging, infection prevention is crucial for blocking the spread of infection. Infection transmission routes include droplets, contact, air, biology, and common vectors.[18,19] Hence this study devised a conceptual framework for blocking community infection transmission routes based on transmission precautions and isolation guidelines. The components of the conceptual framework are referred to as droplet prevention, contact prevention, airborne prevention, bloodborne prevention, and environmental prevention.

Composition of Preliminary Items
We searched the DBpia (https://www.dbpia.co.kr/), Google Scholar, KISS (https://kiss.kstudy.com/), Kmbase (https://kmbase.medric.or.kr/), NDSL (http://www.ndsl.kr/), and RISS (http://www.riss.or.kr/) databases for literature to review existing preventive behavior scales against emerging infectious diseases in Korea over the last ten years. In addition, we searched the CINAHL, MEDLINE, and Google Scholar databases for worldwide literature by entering keywords using a combination of "and/or" in "emerging infectious diseases", "preventive behaviors", "infectious diseases", "scale", and "tool". Exclusion criteria for the literature included: 1) infectious diseases that were not classified as emerging infectious diseases; 2) studies that did not target adults; 3) studies that targeted specific genders, age groups, and occupational groups; 4) studies in which the instrument question content was not clearly described; and 5) studies that were not in Korean or English. The final analysis included 16 domestic and 21 international studies that addressed the definitions and

Phase	Step	Procedures	Detailed contents

Development of the scale	Determine clearly what it is you want to measure	Literature review	Abstract review
			    Korean studies 16,491
			    Overseas studies 20,221
			1st selection of
			    Korean studies 490
			    Overseas studies 133
			2nd selection of
			    Korean studies 91
			    Overseas studies 76
			3rd selection of
			    Korean studies 16
			    Overseas studies 21

		Interviews	15 focused group interview
	Generate an item pool	Composition of preliminary items	Developing and reviewing items 7components, 18 indicators, 147 items
	Determine the format for measurement		Likert 5 point scale
Reduction of the scale	Have initial item pool reviewed by experts	Content validity test by experts (ICVI≥ .78)	1st content validity (n=9) Delete 52, Add 11, Total of 106 items
			2nd content validity (n=6) Delete 44, Add 2, Total of 64 items
		Consultation of Expert & Researchers	3rd content validity (n=4) Total of 64 items
	Consider inclusion of validation items	Face Validity Pilot test	Adults (n=20) Total of 64 items
Evaluation of the scale	Administer items to a development sample	Main survey	Adults (n=533)

	Evaluate the items	Validity test	Construct validity
			    Item analysis (n=330)
			    Exploratory factor analysis (n=330)
			    Confirmatory factor analysis (n=203)
			Convergent validity (n=203)
			Discriminant validity (n=203)

			Criterion validity (n=203)
		Reliability test	Internal consistency reliability Test-retest reliability (n=34)
	Optimize scale length	Final instrument	Derive 6 components, 9 indicators, Total of 34 items

Figure 1 Phase of development and validation of the scale.

attributes of these concepts. We conducted qualitative content analysis through two focus group interviews with 15 adults aged 19~69 to discuss their experiences in preventing of emerging infectious diseases. Then, we confirmed the conceptual underpinning of the notion through a literature review. Consequently, new variables such as health care

and emotional support that were not included in the components were discovered. These components are referred to as daily life prevention and psychological coping.

Reduction of the Scale
Content Validity
Based on Lynn's (1986) opinion that verifying the content validity of preliminary items with at least three to ten experts is desirable, the researcher sent emails or letters to nine experts with backgrounds in medicine and nursing on infection control. The Content Validity Index (CVI) was used to determine validity. Previous evidence suggests that the Item-level Content Validity Index (I-CVI) should be 0.78 or higher when there are six to ten evaluators.[20,21] Items with an I-CVI of less than 0.78 were therefore excluded. The items' relevancy was evaluated on a four-point scale. The I-CVI was calculated using items with three or four points. The items with ratings of one or two points were left out of the computation, however, experts gave their opinions regarding potential modifications of the items.

Face Validity
A pilot study was conducted on April 14~15, 2023 with 20 adults aged 19~69 living in the Seoul and Gyeonggi regions using refined preliminary questions to test face validity through the validity and comprehensibility. Furthermore, opinions were openly shared, and modifications and supplements to the questions, font size, question length, question placement, and survey time were considered.

Evaluation of the Scale
Participants and Data Collection
The main survey was conducted nationwide, targeting adults residing in Korea, aged 19~69 years, who could communicate, understood the purpose of the study, and voluntarily agreed to participate. Based on the rationale that the number of participants should be more than five times the number of questions or at least 200 cases,[17,21,22] the total number of participants was calculated by combining Exploratory Factor Analysis (EFA, n = 330) and Confirmatory Factor Analysis (CFA, n = 203). The survey was conducted online by a professional research company between April 28 and May 3, 2023. A total of 533 people responded to the online survey; only those who accepted the consent form were allowed to participate. The second survey was performed online on May 23, 2023, 20 days after the first survey, on the basis that a time interval of two to four weeks was appropriate for the study's subjects' memories to fade. Thirty-four participants were randomly selected and tested repeatedly for test-retest reliability.

Research Tools
The questionnaire included 64 questions on the EID-PHB, 10 on general characteristics for tool validation, and 12 on the Infection Prevention Behavior Scale of Individuals (IPBS-I) to verify criterion validity. The IPBS-I is a tool developed by Heo and Jang[23] to assess individual infection prevention behaviors in adults. Permission to use the tool was obtained to verify the criterion validity.

Data Analysis Method
Data were analyzed using IBM SPSS Statistics version, 29.0 and R version 4.1.2 for Windows software. The adjusted correlation coefficients between the items and the overall score were reviewed as well as the items analyzed below 0.30 were discarded.[22] Construct validity was verified using EFA and CFA. The suitability of the EFA was confirmed using Kaiser-Meyer-Olkin (KMO) and Bartlett's sphericity tests. The Principal Component Analysis (PCA) approach and the Varimax rotation method were utilized for factor extraction. The criteria for determining the number of factors were a communality and factor loading value of 0.50 or greater, and a total cumulative variance of 60% or greater. Through CFA, the model's goodness of fit was confirmed by χ^2/degree of freedom, Standardized Root Mean Residual (SRMR), Root Mean Square Error of Approximation (RMSEA), Comparative Fit Index (CFI), and Tucker Lewis Index (TLI).[24] Convergent validity was assessed using standardized factor loadings, Construct Reliability (CR), and Average Variance Extracted (AVE) values. Discriminant validity was determined based on whether the AVE value exceeded the squared value of the correlation coefficient. According to the validity criteria, CR was applied at 0.70 or higher and AVE at 0.50

or higher,[24,25] and the standard for obtaining stable findings if one factor has at least three questions.[26] The Pearson correlation coefficient between the EID-PHB and IPBS-I was used to assess criterion validity. Cronbach's alpha was employed to calculate the tool's internal consistency, and test-retest reliability was examined using Cronbach's alpha and intraclass correlation coefficient criteria.[27]

Ethical Considerations

This study obtained approval from the Institutional Review Board of the researcher's affiliation (IRB No. SYU 2021–12-007-001). The survey was designed to voluntarily agree to participate after being informed of the purpose of the study, method, procedure, time required, issues related to the provision of personal information, data confidentiality, management of collected data, and the possibility of withdrawal from research participation, among others via an online questionnaire. A professional research company rewarded those who completed the survey with a few points.

Results

Development of the Scale

The study derived seven components and 18 indicators, which included 147 preliminary items based on the tools from the reviewed literature, guidelines,[19,28–31] and qualitative content analysis. The components are referred to as droplet prevention, contact prevention, airborne prevention, bloodborne prevention, environmental prevention, daily life prevention, and psychological coping. The item-response scale of the tool was assessed using a five-point Likert scale.

Reduction of the Scale

Following the first content validity verification, 52 items were deleted, and 11 questions were added, resulting in 106 items, reorganizing the second preliminary questions. For the second round, three experts from the first round were included, and a total of six experts evaluated resulting in the deletion of 44 items and addition of 2 items. A total of 64 items were chosen as the third preliminary questions. After the second content validity verification, the I-CVI was 0.83~1.00, and the S-CVI/Average was 0.97. In the third round, the accuracy and readability were confirmed in line with the components and indicators. The selected items were forwarded to a Korean literary professional for feedback, and advice was sought regarding on the appropriateness of grammar, spelling, vocabulary accuracy, spacing, and sentence flow.

As a result of the pilot study, the time required to complete the questionnaire ranged from six to 15 minutes. The I-CVI for validity was 0.70~1.00 and S-CVI was 0.95, the I-CVI for comprehensibility was 0.90~1.00 and S-CVI was 0.99. Modification were made based on the feedback.

Confirmation of Validation Items

A total of 64 items were finalized and were classified by attributes: eight items on droplet prevention, 20 on contact prevention, six on airborne prevention, seven on bloodborne prevention, four on environmental prevention, 10 on daily life prevention, and nine on psychological coping (Supplementary 1).

Evaluation of the Scale
General Characteristics of the Subjects

After randomly extracting data from the 533 respondents, they were divided into two samples, with the first (n = 330) chosen for EFA and the second (n = 203) chosen for CFA (Table 1).

Item Analysis

According to the data analysis of the 330 EFA participants, the mean and standard deviation of the items ranged from 2.92 ± 1.11 to 4.70 ± 0.53. The skewness and kurtosis were −1.99~0.13, and −0.94~4.25, respectively, and the criteria[32] of skewness and kurtosis of less than two and seven were met, indicating the normality of the distribution. Two items with adjusted correlation coefficients overall score of less than 0.30 were evaluated as having a poor contribution to the scale[22] and eliminated. In addition, the correlation between the remaining items and the overall score ranged from r = 0.31 to 0.58. The Cronbach's a for all 62 items was 0.95.

Table 1 Characteristics of Participants (N = 533)

Characteristics	Categories	EFA (n = 330) n (%)	CFA (n = 203) n (%)
Gender	Male	145 (43.9)	119 (58.6)
	Female	185 (56.1)	84 (41.4)
Age group	19~29	64 (19.4)	43 (21.2)
	30~39	79 (23.9)	25 (12.3)
	40~49	61 (18.5)	42 (20.7)
	50~59	65 (19.7)	45 (22.2)
	60~69	61 (18.5)	48 (23.6)
Marital status	Married	184 (55.8)	114 (56.2)
	Unmarried	128 (38.8)	77 (37.9)
	Divorce/Seperate/Bereave	18 (5.5)	12 (5.9)
Education	Secondary level	60 (18.2)	32 (15.8)
	Tertiary level	228 (69.1)	146 (71.9)
	Postgraduate	42 (12.7)	25 (12.3)
Employment	Employed	224 (67.9)	149 (73.4)
	Unemployed	106 (32.1)	54 (26.6)
Monthly household income (won)	< 2,000,000	55 (16.7)	30 (14.8)
	2,000,000~6,000,000	200 (60.6)	122 (60.1)
	6,000,000 <	75 (22.7)	51 (25.1)
History of chronic diseases	Present	66 (20.0)	49 (24.1)
	Absent	264 (80.0)	154 (75.9)
Perceived health status	Healthy	79 (23.9)	49 (24.1)
	Uncertain	213 (64.5)	132 (65.0)
	Unhealthy	38 (11.5)	22 (10.8)
Infected by EID	Present	167 (50.6)	108 (53.2)
	Absent	163 (49.4)	95 (46.8)
Experience of quarantine	Present	164 (49.7)	108 (53.2)
	Absent	166 (50.3)	95 (46.8)

Abbreviations: EFA, Exploratory Factor Analysis; CFA, Confirmatory Factor Analysis; EID, Emerging Infectious Diseases.

Exploratory Factor Analysis

PCA using the Varimax rotation approach was repeatedly conducted to confirm the construct validity of the chosen 62 items. EFA was carried out with the factors set to ten based on the conceptual framework. Twenty-seven analyses were performed, and 28 of the 62 items were discarded. The eliminated items were one with a communality of less than 0.50 and 22 items with factor loadings less than 0.50, and three with common loadings. In addition, based on the standard,[26] a factor must consist of at least three questions to obtain stable results, and two additional items must be reviewed and removed. The EFA was repeated three times in the same manner, and the results were consistent. The KMO value of the selected 34 questions was 0.88, and Bartlett's test of sphericity was statistically significant at χ^2=5521.41 ($p < 0.001$). The communality of the 34 items ranged from 0.49 to 0.86, while the factor loadings were between 0.42 and 0.86. The three items with a communality and factor loadings below 0.50 were considered essential questions for the tool and were not eliminated. Nine factors exhibited eigenvalues greater than 1.0, and the overall cumulative variance was 63.0% (Table 2).

Confirmatory Factor Analysis, Convergent, and Discriminant Validity

CFA was performed with a new sample of 203 participants, and the model was developed using nine extracted subfactors based on the EFA result. The model resulted in a good fit, with the χ^2/degree of freedom of the model equal to 1.25, CFI was 0.94, TLI was 0.94, and RMSEA was 0.04 (90% confidence interval, 0.03~0.05), and SRMR was 0.08 (Table 3 and Supplementary 2). However, in this study we developed another model based on the proposed conceptual framework, resulting in six components and nine indicators. The model resulted in a good fit, with the χ^2/degree of freedom of the

Table 2 Exploratory Factor Analysis (N = 330)

Factors (Indicators)	No	M±SD	Com.	Factor Loading									
				F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
Attitude	61	3.86±.084	0.68	**0.78**	0.03	0.10	0.07	0.11	0.18	0.14	−0.02	−0.01	0.03
	62	4.06±0.71	0.66	**0.76**	0.02	0.08	0.02	0.09	0.15	0.10	0.09	0.14	0.12
	59	4.28±0.69	0.62	**0.72**	0.07	0.16	−0.01	0.07	−0.10	0.07	0.10	0.09	0.21
	63	4.14±0.70	0.59	**0.67**	0.07	0.12	0.02	0.18	−0.01	0.16	0.07	0.17	0.17
	58	4.05±0.73	0.67	**0.69**	0.11	0.08	0.19	0.16	0.11	0.10	0.06	0.01	0.35
Social distancing	16	3.18±1.09	0.77	0.06	**0.83**	0.14	0.12	−0.01	0.16	0.02	0.04	0.06	0.05
	17	2.92±1.11	0.71	−0.08	**0.82**	0.04	0.07	0.13	0.04	0.02	0.01	0.06	0.02
	18	2.93±1.11	0.75	0.06	**0.81**	0.02	0.09	0.03	0.08	0.22	−0.06	−0.15	0.06
	15	3.38±1.07	0.69	0.09	**0.72**	0.15	0.20	0.04	0.25	0.12	0.10	0.12	0.07
	9	3.41±0.98	0.56	0.18	**0.66**	0.03	0.10	0.06	0.16	0.05	0.06	0.19	−0.10
Hand hygiene	25	4.41±0.71	0.71	0.29	0.01	**0.77**	0.06	0.04	−0.06	0.01	0.09	0.10	−0.04
	26	4.32±0.81	0.70	0.04	0.06	**0.76**	0.14	0.14	−0.01	0.06	0.10	0.24	0.02
	24	4.15±0.78	0.68	0.14	0.14	**0.70**	0.03	0.13	0.15	0.28	0.09	0.02	0.14
	23	3.91±0.86	0.63	0.02	0.14	**0.54**	−0.03	0.29	0.30	0.28	0.18	−0.07	0.16
	27	3.78±0.91	0.56	0.17	0.22	**0.48**	0.11	0.34	0.28	0.08	0.17	−0.03	−0.09
Wearing masks	5	4.21±1.00	0.84	0.01	0.17	0.05	**0.86**	0.14	0.09	0.12	−0.06	0.13	0.06
	4	4.26±0.99	0.79	0.01	0.20	0.04	**0.86**	0.05	0.06	0.07	−0.03	0.02	0.06
	6	4.34±0.89	0.65	0.20	0.12	0.15	**0.71**	0.09	0.11	0.06	0.19	0.05	−0.11
Environmental management	43	3.30±.1.04	0.69	0.11	0.05	0.08	0.12	**0.78**	0.19	0.04	0.01	0.04	0.05
	44	3.60±0.93	0.70	0.23	0.11	0.13	0.03	**0.76**	0.05	0.13	−0.01	0.15	0.02
	42	4.18±0.77	0.57	0.11	0.03	0.19	0.11	**0.66**	−0.02	0.01	0.23	0.13	0.03
Ventilation	31	3.27±0.95	0.79	0.15	0.27	0.02	0.13	0.04	**0.80**	0.11	0.14	0.06	0.07
	32	3.26±.1.01	0.79	0.10	0.33	0.07	0.09	0.10	**0.78**	0.05	0.09	0.09	0.08
	34	3.42±.1.00	0.54	0.06	0.14	0.26	0.07	0.32	**0.50**	0.00	−0.04	0.29	0.13
Contaminated carriers	19	4.08±0.83	0.74	0.13	0.13	0.14	0.14	0.20	0.03	**0.76**	0.16	0.07	0.11
	20	4.22±0.72	0.76	0.29	0.17	0.20	0.10	0.02	0.03	**0.75**	0.06	0.18	0.06
	21	4.12±0.91	0.65	0.41	0.17	0.11	0.09	−0.04	0.26	**0.55**	0.18	0.17	−0.04
Respiratory etiquette	1	4.11±0.85	0.63	0.06	0.04	0.16	0.05	0.09	0.10	0.05	**0.76**	0.04	−0.02
	2	4.19±0.86	0.61	0.03	0.04	0.08	−0.03	0.17	0.14	0.09	**0.72**	−0.03	0.15
	3	4.70±0.53	0.65	0.25	−0.01	0.14	0.11	−0.14	−0.12	0.22	**0.60**	0.33	0.08
Bloodborne protection	37	4.02±0.98	0.71	0.03	0.17	0.06	−0.11	0.28	0.07	0.21	0.04	**0.73**	0.02
	38	3.95±0.98	0.49	0.20	0.04	0.06	0.16	0.13	0.23	0.14	−0.02	**0.57**	0.07
	39	4.46±0.77	0.61	0.18	0.03	0.34	0.32	−0.05	0.01	−0.10	0.26	**0.51**	0.09
	40	4.34±0.81	0.55	0.37	0.07	0.27	0.28	0.04	0.03	0.05	0.25	**0.42**	−0.07
Excluded	57	3.98±0.78	0.86	0.38	0.01	0.13	0.01	0.03	0.11	0.07	0.12	0.04	**0.81**
	56	4.05±0.84	0.84	0.39	0.06	−0.01	0.01	0.06	0.09	0.07	0.07	0.07	**0.81**
Eigen value				9.5	3.3	2.2	1.9	1.7	1.3	1.3	1.2	1.1	1.0
Explained variance(%)				10.4	9.7	7.7	6.8	6.4	6.0	5.4	5.4	5.1	4.8
Cumulative variance(%)				10.4	20.2	27.9	34.7	41.2	47.1	52.5	57.9	63.0	67.8
Kaiser-Meyer-Olkin: 0.88,				Bartlett's test of sphericity: χ^2=5521.41 (p < 0.001)									

Note: The factor's significant factor loading is highlighted by bold text.
Abbreviations: M, Mean; SD, Standard Deviation; Com, Communality.

Table 3 Confirmatory Factor Analysis of the Models

Factors/ Model	No	β	SE (p)	χ²/degree of freedom	CFI	TLI	RMSEA (90% CI)	SRMR	Cronbach's a
Six-factor model				1.37	0.91	0.91	0.05 (0.04~0.06)	0.09	0.92
Nine-factor model				1.25	0.94	0.94	0.04 (0.03~0.05)	0.08	0.92
Respiratory etiquette	1	0.58							
	2	0.63	0.20 (0.001)						
	3	0.67	0.21 (0.001)						
Wearing masks	4	0.86							
	5	0.90	0.10 (0.001)						
	6	0.57	0.09 (0.001)						
Social distancing	9	0.51							
	15	0.70	0.24 (0.001)						
	16	0.80	0.26 (0.001)						
	17	0.81	0.26 (0.001)						
	18	0.80	0.26 (0.001)						
Contaminated carriers	19	0.66							
	20	0.72	0.17 (0.001)						
	21	0.63	0.16 (0.001)						
Hand hygiene	23	0.72							
	24	0.77	0.12 (0.001)						
	25	0.72	0.12 (0.001)						
	26	0.68	0.12 (0.001)						
	27	0.74	0.12 (0.001)						
Ventilation	31	0.86							
	32	0.93	0.09 (0.001)						
	34	0.46	0.09 (0.001)						
Bloodborne protection	37	0.49							
	38	0.64	0.26 (0.001)						
	39	0.71	0.27 (0.001)						
	40	0.69	0.27 (0.001)						
Environmental Management	42	0.54							
	43	0.70	0.23 (0.001)						
	44	0.81	0.26 (0.001)						
Attitude	58	0.84							
	59	0.73	0.90 (0.001)						
	61	0.74	0.90 (0.001)						
	62	0.80	0.90 (0.001)						
	63	0.73	0.90 (0.001)						

Abbreviations: SE, Standard Error; CFI, Comparative Fit Index; TLI, Tucker Lewis Index; RMSEA, Root Mean Square Error of Approximation; CI, Confidence Interval; SRMR, Standardized Root Mean Residual.

model equal to 1.37, CFI was 0.91, TLI was 0.91, and RMSEA was 0.05 (90% confidence interval, 0.04~0.06), and SRMR was 0.09, all of which met the standards. CR was 0.73~0.93 (≥ 0.70) and AVE was 0.41~0.61 (≥ 0.50), indicating that AVE values for bloodborne and environmental prevention were slightly below the recommended levels.[24,25] To verify discriminant validity, the correlation coefficient between factors was proven to be r = 0.21~0.60 (p < 0.001) and the AVE values exceeded all squared correlation coefficients, confirming that discriminant validity was established (Table 4 and Supplementary 3).

Table 4 Confirmatory Factor Analysis, Convergent & Discriminant Validity of the Six-Factor Model (N = 203)

Factors/ Indicators	No	Items	β	SE (p)	CR	AVE	α*	Correlation r(p) / <√AVE>					
								F1	F2	F3	F4	F5	F6
Factor 1 Droplet prevention				(0.001)	0.86	0.51	0.74	<0.71>					
Respiratory etiquette	1	I cover my nose and mouth with a tissue, handkerchief, sleeves etc. when coughing or sneezing.	0.58	0.16									
	2	I discard the used tissue immediately after coughing or sneezing.	0.63	0.16									
	3	I try to turn my head away from others when coughing or sneezing.	0.67										
Wearing masks	4	I prepare a mask when going out.	0.86	0.21									
	5	I wear a mask when going out in public places.	0.90	0.22									
	6	I wear a mask when I have respiratory symptoms.	0.57										
Factor 2 Contact prevention				(0.001)	0.93	0.51	0.86	0.50	<0.72>				
Social distancing	7	I try not to have physical contacts such as shaking hands or hugging others.	0.51	0.10				(0.001)					
	8	I avoid going to crowded places.	0.70	0.10									
	9	I refrain from participating social gatherings.	0.80	0.10									
	10	I try to refrain from eating out.	0.81	0.10									
	11	I try to refrain from traveling within the country or abroad.	0.80										
Contaminated carriers	12	I stay home when I have symptoms (fever, cough, rash etc).	0.66	0.17									
	13	I would be cautious not to have close contact with others who have symptoms.	0.72	0.18									
	14	I would be cautious not to visit the affected areas.	0.63										

(*Continued*)

Table 4 (Continued).

Factors/ Indicators	No	Items	β	SE (p)	CR	AVE	α*	Correlation r(p) / <√AVE>					
								F1	F2	F3	F4	F5	F6
Hand hygiene	15	I clean my hands (washing hands, using sanitizer) after coughing, sneezing, or nose-blowing.	0.72	0.12									
	16	I clean my hands (washing hands, using sanitizer) before having a meal.	0.77	0.12									
	17	I wash my hands with water and soap after using restroom.	0.72	0.12									
	18	I clean my hands (washing hands, using sanitizer) first, right after entering home.	0.68	0.12									
	19	I clean my hands using hand sanitizer when I am not able to wash my hands with water and soap.	0.74										
Factor 3 Airborne prevention				(0.001)	0.81	0.61	0.77	0.31	0.60	<0.78>			
Ventilation	20	I would be cautious not to enter a place where it is not equipped with ventilation.	0.86	0.32				(0.001)	(0.001)				
	21	I leave the place as soon as possible when it is judged hard to be ventilated.	0.93	0.34									
	22	I would be cautious controlling temperature and humidity of the indoor.	0.46										
Factor 4 Bloodborne prevention				(0.001)	0.73	0.41	0.72	0.46	0.47	0.21	<0.64>		
Bloodborne protection	23	I open the window only when the mosquito protective screens are installed.	0.49	0.14				(0.001)	(0.001)	(0.003)			
	24	I try to control the pest using the bug catcher (including electronic)/ household pest control, etc.	0.64	0.14									
	25	I wash in running water when exposed to other's blood.	0.71	0.14									
	26	I try not to be infected when using injection needle (self- injection, blood transfusion, blood donation, blood draw etc.)	0.69										

Factor 5 Environmental prevention				(0.001)	0.73	0.48	0.71	0.34	0.45	0.46	0.38	<0.69>	
Environmental management	27	I clean my house regularly.	0.54	0.11				(0.001)	(0.001)	(0.001)	(0.001)		
	28	I use disinfectants to maintain the hygiene of my home.	0.70	0.12									
	29	I clean or disinfect objects or surfaces that are frequently touched.	0.81										
Factor 6 Psychological coping				(0.001)	0.88	0.59	0.88	0.49	0.49	0.37	0.51	0.43	<0.77>
Attitude	30	I try to cope with the Emerging Infectious Diseases.	0.84	0.12				(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	
	31	I try to be considerate of others to prevent others from getting infected.	0.73	0.12									
	32	I try to get information about Emerging Infectious Diseases.	0.74	0.12									
	33	I try to comply the preventing behaviors when I acquire information regarding Emerging Infectious Diseases.	0.80	0.12									
	34	I comply preventive behaviors with a confidence in medical staff.	0.73										
Model fit χ^2/degree of freedom = 1.37, CFI= 0.91, TLI= 0.91, RMSEA= 0.05 (0.04~0.06), SRMR= 0.09, Cronbach's a = 0.92													

Note: <√AVE> stands for root AVE, which is used to validate the discriminant validity.
Abbreviations: SE, Standard Error; CR, Construct Reliability; AVE, Average Variance Extracted; α*, Cronbach's α; CFI, Comparative Fit Index; TLI, Tucker Lewis Index; RMSEA, Root Mean Square Error of Approximation; SRMR, Standardized Root Mean Residual.

Criterion Validity

Heo and Jang's (2021) IPBS-I scale and EID-PHB scales showed a significant positive correlation (r = 0.85, *p* < 0.001). The correlation between the six components of EID-PHB and IPBS-I was r =0.50~0.73 (*p* < 0.001), suggesting a substantial positive association and verifying criterion validity.

Reliability

The Cronbach's a of 34 items was 0.92, along with droplet prevention equal to 0.74, contact prevention at 0.86, airborne prevention at 0.77, bloodborne prevention at 0.72, environmental prevention at 0.71, and psychological coping at 0.88. All these values were above 0.70, the reliability criterion for the new tools.[33] For the test-retest reliability, 34 participants took part in the second survey, and Cronbach's a was 0.93; we observed a slight difference from the first test for each component. The intraclass correlation coefficient was r = 0.88 (95% CI = 0.81~0.93), *p* < 0.001, meeting the criteria,[27] ensuring stability and reliability.

Confirmation of Final Scale

The EID-PHB scale consists of six components and nine indicators: droplet prevention (respiratory etiquette, wearing masks), contact prevention (social distancing, contaminated carriers, hand hygiene), airborne prevention (ventilation), bloodborne prevention (blood protection), environmental prevention (environmental management), and psychological coping (attitude). The measurement range was a five-point Likert scale from one (not at all) to five (very much), with higher scores indicating more preventive behaviors.

Additional Research and Applicability of Complex Model

The preventive behavior path analysis of the final model showed that all six components had a significant positive correlation with preventive behaviors (r = 0.67~0.80, *p* < 0.001) and had an influence on preventive behaviors *(β* = 0.24, *p* = 0.032~0.45, *p* < 0.001) (Supplementary 4). According to general characteristics, the 60s (3.63 ± 0.79) were found to do more airborne prevention (F = 5.17, *p* < 0.001) than the 20s (2.87 ± 1.00), and those with higher income performed more environmental prevention (3.76 ± 0.67, 3.10 ± 0.75) and psychological coping (4.04 ± 0.63, 3.83 ± 0.78) than those with lower income (F = 9.47, *p* < 0.001, F= 5.21, *p* = 0.006). Individuals perceived as healthy engaged in more environmental prevention (3.88 ± 0.80, 3.44 ± 0.69), psychological coping (4.26 ± 0.46, 3.96 ± 0.68), and overall preventive behaviors (4.00 ± 0.40, 3.78 ± 0.68) than those who were uncertain (F = 6.21, *p* = 0.002, F = 4.32, *p* = 0.015, F = 4.11, *p* = 0.018). Additionally, those with experience of being quarantined due to an emerging infectious disease (3.68 ± 0.69) were found to engage more in environmental prevention (t = 2.15, *p* = 0.033) than those without the experience of being quarantined (3.45 ± 0.81). The model fit was confirmed to be good, and its reliability was verified.

The preventive behavior scale needed for emerging infectious diseases differs depending on the infection transmission route and the purpose of the research. Hence a complex model was built by grouping the components according to the conceptual framework to assess preventive behaviors' fit, validity, and reliability (Table 5). In addition, daily life prevention excluded from the study was analyzed independently using EFA. Three items were selected, and their model fit was confirmed through CFA (Supplementary 5).

Discussion

This study's factor classification process of blocking infection transmission routes based on the conceptual framework contributed to further subdividing preventive behaviors against emerging infectious diseases. Through interviews, the qualitative research content analysis identified daily life prevention and psychological coping that could not be extracted from the conceptual framework.

The droplet prevention factor is constructed by integrating two indicators which are respiratory etiquette and wearing masks. The first model, which includes these components, is confirmed to be a good fit. However, we reconstructed the model based on the transmission route, and the indirect contribution of the the two indicators was validated using CFA. The average for droplet prevention was relatively high but the adjusted item-total correlation coefficient was relatively low, at r = 0.32~0.43 in the item analysis. Although the droplet prevention performance level was high, the relationship

Table 5 Model Fit of the Additional Complex Model Scale (N = 203)

	Model / Prevention	χ^2/degree of Freedom	CFI	TLI	RMSEA (90% CI)	SRMR	AIC	Cronbach's a
1	Droplet prevention Contact prevention Airborne prevention	1.40	0.94	0.93	0.05 (0.04~0.07)	0.08	8162.74	0.89
2	Contact prevention Environmental prevention Psychological coping	1.32	0.96	0.95	0.05 (0.03~0.06)	0.07	7729.74	0.89
	Including daily life prevention							
3	Droplet prevention Contact prevention Airborne prevention Bloodborne prevention Environmental prevention Psychological coping Daily life prevention	1.29	0.92	0.91	0.04 (0.04~0.05)	0.09	13,766.29	0.92

Abbreviations: CFI, Comparative Fit Index; TLI, Tucker Lewis Index; RMSEA, Root Mean Square Error of Approximation; CI, Confidence Interval; SRMR, Standardized Root Mean Residual; AIC, Akaike Information Criteria.

with the overall preventive behavior items required improvement in constructing the questions. The question "I completely cover my nose, mouth, and chin when wearing a mask" had a relatively high average of 4.65 ± 0.62 but was removed as the factor loading value was less than 0.50. On the other hand, in the earlier investigation,[8] the result was 0.67. As the debate and interest in proper mask wear continue, the item included in a previous study highlights the need for additional research on wearing masks.

The contact prevention factor is developed by integrating three indicators which are social distancing, contaminated carriers, and hand hygiene. CFA was used to verify the indirect influence of the three components. Items related to social distancing were included in several prior studies[34,35] and were discovered to be an inevitable component. During the interviews, most participants emphasized the value of social isolation, and dining out. Some even claimed that they avoided using shared utensils with family members in favor of disposable or personal ones. In contrast, the average level of social distancing in this survey was considered low, ranging from 2.92 ± 1.11 to 3.41 ± 0.98, and was lower than the previous studies (4.07 ± 0.64, 4.68 ± 0.64)[34,35] relatively. It was assumed due to the difference in the interval between the interview period (October~November, 2022) and the main survey period (April~May, 2023), which accounted for the difference in the social distancing stage and the social atmosphere and environment. Since it can be presumed that the difference affected the number of preventative behaviors taken into account, quarantine rules and policies should be developed. Previous research[6,35] covered all components of the contaminated carrier index, and both the average value in this study (4.08 ± 0.83 to 4.22 ± 0.72), and the previous one (4.72 ± 0.57 to 4.75 ± 0.61)[35] were typically high. This result implies that avoiding contact with symptomatic individuals and their surroundings is crucial to preventing the spread of infectious diseases. Therefore, when developing quarantine strategies, significant efforts must be made to develop efficient isolation plans. It is challenging to discern between social distancing and contaminated carriers. Keeping a distance from a symptomatic individual was subcategorized as contaminated carriers rather than social distancing. In practice, contact prevention is a common preventive measure. However, it included large number of items to be evaluated as a single factor. As a result, three indicators are covered in this study: social distancing, contaminated carriers, hand hygiene. In order to generate a simple tool, we suggest merging the indicators into one, and reducing the items in further study.

The average airborne prevention was relatively low, indicating that ventilation and air conditioning were not easy to implement. Despite the fact that ventilation is a subject of government guidelines,[30] only few researches[34] included ventilation-related items.The item "I use an air purifier/air sterilizer/ air purifier", which had the highest mean of 3.48 ± 1.20, was eliminated owing to common loading. Because air prevention requires not only ventilation and air conditioning

but also wearing a mask, an indicator of droplet prevention, this overlapping tendency is believed to limit the classification of air prevention as a single component. Therefore, we recommend reclassifying airborne prevention-related items in future research due to shortcomings in clarifying the boundaries of the items.

The public's awareness of and implementation of bloodborne prevention could not be determined because it was not included in Korea's most recent emerging infectious disease (COVID-19) prevention guidelines. However, the average in this study was considered significant in confirming the level of interest in bloodborne prevention and deriving as a component. The item "I try to use condom for a safe sexual life" was deleted as the item-total correlation coefficient was less than 0.30, whereas the average was 3.95 ± 0.98. Considering the differences in awareness and culture of sexual relations within the country and overseas, issues pertaining to condom use are challenging to employ as a domestic survey item. It is nevertheless, a significant query in terms of EID bloodborne prevention. Hence, condom use and sextual intercourse should be taken into account in future studies.

Although the majority of interviewees stated that they often used alcohol to disinfect their surroundings or their possessions, the associated item's average score was low. Because society, the environment, and quarantine regulations all have an impact on infection spreads. Environmental management was defined as the dissemination of common vectors, and included items such as keeping the environment clean and using disinfectants. Ventilation, air quality management, and water and food-related queries were not categorized as environmental prevention. These may be accounted for as environmental factors, whereas were reclassified during content validity. Future research should focus on developing items and conducting research on environmental prevention in the future to safeguard the environment, which has a significant effect on public health.

The psychological coping items were developed through qualitative research, and the explanatory power was the highest at 10.4%, indicating the importance of the public's attitude toward emerging infectious diseases. The average of psychological coping was relatively high, and it was proven that individuals had a caring attitude toward themselves and others. Many interviewees described their experiences of causing harm to others due to infection, giving insight into their thoughts and attitudes toward family members and acquaintances. This result demonstrates how challenging it is to isolate oneself from community life and take preventive actions perceived as inevitable The previous finding[9] proved that the impact on others of not performing preventive measures influences an individual's willingness to take preventive action. Nonetheless, another study[36] ascertained that social groups are influenced by our society and what others think affect in decision-making when it comes to engaging in preventive behavior. In either circumstance, it highlights the influence of others on an individual's decision to comply preventive action.In addition, results[35] indicated that information seeking influences preventive behavior. Thus, it has been determined that each item is appropriate for use as psychological coping factor. Furthermore, future studies should focus on community prevention actions and public attitudes and design plans to promote the government's efforts to prevent emerging infectious diseases.

All items regarding daily life prevention, including those found in earlier studies,[10,23] were eliminated. In line with the accepted approach of removing one item each time an EFA was carried out after one item was eliminated, the factor loading values of the related items changed continuously, leading to the removal of several items in a row. An individual's immunity must be strengthened through daily life prevention. However, maintaining a healthy lifestyle and devoting time to health management is often challenging in today's hectic world. Furthermore, because infections mediated by vital elements such as water and food may impact the prevention of emerging infectious diseases in the future, the components were reanalyzed based on conceptual framework as an extra study, and a complex model verification was undertaken.

This study demonstrated that scales may be adequately set up and used following the research requirements. Hence, six- and nine-factor scales were introduced. Therefore, a practical tool that can be used in various fields was developed. Overall, the study's findings suggest the need for conducting additional research and developing scales based on conceptual frameworks.

Finally, caution is needed in generalizing the findings to adults because the proposed survey was conducted online. In addition, one component could not be assessed since relevant questions were eliminated during the verification procedure.

Conclusion

This study developed a 34-item scale consisting of six components and nine indicators of an emerging infectious disease prevention behavior (EID-PHB), and it's validity and reliability were verified. This approach provides information for

future research on preventing new infectious diseases, contributing to the government's quarantine policy preparation and promotion strategy, and provides helpful primary data for developing theories or tools for preventive behaviors against emerging infectious diseases.

This study has addresses specific and practical questions by subdividing preventive behaviors by transmission route. However, some items were discarded when processing content validity or EFA. Hence, additional analyses are presented in the the Supplementary Material. Furthermore, due to the large number of items, a complex model of contact prevention was designed. Therefore, further study should be conducted to develop a revised version of the EID-PHB in order to simplify the scale.

Ethics Approval and Consent to Participate

The study was conducted following the Declaration of Helsinki, and approved by the Institutional Review Board of Sahmyook University (IRB No. SYU 2021-12-007-001).

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Disclosure

The authors report no conflicts of interest in this work.

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