International Journal of Women's Health

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METHOD

Development and Psychometric Properties of the Health Belief Model Scale for Premature Birth Prevention (HBM-PBP) for Women of Childbearing Age

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Purpose: This study aimed to develop the Health Belief Model scale for premature birth prevention (HBM-PBP) and evaluated its psychometric properties in women of childbearing age.

Methods: This study employed a cross-sectional design and included 724 women of childbearing age with intentions of future childbirth or in their first trimester of pregnancy. An item pool was formulated from the literature and in-depth interviews based on the health belief model. Content validation was conducted by experts and through cognitive interviews with women of childbearing age. Construct and concurrent validity and reliability were evaluated using factor analysis, Pearson's correlation analysis, and Cronbach's alpha.

Results: The HBM-PBP consisted of 96 items, including perceived susceptibility (21 items, 5 subscales), severity (26 items, 5 subscales), benefits (27 items, 5 subscales), and barriers (22 items, 5 subscales). Convergent and discriminant validity were supported. The Cronbach's alpha coefficient of the domains ranged from 0.87 to 0.94.

Conclusion: The HBM-PBP is a valid and reliable measurement scale with good psychometric properties. It can be used to measure health beliefs in women, either as a whole or in individual domains. Health professionals can leverage the HBM-PBP to discern women's health beliefs on premature birth, facilitating tailored interventions and educational efforts.

Keywords: health belief model, premature birth, reproducibility of results, surveys and questionnaires, women

Introduction

The global preterm birth rate is estimated at 10.6%.[1] Complications of prematurity are the leading cause of mortality before the age of 5 years.[2] Surviving preterm infants have a high risk of long- and short-term morbidities.

Numerous risk factors such as socio-demographic, medical, obstetric, fetal, and environmental factors contribute to premature birth (PB).[3,4] The main risk factors for PB are premature labor, preterm premature rupture of membranes, and iatrogenic medical intervention due to maternal (such as placental abruption, placenta previa, pre-eclampsia, eclampsia) or fetal (such as fetal distress, intrauterine growth restriction) health problems. Approximately two-thirds of preterm births occur without any evident risk factors.[4]

The causes of premature birth are complex with many confounding factors, so that elimination of one risk factor for premature birth does not always prevent premature birth.[4] However, preventive actions that reduce or eliminate the occurrence of known risk factors as much as possible, lower the risk of premature birth.[5,6] Prevention strategies include early and continuing risk assessment, health promotion, and medical and psychosocial intervention. As the risk factors for premature birth are identified during preconception and prenatal care, plans to prevent, monitor, and intervene can be established.[6] Health promoting activity, chronic disease management, and work environment regulation before and

Received: 25 December 2023
Accepted: 11 June 2024
Published: 26 June 2024

during pregnancy may be helpful.[5,6] Early recognition of symptoms of premature birth and coping can allow time for medical intervention, thereby prolonging pregnancy, improving the health of both mother and baby, and ultimately reducing newborn morbidity and mortality.[6,7]

Recognition of risks results in a reduction in PB because necessary interventions can be instituted.[6] To take preventive action, women of childbearing age (WCA) must first have the health belief that managing risk factors for PB and maintaining health preconception and antenatally can reduce the risk of and prevent PB. However, awareness of prevention of PB is still insufficient.[8] Most WCA do not even know the term "premature birth" and assume that they will have a healthy birth.[9] At least, women with a history of preterm labor are likely to pursue medical care to reduce the risk of PB, but women without this history are less likely to do this.[8] Therefore, knowledge of the severity of the consequences of and sensitivity to PB are low; women are unaware of which actions may be helpful in preventing PB, or what obstacles there are to these preventive actions.[9] Health beliefs regarding the prevention of PB remain limited among WCA.

Health beliefs can be defined by perceived susceptibility, severity, benefits, and barriers that predict whether and why people will take action to prevent and control an illness condition.[10] If women perceive themselves to be at risk for a disease (premature birth) with potential serious consequences, they are more likely to adopt health-promoting behaviors. This likelihood increases if these behaviors can mitigate susceptibility to or alleviate the severity of the condition. Moreover, when the benefits of taking action outweigh perceived barriers, women are more inclined to engage in such health behaviors.[11–13] Therefore, pregnant women's health beliefs explain and predict their health behaviors. It is necessary to identify women's health beliefs to encourage their actions in promoting and maintaining reproductive health to prevent PB.

However, to date, there is no measurement scale to assess health beliefs regarding the prevention of PB. Recently, reported studies have developed questionnaires regarding beliefs about specific health conditions or health behaviors, rather than scales for preventing PB. Only 2–3 questions for each component of perceived susceptibility, severity, benefits, and barriers were developed, and content and/or face validity was tested, but construct validity was not confirmed,[11,14] or there was no report on validity testing.[12,13] Therefore, it is considered that there is no scale that has been tested for systematic validity and reliability. Identifying health beliefs regarding the prevention of PB among WCA can help design interventions to promote such beliefs. To assess the Health Belief Model scale for premature birth prevention (HBM-PBP) and provide timely and useful interventions for the prevention of PB, the target population should include WCA and at least those in the early stages of pregnancy before they are exposed to the risk of PB due to high-risk pregnancies. Additionally, to ensure content validity of health beliefs, it is crucial to assess the full range of components that may influence the behavior.[10] The predictive power of any one of four components might be contingent on values of another. It is advisable to compute a multiplicative variable that integrates perceived susceptibility, severity, benefits, and barriers, rather than considering each individually.[10] This study aimed to develop and evaluate the psychometric properties of a Health Belief Model scale including four components for Premature Birth Prevention.

Materials and Methods

Study Design

This methodological study aimed to develop and evaluate a HBM-PBP for WCA.

Conceptualization

Theoretical Framework and Literature Review

The HBM has been used in health behavior changes research and has been applied to describe, explain, and predict healthy pregnancy preparation behaviors[14] and vaccination during pregnancy.[13,15] Most women believe that they will have a healthy pregnancy, not that they will experience PB.[9] Women become aware of the risk of PB after being diagnosed with a high-risk pregnancy by a physician.[8] PB can be prevented if the risk factors for investigation are recognized and healthcare is provided.[16] Identifying women's health beliefs can reduce PB risk.[11,13] However, a measurement scale to assess the preventive behaviors for PB has not yet been developed. Additionally, it is advisable to confirm the relationships among other HBM components because of their possible interaction.[10] Therefore, we used the HBM as a theoretical framework to develop a four-component measure for assessing behaviors to prevent PB.

We searched PubMed, Embase, Cochrane Library, and CINAHL database on January 5, 2023, and January 6, 2023. We searched combined controlled and text words such as “women”, “pregnancy”, “pregnancy, high-risk”, “premature birth”, “health belief model”, “preconception care”, “health behavior”, “primary prevention”, “secondary prevention”, and “tertiary prevention”. Among the 185 extracted data points, duplicate studies (25), conference abstracts (12), and trial registry records (4) were excluded. A total of 143 articles were reviewed; 41 articles with inappropriate content were removed, and finally, 102 articles were retained.

Qualitative Interviews

One-on-one interviews were conducted with 34 women (mean age: 37.8 years) who had experienced PB or were at risk of PB. The women were married. Twenty-five had one PB, and six had two PBs.

Item Generation and Evaluation of Content Validity

Item Generation

The initial items were developed based on four domains of the HBM: 4 sub-categories with 28 items for perceived susceptibility, 7 sub-categories with 44 items for perceived severity, 4 sub-categories with 36 items for perceived benefits, and 4 sub-categories with 36 items for perceived barriers. Responses to questions were selected using a 5-point Likert scale ranging from 1 (not likely at all) to 5 (very likely).

Expert Content Validity Assessment

Items were modified, deleted, or added during two rounds through a content validity test conducted by experts in terms of relevance and comprehensiveness.[17,18] In the first round, five nursing professors and one nurse, each with an average of 11.2 years of experience in women’s health nursing, participated. Six of the seven experts participated in the content validity assessment in the second round. Three measures were used to assess content validity. First, we utilized the Item Content Validity Index (I-CVI), which gauges the content validity of individual items within a tool, such as a questionnaire or scale. Additionally, we calculated the Average Item Content Validity Index (I-CVI/Ave), representing the mean value of I-CVI across all items. Finally, we determined the Scale Content Validity Index/Universal Agreement (S-CVI/UA), which indicates the level of agreement among experts.

Cognitive Interviewing

The researchers conducted one-on-one cognitive interviews[19,20] with 10 WCA to assess the comprehensibility of the items. The items were modified according to the WCAs’ comments. The average age of the WCAs was 30.7 years, including two in their teens, two in their 20s, three in their 30s, and three in their 40s. Five out of ten had childbirth experience, and one had a PB.

Finally, we reviewed the items and sub-categories and the opinions of experts and the WCA and deleted items through discussion. The final preliminary items were divided into 4 sub-categories with 28 items for perceived susceptibility, 7 sub-categories with 40 items for perceived severity, 4 sub-categories with 34 items for perceived benefits, and 4 sub-categories with 36 items for perceived barriers.

Evaluation of Construct Validity and Reliability

Study Participants

Eligibility criteria for the psychometric evaluation of the measurement scale included WCA residing in Korea, between the ages of 19 and 49, who had intentions of future childbirth or were in the early stages of pregnancy (up to 13 weeks of gestation). The participants agreed to participate using an online consent form prior to enrollment in the study. A sample size of 200–400 individuals was considered appropriate for factor analysis in assessing construct validity.[21] Based on this, a total of 724 data points were collected for both exploratory factor analysis (EFA) and confirmatory factor analysis (CFA).

Data Collection

Thirty WCAs participated in the pilot test to assess the comprehensibility of the preliminary items and the online survey design. No modifications were made to the items based on the survey results. The online survey took approximately 20–30 minutes. The survey consisted of questions related to eligibility criteria, research explanation and consent, the HBM-PBP, preconception of health behavior, Korean self-rated abilities for health practices (K-SRAHP), and general characteristics.

The data for this study were collected using a survey research company to recruit participants nationwide, considering the population distribution. The data were collected in March 2023. A total of 800 responded to the survey. Considering the fidelity of responses, 724 was selected as the final subjects, resulting in a response rate of 90.5%. A total of 724 final subjects were divided into two groups for EFA and CFA using a stratified random sampling method using SPSS according to "PB experience and number of children". As a result, 361 people were selected for EFA and 363 people were set for CFA.

Ethical Considerations

This study was approved by the institutional review board of Daegu Catholic University (approval no: CUIRB-2022-0019-01). All participants voluntarily participated, read the online study explanation, including the right to withdraw and a guarantee of anonymity. All of them signed the consent form before taking part in the study. They received compensation (approximately USD 3.5) after completing the survey.

Data Analysis

The data of this study were analyzed using the IBM SPSS Statistics (Version 19.0) and AMOS (Version 22.0) for Windows (Armonk, NY: IBM Corp). First, the participants' general characteristics were calculated as N (%), and the differences in characteristics between the participants were analyzed using the chi-square test. It was then analyzed according to the following steps:

Construct validity: Cross-validation was performed for construct validity in this study.

Step 1: Principal axis factor analysis, utilizing the common factor extraction method, was employed for each domain in this study. This method, recommended by Heo,[22] is suitable for extracting factors relevant to items by utilizing only common variance for analysis. Promax rotation was applied due to factor correlations. Evaluation of data appropriateness for factor analysis involved the Kaiser (Mayer) Olkin (KMO) test and Bartlett's test of sphericity. Item deletion criteria included commonality less than 0.30, pattern matrix regression coefficient less than 0.40, and simultaneous correlation coefficient greater than 0.50 in several factors in the structure matrix.[23] The items were finally deleted, considering their importance. The number of factors was identified through eigenvalues higher than 1.0 and scree graphs, and factors were extracted such that the total explained variance was 60% or more.[23]

Step 2: CFA was conducted for each domain and then for all domains. After testing the models for each domain using CFA, the models were modified. The modified models for the four domains were combined to test the hypothetical model of HBM-PBP (first-order model); subsequently, the second-order model was tested. In CFA, model fitness was evaluated using the chi square minimum test ($p>0.05$), Normed chi square minimum/degree of freedom (CMIN/DF<3 good, <5 acceptable), goodness of fit index (GFI>0.9), comparative fit index (CFI>0.9), Turker-Lewis Index (TLI>0.9), root mean square error of approximation (RMSEA<0.05 −0.08), and Akaike information criterion (AIC<other model AIC) were evaluated.[24]

Step 3: Convergent validity and discriminant validity of HBM-PBP.

To assess the adequacy of constructs measured by measurement variables in CFA, convergent and discriminant validity were examined, following the guidelines of Yu.[24] Convergent validity was evaluated using two criteria: average variance extracted (AVE) and construct reliability (CR). The results showed that all factors had AVE values exceeding 0.5, CR values surpassing 0.7, and item factor loadings exceeding 0.5, demonstrating a good convergence validity for the CFA model.[24]

Concurrent validity: To verify convergent and discriminant validity, Pearson's correlation test was performed with preconception health behavior (PHB) and the K-SRAHP. Evaluation of correlation coefficients followed Cohen's criteria,[25] categorizing 0.1 to 0.3 as low, 0.3 to 0.5 as medium, and 0.5 or above as high correlation for both convergence and discriminant validity. Hair et al[23] stated that a high correlation should be shown in the case of convergent validity and that a low correlation was appropriate for discriminant validity.

Higher HBM increases health behaviors,[14,24] and HBM-PBP measures health beliefs before and during pregnancy, whereas PHB measures health behavior before pregnancy. The constructs of PHB measure different constructs of HBM-PBP. PBP and preconception health behaviors showed a moderate to low positive correlation.

A scale for PHB was developed by Yeom and Kim,[26] and a validity and reliability test were conducted.[26] The scale consisted of six sub-categories and 27 items. Each item was measured on a 5-point Likert scale, ranging from strongly disagree (1 point) to strongly agree (5 points). The scores were calculated as a total sum, ranging from 27 to 135. Higher scores indicated a higher preconception of health behaviors. Yeom and Kim[26] found the Cronbach's alpha to be 0.92, and it was 0.92 in this study.

According to the HBM, the four domains of the HBM and self-efficacy had no correlation.[10] Therefore, in this study, the correlation between HBM-PBP and K-SRAHP was hypothesized to be low or non-correlated. The constructs of the K-SRAHP measure different constructs of HBM-PBP.

The Self-Rated Abilities for Health Practices (SRAHP) test was developed by Becker et al,[27] translated into Korean, and evaluated for validity and reliability by Lee et al.[28] The scale consisted of four sub-categories and 24 items. Each item was measured on a 5-point Likert scale ranging from strongly disagree (1 point) to strongly agree (5 points). The scores were calculated as the total sum, ranging from 24 to 120 points. Higher scores indicate higher health self-efficacy. Cronbach's α was 0.91 in Lee et al[28] and 0.93 in this study.

Reliability analysis: For the reliability of the scale, Cronbach's alpha coefficient, which indicates internal consistency, was used, and 0.70 or higher of domains was considered appropriate.[29]

Results

Evaluation of Content Validity

In the first round of content validity evaluation, items on susceptibility, severity, benefits, and barriers with an I-CVI below 0.78 were revised. Additionally, of the 49 items on severity, five duplicate items were removed. In the second round, the I-CVI, I-CVI/Ave, and S-CVI/UA values for all 28 susceptibility items were all 1.00. For the 44 severity items, the I-CVI was above 0.83, I-CVI/Ave was 0.99, and S-CVI/UA was 0.96. For the 36 benefits items, the I-CVI, I-CVI/Ave, and S-CVI/UA were > 0.83, 0.96, and 0.94, respectively. For the 36 barrier items, the I-CVI, I-CVI/Ave, and S-CVI/UA were > 0.83, 0.98, and 0.92, respectively. The comprehensiveness of the four domains was evaluated as "sufficient" or "very sufficient" by all experts for each subcategory.

After cognitive interviewing, the domains' comprehensibility averaged 3.94, 3.97, 3.96, and 3.96 for the domains of perceived susceptibility, severity, benefits, and barriers, respectively.

Evaluation of Psychometric Properties

General Characteristics of Participants

In the overall study population, the majority of participants, 404 individuals (55.8%), were in their 30s, 554 participants (76.5%) held a bachelor's degree, 585 (80.8%) were employed, and 462 (63.8%) were unmarried. Additionally, 434 participants (59.9%) reported not enough family income. Regarding the number of children, 588 individuals (81.2%) did not have any children, and 712 (98.3%) were not currently pregnant. Regarding newborn's health status at birth, 101 participants (86.3%) reported their newborns as healthy, and 89 (76.1%) stated they had not received hospital treatment during pregnancy and childbirth. Furthermore, 588 participants (81.2%) had not the PB experience. Among those who perceived the possibility of PB, 341 individuals (47.1%) reported a moderate likelihood, followed by 215 (29.7%) who perceived it as low. Additionally, 372 participants (51.4%) stated they had not received education or information about PB. The general characteristics of all participants in the EFA and CFA are presented in Table 1. There was no statistically significant difference in the distribution of subjects according to all general characteristics of the two subject groups for EFA and CFA in this study ($p>0.05$).

Construct Validity

Step 1: EFA. On item analysis, the item-total correlation coefficients ranged from 0.40 to 0.77, and because there were no items with an absolute value less than 0.30, they were neither added nor deleted. In addition, each inter-item correlation

Table 1 General Characteristics of Participants (N=724)

Categories	Total (n=724)	EFA (n=361)	CFA (n=363)
	n (%)	n (%)	n (%)
Age (year)			
19, 20s	242 (33.4)	120 (33.2)	122 (33.6)
30s	404 (55.8)	202 (56.0)	202 (55.5)
40s	78 (10.8)	39 (10.8)	39 (10.7)
Education			
High school or below	76 (10.5)	43 (11.9)	33 (9.1)
Bachelor's degree	554 (76.5)	276 (76.5)	278 (76.6)
Master's degree or higher	94 (13.0)	42 (11.6)	52 (14.3)
Employment status			
Yes	585 (80.8)	294 (81.4)	291 (80.2)
No	139 (19.2)	67 (18.6)	72 (19.8)
Marital status			
Unmarried	462 (63.8)	232 (64.3)	230 (63.4)
Married	257 (35.5)	125 (34.6)	132 (36.4)
Divorced	5 (0.7)	4 (1.1)	1 (0.3)
Family income			
Very not enough	74 (10.2)	38 (10.5)	36 (9.9)
Not enough	434 (59.9)	215 (59.5)	219 (60.3)
Enough	213 (29.4)	106 (29.4)	107 (29.5)
Very enough	3 (0.4)	2 (0.6)	1 (0.3)
Number of children*			
0	588 (81.2)	293 (81.2)	295 (81.3)
1	95 (13.1)	49 (13.6)	46 (12.7)
2	34 (4.7)	16 (4.4)	18 (5.0)
3 or more	7 (1.0)	3 (0.8)	4 (1.1)
Current pregnancy status			
Yes	12 (1.7)	8 (2.2)	4 (1.1)
No	712 (98.3)	353(97.8)	359 (98.9)
Newborn's health status at birth*			
Healthy	101 (86.3)	55 (90.2)	46 (82.1)
Not healthy	16 (13.7)	6 (9.8)	10 (17.9)
Hospital treatment during pregnancy and childbirth*			
Yes	28 (23.9)	12 (19.7)	16 (13.7)
No	89 (76.1)	49 (80.3)	40 (71.3)
PB experience			
Yes	136 (18.8)	68 (18.8)	68 (18.7)
No	588 (81.2)	293 (81.2)	295 (81.3)
Perceived possibility of PB			
Very low	50 (6.9)	28 (7.8)	22 (6.1)
Low	215 (29.7)	104 (28.8)	111 (30.6)
Moderate	341 (47.1)	166 (46.0)	175 (48.2)
High	105 (14.5)	55 (15.2)	50 (13.8)
Very high	13 (1.8)	8 (2.2)	5 (1.4)
Education or information of PB			
Yes	352 (48.6)	164 (45.4)	188 (51.8)
No	372 (51.4)	197 (54.6)	175 (48.2)

Note: *Missing data were excluded.
Abbreviations: EFA, exploratory factor analysis; CFA, confirmatory factor analysis; PB, premature birth.

was not higher than 0.80.[30] However, three items on perceived susceptibility and five items on perceived severity were deleted due to low commonality, and 130 items were derived.

In the results of EFA (Supplementary Table 1), the KMO values for each domain were 0.84 to 0.93, respectively. In addition, the p-value for the chi-square score of Bartlett's test of sphericity was smaller than 0.05, proving that the correlation matrix between items was not an identity matrix and that the items in this scale were suitable for factor analysis.[22]

First, in the case of perceived susceptibility, the first domain (25 items) was analyzed while sequentially deleting, considering the commonality and factor loading of EFA, except for the three items previously deleted due to low commonality, and the commonality and factor loading were less than 0.40. Four items were thus excluded. In addition, the explained variance by these factors was 62.8%, which satisfied the standard; therefore, the number of factors was set to five.

In the case of perceived severity, in the second domain, 35 items were analyzed while sequentially deleting in consideration of the commonality and factor loading of EFA, except for the five items previously deleted because of low commonality, and the commonality and factor loading were less than 0.40. Four items were thus excluded. In addition, the variance explained by these factors was 72.1%, which satisfied the standard; therefore, the number of factors was set to five. In the case of perceived benefits, the third domain (34 items) was analyzed while sequentially deleting, considering the commonality and factor loading of EFA, except for the five items previously deleted due to low commonality, and the commonality and factor loading were less than 0.40. Thus, seven items were excluded. The explained variance by these factors was 65.9%, which satisfied the standard; therefore, the number of factors was set to five.

In the case of perceived barriers, the fourth domain (36 items) was analyzed while sequentially deleting, considering the commonality and factor loading of EFA, except for the 14 items previously deleted due to low commonality, and the commonality and factor loading were less than 0.40. Among these items, items with a factor loading of 0.40 or less but theoretically of high importance (item perceived barriers 33) were not deleted. In addition, the explained variance by these factors was 64.5%, which satisfied the standard; therefore, the number of factors was set to five.

Step 2: CFA. First, CFA was performed on factors extracted from an EFA for each domain. Model adjustments considered fitness, item estimates, and modification indices. Because certain models did not meet fit criteria, error term correlations were established, specifically correlating errors within sub-factor items based on the modified index (MI). In the case of perceived susceptibility, two error terms in factor "inappropriate coping strategies for the risk for premature birth" and two error terms in factor "health issues of pregnant women" were set as correlations. In the case of perceived severity, 3 error terms in factor "worsening emotional state", one error term in factor "health and developmental issues of the baby", and one error term in factor "difficulties with daily activities" were set as correlations. In the case of perceived benefits, two error terms in factor "benefits of healthy lifestyle management during pregnancy", one error term in factor "benefits of appropriate coping strategies for the risk of premature birth", and two error terms in factor "benefits of risk trigger management for pregnancy" were set; in the case of perceived barriers, three error terms in challenges in factor "implementing appropriate coping strategies for the risk of premature birth" were set as correlations.

Next, a first-order CFA, consisting of 20 factors in four domains, was implemented as a hypothetical model of the HBM-PMP. The model fit was $\chi 2=7410.29$ ($p<0.05$), CMIN/DF 1.68, CFI 0.86, TLI 0.86, RMSEA 0.04. The CMIN/DF and RMSEA were acceptable, but χ 2, CFI, and TLI were not acceptable The standard factor loading was over 0.40, the Critical ratio (C.R.) was significant, and the degree of squared multiple correlations (SMC) was appropriate.

Finally, endogenous variables were created for each domain, and a second-order CFA was performed using a model consisting of four domains and 20 factors (Figure 1). In the second-order CFA for all instruments, the model fit was χ 2=7265.11 ($p<0.05$), CMIN/DF 2.12, CFI 0.91, TLI 0.90, and RMSEA 0.04. The model fit is presented in Table 2. The CMIN/DF, CFI, TLI, and RMSEA were acceptable, except for the χ 2 statistics. The Akaike information criterion (AIC) of the second-order model was lower than that of the first-order model. The standard factor loading was over 0.40, the C. R. was significant, and the degree of SMC was appropriate.

Step 3: Convergent and discriminant validity. First, as a result of evaluating the convergent validity of the items to see if the items measuring latent variables were measured consistently well, the standard factor loading was 0.40–0.95, satisfying the threshold of 0.40.[30] The significant C.R. values ranged from 6.22–23.72, exceeding the standard of 1.97. AVE ranged from 0.89–0.98, satisfying the threshold of 0.50, and the construct reliability was 0.97–0.99, exceeding.70, thus confirming convergent validity (Supplementary Table 2). Second, as a result of evaluating discriminant validity to

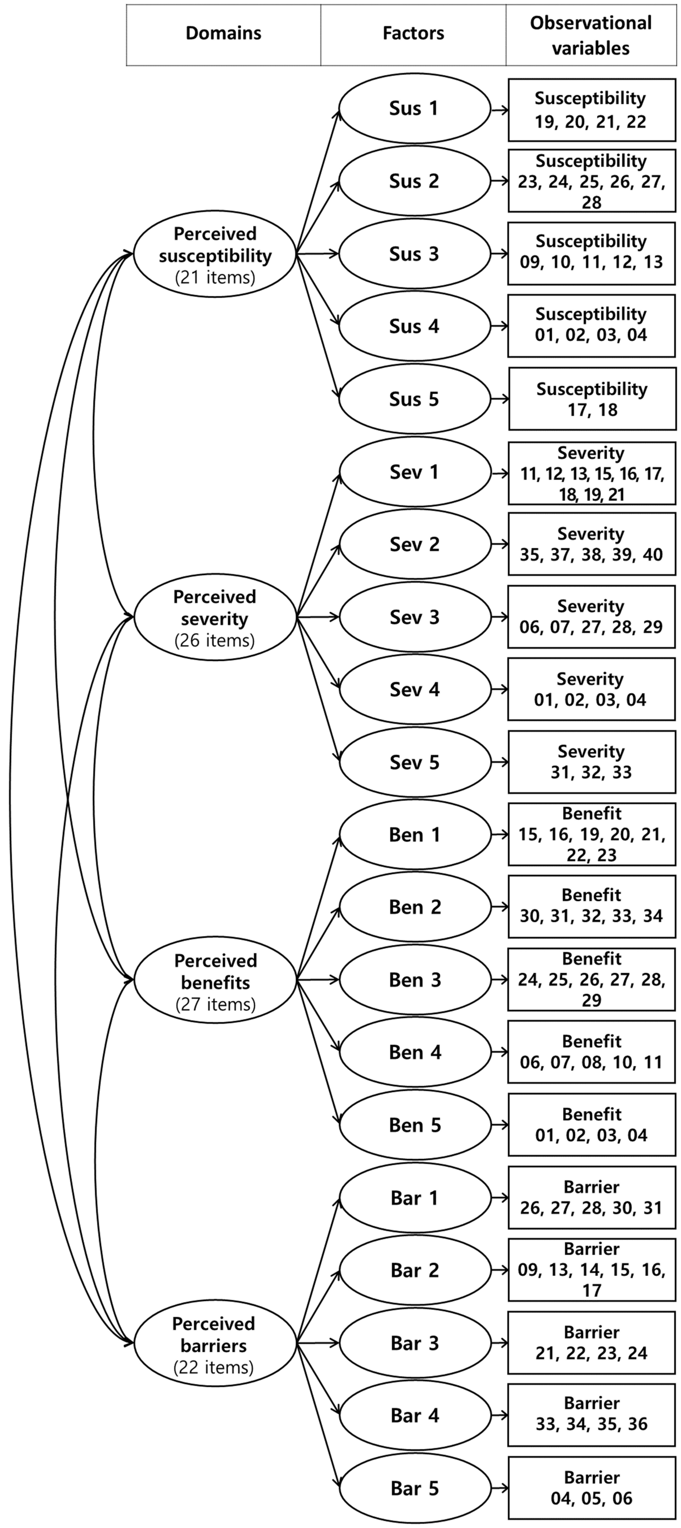

Figure 1 Second-order confirmation factor model of the HBM-PBP including standardized estimations.

Notes: Sus 1, inadequate access to prenatal care; Sus 2, inappropriate coping strategies for the risk for premature birth; Sus 3, health issues of pregnant women; Sus 4, inadequate health lifestyle management of pregnant women; Sus 5, psychological health issues of pregnant women; Sev 1, worsening emotional state; Sev 2, health and developmental issues of the baby; Sev 3, difficulties with daily activities; Sev 4, physical unwellness; Sev 5, physical illness; Ben 1, benefits of healthy lifestyle management during pregnancy; Ben 2, benefits of appropriate coping strategies for the risk of premature birth; Ben 3, benefits of clinical management during pregnancy; Ben 4, benefits of risk trigger management for pregnancy; Ben 5, benefits of a planned pregnancy; Bar 1, challenges in implementing appropriate coping strategies for the risk of premature birth; Bar 2, difficulties in healthy life management during pregnancy; Bar 3, challenges in clinical management during pregnancy; Bar 4, challenges in implementing self-management for the risk of premature birth; Bar 5, difficulty in receiving frequent clinical (medical) management for pregnancy.

Table 2 Fit Indices of the First- and Second-Order Confirmatory Factor Models of the HBM-PBP (N=363)

Domains	Models	χ^2	df	p	CMIN/DF	CFI	TLI	RMSEA (LO, HI)	AIC
Perceived susceptibility	Hypothetical	575.47	179	<0.001	3.22	0.88	0.86	0.08 (0.04, 0.06)	721.47
	First-order	346.18	175	<0.001	1.98	0.95	0.94	0.05 (0.04, 0.06)	500.18
	Second-order	353.09	180	<0.001	1.96	0.95	0.94	0.05 (0.04, 0.06)	497.09
Perceived severity	Hypothetical	575.47	179	<0.001	3.22	0.88	0.86	0.08 (0.04, 0.06)	721.47
	First-order	699.01	283	<0.001	2.40	0.94	0.93	0.06 (0.06, 0.07)	867.10
	Second-order	709.20	288	<0.001	2.46	0.94	0.93	0.06 (0.06, 0.07)	887.20
Perceived benefits	Hypothetical	904.88	314	<0.001	2.88	0.90	0.89	0.07 (0.07, 0.08)	1086.88
	First-order	728.11	309	<0.001	2.34	0.93	0.92	0.06 (0.06, 0.07)	920.11
	Second-order	817.38	314	<0.001	2.60	0.92	0.91	0.07 (0.06, 0.07)	999.38
Perceived barriers	Hypothetical	464.83	199	<0.001	2.34	0.93	0.91	0.06 (0.05, 0.07)	616.83
	First-order	417.02	196	<0.001	2.12	0.94	0.93	0.06 (0.05, 0.06)	575.02
	Second-order	488.59	201	<0.001	2.43	0.92	0.91	0.06 (0.06, 0.07)	636.59
Total domains	Hypothetical (First-order)	7410.29	4420	<0.001	1.68	0.86	0.86	0.04 (0.04, 0.04)	8074.29
	Second-order	7265.11	4416	<0.001	1.65	0.91	0.90	0.04 (0.04, 0.04)	7937.11

Notes: Fit indices: CFI, TLI (>0.9), RMSEA (<0.08), CMIN/DF (<3 good, <5 acceptable).
Abbreviations: df, degree-of-freedom; CMIN/DF, chi-square/degree-of-freedom ratio; CFI, comparative fit index; TLI, Tucker-Lewis Index; RMSEA, root mean square error of approximation, AIC: Akaike information criterion.

determine if low correlation and independence were maintained between sub-factors, the range of the squared value of the correlation coefficient between latent variables was 0.41–0.75, smaller than the AVE value range of 0.89–0.98 (Supplementary Table 2); thus, discriminant validity was verified.[24]

Concurrent Validity: Convergent and Discriminant Validity

Convergent validity. The correlation between the HBM-PBP and PHB was 0.40. The correlations between the four domains of the HBM-PBP and PHB were 0.29, 0.18, 0.16, and 0.47 (Table 3). All correlations between the HBM-PBP domains and the PHB sub-factors were low (< 0.50). Therefore, the convergent validity hypothesis was supported.
Discriminant validity. The correlation between the HBM-PBP and the K-SRAHP was 0.27. The correlation between the K-SRAHP and perceived susceptibility was 0.17, with perceived benefits of 0.24, perceived barriers of 0.29, and perceived severity not significant. In addition, the correlations between the domains of the HBM-PBP and the sub-factors of the K-SRAHP were all less than 0.30 or were not significant (Table 3). Therefore, the discriminant validity hypothesis was supported.

Reliability

The internal consistency Cronbach's alpha coefficient of the scale's 96 items was 0.96, and the Cronbach's α value of reliability by domain was 0.87, 0.94, 0.94, 0.92–0.94, respectively (Table 4).

Table 3 Correlation Among Variables (N=361)

Variables	HBM-PBP	Susceptibility	Severity	Benefits	Barriers	PHB	K-SRAHP
HBM-PBP	1						
Susceptibility	0.69**	1					
Severity	0.39**	0.27**	1				
Benefits	0.83**	0.31**	0.17**	1			
Barriers	0.76**	0.38**	0.17**	0.47**	1		
PHB	0.40**	0.29**	0.18**	0.23**	0.47**	1	
K-SRAHP	0.27**	0.17**	−0.10	0.24**	0.29**	0.46**	1

Notes: *p < 0.05; **p < 0.01.
Abbreviations: Susceptibility, perceived susceptibility; Severity, perceived severity; Benefits, perceived benefits; Barriers, perceived barriers; PHB, preconception health behavior; K-SRAHP, Korean self-rated abilities for health practices.

Table 4 Reliability of the HBM-PBP (N=361)

Domains	Factors (Items)	Numbers of Items	Cronbach's α
Perceived susceptibility	Sus 1 (susceptibility 19, 20, 21, 22)	4	0.92
	Sus 2 (susceptibility 23, 24, 25, 26, 27, 28)	6	0.85
	Sus 3 (susceptibility 09, 10, 11, 12, 13)	5	0.77
	Sus 4 (susceptibility 01, 02, 03, 04)	4	0.70
	Sus 5 (susceptibility 17, 18)	2	0.63
	Sus Total	21	0.87
Perceived severity	Sev 1 (severity 11, 12, 13, 15, 16, 17, 18, 19, 21)	9	0.95
	Sev 2 (severity 35, 37, 38, 39, 40)	5	0.90
	Sev 3 (severity 06, 07, 27, 28, 29)	5	0.83
	Sev 4 (severity 01, 02, 03, 04)	4	0.86
	Sev 5 (severity 31, 32, 33)	3	0.89
	Sev Total	26	0.94
Perceived benefits	Ben 1 (benefit 15, 16, 19, 20, 21, 22, 23)	7	0.88
	Ben 2 (benefit 30, 31, 32, 33, 34)	5	0.91
	Ben 3 (benefit 24, 25, 26, 27, 28, 29)	6	0.88
	Ben 4 (benefit 06, 07, 08, 10, 11)	5	0.88
	Ben 5 (benefit 01, 02, 03, 04)	4	0.80
	Ben Total	27	0.94
Perceived barriers	Bar 1 (barrier 26, 27, 28, 30, 31)	5	0.88
	Bar 2 (barrier 09, 13, 14, 15, 16, 17)	6	0.80
	Bar 3 (barrier 21, 22, 23, 24)	4	0.86
	Bar 4 (barrier 33, 34, 35, 36)	4	0.81
	Bar 5 (barrier 04, 05, 06)	3	0.74
	Bar Total	22	0.92
Total domains		96	0.96

Notes: Sus 1, inadequate access to prenatal care; Sus 2, inappropriate coping strategies for the risk for premature birth; Sus 3, health issues of pregnant women; Sus 4, inadequate health lifestyle management of pregnant women; Sus 5, psychological health issues of pregnant women; Sev 1, worsening emotional state; Sev 2, health and developmental issues of the baby; Sev 3, difficulties with daily activities; Sev 4, physical unwellness; Sev 5, physical illness; Ben 1, benefits of healthy lifestyle management during pregnancy; Ben 2, benefits of appropriate coping strategies for the risk of premature birth; Ben 3, benefits of clinical management during pregnancy; Ben 4, benefits of risk trigger management for pregnancy; Ben 5, benefits of a planned pregnancy; Bar 1, challenges in implementing appropriate coping strategies for the risk of premature birth; Bar 2, difficulties in healthy life management during pregnancy; Bar 3, challenges in clinical management during pregnancy; Bar 4, challenges in implementing self-management for the risk of premature birth; Bar 5, difficulty in receiving frequent clinical (medical) management for pregnancy.

Final HBM-PBP Scale

The final scale consisted of a second-order 4-domain and, a 20-factor scale with 96 items (Supplementary Table 1).

Discussion

This study developed a measurement scale based on the HBM, which has been utilized to research health behavior changes. The HBM has been utilized to research health behavior changes, particularly in behaviors like healthy pregnancy preparation.[11,13] Specifically, the relevance of the measurement scale has been reported in relation to WCAs' reproductive health behaviors,[31] contraceptive use,[32] healthy dietary practices during pregnancy,[33] alcohol consumption,[34] and vaccine administration.[13] To comprehensively assess health beliefs regarding PB prevention,[10] this study developed a scale that measures perceived susceptibility, severity, benefits, and barriers. The content validity, construct validity, and reliability of the scale were evaluated for each of the four domains and were found to be acceptable Therefore, the scale of each domain could be used independently.

To validate the HBM-PBP construct, we conducted EFA and CFA to assess the convergent, discriminant, and criterion validities of the items. The EFA revealed that the HBM-PBP comprised four sub-factors: perceived susceptibility, perceived severity, perceived benefits, and perceived barriers. Despite aiming for items with a factor loading value of 0.40 or higher,[35] one item under perceived barriers scored below this threshold. However, it was deemed significant as early detection of premature labor symptoms is critical to prevent PB and reduce negative outcomes.[36,37] Thus, the item was retained.

Given the multifaceted nature of our scale, interpreting the CFA results necessitates a thorough understanding of various fit indices[38,39] and theoretical foundations, involving a blend of fit indices, quantitative indicators, and qualitative reviews. The initial CFA results demonstrated adequate standardized factor loading values for CR and SMC; however, CMIN/DF, CFI, and TLI did not meet the fit criteria. To rectify this issue, we developed a revised model to validate the overall suitability of this scale. The second-order CFA further verified that each domain scale met the recommended fit indices, and the AIC for this model was lower than that of the first-order CFA, thus proving the second-order model fit and validity within the recommended range. The resulting HBM-PBP scale, having achieved validity in each domain and the overall scale, can now be used independently for PB prevention.

To test convergent validity, we used the PHB scale, focusing on health behavior, a key concept in the HBM. As there is no appropriate scale for assessing health behaviors for PB prevention in the Korean population, we used this scale. The correlation between the HBM-PBP overall scale, its domains, and preconceptions of health behavior was less than 0.50. Despite differing from the general criterion for convergent validity (typically above 0.50), it is considered valid given the clinical specificity of our study.[40] The HBM-PBP, designed to examine health beliefs about PB during the preconception and pregnancy phases, demonstrated a moderate or lower correlation with the scale used for convergent validity, specifically limited to the preconception phase, confirming the convergent validity hypothesis of this study.

We used the K-SRAHP, a self-efficacy measure in health management, to evaluate discriminant validity. Unlike convergent validity, discriminant validity means that there should be a low correlation with the scores of the comparison scale.[35,40] The correlations between the HBM-PBP domains and the K-SRAHP sub-factors were all ≤ 0.29 or non-existent, confirming discriminant validity.

Our study confirms the suitability of the scale for measuring health beliefs related to PB and endorses its broad use, either as a whole or in individual domains in the public health community. Existing HBM scales, mostly designed for general adults[41,42] rarely focus on PB, making this study's findings particularly relevant. This suggests potential applications in both research and clinical practice, ultimately improving pregnancy and childbirth health in WCA.

This study significantly contributes to the development of the HBM-PBP, which includes all four domains of health beliefs, and verifies its validity and reliability. The novelty lies in the ability to use each domain individually, given its tested reliability. Existing HBM scales, mostly designed for specific target populations[11,14,23] rarely focus on premature births, making this study's findings particularly relevant. Our study confirms the suitability of the scale for measuring health beliefs related to premature birth among WCA and endorses its broad use, either as a whole or in individual domains. This allowed us to assess the health beliefs regarding WCA planning for pregnancy, which could guide the design of educational programs and interventions. This suggests potential applications in both research and clinical practice, ultimately improving pregnancy and childbirth health in WCA. The data for this study were gathered nation-wide in Korea via an online survey, ensuring a diverse range of participants, which further strengthened the findings and implications.

Although impactful, this study had limitations. First, the convergent validity of the developed HBM-PBP was not adequately validated due to the absence of a dedicated scale for PB prevention health behavior. Future studies are needed to validate these findings. Second, the self-report scale used did not ensure that the reported health beliefs coincided with actual health behaviors, and the effect of health beliefs on actual health behaviors remains to be determined in future studies. Third, prudence is warranted in the utilization, particularly for individuals grappling with heightened stress or anxiety pertaining to pregnancy. This is pivotal, as there exists the potential for an inadvertent exacerbation of stress or anxiety. Fourth, while the HBM-PBP affords the advantage of delineating comprehensive health beliefs, the response time to inquiries may be compromised by the complex interplay among its four domains. Despite potential time reduction, the abundance of questions may extend the overall application period. In forthcoming research efforts, we advocate for the perpetuation of feasibility studies concentrating on pivotal queries within each domain. Fifth, Given the small number of women in the early stages of pregnancy among the study participants, it is difficult to adequately represent this group, which may lead to a bias towards specific groups (eg, women with intentions of future childbirth rather than those who are pregnant). Additionally, it is unclear how urgent the intentions of future childbirth are among WCA or how quickly they are planning to conceive. As a result, there may be uncertainty about how closely the study findings relate to the current desires or plans for pregnancy among these women. Since this study did not evaluate the optimal timing for assessing the HBM-PBP among WCA, future research should determine the best timing for applying this tool. Finally, our online participant recruitment may have biased the sample towards those proficient in online information usage. Future research should aim for a more diversified participant pool to understand information disparity's influence health beliefs about PBs.

This study developed and validated a comprehensive scale based on the HBM. It uniquely investigated all four domains of health beliefs to prevent PBs in WCA. This scale fills an important gap in the existing measurement scales and has significant implications for both research and clinical practice. The developed HBM-PBP aids in understanding the health beliefs related to PBs. Each domain can be applied individually, paving the way for tailored educational and intervention strategies for prospective mothers. Broadly, this study contributes to the enhancement of health outcomes during pregnancy and childbirth in women.

Abbreviations

HBM-PBP, Health Belief Model scale for Premature Birth Prevention; PB, premature birth; WCA, women of child-bearing age; SRAHP, Self-Rated Abilities for Health Practices; K-SRAHP, Korean Self-Rated Abilities for Health Practices; PHB, Preconception Health Behavior.

Data Sharing Statement

The datasets used/or analyzed during the current study is available from the corresponding author on reasonable request.

Ethics Approval and Consent to Participate

Ethical approval was granted by the institutional review board of Daegu Catholic University (approval no: CUIRB-2022-0019-01) on June 13, 2022. And adhered to the Declaration of Helsinki's ethical standards for human medical research. All participants were provided with written information about the study, outlining their right to withdraw and ensuring anonymity. Each participant signed the consent form before taking part in the study. Participation was entirely optional, and potential participants were given access to online information about the study, including its purposes, importance, and methodology. To indicate their agreement to participate, they clicked a consent button, after which they were granted access to the survey. This process ensured that participants willingly agreed to partake in the study before beginning the survey. The IRB approved a waiver for physical consent forms, recognizing the challenges of obtaining such forms in online surveys. The researcher made the study details available online. After reviewing these details, participants could express their consent by clicking a button labeled "I agree to participate in the study", effectively signing the digital consent form.

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.

Funding

This research was supported by the Basic Science Research Program through the National Research Foundation of Korea (NRF), funded by the Ministry of Education (grant number: 2021R1I1A3047489). The funder had no role in the study design, collection, analysis, interpretation of data, or writing of this report.

Disclosure

The authors report no conflicts of interest in this work.

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