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Development and Psychometric Properties of Pregnancy-Specific Climate Change Awareness Scale

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ABSTRACT

Objective: Climate change is a global health problem and threatens our society from all aspects. Pregnant women, fetuses, and newborns are considered vulnerable groups in the context of climate change. Steps to increase awareness about the consequences of climate change on maternal and child health and future generations are important for adaptation strategies.

Aim: This study aims to develop a measurement tool that assesses pregnancy-specific awareness of the effects of climate change on maternal–fetal health.

Method: This study used a cross-sectional and methodological design. Data were collected through face-to-face interviews with pregnant women who agreed to participate in the study between May and July 2022. Thirty-six items were rated on a 5-point Likert scale (from entirely disagree to entirely agree) and applied to 500 voluntary pregnant. SPSS Statistics 22 and Mplus 7 programs were used for data analysis.

Results: As a result of EFA, a 21-item, 3-factor final scale was obtained from the 36-item draft version scale. Result of CFA, the fit index values were found as RMSEA = 0.074, NFI = 0.978, and CFI = 0.975. The fit indices of the awareness scale model were significant ($x^2 = 428.438$, sd = 181, $p = 0.0000$, x^2/sd = 2.367). The total internal consistency Cronbach's α coefficient of the 21-item final scale is 0.946.

Conclusion: In line with these data, Pregnancy-Specific Climate Change Awareness Scale is a valid and reliable measurement tool that can be used to evaluate the pregnancy-specific climate change awareness level. Studies testing the applicability of the scale in the population of midwives and obstetricians working with pregnant women are recommended.

1 | Introduction

Climate change, mostly caused by human activities, affects human health directly or indirectly through several mechanisms including temperature, poor air quality, extreme weathers, water and food insecurity, and vector-borne diseases by affecting ecosystems and the functioning of species (Kim 2016; Pörtner et al. 2022). These critical changes in environmental conditions could negatively affect people's physical, mental, and social health (UN 2023; Romanello et al. 2023; WHO 2023a). The increase in exposure causes forced population movements, deepens inequalities, and weakens people's livelihoods and mental health (Kelman et al. 2021; Pörtner et al. 2022).

These effects on individuals are not homogenous, and some social groups are affected more than others (Riverra-Ferra 2022).

Vulnerable groups in the context of inequalities, such as the elderly, children, people with disabilities, women, pregnant women, and newborns require attention in the design, implementation, and evaluation of climate change adaptation strategies (UN Women 2020). Interventions that do not take these populations into account are reported to be inadequate or, even worse, may increase the vulnerability of those they are trying to help (Ireland and McKinnon 2013; Shackleton et al. 2015). Hence, available data suggest that compared to the male population, the impacts of climate change are significantly higher, particularly on women and children (UN Women 2020; Süğüt et al. 2022). In this respect, the changing climate seems to have dramatic impacts on women's health and maternal and child health because poor maternal health could cause significant problems for women's health and pose a serious risk to meeting childcare needs.

Increasing research findings in the literature reveal that climate change affects health in numerous physical, mental, and social dimensions, both directly and indirectly. These impacts include a wide range of injuries and deaths, respiratory and cardiovascular diseases, vector-borne illnesses, malnutrition, non-communicable diseases, and mental health disorders (WHO 2023a).

Evidence is steadily growing that climate change adversely affects the pregnancy process and contributes to poor pregnancy outcomes, particularly among pregnant individuals, a more vulnerable population group. Climate-related adverse pregnancy outcomes may have lasting implications for the health of newborns and future generations. Pregnant people possess unique physiological characteristics that render them particularly sensitive to certain environmental exposures. Specifically, typical physiological changes during pregnancy—such as a 20% increase in oxygen consumption, a 40%–50% rise in respiratory rate, and a 40% elevation in cardiac output—make them especially vulnerable to air pollution and heat stress. Maternal health consequences linked to climate change include dehydration, kidney disorders, malnutrition, anemia, infections, diarrhea, respiratory illnesses, hypertension, preeclampsia/eclampsia, and vector-borne diseases (Veras and Saldiva 2024; Rocque et al. 2021; Romanello et al. 2023). The physiological changes that occur during pregnancy can impair the capacity to cope with environmental stressors induced by climate change. Consequently, pregnant individuals are more susceptible to both the direct and indirect effects of climate change. This heightened vulnerability increases the risk of complications such as spontaneous abortion, intrauterine growth restriction, low birth weight, preterm birth, congenital malformations, and elevated fetal mortality (Veras and Saldiva 2024).

The increasing evidence of the effects of climate change on maternal and fetal health has led international professional organizations such as the International Federation of Gynecology and Obstetrics (FIGO), American College of Obstetricians and Gynecologists (ACOG), and International Confederation of Midwives (ICM) to encourage their members to be more sensitive to climate change and to develop adaptation policies (Giudice et al. 2021; ACOG 2021; ICM 2024).

An important step in adaptation includes approaches that raise awareness about the consequences of climate change on maternal and child health and future generations. There is a need to improve public knowledge to access high-quality data on the impact of climate change on maternal, fetal, and newborn health and to understand the global burden and the nature of this burden (UNFCCC 2017; Romanello et al. 2023). WHO states that increasing awareness and thus understanding the effects of climate change on health facilitate both behavioral change and public support for actions needed to reduce greenhouse gas emissions (WHO 2023a). In addition, women could be protected from the harmful effects of climate change by talking to them about the health risks of climate change by giving advice on how to minimize these risks during pregnancy and the prenatal period and educating health professionals and the community about the effects of climate change on the health of pregnant women and their babies (WHO 2023b).

Pregnancy is a period when women are most open to changing their health behaviors by moving away from negative behaviors, such as smoking and unhealthy diets, and toward positive behaviors. Similarly, those around pregnant women also tend to engage in various positive behaviors for both the mother and the fetus. In this regard, using the pregnancy period to raise awareness about climate change and accelerate adaptation can create a social advantage. Each individual or community varies in terms of level of awareness, knowledge, and needs. Therefore, policies to be developed by identifying the condition of the relevant group are believed to be much more effective than developing standardized policies for adaptation. In addition, the pregnancy process is long-lasting nature, so the potential is high in terms of sustaining the positive behaviors acquired (Rylander et al. 2013; Kısrık et al. 2022; Usta, 2023). Thus, the increased awareness will help protect maternal–fetal health in the short-term, and neonatal health, public health, and family health in the long-term. The international and national literature includes no valid and reliable measurement tools that assess awareness about the maternal–fetal effects of climate change. In line with these assessments, assumptions, and requirements, the present study aims to develop a measurement tool that assesses pregnancy-specific awareness of the effects of climate change on maternal–fetal health.

2 | Materials and Methods

2.1 | Study Design and Participants

This study used a cross-sectional and methodological design. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) checklist was used in the reporting of this study. The study data were collected from volunteer pregnant women who sought treatment in the Pregnancy Outpatient Clinics of Adana City Training and Research Hospital between May and July 2022 by meeting them face-to-face ($n = 500$).

2.2 | Ethical Considerations

Ethical approval for the study was obtained from the Cukurova University Medical Faculty Non-invasive Clinical Research Ethics Committee (Approval number:01.10.2021-115/45). The Declaration of Helsinki was complied with at all stages of the study. Before applying the questionnaires, all participants were informed about the purpose of the study, and written informed consent was signed for participation and dissemination of the results.

2.3 | Instruments

Data were collected through the sociodemographic characteristics form originally prepared by the researchers; the semi-structured qualitative interview form for the tool development process; and the Pregnancy-Specific Climate Change Awareness Scale (PSCCAS) draft form which was finalized for validity and reliability.

2.3.1 | Sociodemographic Characteristics Form

The form consists of two sections and 37 questions including the participants' demographic characteristics and knowledge about climate change. The 19 items in the demographic characteristics section include personal data such as age, education level, place of residence, employment status, and obstetric history. The second section includes 18 items about the participants' knowledge, attitudes, and behaviors on climate change.

2.4 | Tool Development Process and Procedures

2.4.1 | Development of Items

A deductive approach was used to generate potential items for the scale. Upon determining the research focus, a comprehensive review of relevant literature was conducted to examine existing studies and awareness scales related to climate change. A review was performed in PubMed, CINAHL, Science Direct, Wiley databases, Lancet Countdown reports, and the web pages of international professional health associations in the field of obstetrics and gynecology. The words used for search in the databases included "climate change", "maternal effect", "fetal effect", and "climate change" and "pregnancy". Given the absence of a psychometric instrument specifically addressing the awareness of pregnant women regarding the impacts of climate change on pregnancy, it was deemed necessary to develop a context-specific measurement tool. In addition to the literature information, individual interviews were conducted with 10 women using a semi-structured interview form consisting of six main questions (Table 1). The interview protocol included six open-ended questions designed to elicit participants' perceptions, emotional responses, and behavioral tendencies regarding climate change and its potential effects during pregnancy. The interviews were audio-recorded and transcribed by the researcher D.K. Then, the researchers D.K. and B.A.V. manually performed thematic analysis together by reading and rereading the data obtained. The participants' views demonstrated that the data are believable and trustworthy from the literature. The qualitative data obtained from the interviews informed the refinement of the initial item pool by revealing key themes and insights aligned with the construct of awareness. This process contributed to enhancing the content validity of the scale and grounding it in the lived experiences of the population under study. Following the literature and the findings obtained from qualitative interviews, the draft items to be included in the scale and the three main factors were determined. Initially, a draft item pool of 23 items was created. The items were rated on a 5-point Likert scale as "strongly agree, agree, neither agree nor disagree, disagree, strongly disagree".

TABLE 1 | Semi-structured interview form questions.

- Have you ever heard the term climate change? Can you tell us what you know about it?
- What do you think about the effects of climate change on human health?
- Does climate change affect all populations (female, male, child, geriatric…) at the same level?
- Does climate change have effects on pregnancy?
- Do you think climate change affects the health of the mother and the baby?
- Can you tell us about your feelings about climate change today or in the future?

2.4.2 | Analysis of the Item Content Validity

The draft items were presented to a total of 12 academic experts from the fields of Midwifery ($n = 4$), Women's Health and Diseases Nursing ($n = 4$), Pediatric Health and Diseases Nursing ($n = 1$), Biology Education (measurement and evaluation specialist) ($n = 2$), and Environmental Science ($n = 1$). The experts were asked to rank the comprehensibility of each item on a scale from 1 to 4, with 4 points indicating "completely appropriate", 3 points "quite appropriate", 2 points "somewhat appropriate" and 1 point "not appropriate". After expert opinions and suggestions were received, necessary corrections, additions, and deletions were made by the researchers. The Item Content Validity Index (I-CVI) was calculated, and with a ≥0.80, it was considered to have sufficient content validity. Items with a corrected item-scale correlation coefficient <0.3 were examined and removed from the item pool. After the revisions were made, the initial number of 23 items increased to 36. The form was reevaluated by five field experts, one measurement and evaluation expert, and one Turkish language expert (Polit and Beck 2008). A draft version scale form consisting of 36 items was given its final form for validity and reliability.

2.4.3 | Pilot Study With the Draft Version Scale

The 36-item final draft version of the scale was piloted face-to-face with 20 volunteer pregnant women. These participants, who represented the target population, were asked to carefully read the 36 items in the draft version and evaluate their meaning. In addition, the time to fill out the form was monitored to get an idea of how long on average it would take to complete the scale. Pregnant women included in the pilot study were not included in the study.

2.5 | Sample Size and Settings

Data were collected through face-to-face interviews with pregnant women who agreed to participate in the study at Antenatal Class and Obstetrics Outpatient Clinics of Adana City Training and Research Hospital between May and July 2022. The literature recommends reaching 10 times as many people as the number of items in the scale for the determination of the sample size in validity-reliability studies (DeVellis and Thorpe 2021). Since the draft version of the scale consisted of 36 items, the number targeted to be reached was determined as a minimum of 360 pregnant women. Scale development studies recommend a data set of at least 200 people for Exploratory Factor Analysis (EFA) and confirmatory factor analysis (CFA) each. Considering the possible losses in the data, it was targeted to reach 500 people, and the targeted sample size was reached ($n = 500$). Inclusion criteria were being over 18 years of age, being pregnant, and not having received training on climate change before. Pregnant women who had cognitive impairment, who had maternal-fetal risks, and who could not establish written or verbal communication in Turkish were not included in the study.

2.6 | Data Analysis

SPSS Statistics 22 and Mplus 7 programs were used for data analysis. Data on descriptive characteristics and knowledge of climate change are presented as frequencies and percentages. Normality distribution was evaluated by the Shapiro–Wilks test. Of the data obtained from the 500 participants, 250 were used for EFA and 250 for CFA. In the scale validity and reliability analyses, firstly, the Kaiser–Meyer–Olkin (KMO) test was utilized to determine whether the data were appropriate for conducting EFA. Bartlett's test of sphericity was used to determine whether the variables were sufficiently correlated to proceed with factor analysis. Principal Component Analysis (PCA) was used for factorization and Promax rotation, one of the oblique rotation techniques. Scree plots and eigenvalue coefficients were used to determine the factors. Eigenvalues indicate the variance explained by each factor, making them useful for determining the number of factors to extract. A scree plot visualizes eigenvalues for all factors, with the optimal number identified at the point where they drop sharply. In this study scree plots and eigenvalue coefficients were used to determine the appropriate number of factors. Following factor extraction, a rotation procedure was employed to enhance the interpretability of the solution. In EFA, when multiple factors (two or more) are identified, axes to a rotation process rotation are essential to achieve independence, clarity in prediction, and meaningfulness. This involves subjecting the axes to a rotation process. Whereby the loading of items on one factor increases while decreasing on others (Brown 2006). Through this process, researchers gain a clearer understanding of the underlying structure. There are two main types of rotation: orthogonal and oblique. Orthogonal rotation is preferred when factors are assumed to be uncorrelated, whereas oblique rotation is used when factors are expected to be related (Cokluk et al. 2010). In this study, oblique rotation was chosen, as the five factors identified through factorization were considered interrelated, with all factors associated with pregnant women and their awareness of climate change. Under the oblique rotation methods, the Promax technique was preferred due to its speed and efficiency. Since a kappa value of 4 is considered optimal for the Promax rotation method (Tabachnick and Fidell 2001), this study also used a kappa value 4. The rotated component matrix for the dataset, analyzed using PCA and the Promax rotation method, is presented in Table 4 and displays the factor loadings for each item. Factor loadings represent the coefficients that describe the relationship between items and factors, with higher loadings indicating stronger associations within a given factor. Items with factor loads of 0.30 or greater (accounting for 9% of the variance) are considered significant. Regardless of sign, factor loadings between 0.30 and 0.59 are interpreted as moderate, while those of 0.60 and above are considered high (Buyukozturk 2002).

For factorization, factor loadings of the items were analyzed, items were reduced, and similar items were grouped under common factors. After factor labeling, correlation coefficients were used to assess whether there was a multicollinearity problem between the factors of the scale. Analyses included whether the model that emerged in line with the results of the EFA was confirmed or not according to the CFA fit indices. Inter-factor correlations help assess how different dimensions (factors) relate to each other after rotation in a factor analysis. Significant relationships are indicated by p values less than 0.05. A correlation matrix was used to examine these patterns. Low correlations ($r < \pm 0.30$) suggest that a factor does not meaningfully contribute to explaining the scale. Moderate correlations ($r > 0.30$) can support factor relevance. Very high correlations ($r > 0.90$) point to multicollinearity, meaning overlapping content between factors (Field 2009). Such variables should be excluded to avoid distortion. When examining the awareness scale (General, Fetal, Maternal), the inter-factor correlations were checked to ensure statistical distinctiveness. A threshold of $r < 0.90$ was recommended to avoid multicollinearity. In selecting an appropriate estimation method, the distributional characteristics and categorical nature of the data were considered. The Chi-square (χ^2) test was used for goodness of fit. Convergent validity was examined for all items within our model to demonstrate statistically significant factor loadings. Additionally, it can be assessed through the computation of the average variance extracted (AVE) for each construct. Discriminant validity refers to the degree to which a construct is truly distinct from other constructions within a measurement model. In the context of CFA, establishing discriminant validity ensures that the latent variables (factors) are conceptually and empirically separate from one another, meaning that they measure different underlying constructs. Discriminant validity was examined by inspecting the correlation coefficients between latent constructs. Finally, reliability analyses, internal consistency coefficients, and split-half reliability coefficients were calculated. Statistical significance value was taken $p < 0.05$.

3 | Results

The average age of the participants was 27.68 ± 5.17 and the median value was 27 (min—max = 18–43). The participants' gestational weeks ranged between 8 and 42, with a mean gestational week of 32.92 ± 7.74 and a median of 35.50 (Table 2).

Table 3 presents the findings regarding the participants' knowledge, attitudes, and opinions regarding climate change. When the

TABLE 2 | Demographic characteristics of participants.

Characteristics	n (500)	%
Age (mean/median) 27.68 ± 5.17/27		
27 and ↓	258	51.6
28 and ↑	242	48.4
Employment status		
Employed	106	21.2
Unemployed	394	78.8
Education level		
Illiterate	26	5.2
Literate	14	2.8
Primary school	73	14.6
Secondary school	121	24.2
High school	131	26.6
University and above	135	27.0
Place of living		
Rural	32	6.4
Urban	468	93.6
Presence of chronic diseases		
Yes	65	13.0
No	435	87.0
Number of pregnancies		
First	160	32.0
Second	149	29.8
Third and above	191	38.2
Trimesters		
1st trimester	23	4.6
2nd trimester	42	8.4
3rd trimester	435	87.0
History of stillbirth		
Yes	32	6.4
No	468	93.6
History of baby with congenital anomalies		
Yes	13	2.6
No	487	97.4
History of preterm birth		
Yes	51	10.2
No	449	89.8
History of miscarriage		
Yes	120	24.0
No	380	76.0
History of voluntary termination of pregnancy		
Yes	88	17.6
No	412	82.4

(Continues)

TABLE 2 | (Continued)

Characteristics	n (500)	%
Diseases occur during pregnancy ($n = 123$)		
Yes	123	75.4
No	377	24.6
Diseases occur during pregnancy ($n = 123$)		
Gestational diabetes	42	8,4
Gestational hypertension	41	8,2
Preeclampsia	3	0,6
Sleep disorder during pregnancy	17	3,4
Thyroid diseases during pregnancy	7	1,4
Hematological diseases	7	1,4
Pregnancy-induced heart disease	1	0,2
Others (kidney problems, fractures, anxiety)	4	1.0

pregnant women were asked whether they had any information about climate change, 55.6% (n = 278) reportedly did not have any information. Although 56% stated that climate change would have negative effects, 15.4% thought that climate change may affect different groups at different levels. Of all the participants, 44.8% stated that the group that would be most affected by climate change would be children, and 70.2% stated that men are the group that would be least affected (Table 3).

3.1 | Findings About Validity and Reliability Analyses

3.1.1 | EFA

3.1.1.1 | Construct Validity. Before EFA, the KMO test was performed data suitable for factor analysis. It provides a value between 0 and 1, with higher values indicating better suitability for factor analysis. The test conducted to compare the magnitude of the observed correlation coefficients with the magnitude of the partial correlation coefficients revealed the KMO value of the data set as 0.939. A KMO value closer to 1 suggests that the variables in your dataset have a high degree of common variance, making them suitable for factor analysis. This value indicates that the data were excellent for EFA. In addition, the significance value of Bartlett's Test (χ^2 = 7210.518, df = 630, p = 0.000) was less than 0.05, indicating a sufficient correlation between variables to justify further exploration through factor analysis.

3.1.1.2 | Factorization and Rotation. Factor analysis was employed to derive new variables, termed factors or dimensions, by leveraging the factor loadings of individual items. This process aimed to achieve variable reduction, ensure the independence of the resulting factors, and establish their meaningful interpretability. PCA, one of the factorization techniques, was preferred in the factorization process. The primary objective of PCA is to condense a large set of variables into a smaller number of underlying factors, thereby maximizing the variance extracted from the dataset with each component (Cokluk et al. 2010). Rotation is

TABLE 3 | Participants' knowledge, attitudes, and opinions on climate change.

Variable		*n*	%
Do you know about "climate change/climate crisis"?	Yes	148	29.6
	No	278	55.6
	Partially	74	14.8
What do you think the consequences of climate change could be?	Positive	22	4.4
	Negative	280	56.0
	I don't know	198	39.6
Do you follow news about climate change?	Yes	142	28.4
	No	358	71.6
Are there any negative effects of the consequences of climate change on health	Yes	351	70.2
	No	26	5.2
	Don't know	123	24.6
Are all people (women, men, children, elderly, pregnant, etc.) affected by the consequences of climate change at the same level?	Yes	77	15.4
	No	324	64.8
	Don't know	99	19.8
If they were affected at different levels, which group do you think would be affected the most?	Women	52	10.4
	Men	12	2.4
	Children	224	44.8
	Elderly	107	21.4
	Pregnant	105	21.0
Do you know/have you heard about climate change and its effects on pregnant women's health?	Yes	94	18.8
	No	406	81.2
Do you think climate change affects women's economic level?	Yes	172	34.4
	No	118	23.6
	Don't know	210	42.0
Do you think climate change affects pregnant women's physical/physiological health?	Yes	320	64.0
	No	51	10.2
	Don't know	129	25.8
Do you think climate change affects pregnant women's mental health?	Yes	362	72.4
	No	31	6.20
	Don't know	107	21.4
Do you think climate change affects pregnant women's nutrition levels?	Yes	347	69.4
	No	44	8.80
	Don't know	109	21.8
Do you think climate change affects pregnant women's healthcare needs?	Yes	277	55.4
	No	72	14.4
	Don't know	151	30.2

intended to produce a simple structure, a pattern of associations in which each observed variable associates strongly with one factor and only one factor.

Scree plot was used to have an idea about the latent structure of the 36 items in the draft version of the scale and to help determine the factor structure. The analysis identified five factors with eigenvalues greater than 1, collectively accounting for 66.30% of the total variance. The variance contributions of these factors were as follows: 47.741% (10 items), 7.839% (8 items), 4.046% (10 items), 3.370% (6 items), and 3.300% (2 items), respectively. The rotation process of the 36-item draft version scale was repeated four times by removing the items with factor loadings less than 0.30 one by one. During item elimination, attention was paid to ensure that the difference between the two loadings was at least 0.10. The initial five-factor structure of the scale was supported by the eigenvalue coefficients and the cumulative variance explained by these prominent factors. Item 14, which

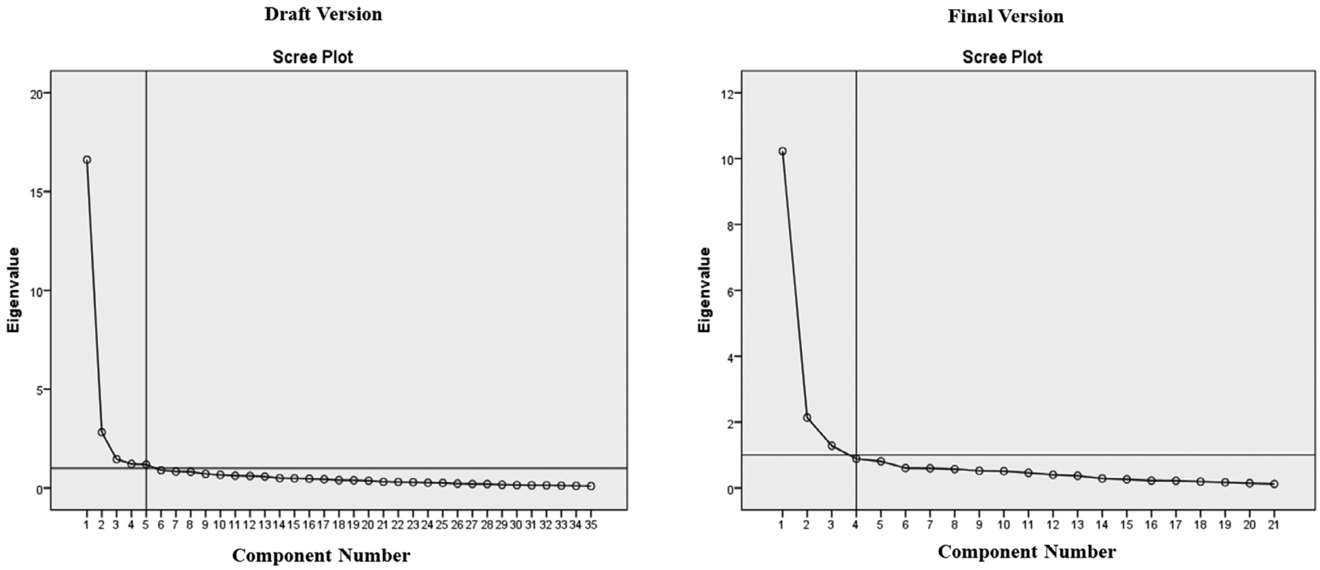

FIGURE 1 | Screen plot graphics of the eigenvalue of the draft and final version scale.

had a factor loading below 0.30, was first removed from the scale, and the rotation process was repeated. Additionally, items 4, 13, 16, and 32 exhibited factor loading discrepancies of less than 0.10 across two distinct sub-dimensions. The close proximity of these factor loadings indicated a lack of clear differentiation between the sub-dimensions for these items. Consequently, an iterative removal process was conducted, prioritizing items with the smallest absolute difference in factor loadings between the two sub-dimensions. After each removal, the factor loadings of the remaining items were recalculated. Following this process, the factor loadings of the remaining 31 items were re-evaluated. Upon completion of the rotation procedures, it was observed that the fifth factor comprised only two items. However, established analytical standards recommend that each factor contain at least three items for robust measurement (Buyukozturk 2002). Accordingly, item 12, which had the lowest factor loading within the fifth factor, was initially removed from the scale, and the rotation process was repeated. Subsequent analysis revealed that Items 10 and 11 exhibited a factor loading difference of less than 0.10, indicating insufficient discriminant validity. As a result, these two items were also excluded, and the rotation procedure was repeated for the remaining 28 items on the scale. Within the fourth factor (Items 7, 8, and 9), Item 9, which had the lowest factor loading, was removed from the item pool due to its inconsistency with the theoretical structure and insufficient discriminant validity. After this adjustment, only two items (Items 7 and 8) remained in the fourth factor. However, given that a minimum of three items per factor is recommended for robust measurement, Items 7 and 8 were also removed from the scale. To ensure the coherence of the identified dimensions, the similarity among items, their alignment within a single factor, and their compatibility with the theoretical model were examined. As a result of this evaluation, it was determined that Items 28 and 29 in the first factor, Item 30 in the second factor, and Item 5 in the third factor should also be removed. Following these refinements, the remaining 21 items on the scale accounted for 65% of the total variance. The variance explained by each factor is 48.71%, 10.17%, and 6.11%, respectively. The results showed that the final version of the scale consisted of 21 items and three factors (Figure 1, Table 4).

Then the phase of appropriate name (labeling) was started. The labeling process included the names of the theoretically created draft names and the names that would cover the items with high factor loadings. PSCCAS had a 3-factor structure: general awareness (six items), fetal awareness (eight items), and maternal awareness (seven items). Correlations between the factors were analyzed to determine the relationship between the sub-scales. Inter-factor correlations are derived when multiple factors are extracted and implemented in rotation. These correlations indicate the extent to which the underlying dimensions of the observed variables are related to one another. *p* value ($p < 0.05$) was interpreted as the relationship between the factors being significant. To assess this, a correlation matrix was applied to examine pattern relationships among the factors. A low correlation coefficient ($r < \pm 0.30$) in the matrix indicates that the factor does not significantly contribute to explaining the associated scale. Generally, correlations below 0.30 fail to demonstrate the presence of a potential factor or relationship, whereas correlations above 0.30 provide evidence suggesting insufficient commonality to confirm contributing factors. However, extremely high correlation coefficients ($r > 0.90$) suggest a potential multicollinearity issue. Therefore, it is recommended that variables with correlations exceeding ± 0.90 be excluded from the analysis (Field 2009). In order to determine the relationship between the factors of the awareness scale (General, Fetal and Maternal), correlations between factors were examined. The correlations between the sub-scales of the scale were found to be significant ($p < 0.001$). The correlation coefficient between the general awareness factor and the fetal awareness factor is $r = 0.578$, the correlation coefficient between the general awareness factor and the maternal awareness factor is $r = 0.706$, and the correlation coefficient between the fetal awareness factor and the maternal awareness factor is $r = 0.644$. Since all the correlation coefficients obtained are below 0.90, there is no multicollinearity problem between the factors.

TABLE 4 | Factor loadings of the final version of PSCCAS as a result of EFA.

No	Item	Factor 1	Factor 2	Factor 3
1	Pregnant women are more vulnerable groups to the effects of climate change.	0.778		
2	Climate change negatively affects mental health of pregnant women.	0.923		
3	Climate change negatively affects the physical health of pregnant women.	0.870		
6	Climate change is detrimental to the health of pregnant women.	0.772		
18	Extreme weather events (such as extremely hot/cold weather, floods, storms, and drought) negatively affect the nutrition of the pregnant woman.	0.573		
19	Climate change is an influential stressor during pregnancy.	0.526		
15	The negative effects of climate change cause preterm birth.		0.588	
17	Exposure to air pollution during pregnancy causes preterm birth.		0.669	
22	Extreme weather events cause preterm birth.		0.767	
23	Extreme weather events cause low birth weight.		0.815	
24	Extreme weather events cause stillbirth.		0.956	
25	Extreme weather events cause congenital anomalies in the baby.		0.964	
26	Exposure to air pollution during pregnancy causes low birth weight in the newborn.		0.759	
27	Exposure to air pollution during pregnancy causes growth restriction in the unborn baby.		0.765	
20	Malnutrition caused by climate change causes anemia during pregnancy.			0.691
21	Poor nutritional conditions caused by climate change cause calcium deficiency and related diseases in pregnant women.			0.612
31	Extremely hot weather causes high blood pressure during pregnancy.			0.957
33	Extremely hot weather causes dehydration during pregnancy.			0.983
34	Air pollution caused by climate change is harmful to pregnant women's health.			0.696
35	Exposure to air pollution during pregnancy causes respiratory distress in pregnant women.			0.834
36	Exposure to extreme weather events causes an increased need for health care during pregnancy.			0.462

3.1.2 | CFA

CFA was conducted to assess the relationships among the sub-dimensions of the Climate Change Awareness Scale—namely, General, Fetal, and Maternal. Inter-factor correlations were examined to evaluate the extent of association between these dimensions. In accordance with established psychometric guidelines, correlation coefficients equal to or exceeding 0.90 may indicate multicollinearity and are therefore considered problematic (Field 2009). The analysis revealed statistically significant correlations among the sub-dimensions ($p < 0.001$). Specifically, the correlation between the General and Fetal dimensions was $r = 0.491$; between the General and Maternal dimensions, $r = 0.631$; and between the Fetal and Maternal dimensions, $r = 0.486$. Since all correlation coefficients are below the 0.90 threshold, multicollinearity is not present, thereby supporting the structural distinctiveness of the scale's sub-dimensions.

Mardia's multivariate normality test was employed to evaluate the assumption of multivariate normality by independently analyzing two components: multivariate skewness and multivariate kurtosis. The resulting *p* values were below 0.05, indicating significant deviations from multivariate normality. When data are ordinal or demonstrate substantial non-normality, Weighted Least Squares (WLS) estimation is recommended (Muthén 1993). Accordingly, the selection of an appropriate estimation method in this study was guided by the distributional properties and categorical structure of the dataset. Given the presence of non-normal and ordinal data, the Weighted Least Squares Mean and Variance adjusted (WLSMV) method was adopted. WLSMV is particularly advantageous as it does not assume multivariate normality, accommodates ordinal variables, and performs reliably with moderate sample sizes (Brown 2006). Based on these considerations, WLSMV was deemed the most suitable estimation method for the present study.

The first level of CFA included the analysis of each subscale model separately. The Chi-square fit index evaluates the degree to which the hypothesized model aligns with the data obtained from a set of measurement items (observed variables). The model Chi-square is a statistical measure derived using the maximum likelihood method. As the most commonly used global fit index in CFA, the Chi-square test also serves as the basis for generating other fit indices. It assesses whether the covariance matrix estimated by the model adequately represents the population covariance. The Chi-square fit statistic is sensitive to large sample sizes; therefore, the ratio of the Chi-square statistic to its degrees of freedom (χ^2/df) is commonly used as an alternative measure. A ratio of ≤2 is generally considered indicative of a superior fit between the hypothesized model and

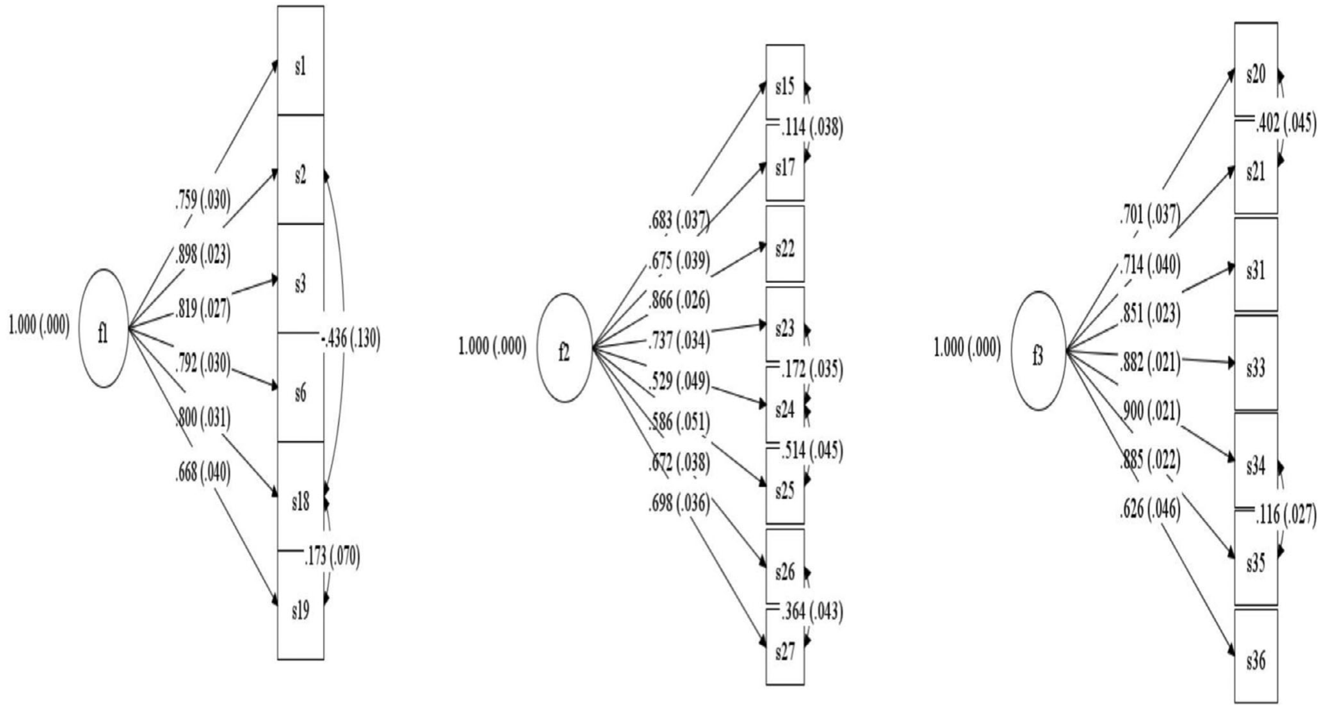

FIGURE 2 | First-level CFA results for the three-factor PSCCAS. f1, general awareness; f2, fetal awareness; f3, maternal awareness.

the sample data (Schermelleh-Engel et al. 2003). Each sub-scale was considered as a model and associated with the items of the factors (general awareness, fetal awareness, and maternal awareness) created with EFA. The fit indices of the general awareness factor model were found to be significant ($x^2 = 18.847$, sd = 7, $p = 0.008$, x^2/sd = 2.692). The fit index values were found as RMSEA = 0.082, NFI = 0.995, CFI = 0.989. The fit indices of the fetal awareness factor model were significant ($x^2 = 34.026$, sd = 16, $p = 0.052$, x^2/sd = 2.127). The fit index values were found as RMSEA = 0.067, NFI = 0.994, CFI = 0.989. The fit indices of the maternal awareness factor model were significant ($x^2 = 16.783$, sd = 12, $p = 0.015$, x^2/sd = 1.398). The fit index values were found as RMSEA = 0.040, NFI = 0.999, CFI = 0.999 (Figure 2).

In the fetal awareness sub-dimension of the scale, items 15 (*The negative effects of climate change cause preterm birth*) and 17 (*Exposure to air pollution during pregnancy causes preterm birth*) are related to each other. Increasing greenhouse gases due to air pollution cause climate change and can lead to premature birth in pregnant women. Items 23 (*Extreme weather events cause low birth weight*) and 24 (*Extreme weather events cause stillbirth*) are related to each other. Both conditions are closely related, and some premature births result in stillbirth. Items 24 (*Extreme weather events cause stillbirth*) and 25 (*Extreme weather events cause congenital anomalies in the baby*) are related to each other. One of the most significant adverse outcomes during pregnancy is stillbirth, while fetal anomalies represent another serious risk. Pregnant women may encounter these complications due to extreme weather events. If a pregnant woman understands the impact of such events, she is likely to respond similarly to both items. Consequently, these two items are interconnected. Items 26 (*Exposure to air pollution during pregnancy causes low birth weight in the newborn*) and 27 (*Exposure to air pollution during pregnancy causes growth restriction in the unborn baby*) related to each other. Because both events may occur in the fetus when the pregnant woman is exposed to air pollution. In the maternal sub-dimension of the scale, items 20 (*Malnutrition caused by climate change causes anemia during pregnancy*) and 21 (*Poor nutritional conditions caused by climate change cause calcium deficiency and related diseases in pregnant women*) are related to each other and the nutrition of the pregnant women. Items 34 (*Air pollution caused by climate change is harmful to pregnant women's health*) and 35 (*Exposure to air pollution during pregnancy causes respiratory distress in pregnant women*) are related to each other. Respiratory distress is harmful to pregnant women's health. Furthermore, the connections made between all the related items contributed to the increase in the fitness of the model.

After the suitability of the models was analyzed according to the fit indices for the factors of the PSCCAS, the overall fit indices of the scale were started to be analyzed using the second level of CFA since the scale had three factors. A second level CFA model was developed to examine the interrelationships among the latent variables within the Awareness Scale structure. The latent variables (three sub-dimensions: General, Fetal, and Maternal) were hypothesized to be interrelated. These relationships are depicted in Figure 3 using bidirectional curved arrows, representing the presumed correlations between the latent constructs. The 21 observed variables (items) are illustrated as rectangles, while the latent variables (sub-dimensions) are represented by circles (ellipses). Unidirectional arrows extending from the latent variables to the observed variables indicate direct effects, demonstrating the influence of each sub-dimension on its respective items. This study aimed to develop a scale to assess and measure pregnant women's awareness of climate change. To achieve this, items related to the general effects of climate change were first theoretically categorized under the "General" dimension. These items included statements highlighting that

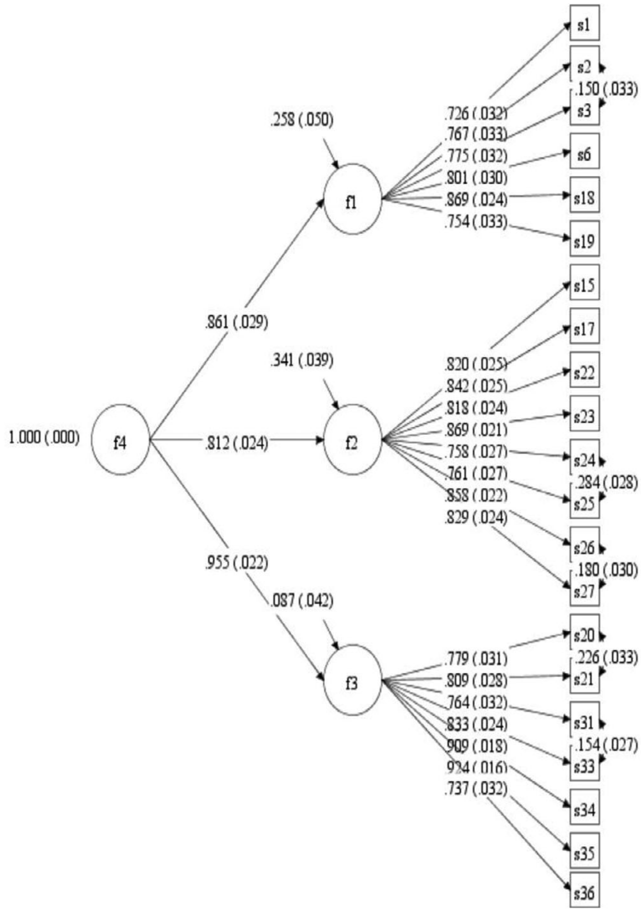

FIGURE 3 | PSCCAS second level CFA results. f1, general awareness; f2, fetal awareness; f3, maternal awareness; f4, PSCCAS.

pregnant women constitute a more vulnerable group to the effects of climate change, its negative impact on their mental and physical health, and its role in inducing stress. Additionally, items addressing the effects of climate change on maternal health -such as respiratory distress during pregnancy, pregnancy complications, kidney problems, fluid loss, anemia, and mineral deficiencies- were included. Another category focused on fetal effects, including risks such as preterm birth, miscarriage, low birth weight, stillbirth, and developmental delays. These three sub-dimensions -General, Fetal, and Maternal—are considered latent variables that underlie and explain the items associated with each dimension. Together, they represent pregnant women's awareness of climate change. Furthermore, general climate change awareness among pregnant women is interrelated with both fetal and maternal awareness regarding climate change.

The fit index values were found as RMSEA = 0.074, NFI = 0.978, CFI = 0.975, x^2 = 428.438, sd = 181, p = 0.000, x^2/sd = 2.367 (Table 5). The fit indices of the awareness scale model were acceptable. It has been observed that alternative fit indices, which serve as substitutes for the χ^2 test and are influenced by sample size, have become increasingly prevalent in recent years. Among these, the most frequently recommended indices include χ^2/sd, CFI, NNFI/TLI, and RMSEA, among others. In this context, multiple goodness-of-fit indices were utilized together to assess and report the overall model fit comprehensively. Figure 3 below presents the second-level CFA results for the three-factor PSCCAS.

In the general sub-dimension of the scale, items 2 (Climate change negatively affects the mental health of pregnant women) and 3 (Climate change negatively affects the physical health of pregnant women) are related to the health description. The WHO (World Health Organization) constitution states: ''Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity. These items are thought to be related to each other. In the fetal awareness sub-dimension of the scale, items 24 (Extreme weather events cause stillbirth) and 25 (Extreme weather events cause congenital anomalies in the baby) are related to each other. One of the most significant adverse outcomes during pregnancy is stillbirth, while fetal anomalies represent another serious risk. Pregnant women may encounter these complications due to extreme weather events. If a pregnant woman understands the impact of such events, she is likely to respond similarly to both items. Consequently, these two items are interconnected. Items 26 (Exposure to air pollution during pregnancy causes low birth weight in the newborn) and 27 (Exposure to air pollution during pregnancy causes growth restriction in the unborn baby) related to each other. Because, both events may occur in the fetus when the pregnant woman is exposed to air pollution. In the maternal sub-dimension of the scale, item 20 (Malnutrition caused by climate change causes anemia during pregnancy) and 21 (Poor nutritional conditions caused by climate change cause calcium deficiency and related diseases in pregnant women) are related to each other and the nutrition of the pregnant women. Items 31 (Extremely hot weather causes high blood pressure during pregnancy) and 33 (Extremely hot weather causes dehydration during pregnancy) are related to each other and the consequences of pregnant women being exposed to extremely hot weather. In addition, the connections made between all the related items contributed to the increase in the fitness of the model.

Convergent validity is established when all items within a measurement model demonstrate statistically significant factor loadings. Additionally, it can be assessed through the computation of the AVE for each construct. An AVE value of 0.50 or higher indicates that the construct explains at least 50% of the variance in its indicators, thereby supporting convergent validity. As shown in Figure 3, all factor loadings have values above 0.50. The factor loadings of the general awareness subscale items ranged from 0.726 to 0.869, the factor loadings of the fetal awareness subscale items ranged from 0.758 to 0.869, and the factor loadings of the maternal awareness scale items ranged from 0.737 to 0.924. The factor loadings of the subscales of the awareness scale were calculated as 0.861 (general), 0.812 (fetal), and 0.955 (maternal).

Discriminant validity refers to the degree to which a construct is truly distinct from other constructs within a measurement model. In the context of CFA, establishing discriminant validity ensures that the latent variables (factors) are conceptually and empirically separate from one another, meaning that they measure different underlying constructs. Inter-Factor Correlations: Discriminant validity is also examined by inspecting the correlation coefficients between latent constructs. If the correlations are too high (commonly $r > 0.85$ or 0.90), this suggests a lack of discriminant validity, meaning the constructs may not be empirically

TABLE 5 | Results of PSCCAS, CFA fit indices criteria, and acceptance.

Fit indices	Good fit	Acceptable fit	Second-level CFA (without modified model)	Second-level CFA (modified model)	Result
x^2/sd	$0 \leq x^2/sd \leq 2$	$2 \leq x^2/sd \leq 3$	4.198	2.367	Acceptable
RMSEA	0 ≤ RMSEA ≤ 0.05	0.05 ≤ RMSEA ≤ 0.08	0.113	0.074	Acceptable
NFI	0.95 ≤ NFI ≤ 1.00	0.90 ≤ NFI ≤ 0.95	0.942	0.978	Excellent
CFI	0.97 ≤ CFI ≤ 1.00	0.95 ≤ CFI ≤ 0.97	0.949	0.975	Excellent

distinct. Moderate or low correlations between constructs support discriminant validity. The inter-factor correlations of the general awareness subscale items ranged from 0.351 to 0.777, the factor loadings of the fetal awareness subscale items ranged from 0.319 to 0.833, and the factor loadings of the maternal awareness scale items ranged from 0.457 to 0.912.

3.1.3 | Ensuring Credibility

Internal consistency coefficient (Cronbach's alpha), split-half reliability coefficient, and item-total score correlations were calculated for all the items in the scale, which was given its final form with EFA and CFA analyses. Table 6 presents Cronbach's alpha internal consistency coefficients, the coefficients obtained from the split-half test reliability, and the coefficients of item-total correlations of the awareness scale items. The total internal consistency Cronbach's alpha coefficient of the final version of the 21-item scale was calculated as 0.946.

TABLE 6 | Data on the final version of PSCCAS reliability coefficients.

Item No	Item-total correlation	Cronbach's alpha	Split-half reliability
1	0.561	0.945	0.913
2	0.601	0.945	0.913
3	0.615	0.945	0.912
6	0.624	0.944	0.911
15	0.682	0.944	0.913
17	0.694	0.943	0.913
18	0.696	0.943	0.910
19	0.595	0.945	0.913
20	0.668	0.944	0.910
21	0.705	0.943	0.909
22	0.668	0.944	0.910
23	0.702	0.943	0.912
24	0.616	0.945	0.917
25	0.614	0.945	0.916
26	0.735	0.943	0.912
27	0.696	0.943	0.911
31	0.614	0.945	0.913
33	0.666	0.944	0.912
34	0.739	0.943	0.911
35	0.724	0.943	0.911
36	0.611	0.945	0.912

4 | Discussion

The PSCCAS was developed to measure pregnant women's awareness of the effects of climate change on pregnancy. The results obtained from testing the psychometric properties of the scale provided sufficient initial evidence that the PSCCAS is a valid and reliable scale for assessing pregnant women's awareness of climate change.

Several scales in the literature are available for the determination of individuals' awareness or perceptions of climate change (Gönen et al. 2023; Ataklı and Kuran 2022; Van Valkengoed et al. 2021; Ghasura et al. 2021). However, these scales include general evaluations of climate change. The difference between PSCCAS and these scales is that the PSCCAS includes the effects on maternal and fetal health during the pregnancy period. In addition, the study sample includes pregnant women. Being specific to pregnancy and pregnant women constitutes the originality and main purpose of the scale because pregnancy is a process that generally involves behavioral changes. Determining the awareness of women about climate change during pregnancy and informing them in this process are believed to encourage them to change their behavior. In this way, the steps they will take to protect themselves and the fetus from the effects of climate change could become acquired behaviors at the end of the pregnancy process. Not only pregnant women but also their families and environment in general exhibit positive behaviors during pregnancy for the well-being of pregnant women and their fetuses. Therefore, pregnant women's increasing awareness and changing behaviors may also affect their environment. In this respect, the adaptation steps to be planned after determining awareness using the PSCCAS may positively affect the individuals around them with secondary outcomes.

The construct validity of the PSCCAS scale was assessed by performing first EFA and then CFA. KMO and Bartlett's tests were calculated to determine whether factor analysis could be performed. The KMO test should be 0.50 or more and Bartlett's test should have a statistical significance value of less than 0.05 (Tavsancil 2010; Sencan 2005). In this study, the KMO value was found to be 0.939 and Bartlett's test of sphericity ($p = 0.000$) was found to be significant. A significant and high value of KMO (moderate between 0.70 and 0.80, good between 0.80 and 0.90, and excellent above 0.90) is interpreted as the sufficiency of the sample size for factor analysis (Tavsancil 2010). These data indicate that there is a high correlation between our variables, and they are suitable for factor analysis.

Factor analysis aims to reveal new variables called factors by using the factor loadings of the items. In EFA, the eigenvalue coefficient is used to calculate the proportion of variance explained by each factor and to determine the number of significant factors (Tabachnick and Fidell 2001). In general, eigenvalue coefficient values greater than "1" are considered significant factors (Buyukozturk et al. 2013). The draft version of the scale was found to consist of five factors. After factorization, the Promax technique was used under oblique rotation methods. Regardless of the sign of the factor loadings, values between 0.30 and 0.59 are considered moderate and 0.60 and above are considered high (Buyukozturk et al. 2013). The items in the draft version of the scale were subjected to factorization and item elimination process, and the final version included three factors and 21 items.

Correlations between factors were examined for the construct validity of the factors. When the correlation between sub-scales is analyzed, it is recommended that the correlation coefficient should not be 0.90 and above to avoid multicollinearity (Field 2009). This study found that the correlations between the sub-scales of the awareness scale were significant ($p < 0.001$) and all correlation coefficients were below 0.90, so there was no multicollinearity problem between the sub-scales.

Various tests and values are used to test the fit of the model in CFA. For an acceptable model, the degrees of freedom in the Chi-square test is an important value that should be less than three (Meydan and Sesen 2011). Hence, the findings of the general awareness sub-scale, fetal awareness sub-scale, and maternal awareness sub-scale showed that the fit indices of the model were significant. RMSEA is another fit index value that should be 0.05 or less for the model to be considered significant (Simsek 2007). NFI investigates the fit of the hypothesized model with the base or H_0, and a value ranging between 0 and 1, and an NFI value above .90 is interpreted as an acceptable fit of the model (Meydan and Sesen 2011). CFI is a comparative fit index. It compares the fit of the model with the fit of the H_0 model. CFI takes values ranging between 0 and 1, and a model with a CFI value between 0.97 and 1 is interpreted as a good fit (Meydan and Sesen 2011). The fit index values for our study findings were RMSEA = 0.082, NFI = 0.995, CFI = 0.989 for the general awareness sub-scale, RMSEA = 0.067, NFI = 0.994, CFI = 0.989 for the fetal awareness sub-scale, and RMSEA = 0.040, NFI = 0.999, CFI = 0.999 for the maternal awareness sub-scale. Multiple goodness-of-fit indices (χ^2/df, CFI, NNFI/TLI, and RMSEA) were employed simultaneously to ensure comprehensive evaluation and reporting of the overall model fit. The fit index values of PSCCAS scale were determined as RMSEA = 0.074, NFI = 0.978, CFI = 0.975, $\chi^2 = 428.438$, df = 181, $p = 0.000$, and $\chi^2/\text{df} = 2.367$, indicating an acceptable model fit for the awareness scale.

Internal consistency analysis was conducted for the reliability of the scale, which was validated by EFA and CFA analyses. Cronbach's alpha coefficient is recommended to be above 0.80 for reliability to be considered high (Buyukozturk et al. 2013). Total internal consistency Cronbach's alpha coefficient of the 21-item scale was calculated as 0.946. Cronbach's alpha internal consistency coefficients of all the items in the scale were 0.943 and above. The split-half reliability coefficients were also found to be 0.909 and above. The internal consistency Cronbach's alpha coefficients of the sub-scales were calculated as 0.871 for the "general awareness sub-scale", 0.924 for the "fetal awareness sub-scale" and 0.907 for the "maternal awareness sub-scale". Accordingly, when Cronbach's alpha coefficients of both the total and the three sub-scales are evaluated, it can be said that the reliability of the scale items is high/excellent. When the reliability coefficients of the awareness scale are analyzed, the reliability of the scale items seems to be high/excellent.

5 | Conclusion

PSCCAS is a valid and reliable scale that can be used to determine the awareness of pregnant women about the maternal and fetal effects of climate change. PSCCAS consists of 21 items and three sub-scales: general awareness, maternal awareness, and fetal awareness. Each of the items is responded on a 5-point Likert-type scale as "1- entirely disagree, 2- disagree, 3- neither agree nor disagree, 4- agree, 5- entirely agree". There are no reverse items in the scale. The score obtained from each sub-scale indicates the awareness about that sub-scale. The total score to be obtained from the scale ranges between 21 and 105, with an increase in the total score indicating an increase in the awareness of pregnant women about climate change.

Pregnant individuals and newborns are increasingly recognized as vulnerable groups in the context of climate change. Although evidence linking prenatal climate exposures to negative birth outcomes is still limited, proactive interventions are essential. Understanding climate-related impacts on maternal and child health is a crucial step for adaptation, and awareness levels help guide tailored responses. This study, conducted among pregnant participants, emphasizes the importance of preconception care and suggests future testing of the tool with individuals of reproductive age. It also recommends broader research that considers variables like education and geography and encourages comparison with national and international data.

The research findings are limited to the population in which the study was conducted. The Climate Change Awareness Scale for Pregnant Individuals (CCAS-P) represents the first tool developed to assess awareness levels regarding the maternal and fetal health impacts of climate change among pregnant individuals. It was applied for the first time in this study.

Author Contributions

Damla Kısrık: Conceptualization, methodology, formal analysis, resources, writing – original draft, writing – review & editing, project administration. **Burcu Avcıbay-Vurgeç**: Conceptualization, methodology, writing – review& editing, project administration, supervision. **Ali Derya Atik**: Conceptualization, methodology, formal analysis, data curation, editing, supervision.

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Ethics Statement

Ethical approval for the study was obtained from the Cukurova University Medical Faculty Non-invasive Clinical Research Ethics Committee (Approval number: 01.10.2021-115/45). The Declaration of Helsinki was complied with at all stages of the study. Before applying the questionnaires, all participants were informed about the purpose of the study, and written informed consent was signed for participation and dissemination of the results.

Conflicts of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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