Development and validation of a scale evaluating pregnant women's breastfeeding competency in third trimester: Breastfeeding Competency Scale(BCS)

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Abstract

Background: Breastfeeding plays an important role in the early stages of humans and throughout the development process. Breastfeeding competency is a self-assessment of pregnant women's overall competency to breastfeeding which could predict behaviors of pregnant women' breastfeeding. However, a valid and reliable scale to assess the breastfeeding competency has not yet been developed and validated. This study was designed to develop and validate an assessment scale designed to assess the pregnant women's breastfeeding competency in third trimester: Breastfeeding Competency Scale(BCS).

Methods: The BCS was developed and validated over three phases between September 2018–September 2019 which include item statistics, exploratory factor analysis(EFA), content validation, internal consistency assessment, split-half reliability and confirmatory factor analysis.

Results: Item statistics and exploratory factor analysis resulted in 38 items, 4 factors that explained 66.489% of total variance. The Cronbach's *α* coefficient in total scale and 4 factors were 0.970, 0.960, 0.940, 0.822, 0.931 respectively. The split-half reliability of BCS was 0.894, 0.890. Confirmatory factor analytic model showed the 4-factor model matching the data well.

Conclusions: The BCS was a new instrument with certain validity and reliability for assessing the breastfeeding competency of pregnant women in third trimester.

Background

Breastfeeding plays a self-evident role in the personal entire process of growth and development. It promotes maternal physical and psychological recovery, contributes to early initiation of infants' growth and development, decreases the risk of long-term disease[1, 2].Promoting and supporting breastfeeding can bring ten times the economic return and a billion-dollar demographic dividend[3, 4]. For this, large-scale breastfeeding promotion measures have been implemented worldwide[5]. Estimatedly, 78 million babies are not early breastfed within the first hour of life and get the few benefits they deserve. Therefore, effective intervention studies of breastfeeding are still necessary. Psychology studies showed that competency influences behaviors. Breastfeeding behaviors were studied through psychological competency iceberg model to develop and validate the new assessment scale of breastfeeding competency.

Breastfeeding is the best nutrition for the infants and the cornerstone for personal healthy growth and development[6].The World Health Organization has recommended that infants should be exclusively breastfed for the first 6 months of life, receives only breast milk, without any additional breast milk substitutes or liquid[7, 8]. Families and society have been brought great benefits by breastfeeding. For families, breastfeeding is the best way to improve infants survival through protecting infants from the threat of infection such as necrotizing enterocolitis, diarrhea, respiratory tract infections, etc. and saves the lives of about 820 thousand children under five[9]. Children who had breastfeeding have higher IQ levels in the long run and less risk of acute and chronic illnesses such as dental caries, leukemia, obesity, type 2 diabetes mellitus later in life[2, 6, 10–13]. Mothers who breastfeed have a reduced incidence of breast and ovarian cancers, depressive disorder, also could keep the balance of weight after giving birth[14–16]. For society,

breastfeeding is the best way to bring ten times the economic return and a billion-dollar demographic dividend through better academic performance and more labor force[3, 4]. However, some recent studies indicated that the rate of exclusive breastfeeding is 38% and the rate of exclusive breastfeeding among 30.71% countries around the world within six months of birth is lower than 20%[17–19]. The status and rate of breastfeeding is different between high-income, low-income countries and middle-income countries[2, 19].Therefore, increasing breastfeeding rate is the one of urgent problems that should be solved.

Competency is an organic combination of cognition, motivation, morality, and social skills. People could successfully master a certain skill or operation by understanding and operating on a series of tasks, problems, and goals based on their competency[20]. Different frameworks have slightly different understandings of abilities, for example in competency iceberg model, abilities are defined as individual, underlying, and deep-seated features which could distinguish between high performers and average performers in any jobs. It could be personal motivations, features, self-images, attitudes or values and knowledge, cognition or skills in any field which could be reliably measured or counted[21]. Competency is closely related to activities, and form, develop, and express in activities which is a prerequisite for engaging activities[22]. In other words, breastfeeding competency affects the occurrence of breastfeeding and mothers who have high competency of breastfeeding have high tendency to breastfeed[23]. The National Nutrition Plan (2017–2030) promulgated by The State Council of the People's Republic of China proposed to increase the rate of breastfeeding, cultivate scientific feeding behaviors, and formulate scientific feeding strategies[24]. The "Thirteenth Five-Year Plan" of Health and Wellness Plan also proposed to vigorously promote breastfeeding and carry out guidance of infant nutrition, feeding, growth and development, and psychological behaviors[25].

The occurrence and duration of breastfeeding behaviors are affected by multiple factors such as individual factors, socioeconomic, health care systems[14]. Individual factors including maternal attitudes, self-efficacy and knowledge were the reasons for breastfeeding which could predict the beginning and duration of breastfeeding[26, 27]. At the socioeconomical and cultural level, duration and experience of breastfeeding were affected by the factors including workplace, mass media and market context[28]. In health systems, legislation and policy of breastfeeding influence beginning and duration of breastfeeding by providing support[14, 29]. These factors must be understood and controlled at the same time to promote breastfeeding behaviors and increase breastfeeding rate. Only could the effective intervention of breastfeeding be maximized by grasping different factors together. Breastfeeding competency is defined as maternal grasp of different breastfeeding factors. These factors are the prerequisites for establishing and implementing interventions of breastfeeding, and understanding grasp of breastfeeding factors could effectively assess the breastfeeding competency.

Theoretical Framework

In 1973, the competency iceberg model was first established by Harvard psychologist McClelland. It is a common model to assess competency which can distinguish the high performers from the average performers[30]. The four parts of the competency iceberg model include knowledge, skills, self-concept,

traits, and motivation[31]. Knowledge and skills are the visible part of the iceberg on the water, motivation and traits are hidden parts of the iceberg underwater, and self-concept lies between the two factors which could be changed by education, psychology and accumulated experience in long term[32]. The competency iceberg model has been used in related research on capacity building in different disciplines, for example, based on this model, Gardner developed training programs for nurses in Australia and New Zealand[33]; Supamane formulated the qualitative interviews outline of the leadership for clinical nurses and established the Thailand clinical nurse leadership model[34]; Wang Xiaoyun applied this model to the safety and quality management of pediatric nursing in order to reduce the occurrence of adverse events[35]; Ma Chifen formulated senior caregivers competency model to promote the development of elderly care[36].

In order to form a scientific and comprehensive assessment scale for breastfeeding competency, breastfeeding related contents were included in the competence iceberg model. Combining breastfeeding knowledge with "knowledge", breastfeeding skills with model "skills", breastfeeding self-efficacy and maternal self-concept with "self-concept", attitudes and social breastfeeding-related support is combined with " traits and motivation". Breastfeeding competency could be broken down into different parts that could be easier to assess, and divided parts are closely related and independent of each other which can more reliably represent and evaluate breastfeeding competency.

Methods

Design

Items of Breastfeeding Competency Scale(BCS) was designed on the basis of breastfeeding competency framework which was constructed based on the competency iceberg model, combined review of the literature published in international or Chinese academic journals and qualitative interview, with the references of Breastfeeding Self-Efficacy Energy Scale(BSES)[37], Breastfeeding Knowledge Scale[38] and Conceptual Model of Components of An Enabling Environment for Breastfeeding[14].

Firstly, Delphi method was applied to form a breastfeeding competency framework based on the competency iceberg model and review of the literature published in international or Chinese academic journals. 3 rounds of Delphi method performed by 14 specialists whose research directions are maternity and midwifery management, education and clinical nursing, and of which 5 are international board certified lactation consultant(IBCLC). After deleting, adding and merging, breastfeeding competency framework including 3 first-level indicators, 8 second-level indicators, and 54 third-level indicators was formed by appraised indicators such as positive coefficient of experts, coefficient of experts and Kendall's coefficients of concordance[39].

Then, qualitative interview, in-depth interviews with 15 pregnant women, were applied to understand the status and needs of maternal breastfeeding. The results showed that deficiencies and needs of maternal breastfeeding included theoretical knowledge, skills, psychological aspects, social support, and self-concept of breastfeeding. Pregnant women required professional knowledge-skill guidance, adequate social support, convenient access of breastfeeding support. They questioned their breastfeeding competency and

behaviors on account of they might not know the changes of negative psychological with vague self-concepts.

Based on results, after deletion and combination, Breastfeeding Competency Scale(BCS) including 44 items was formed by group discussions, and 5 specialists of IBCLC took an assessment of validity of items who had experiences in breastfeeding practice and guidance. Four-point Likert-type response scale was applied in the scale on the preliminary index system of breastfeeding competency, S-CVI and I-CVI were used to assess the content validity. The categories of relevance were marked as: 1 = 'Not at all', 2 = 'Somewhat',3 = 'Moderately so', 4 = 'Very much so'. S-CVI and I-CVI were calculated as 0.965(⩾0.9) and 0.875 ~ 1.000(⩾0.78) respectively, and indicated that the scale including 44 items has content validity.

Study procedure

In the department of gynaecology and obstetrics, consent forms which included content and methods of this study were distributed. Pregnant women took questionnaires after agreeing to participate in this study while standardized explanations of research objectives, research procedures, questionnaires were given to pregnant women for their full understanding. The questionnaires were completed on the day of obtaining the questionnaires and was sent to the researchers in the same day or the next hospital visit.

Measures

Data collected consisted in questionnaire of socio-demographic characteristics, and Breastfeeding Competency Scale(BCS).

Questionnaire of socio-demographic characteristics

The socio-demographic characteristics of pregnant women were age, gestational week, parity, education, occupation and frequency of education program for pregnant women.

Breastfeeding Competency Scale(BCS)

Each item of the scale assesses the breastfeeding competency that has possessed for the pregnant women at present. Participants responded all items by using five-point Likert-type scale (from 1 = completely no corresponding to 5 = completely corresponding). The scale's score was calculated as the sum of the scores in each item, and mean score was the sum of the items divided by the number of items answered. Higher scores for the sum of the items indicated a greater competency of pregnant women for breastfeeding.

Sample and sample size determination

Pregnant women were invited to participate in the study who were recruited from two provincial general hospitals in China between September 2018–September 2019. Inclusion criteria were being in third trimester and able to read, understand the scale explanations, have no contraindications for breastfeeding. Exclusion criteria were cognitive deficits and/or could not participate independently in this study. At least 10–15 times the total number of items for women should be invited to satisfying criteria of factor analysis[40]. Total number of 440–660 participants was required because the draft BCS included 44 items.

Data collection

Sample 1 consisted of 580 pregnant women was conveniently sampled by selecting from two provincial general hospitals in China, with the predefined methods and inclusion and exclusion criteria. Completion of the questionnaires (missed or randomly wrote) was reviewed after pregnant women completed the questionnaires. This sample was applied for item analysis, reliability, validity of the scale and for construction of the BCS.

Sample 2 consisted of 280 pregnant women was conveniently sampled by selecting from two provincial general hospitals in China, with the same methods and criteria as sample 1. Completion of the questionnaires (missed or randomly wrote) was reviewed. This sample was applied to assess the scale's effectiveness and degree of data fitting.

Ethical considerations

This study obtained the approval from the Medical Ethics Committee of Weifang Medical College(2019SL060) and the consent from the ethnic committee of two hospitals. Informed consents were taken from the pregnant women and their personal information was kept strictly confidential.

Data analyses

Socio-demographic characteristics, scale scores of pregnant women were used the descriptive statistics to analyze. Mean and standard deviations (SD) were used to calculate the measurement data, such as the age of pregnant women, score of items, and for the counting data, such as the educational background and occupation of pregnant women, frequency and percentage were used. Data were analyzed by SPSS version 23.0 or Amos version 23.0. $P < 0.05$ was considered to be the level of statistical significance.

Item statistics

(1) Ceiling effect or floor effect: describe and analyze participants grading the highest and lowest score for each items. The items with ceiling effect (highest score of an item is more than 15%) or floor effect (lowest score of an item is more than 15%) were considered as deletion[41].

(2) Item distribution method: describe and analyze the distribution of item options. If the selection rate of each option from items accounted for more than 80%, it would be considered to be deleted[42].

(3) The coefficient of variation method: calculate the mean and standard deviations of each item, and calculate its coefficient of variation (CV), CV = s/x. Items with low coefficient of variation (< 15%) were considered to be deleted.

(4) The critical ratio (CR) analysis method: according to the total score of the scale and sorts it, the first 27% was regarded as the upper group, and the last 27% as the lower group, two groups were tested by independent t test[43]. The items were deleted when $P > 0.05$.

(5) The correlation coefficient method: the Pearson's correlation coefficient was used to evaluate the scores of each item and the total score of the scale. Items with low coefficient (< 0.2) or/and high *P* value (> 0.05) were considered to be deleted.

(6) The factor analysis method: after factor analysis, the cumulative variance contribution rate of common factors < 40%, the factor loading values < 50%, or the factor loading in non-unique common factor > 50%, treatment of discarded was considered[44].

(7) The Cronbach's α coefficient method: Cronbach's *α* coefficient was used to analyze the internal consistency of the scale, and if the existence of an item caused the Cronbach's *α* coefficient to reduction, it would be considered to be deleted[45].

Following these methods, the item was recommended to be discarded when it met more than three criteria. Moreover, if an item was selected by less than three criteria, it should be discussed for modifying, merging or deletion according to the group discussions of experts.

Reliability

The Cronbach's α coefficient and split-half reliability were used to test the reliability of the scale. For the total scale, factors and items, the Cronbach's *α* coefficient ≥ 0.7, Spearman-Brown split-half reliability and Guttman split-half reliability ≥ 0.7 were assessed as mapping[43, 46].

Validity

Content validity, Pearson's correlation analysis, exploratory factor analysis and confirmatory factor analysis were used to test the validity of the scale. Firstly, the content validity of the scale was tested by the Delphi method. Secondly, the correlation coefficient analysis among factors and between factor to and the BCS. Thirdly, the exploratory factor analysis and confirmatory factor analysis were carried out by two-step strategy. Sample 1 was randomly selected for exploratory factor analysis and sample 2 were selected for confirmatory factor analysis to verify the fitting degree of the model. The validity of the scale is trustworthy when the following criteria are confirmed. In content validity method, I-CVI > 0.78 and S-CVI/Ave > 0.9 were accepted[47]. The range of correlation coefficient among factors is 0.1–0.6, and the correlation coefficient between factor to and the range of BCS is 0.3–0.8. There should not be less than 3 items under each common factor for exploratory factor analysis[43]. In confirmatory factor analysis, the model should meet the following criteria[48].

Results

580 pregnant women in third trimester were enrolled for the first round and 565 (97.41%) valid questionnaires were completed, and 280 pregnant women were enrolled for the second round and 244 (87.14%) valid questionnaires were completed and obtained.

Item analysis

Item statistics

All of 565 pregnant women in third trimester completed the questionnaires, and there were no missing values. Average value for each item of BCS varied between 2.989 ~ 4.520, all items had no floor effect and some items had ceiling effects. The distribution of all items' options was less than 80%. The coefficient of variation of the items was between 0.16 and 0.37 and in critical ration all items had statistical significance (P 0.05) except item 6. The correlation coefficient between the items and the BCS score was between 0.366 to 0.805 and Cronbach 's alpha if item deleted coefficient was between 0.967 to 0.969 with the exception of item 6 (see Table 1).

Table 1
Item statistics results of the draft Breastfeeding Competency Scale (44 items, n = 565)

Item	Distribution of items' options					Coefficient of Variation			critical ration	Cronbach 's alpha if item deleted	correlation coefficient
	1	2	3	4	5	Mean	SD	CV	t		
1	11	28	175	215	136	3.773	0.935	0.25	16.576**	0.968	0.642**
2	12	26	96	245	186	4.004	0.936	0.23	18.361**	0.968	0.673**
3	15	39	96	214	201	3.968	1.021	0.26	23.117**	0.967	0.769**
4	11	25	97	237	195	4.027	0.933	0.23	14.742**	0.968	0.630**
5	17	46	192	178	132	3.641	1.021	0.28	15.252**	0.968	0.621**
6	53	129	187	140	56	3.030	1.118	0.37	-0.244	0.971	-0.057
7	22	39	125	234	145	3.781	1.029	0.27	7.722**	0.969	0.366**
8	18	68	179	168	132	3.581	1.070	0.30	21.340**	0.968	0.728**
9	12	1	16	188	348	4.520	0.757	0.17	8.124**	0.969	0.388**
10	14	50	231	179	91	3.501	0.948	0.27	20.439**	0.967	0.761**
11	10	52	243	176	84	3.481	0.916	0.26	21.720**	0.967	0.790**
12	21	47	126	236	135	3.738	1.031	0.28	24.655**	0.967	0.778**
13	20	49	127	237	132	3.729	1.026	0.28	23.030**	0.967	0.766**
14	23	38	97	247	160	3.855	1.035	0.27	21.554**	0.968	0.741**
15	8	22	114	244	177	3.991	0.894	0.22	17.734**	0.968	0.727**
16	8	25	170	227	135	3.807	0.899	0.24	20.049**	0.968	0.751**
17	13	67	224	158	103	3.480	0.996	0.29	25.485**	0.967	0.805**
18	5	2	45	281	232	4.297	0.705	0.16	13.685**	0.968	0.553**
19	11	45	121	233	155	3.843	0.979	0.25	17.867**	0.968	0.697**
20	21	68	287	124	65	3.255	0.941	0.29	12.033**	0.968	0.570**

Note.*P0.05,**P0.001

SD = Standard Deviation.

CV = Coefficient of Variance.

Item	Distribution of items' options					Coefficient of Variation			critical ration	Cronbach 's alpha if item deleted	correlation coefficient
	1	2	3	4	5	Mean	SD	CV	t		
21	21	68	271	135	70	3.292	0.959	0.29	20.256**	0.967	0.792**
22	5	17	176	245	122	3.818	0.834	0.22	19.796**	0.968	0.729**
23	8	61	239	167	90	3.478	0.933	0.27	20.321**	0.967	0.761**
24	14	67	252	156	76	3.377	0.944	0.28	18.901**	0.968	0.728**
25	10	48	168	236	103	3.662	0.931	0.25	21.979**	0.968	0.748**
26	12	71	194	185	103	3.524	0.997	0.28	20.409**	0.968	0.739**
27	24	131	272	86	52	3.020	0.961	0.32	14.615**	0.968	0.649**
28	17	82	247	150	69	3.304	0.964	0.29	19.381**	0.968	0.726**
29	18	76	211	164	96	3.432	1.023	0.30	19.831**	0.968	0.740**
30	10	57	214	185	99	3.542	0.953	0.27	19.284**	0.968	0.710**
31	22	77	221	164	81	3.363	1.013	0.30	15.592**	0.968	0.635**
32	35	155	210	111	54	2.989	1.050	0.35	8.153**	0.969	0.442**
33	17	54	189	200	105	3.570	0.995	0.28	19.029**	0.968	0.716**
34	10	21	143	232	159	3.901	0.913	0.23	20.069**	0.968	0.745**
35	5	28	166	239	127	3.805	0.872	0.23	24.512**	0.967	0.788**
36	4	6	93	278	184	4.119	0.764	0.19	17.073**	0.968	0.662**
37	14	34	154	215	148	3.795	0.979	0.26	22.638**	0.967	0.754**
38	28	75	215	159	88	3.361	1.052	0.31	13.999**	0.968	0.606**
39	6	4	103	262	190	4.108	0.795	0.19	15.530**	0.968	0.638**
40	8	6	65	248	238	4.243	0.805	0.19	12.757**	0.968	0.580**
41	12	44	104	213	192	3.936	1.012	0.26	11.438**	0.969	0.492**

Note.*P0.05,**P0.001

SD = Standard Deviation.

CV = Coefficient of Variance.

Item	Distribution of items' options					Coefficient of Variation			critical ration	Cronbach 's alpha if item deleted	correlation coefficient
	1	2	3	4	5	Mean	SD	CV	t		
42	4	8	54	230	269	4.331	0.764	0.18	12.409**	0.968	0.510**
43	26	73	256	126	84	3.300	1.021	0.31	20.912**	0.967	0.775**
44	10	5	84	226	240	4.205	0.853	0.20	10.717**	0.969	0.490**
Note.*P0.05,**P0.001											
SD = Standard Deviation.											
CV = Coefficient of Variance.											

Factor Analysis

A total of 3 rounds of factor analysis were performed and identified 4 factors with eigenvalues1.0. In the first round, factor loadings of items 6, 7, 180.5 in the rotated factor solution and item 9 exists in a single dimension. The second round of factor analysis was performed after 4 items were deleted. After the second round of deleting the items 19, 35 which factor loading was less than 0.5, the third round of factor analysis was performed. In the third round of factor analysis, factor loading of all items were shown good psychometric properties. The excluded items considered including “6 I would not use pacifier during lactation. ”, “7 I would not wear breast-patches or bras during lactation. ”, “9 I would avoid bad habits during lactation. ”, “18 I would keep my breasts clean and dry. ”, “19 I would ask galactagogue division for help for breast pain ”, “35 I know how to strengthen my attachment relationship with baby.”.

Factor structure

The KMO (Kaiser-Meyer-Olkin) coefficient of this sample was 0.968 and the approximate chi-square^2 of the Bartlett`s test was 18525.221 (P< 0.05), which was indicated the sample suitable for EFA. Scree plot showed a curve that levelled off at factor number 4 with corresponding eigenvalue > 1 (see Fig. 1). Four factors were identified and explained 66.489% of the total variance. Factor 1 contained 15 items and was named “breastfeeding knowledge,” with factor loadings between 0.599 and 0.818. Factor 2 contained 11 items and was named “breastfeeding skill,” with factor loadings between 0.649 and 0.807. Factor 3 contained 4 items and was named “management of breast-milk,” with factor loadings between 0.558 and 0.764. Factor 4 contained 8 items and was named “self-concept and psychology,” with factor loadings between 0.586 and 0.774(see Table 2). The correlation between BCS (38 items) and the four factors is as follows: r_1 (BCS and factor 1 (breastfeeding knowledge)) = 0.913, r_2(BCS and factor 2 (breastfeeding skill)) = 0.874, r_3(BCS and factor 3 (management of breast-milk)) = 0.771, r_4(BCS and factor 4 (self-concept and psychology)) = 0.799 (P< 0.001).

Table 2
Rotated component matrixa results in exploratory factor analysis for BCS (n = 565)

Item	Factor 1 Breastfeeding Knowledge	Factor 2 Breastfeeding Skill	Factor 3 Self-concept and Psychology	Factor 4 Management of Breast-milk
1	.624	.195	.240	.104
2	.732	.210	.202	.025
3	.760	.298	.210	.114
4	.618	.292	.100	.117
5	.637	.170	.109	.213
8	.732	.168	.287	.133
10	.712	.162	.476	.038
11	.694	.179	.505	.091
12	.818	.126	.203	.290
13	.817	.123	.197	.274
14	.794	.144	.148	.277
15	.695	.301	.158	.180
16	.724	.287	.203	.167
17	.673	.220	.399	.246
20	.131	.667	.212	.146
21	.372	.212	.665	.411
22	.320	.391	.635	.107
23	.418	.193	.737	.186
24	.295	.188	.774	.269
25	.301	.276	.659	.315
26	.235	.720	.283	.270
27	.259	.105	.595	.442
28	.299	.200	.586	.466
29	.337	.181	.613	.439
30	.330	.250	.292	.664
31	.271	.129	.260	.764

Item	Factor 1 Breastfeeding Knowledge	Factor 2 Breastfeeding Skill	Factor 3 Self-concept and Psychology	Factor 4 Management of Breast-milk
32	.128	.092	.237	.558
33	.304	.246	.369	.626
34	.293	.694	.225	.296
36	.237	.650	.171	.289
37	.322	.655	.244	.301
38	.219	.649	.134	.222
39	.230	.728	.067	.252
40	.161	.807	.103	.062
41	.162	.759	.039	− .044
42	.132	.754	.109	− .021
43	.599	.257	.332	.333
44	.144	.748	.106	− .097

Reliability

The Cronbach's *α* coefficient for the BCS was 0.970, and the four factors were 0.960, 0.940, 0.822, 0.931 respectively. The Spearman-Brown split-half reliability of the scale was 0.894, and the Guttman split-half reliability was 0.890. These results showed that the scale had certain reliability.

Validity

The four-factor model identified in the factors structure was tested in the sample 2 using confirmatory factor analysis to determine validity and appropriateness. The fit indices indicated four-factor model fit the data well ($\chi 2 = 898.152(P > 0.05)$, $\chi 2/df = 1.363$, RMSEA = 0.039) except for GFI, RFI, NFI, and AGFI (see Table 3). Some indices (GFI = 0.838, AGFI = 0.817, NFI = 0.879, RFI = 0.871) did not align with the expected study results, but they were close to the cutoff values, that was acceptable. And RMSEA is align with the expectation which is considered worthier as an appropriate index[43] (see Table 3 and Fig. 2).

Table 3
Appropriate indices of model for CFA (n = 224)

Absolute Fit Indexs	result	Incremental Fit Indexs	result	Simplicial Fit Indexs	result
χ^2	898.152	NFI	0.879	χ^2/df	1.363
RMR	0.043	RFI	0.871	PGFI	0.745
RMSEA	0.039	IFI	0.965	PNFI	0.824
GFI	0.838	NNFI/TLI	0.962	PCFI	0.904
AGFI	0.817	CFI	0.964	CN	202
Note. χ^2 = Chi-square goodness of fit statistic.					
RMR = Square root mean residual					
RMSEA = Root-mean-square Error of Approximation.					
GFI = Goodness-of-fit Index.					
AGFI = Adjusted goodness-of-fit index.					
NFI = Normed Fit Index.					
RFI = Relative fit index.					
IFI = Incremental fit index.					
TLI = Tucker Lewis Index.					
CFI = Comparative Fit Index.					
df = Degrees of freedom.					
PGFI = Parsimonious goodness-of-fit Index.					
PNFI = Parsimonious normed Fit Index.					
PCFI = Parsimonious comparative Fit Index.					
CN = Critical N.					

Discussion

The purpose of this study is to construct and evaluate the Breastfeeding Competency Scale (BCS) according to the competency iceberg model. The result showed that BCS with 38 items and 4 factors achieved satisfactory reliability and validity, which can be used to evaluate the breastfeeding competency of pregnant women.

Previous studies have designed different scales to predict breastfeeding behavior from different aspects which mainly assess the aspects of breastfeeding psychology and support systems. Different scales

containing some common factors or items because of the same predictive content. There was differences in the scope of the scale or the assessment population due to different theoretical frameworks. There were such existing various scales to assess breastfeeding effectiveness, breastfeeding attitudes, and social support. However, it is still necessary to make scales to assess the breastfeeding competency. In order to ensure the comprehensiveness, qualitative study of lactating women and Delphi method research were carried out which were on the basis of competency iceberg model. Strict psychological measurements were performed on scale abiding by the scientific process.

BCS showed high and effective response rate in the part of data collection, indicating that the items should be understood easily. The results also indicated that pregnant women had a high degree of interest in this research. Previous research found that pregnant women might obtain incorrect breastfeeding knowledge, skill, and cognition due to errors and false information from the internet[49]. As a result, pregnant women tended to choose "fit" when completing the BCS. The ceiling effect and floor effect should not appeared in the study of the instrument development but in this study, the ceiling effect is unavoidable[50]. Some BCS items had a ceiling effect due to pregnant women`s wrong concept or misunderstanding of breastfeeding competency. However, the selection rate of each option from items was < 80%, indicated that all items on BCS have the ability to distinguish between high breastfeeding competency from the average[42].

Factor analysis showed that BCS is a multidimensional assessment scale composing of 4 factors, which was the same as the results of qualitative study and Delphi method of breastfeeding competency[39]. The four factors included "breastfeeding knowledge", " breastfeeding skill", "management of breast-milk" and "self-concept and psychology". In the above results, the "breastfeeding skill" focuses on the related skills on themselves or the newborn during the breastfeeding process, while the "management of breast-milk" focuses on the related skills and management on the extra breast-milk before and after the breastfeeding process, which is different from the "breastfeeding skill". Therefore, the results of the factor structure in this study showed that " management of breast-milk" was separated from " breastfeeding skill" and became an independent factor.

The internal consistency and split-half reliability of the BCS and 4 factors are within the psychological instrument development criteria, indicated that the BCS had high reliability and could be considered as a good assessment scale[46].

Although quality control was strictly applied throughout the whole study process, certain limitations need to be considered. First limitation of this study is the geographical difference. Breastfeeding rates and behaviors are different from geography, races and culture[2]. So the participants might not be representative of the whole Chinese population of pregnant women, it could only be represented the situation of the two provincial general hospitals selected in Jinan, Shandong, China. Usually a larger number of pregnant women at different risk levels paid regular hospital visit at provincial general hospitals. Therefore, the researchers limited participants to provincial general hospitals rather than community hospitals. Second limitation of this study is that the competency is a dynamic process. Sufficient amount of data could not be collected in a short period of time. But the third trimester of pregnant is a relatively stable stage of breastfeeding competency where pregnant women have been exposed to a certain amount of

breastfeeding-related knowledge. Choosing the third trimester of pregnant as inclusion criteria could alleviate the bias caused by dynamic process of breastfeeding competency. In the further study, the number of participants should be expanded to evaluate the reliability and validity of BCS.

Conclusions

This study developed a breastfeeding competency scale(BCS) whose theoretical basis was the competency iceberg model to evaluate the breastfeeding capacity of pregnant women in the third trimester. The BCS including 38 items showed trustworthy psychometric properties and could be applied as a supplementary assessment scale to predict breastfeeding behaviors. The BCS also could be a reference or assessment scale to develop early intervention of pregnant women's breastfeeding competency for promoting effective breastfeeding behaviors and making earlier and longer breastfeeding.

Abbreviations

BCS: Breastfeeding Competency Scale; BSES: Breastfeeding Self-Efficacy Energy Scale; IBCLC: International board certified lactation consultant; SD: Standard deviations; CV: Coefficient of variation; CR: Critical ratio; KMO: Kaiser-Meyer-Olkin; EFA: Exploratory Factor Analysis; $\chi 2$ = Chi-square goodness of fit statistic; RMR = Square root mean residual; RMSEA = Root-mean-square Error of Approximation; GFI = Goodness-of-fit Index; AGFI = Adjusted goodness-of-fit index; NFI = Normed Fit Index; RFI = Relative fit index; IFI = Incremental fit index; TLI = Tucker Lewis Index; CFI = Comparative Fit Index; *df* = Degrees of freedom; PGFI = Parsimonious goodness-of-fit Index; PNFI = Parsimonious normed Fit Index; PCFI = Parsimonious comparative Fit Index; CN = Critical N.

Declarations

Ethics approval and consent to participate

This study obtained the approval from the Medical Ethics Committee of Weifang Medical University(2019SL060) and the consent from the ethnic committee of two IRBs of hospitals. Two IRBs are the Shandong Qianfoshan Hospital IRB and Affiliated Hospital of Weifang Medical University IRB. Written informed consents in the top of questionnaires were obtained from the all participants and their personal information was kept strictly confidential.

Consent for publication

Not applicable.

Availability of data and materials

The data analyzed in this study are not publicly available due to privacy policy, but are available from the corresponding author on reasonable request. For further information about data access, please contact to the corresponding author, Aihua Wang by email.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

YWU, YWANG, AW and YL designed the study; YWU, YD and QT acquired the data; YWU, ZY and JH analysed the data; YWU, YWANG, AW and YL interpreted the data; YWU, YWANG and JH drafted this manuscript; and YWU, XQ, QT, RM and YL provided critical intellectual feedback to help revise the manuscript. All authors have read and approved the final manuscript.

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References

1. WHO. **Protecting, promoting and supporting breastfeeding in facilities providing maternity and newborn services**. https://apps.who.int/iris/bitstream/handle/10665/259386/9789241550086-eng.pdf;jsessionid=D79466E84E2D6536428026177143AFFD?sequence=1. Accessed 2017.
2. Victora CG, Bahl R, Barros AJ, Franca GV, Horton S, Krasevec J, Murch S, Sankar MJ, Walker N, Rollins NC. Breastfeeding in the 21st century: epidemiology, mechanisms, and lifelong effect. Lancet. 2016;387(10017):475–90.
3. Stenberg K, Axelson H, Sheehan P, Anderson I, Gulmezoglu AM, Temmerman M, Mason E, Friedman HS, Bhutta ZA, Lawn JE, et al. Advancing social and economic development by investing in women's and children's health: a new Global Investment Framework. Lancet. 2014;383(9925):1333–54.
4. Das GM, Engelman R, Levy J, Luchsinger G, Merrick T, Rosen JE: **State of world population 2014**. **The power of 1**.**8 billion**. **Adolescents youth and the transformation of the future**. *New York, New York, United Nations Population Fund [UNFPA], 2014 Jan* 2014, **39**.
5. Spaeth A, Zemp E, Merten S, Dratva J. **Baby-Friendly Hospital designation has a sustained impact on continued breastfeeding**. *Maternal & child nutrition* 2018, 14(1).
6. Ahmed KY, Page A, Arora A, Ogbo FA: **Trends and determinants of early initiation of breastfeeding and exclusive breastfeeding in Ethiopia from** 2000 **to 2016**. *International breastfeeding journal* 2019, **14**:40.

7. WHO. **Feeding and Nutrition of Infants and Young Children**. http://www.euro.who.int/__data/assets/pdf_file/0004/98302/WS_115_2000FE.pdf. [Accessed 2003].
8. De Roza MJG, Fong MMK, Ang MBL, Sadon MRB, Koh M, Teo M. Exclusive breastfeeding, breastfeeding self-efficacy and perception of milk supply among mothers in Singapore: A longitudinal study. Midwifery. 2019;79:102532.
9. Ip S, Chung M, Raman G, Chew P, Magula N, DeVine D, Trikalinos T, Lau J. **Breastfeeding and maternal and infant health outcomes in developed countries**. *Evidence report/technology assessment* 2007(153):1–186.
10. Amitay EL, Keinan-Boker L. Breastfeeding and Childhood Leukemia Incidence: A Meta-analysis and Systematic Review. JAMA pediatrics. 2015;169(6):e151025.
11. Peres KG, Cascaes AM, Nascimento GG, Victora CG: **Effect of breastfeeding on malocclusions: a systematic review and meta-analysis**. *Acta paediatrica (Oslo, Norway*: 1992) 2015, **104**(467):54–61.
12. Victora CG, Horta BL, Loret de Mola C, Quevedo L, Pinheiro RT, Gigante DP, Goncalves H, Barros FC. Association between breastfeeding and intelligence, educational attainment, and income at 30 years of age: a prospective birth cohort study from Brazil. The Lancet Global health. 2015;3(4):e199–205.
13. Horta BL, Loret de Mola C, Victora CG. Long-term consequences of breastfeeding on cholesterol, obesity, systolic blood pressure and type 2 diabetes: a systematic review and meta-analysis. Acta paediatrica (Oslo Norway: 1992). 2015;104(467):30–7.
14. Rollins NC, Bhandari N, Hajeebhoy N, Horton S, Lutter CK, Martines JC, Piwoz EG, Richter LM, Victora CG. Why invest, and what it will take to improve breastfeeding practices? Lancet. 2016;387(10017):491–504.
15. Oshio T, Kan M. Preventive impact of social participation on the onset of non-communicable diseases among middle-aged adults: A 10-wave hazards-model analysis in Japan. Preventive medicine. 2018;118:272–8.
16. Dias CC, Figueiredo B. Breastfeeding and depression: a systematic review of the literature. J Affect Disord. 2015;171:142–54.
17. Black RE, Victora CG, Walker SP, Bhutta ZA, Christian P, de Onis M, Ezzati M, Grantham-McGregor S, Katz J, Martorell R, et al. Maternal and child undernutrition and overweight in low-income and middle-income countries. Lancet. 2013;382(9890):427–51.
18. WHO. **Capture the Moment: Early initiation of breastfeeding – the best start for every newborn**. https://www.unicef.org/press-releases/3-5-babies-not-breastfed-first-hour-life. Accessed 30 July 2018.
19. Tableau Public UaW. **Rates of Exclusive Breastfeeding at 0–5 Months**. https://public.tableau.com/profile/gbc2364#!/vizhome/GBC_Global_Indicators/GLOBALINDICATORS?publish=yes2019. Accessed 1 August 2019.
20. Weinert FE. **Competencies and Key Competencies: Educational Perspective**. *International Encyclopedia of the Social & Behavioral Sciences* 2001:2433–2436.
21. Prahalad CK, Hamel G. **The Core Competence of the Corporation**; 2000.
22. Peng D: [**General Psychology**(**Revised Edition**)]: Beijing Normal University Publishing Group; 2004.

23. Holmgren T, Lee AHX, Hocaloski S, Hamilton LJ, Hellsing I, Elliott S, Hultling C, Krassioukov AV. The Influence of Spinal Cord Injury on Breastfeeding Ability and Behavior. Journal of human lactation: official journal of International Lactation Consultant Association. 2018;34(3):556–65.
24. General Office of the State Council of the People's Republic of China. **National Nutrition Plan**. (2017–**2030**). http://www.gov.cn/xinwen/2017-07/13/content_5210199.htm. Accessed 13 July 2017.
25. General Office of the State Council of the People's Republic of China. **The 13th Five-Year Plan for Hygiene and Health of the People's Republic of China**. http://www.gov.cn/zhengce/content/2017-01/10/content_5158488.htm. Accessed 10 January 2017.
26. Lawton R, Ashley L, Dawson S, Waiblinger D, Conner M. Employing an extended Theory of Planned Behaviour to predict breastfeeding intention, initiation, and maintenance in White British and South-Asian mothers living in Bradford. Br J Health Psychol. 2012;17(4):854–71.
27. DiGirolamo A, Thompson N, Martorell R, Fein S, Grummer-Strawn L. Intention or experience? Predictors of continued breastfeeding. Health education behavior: the official publication of the Society for Public Health Education. 2005;32(2):208–26.
28. Cattaneo A. Academy of breastfeeding medicine founder's lecture 2011: inequalities and inequities in breastfeeding: an international perspective. Breastfeeding medicine: the official journal of the Academy of Breastfeeding Medicine. 2012;7(1):3–9.
29. McAllister H, Bradshaw S, Ross-Adjie G. A study of in-hospital midwifery practices that affect breastfeeding outcomes. Breastfeeding review: professional publication of the Nursing Mothers' Association of Australia. 2009;17(3):11–5.
30. McClelland CD. Testing for competence rather than for "intelligence". Am Psychol. 1973;28(1):1–14.
31. DA H. LM S: Competencies:the right foundation for effective human resources management. Compensation Benefits Review. 1996;28(6):54–5.
32. Michibayashi C, Omote S, Nakamura M, Okamoto R, Nakada AI. Competency model for public health nurses working on tobacco control in local governments in Japan: A qualitative study. Japan journal of nursing science: JJNS. 2020;17(1):e12288.
33. Gardner G, Carryer J, Gardner A, Dunn S. Nurse Practitioner competency standards: findings from collaborative Australian and New Zealand research. International journal of nursing studies. 2006;43(5):601–10.
34. Supamanee T, Krairiksh M, Singhakhumfu L, Turale S. Preliminary clinical nursing leadership competency model: a qualitative study from Thailand. Nurs Health Sci. 2011;13(4):433–9.
35. Wang X, Zhang L. [Application of ability-quality iceberg model on nursing safety management in pediatric department]. Chinese Journal of Modern Nursing. 2016;22(21):3076–9.
36. Ma C. **[Construction of elderly caring ability framework based on competency iceberg model]**. *Contemporary Vocational Education* 2016(12):81–83.
37. Dennis CL. Theoretical underpinnings of breastfeeding confidence: a self-efficacy framework. Journal of human lactation: official journal of International Lactation Consultant Association. 1999;15(3):195–201.

38. Zhao M: [**Factors Associated with Breastfeeding Self-Efficacy among Beijing New Mothers**]. Peking Union Medical College; 2008.
39. Wu Y, Li Y, Wang Y, Zhang Y, Liu Z, Wang A. [Construction of breastfeeding ability framework based on competency iceberg model]. Journal of Nurses Training. 2019;34(13):1162–5.
40. P MA, L NR, J.J. S: **Making Sense of Factor Analysis**: **The Use of Factor Analysis for Instrument Development in Health Care Research**. Sage Publications Inc.,USA; 2003.
41. Terwee CB, Bot SD, de Boer MR, van der Windt DA, Knol DL, Dekker J, Bouter LM, de Vet HC. Quality criteria were proposed for measurement properties of health status questionnaires. J Clin Epidemiol. 2007;60(1):34–42.
42. Yi K, Ding S, Zhong Z, Xie J, Qin C, Zheng F. [Translation, revision and assessment of reliability and validity of the Individualized Care Scale-Patient Version]. Chinese Journal of Nursing. 2017;52(03):373–6.
43. Yuan J, Zhang Y, Xu T, Zhang H, Lu Z, Yang X, Hu M, Yu L, Yu L, Jiang X, et al. Development and Preliminary Evaluation of Chinese Preschoolers' Caregivers' Feeding Behavior Scale. Journal of the Academy of Nutrition Dietetics. 2019;119(11):1890–902.
44. Xia HZ, Gao L, Wang Y, Song H, Shi BX. **Development of the Chinese version of Meaning in Life Scale for cancer patients and psychometric evaluation**. *Journal of clinical nursing* 2017, **26**(21–22):3298–3304.
45. LJ C: **Coefficient Alpha and the internal structure of tests**. *Psychometrik* 1951, 16(3):297–334.
46. Liu YQ, Yu Y, Bai JB, Chen XL. Development and psychometric properties of the maternal health needs scale in Chinese maternal women. Midwifery. 2020;81:102588.
47. Ferrer-Marquez M, Espinola-Cortes N, Reina-Duarte A, Granero-Molina J, Fernandez-Sola C, Hernandez-Padilla JM. Design and Psychometric Evaluation of the Quality of Life in Patients With Anal Fistula Questionnaire. Dis Colon Rectum. 2017;60(10):1083–91.
48. Wu M: **Structural equation model**: **AMOS operation and application**: Chongqing University Press; 2010.
49. Chezem J, Friesen C, Boettcher J. Breastfeeding knowledge, breastfeeding confidence, and infant feeding plans: effects on actual feeding practices. J Obstet Gynecol Neonatal Nurs. 2003;32(1):40–7.
50. Streiner DL, Norman GR: **HEALTH MEASUREMENT SCALES**: **A practical guide to their development and use**. *Journal of Epidemiology & Community Health* 2015, **47**(5):484.e481-484.e481.

Figures

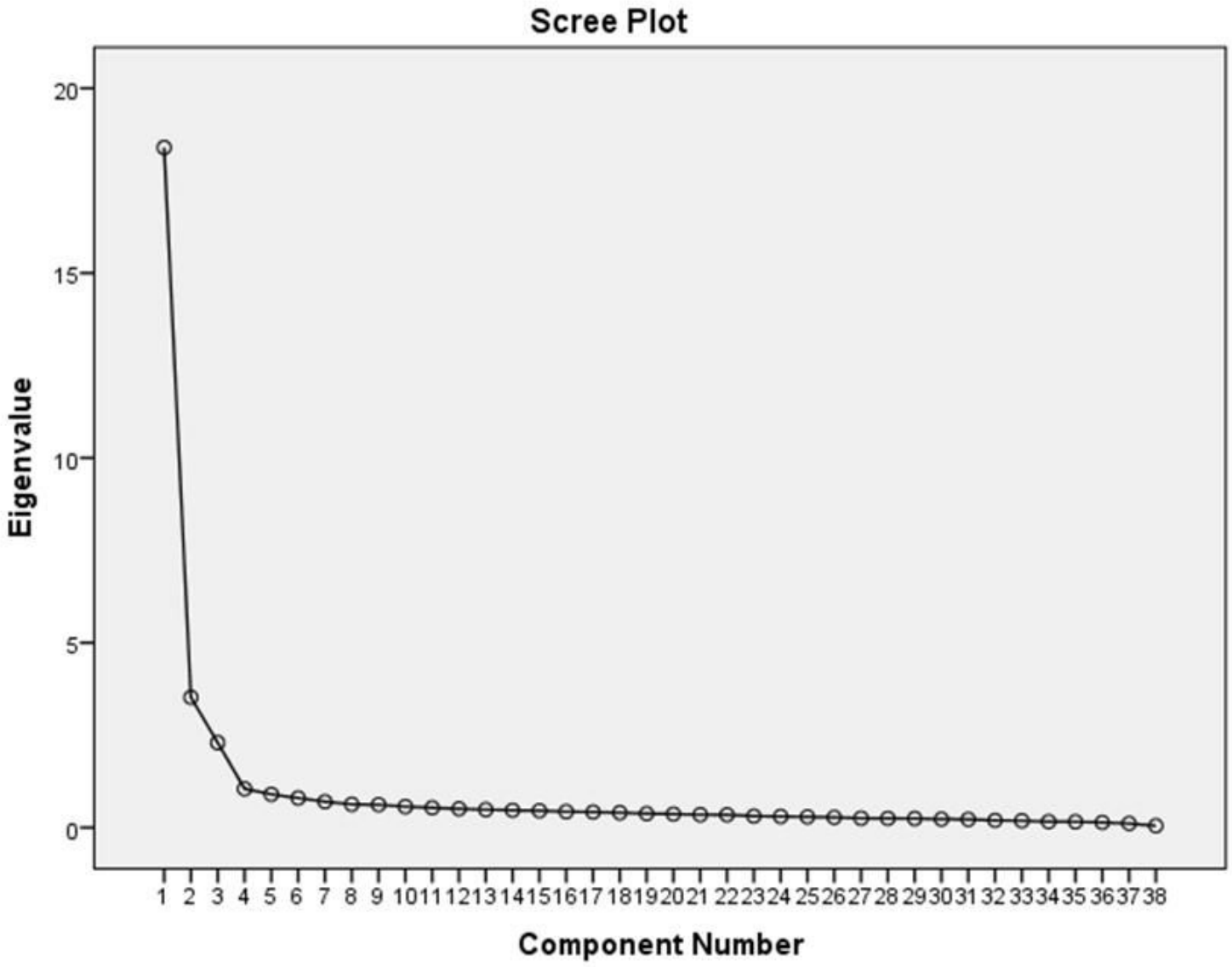

Figure 1

Scree plot showing cut-off point for scale factors (n = 565).

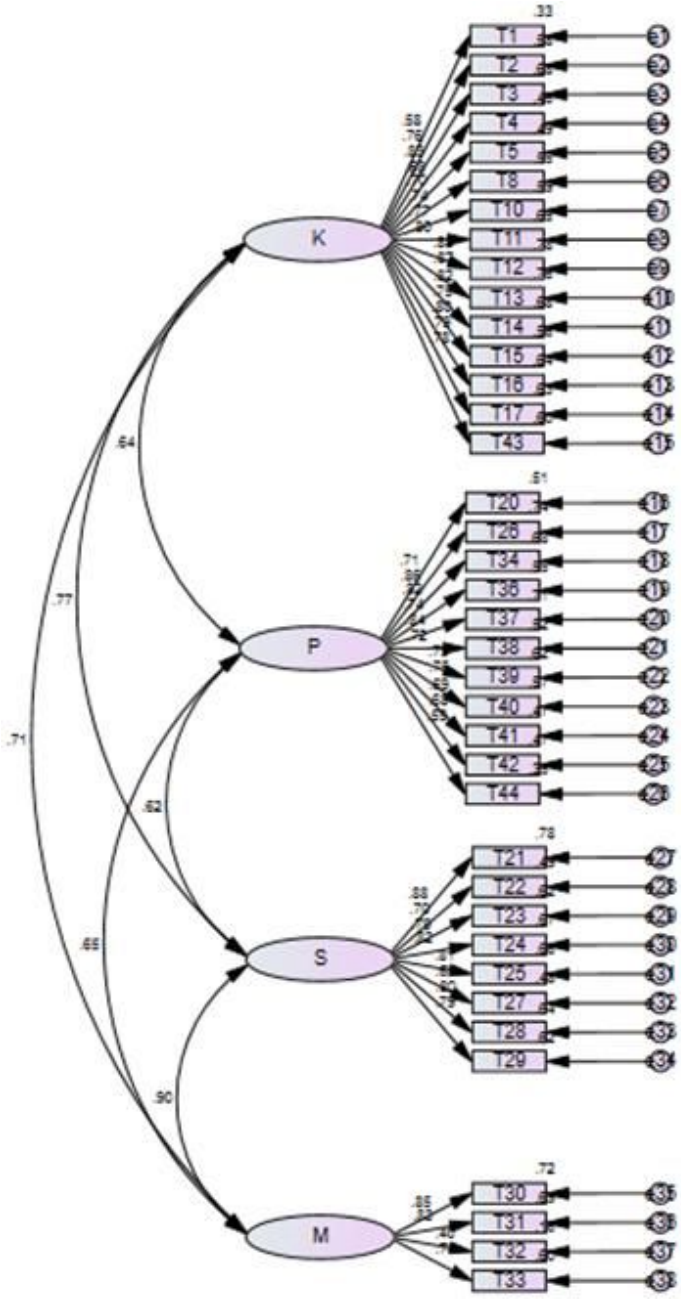

Figure 2

CFA standardised item loadings and factor correlations for Breastfeeding Competency Scale (BCS; n = 244; p<0.001).

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- TheEnglishlanguageversionandsourceofBCS.docx
- STROBEchecklist.doc