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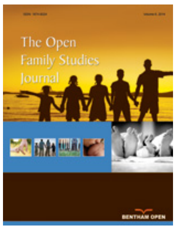

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RESEARCH ARTICLE

The Edinburgh Postnatal Depression Scale: Model Comparison of Factor Structure and its Psychosocial Correlates Among Mothers at One Month After Childbirth in Japan

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Abstract:

Background:

The Edinburgh Postnatal Depression Scale (EPDS; Cox, Holden & Sagovsky, 1987) has been widely used as a screening instrument. It is also used as a measure of Postnatal Depression (PND) severity. Various EPDS factor structure models have been proposed in many studies without an unequivocal conclusion. We compared first-order, higher-order factor, and bifactor models of the EPDS, and examined possible predictors of subscales by Structural Equation Modelling (SEM).

Methods:

Data came from a follow-up study of 758 women after childbirth on two occasions (five days and one month postnatal). We used the EPDS together with items tapping Negative Life Events (NLEs) and coping styles and behaviours.

Results:

The bifactor model showed the best fit with data compared with all other models: CFI = 0.999, RMSEA = 0.14, and AIC = 79.637. A single general dimension alongside three distinct subfactors (anhedonia, anxiety, and dysphoria) was predicted differentially by various predictor variables.

Conclusion:

Our study expanded on a previous factor structural study of the EPDS and developed the hierarchical (bifactor) model. The model's construct validity was confirmed by its meaningful associations with NLEs and coping styles and behaviours.

Keyword: Edinburgh Postnatal Depression Scale, Factor structure, Bifactor model, Negative life events, Coping styles, Screening instrument.

Article History	Received: March 02, 2019	Revised: April 09, 2019	Accepted: April 22, 2019

1. INTRODUCTION

Postnatal depression (PND) is a depressive disorder for which onset is within one month after childbirth [1]. Its prevalence is approximately 13% [2, 3] worldwide and, in Japan, it is approximately 5% [4]. PND is a mental health issue for both women and their children. For example, the prevalence of perinatal women who have thoughts of self-harm is 5–14%, and the prevalence of suicides as the cause of women's death within one year after childbirth reaches 20% [5]. PND also has negative effects on early mother-infant relationships and child development [6, 7]. The child-caring ability of mothers with PND is impaired [8 - 10]. Thus, PND is a major health issue for families.

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As a means of PND screening, many instruments have been developed [11, 12] Among them is the Edinburgh Postnatal Depression Scale (EPDS; Cox, Holden & Sagovsky, 1987) [13], which was translated into multiple languages and evaluated in many countries including Japan [14]. Although the EPDS was developed as a screening instrument with a cut-off point to identify women who are likely to suffer from PND, it has also been used as a measure of PND severity [15 - 19].

Similar to other types of depression, the symptomatology of PND is multifaceted. The number of factors of PND symptomatology differs from one to three in previous studies. Thus, configural invariance remains debatable. For example, a Norwegian study of the EPDS [20] was reported to have a single-component structure by Principal Component Analysis (PCA) in a sample of 411 women at six to 12 weeks postpartum. The French version of the EPDS was also examined by PCA, and a two-component structure was detected in a sample of 87 women in the first four months postpartum [21]. Tuohy *et al*. [22], in a PCA study, reported that the English version of the EPDS had a three-component structure including anhedonia, anxiety, and depression. Similarly, the Vietnamese, Turkish, and Filipino versions of the scale by PCA at six to nine months postpartum were examined and it was reported that these versions of the EPDS had a three-component structure [23]. Previously, PCAs and EFAs that were statistically different [24] were not distinguished and were treated as if they were interchangeable [25]. EFAs are preferable to PCAs because PCAs are the only data reduction method without regard to any underlying structure caused by latent variables [26]. The component calculation is based on using all the variance of the indicators. This is in contrast to the idea of EFAs where researchers analyse data with a Priori theory of internal structures.

Many studies reported that the EPDS had a three-factor structure. Kubota *et al.* [27], in a sample of 690 women at one-month postpartum, used the Japanese version of the EPDS where three factors emerged: anhedonia, anxiety, and depression. Takehara *et al*. [19] re-examined the three-factor structure of the Japanese version of the EPDS reported by Kubota *et al*. [27]. This was a six-time-point study from pregnancy to postpartum in a sample of 1,311 women in Japan. The same three-factor structure was confirmed.

A drawback of EFAs is the choice of the number of factors that are subjectively defined by the researchers. This results in different models of the factor structure. To identify the best factor structure of the EPDS, Confirmatory Factor Analysis (CFA) is necessary.

The model fit of the past investigations of the EPDS CFA studies is presented in Table **1**. The Comparative Fit Index (CFI) ranged from 0.93 to 0.999 and was less than 0.97 approximately half the time. The Root Mean Square Error of Approximation (RMSEA) ranged from 0.00 to 0.10 and it was greater than 0.05 approximately 60% of the time. Therefore, the fit of the factor structure model of the EPDS among the past studies was only modest.

Table 1. The EPDS CFA studies.

References	Country	*N*	Period	Model	Goodness of Fit
Jomeen *et al.* (2007) [76]	UK	148	27–40 GW AN	F1: 1, 2, 8 F2: 3, 4, 5 F3: 10	χ^2 = 28.70, df =13; RMSEA = 0.10; CFI = 0.99; TLI = 0.98
Phillips *et al.* (2009) [77]	Australia	309	0–12 months PN	F1: 1, 2, 6, 7, 8, 9, 10 F2: 3, 4, 5	χ^2 = 20.92, df =8; RMSEA = 0.07; CFI = 0.98; Normed χ^2 = 2.62
Vivilaki *et al.* (2009) [78]	Greece	120	0–16 weeks PN	F1: 7, 8, 9 F2: 4, 5, 6	χ^2 = 9.60, df =8; RMSEA = 0.041; CFI = 0.98; Normed χ^2 = 2.62
Lau *et al.* (2010) [79]	China	300	0–28 GW AN	F1: 1, 2 F2: 3, 4, 5 F3: 6, 7, 8, 9, 10	RMSEA = 0.048; CFI = 0.991; GFI = 0.877; SRMR = 0.0516
Reichenheim *et al.* (2011) [61]	Brazil	811	0–5 months PN	F1: 1, 2, 6 F2: 3, 4, 5 F3: 7, 8, 9, 10 General factor 1-10 bifactor model	RMSEA = 0.026 (90% CI = 0.05–0.41); CFI = 0.997; TLI = 0.995
King *et al.* (2012) [80]	USA	169	1 week–12 months PN	F1: 1, 2 F2: 3, 4, 5 F3: 7, 8, 9, 10	Satorra-Bentler scaled,χ^2 = 21.70, df = 24; RMSEA = 0.00 (90% CI = 0.00–0.06); CFI = 0.98; TLI = 0.97; SRMR = 0.05
Hartley *et al.* (2014) [81]	USA	122	0–10 months PN	F1: 1, 2, 8, 9 F2: 3, 4, 5	χ^2 = 21.02, df = 13; RMSEA = 0.07; CFI = 0.96; SRMR = 0.04
	USA	98		F1: 1, 2, 8, 9 F2: 3, 4, 5	χ^2 = 21.94, df = 13; RMSEA = 0.08; CFI = 0.93; SRMR = 0.05
Kubota *et al.* (2014) [27]	Japan	690 (345 for CFA)	1 month PN	F1: 3, 4, 5 F2: 1, 2 F3: 7, 8, 9	RMSEA=0.092; CFI=0.962; GFI=0.954; AGFI=0.902

(Table 1) contd.....

References	Country	*N*	Period	Model	Goodness of Fit
Töreki *et al.* (2014) [82]	Hungary	266	6 weeks PN	F1: 3, 4, 5, 6 F2: 1, 2, 9, 10	χ^2 = 35.89, df =19; RMSEA = 0.058
Zhong *et al.* (2014) [83]	Peru	1,517	0–16 GW AN	F1: 1, 2 F2: 3, 4, 5, 6 F3: 7, 8, 9, 10	RMSEA=0.034; SRMR=0.022
Cunningham *et al.* (2015) [60]	Australia	478	Admission	F1: 1, 2, 3, 6, 7, 8, 9, 10 F2: 4, 5	χ^2 = 104.713, df = 26; RMSEA = 0.080; CFI = 0.988; TLI = 0.979; SRMR = 0.032
			Discharge	F1: 1, 2 F2: 3, 4, 5 F3: 6, 7, 8, 9, 10	χ^2 = 26.795, df = 18; RMSEA = 0.032; CFI = 0.999; TLI = 0.997; SRMR = 0.016
Odalovic *et al.* (2015) [84]	Australia	76	AN	F1: 3, 4, 5 F2: 7, 9, 10 F3: 1, 2	χ^2 = 47.90; RMSEA = 0.08 (90% CI = 0.02–0.13); CFI = 0.95; TLI = 0.92
		125	0–1 year PN		χ^2 = 389.46; RMSEA = 0.04 (90% CI = 0.00–0.08); CFI = 0.98; TLI = 0.97
Gollan *et al.* (2016) [85]	English	15,172 (10,117 for CFA)	4–6 weeks PN	F1: 1, 2, 6, 7, 8, 9, 10	χ^2 = 1340, df = 14; RMSEA = 0.0968; Standardized Root Mean = 0.0234; Parsimoninous GFI = 0.6418 GFI = 0.9627; Bentler-Bonnet Normed Fit Index = 0.9726
Albuquerque *et al.* (2017) [86]	Brazil	3,891	1–3 months PN	F1: 4, 5, 7, 8, 9, 10	χ^2 = 407.315, df = 9; RMSEA = 0.073; CFI = 0.97; TLI = 0.95; SRMR = 0.030
Coates *et al.* (2017) [87]	UK	12,166	18 GW AN	F1: 1, 2 F2: 3, 4, 5, 6 F3: 7, 8, 9, 10	χ^2 = 729.70, df = 32; RMSEA = 0.052 (90% CI = 0.049–0.055); CFI = 0.97; TLI = 0.94; ParsimoninousCFI = 0.056
		12,110	32 GW AN		χ^2 = 553.67, df = 32; RMSEA = 0.045 (90% CI = 0.042–0.048); CFI = 0.98; TLI = 0.96; ParsimoninousCFI = 0.0569
		11,710	8 weeks PN		χ^2 = 879.50, df = 32; RMSEA = 0.057 (90% CI = 0.054–0.060); CFI = 0.96; TLI = 0.93; ParsimoninousCFI = 0.0559
		11,195	8 months PN		χ^2 = 762.51, df = 32; RMSEA = 0.053 (90% CI = 0.050–0.056); CFI = 0.97; TLI = 0.95; ParsimoninousCFI = 0.0563;
Kozinszky *et al.* (2017) [88]	Hungary	2,967	12–30 GW AN	F1: 1, 2 F2: 4. 5 F3: 8, 9	RMSEA = 0.009; CFI= 0.999; TLI= 0.998
		714	6 weeks PN	F1: 1, 2 F2: 4, 5 F3: 3, 6, 10	RMSEA = 0.060; CFI= 0.965; TLI= 0.912
Kubota *et al.* (2018) [89]	Japan	771	Early pregnancy (25.1 [SD 7.1] weeks)	F1: 7, 9 F2: 4, 5 F3: 1, 2	χ^2 = 7.694, df = 6; CFI = 0.999; RMSEA = 0.01
			Late Pregnancy (36.2 [SD 1.0] week)		χ^2 = 19.824, df = 6; CFI = 0.990; RMSEA = 0.025
			5 days PN		χ^2 = 8.151, df = 6; CFI = 0.999; RMSEA = 0.011
			1 month PN		χ^2 = 6.791, df = 6; CFI = 0.999; RMSEA = 0.007

AGFI, Adjusted Goodness of Fit Index; AN, Antenatal; CFI, Comparative Fit Index; df, Degrees of Freedom; GFI, Goodness-of-Fit Index; GW, Gestation Week; PN, Postnatal; RMSEA, Root Mean Square Error of Approximation; SRMR, Standardised Root Mean Square Residual; TLI=Tucker-Lewis Index

This may mean that a simple first-order one-factor model of the EPDS factor structure did not necessarily represent the real picture of the item structure. Little has been argued regarding whether a higher order (or hierarchical) structure of PND exists. For example, in addition to subscales of PND including anhedonia, anxiety, and depression, we may expect a general factor of PND severity. This echoes the general factor of intelligence [28].

In EFAs, the number of factors ranges between one and the number of items of the instrument. Thus, in the EPDS that consisted of 10 items, the number of factors in EFAs could range between one and 10. We compare in CFAs different factor structure models derived from EFAs. A single-factor model is the most parsimonious model (Fig. **1**). This model predicts that individual differences in all the EPDS items are caused by individual differences in only one common latent factor. The influence of this general factor is represented by a factor loading that is depicted in the figure as a single-headed arrow. A single factor model has the greatest number of *df*. When the single-factor model does not fit the data satisfactorily, we should consider a first-order factor model with more than one latent factor; for example, a two-factor model. In this model, each EPDS item is considered to be influenced by one of the first-order factors (Figs. **2** and **3**). In a two-factor model of the EPDS, for example, items 1 and 2 are influenced only by the second factor, whereas the other eight items are influenced only by the first factor. The first-order factors are considered to be correlated with each other. If all the factor correlations in a first-factor model are fixed to *r*

=1.0, it is equivalent to the single-factor model. Therefore, the former nests the latter. The *df* of a first-order factor model is lower than that of a single-factor model. If χ^2 decreases significantly for the *df* difference, we adopt the first-order model,whereas if χ^2 does not decrease significantly for the *df* difference between the two models, we retain the single-factor model as the best model for the sake of parsimony. This procedure will be continued to a model with a greater number of factors until the χ^2 difference does not reach the significance level.

The difference between single- and first-order factor models lies in the fact that the former focuses on general abilities (*e.g.*, severity of depression), whereas the latter focuses on several specific abilities (*e.g.*, anhedonia, anxiety, and dysphoria among depression symptoms). We consider that the general and specific abilities are located at different levels of the ability hierarchy. Neither model addresses both general and specific abilities simultaneously. When, as is the case of many psychological measurements, the models of a single- or first-factor structure do not satisfactorily fit the data, it is plausible to consider higher-order factor and bifactor models. These models take into account the general and specific abilities in their entirety [28]. In a higher-order factor model (also known as a second-order model or an indirect hierarchical model), as in the single- or first-order factor models, each indicator is influenced by one of the first-order factors. In addition, each first-order factor is influenced by the general factor (Fig. **4**). The shared variance of the higher-order factors is accounted for by the second-order general factor, which is unlikely with the first-order factor models. In other words, the first-order factor model assumes that factors are correlated and that the construct (*e.g.*, postnatal depression) is multidimensional and explained by obliquely related dimensions. In contrast, the second-order model assumes that the factors are uncorrelated and represented by a general depression construct. Therefore, the general factor influences each indicator indirectly *via* first-order factors.

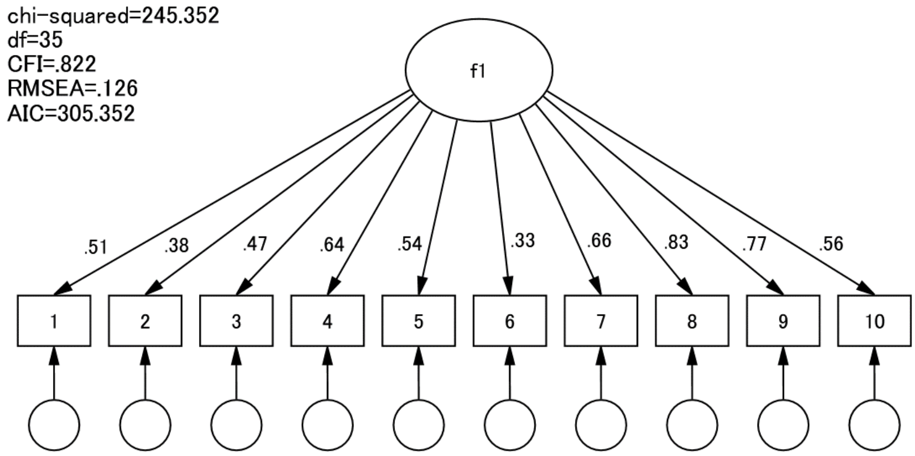

Fig. (1). Single-factor model of the EPDS items.
CFI, Comparative Fit Index; RMSEA, Root Mean Square Error of Approximation; AIC, Akaike Information Criteria. Paths are standardised. The Names of Error Variables are Deleted.

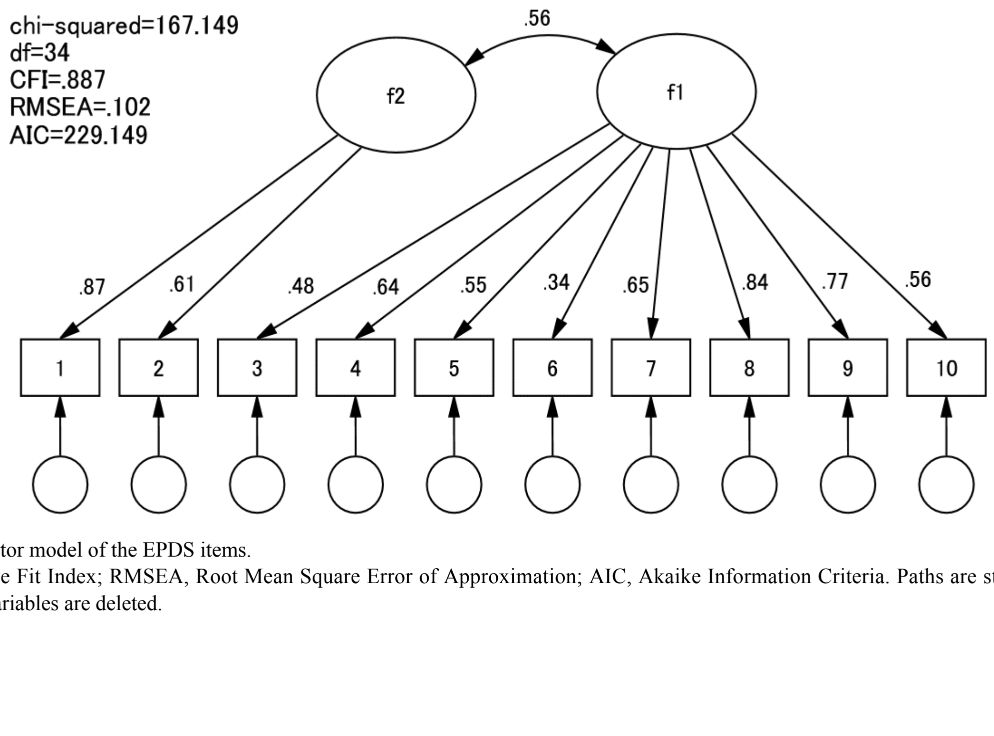

Fig. (2). Two-factor model of the EPDS items.
CFI, Comparative Fit Index; RMSEA, Root Mean Square Error of Approximation; AIC, Akaike Information Criteria. Paths are standardised. The names of error variables are deleted.

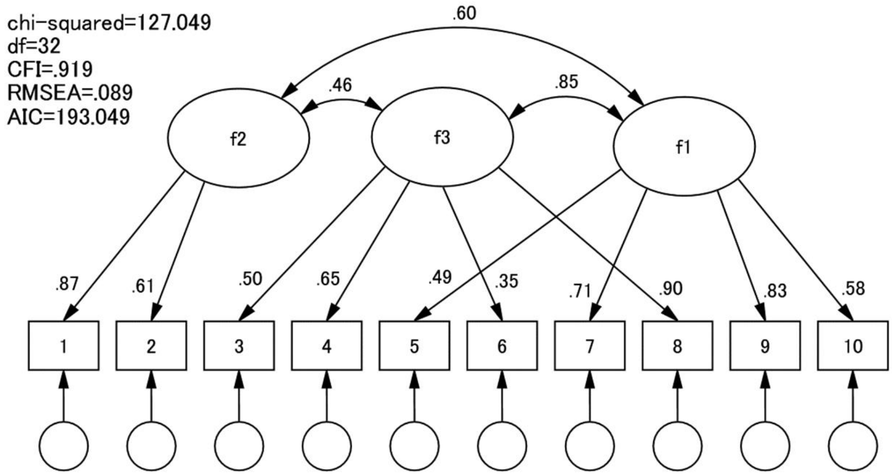

Fig. (3). Three-factor model of the EPDS items.
CFI, Comparative Fit Index; RMSEA, Root Mean Square Error of Approximation; AIC, Akaike Information Criteria. Paths are standardised. The names of error variables are deleted.

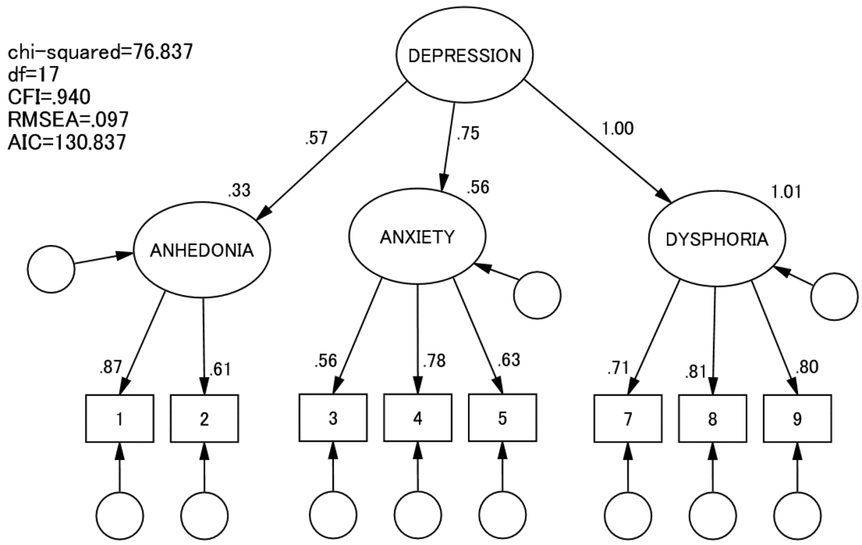

Fig. (4). Second-order factor model of the EPDS items.
CFI, Comparative Fit Index; RMSEA, Root Mean Square Error of Approximation; AIC, Akaike Information Criteria. Paths are standardised. The names of error variables are deleted.

In the bifactor model (also known as a hierarchical factor model or an indirect hierarchical factor model), the general factor influences all the indicators directly but not via the first-order factors (Fig. **5**). The idea is that all the indicators differ according to the general factor, whereas groups of indicators are dependent on each first-factor they belong to independently from the influence of the general factor. Here, the general factor and the first-order factors are independent of each other. For example, an indicator (*e.g.*, "cannot see the funny side of things" is a reflection of a specific aspect (*e.g.*, anhedonia) as well as the general severity (of depression). In our study, we compared different models of EPDS factor structures. We also compared our models with that proposed by Kubota *et al.* [27].

The above argument implies not only statistical precision but also causal as well as consequential issues. For example, even though scores of a subscale were correlated with a possible predictor, it may be a spurious product confounded by the general factor. Such a hypothesis can be examined by Structural Equation Modelling (SEM) where the external variable (a predictor) sends paths to the subscale factors and the general factor (Fig. **6**). Also, the case is the influence of specific and general factors on outcome variables (*e.g.*, parenting difficulties in the case of PND). Our study tries to explore different associations of the factor structure we identify

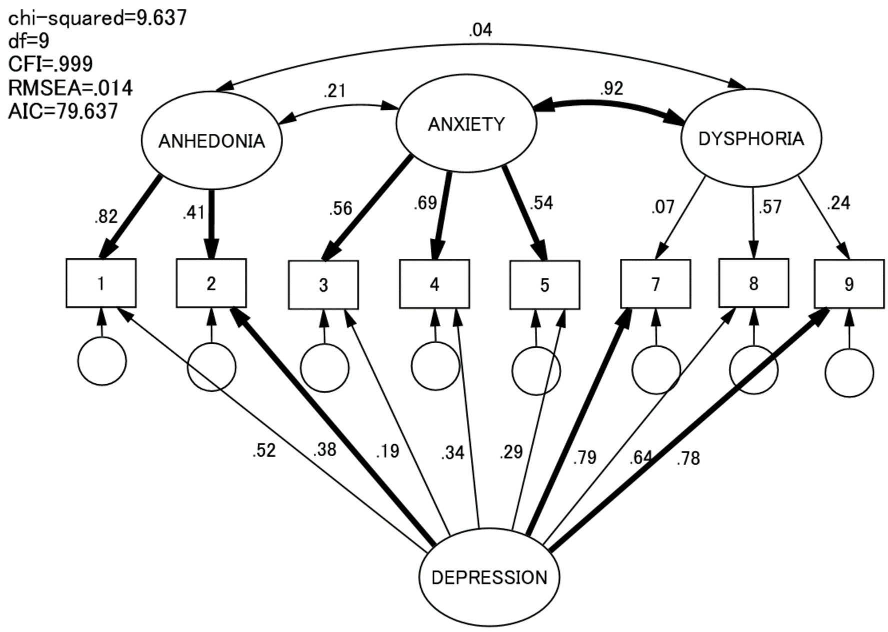

Fig. (5). Bifactor model of the EPDS items.
CFI, comparative fit index; RMSEA, root mean square error of approximation; AIC, Akaike information criteria. Paths are standardised. Significant paths are in bold. The names of error variables are deleted. Paths with significant (p< .05) coefficients are in bold.

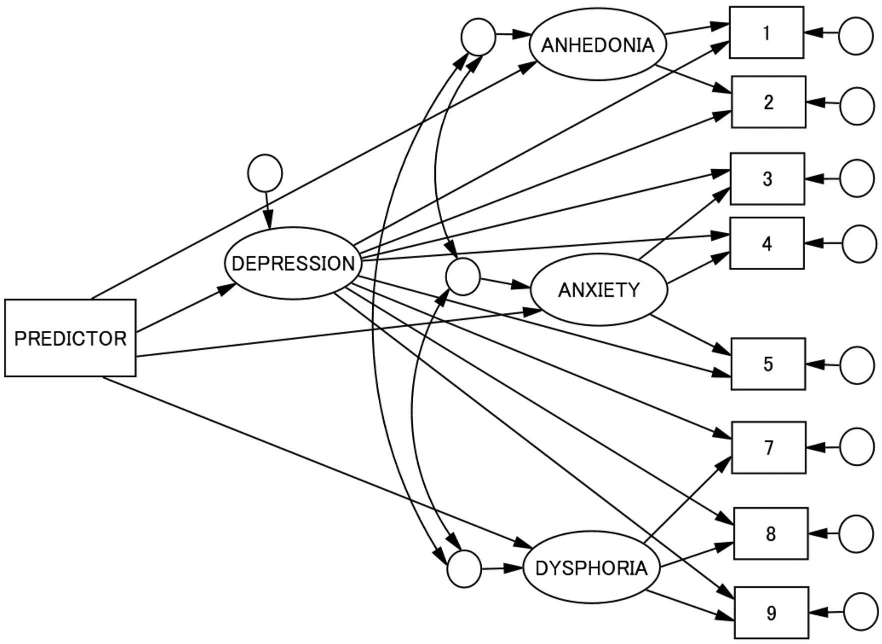

Fig. (6). Predictors and the EPDS general and subscale scores.
The names of error variables are deleted.

as the best fit with the data with demographic, obstetric, and psychosocial variables. We consider that such results may contribute to the construct validity of the model statistically identified [29].

In this study, we selected variables related to Negative Life Events (NLEs) occurring after childbirth and coping styles and behaviours as external indicators. The postnatal period may be characterised as a life stage with many stressors. This period sees a dynamic role transition related to the parental role, adaptation to physical changes, and altered relationships with the spouse, other children, co-workers, or significant others [30 - 38]. Mothers of infants must adapt to the physical and social changes brought about by pregnancy, adopt their new role as a mother, and build new relationships. Hence, they are likely to experience emotional conflicts in themselves and social problems with others. Maternal identity should be established and mothers must learn new social skills to cooperate with others as well as to build a new family. Interpersonal conflict may manifest after childbirth. This may be related to childcare responsibilities and managing the newborn. This, coupled with a poor marital relationship, may lead to psychological maladjustment. Mothers may also have feelings of isolation because they have less time to communicate with other adults compared during non-childbearing periods. Thus, the postpartum period is stressful for women because of the increased incidence of these NLEs. This study explores specific associations that different aspects of PND symptomatology have with different types of NLEs.

Coping is the perception or behaviours people have or take when expecting or facing NLEs [39, 40]. The concept of coping has two components [41, 42]. One is a stable coping style or styles that characterise an individual's reactions to stressful situations. Another is a set of skills or techniques (coping behaviours) that people use to manage specific stressful situations. The former is dispositional and is part of ones personality [43, 44]. In contrast, the coping behaviours may be determined more by one's current situation [45]. The choice of coping behaviours is determined by the specificity of a situation. The coping styles and coping behaviours are moderately correlated [46]. This study explores specific associations that different aspects of PND symptomatology have with different aspects of coping characteristics.

These methodological considerations based on the recent development of statistics related to factor structure prompted us to reanalyse the data we collected in the previous studies conducted several years ago.

2. METHODS

2.1. Study Procedures and Participants

Data came from a two-wave follow-up study on PND among women who gave birth at five antenatal clinics in Okayama City, Japan, between August 2000 and March 2001. One of the clinics was a university hospital, whereas the other four were private clinics. One thousand five hundred and thirty women were eligible for this study. Among them, 1,200 (78%) women received the questionnaires, and 758 (63%) returned the questionnaires at both waves. Our analyses were based on these 758 women's reports. The mean (SD) age of the participants was 28.7 (4.1) years and the mean age (SD) of their partners was 30.7 (5.2) years.Among them, 47%of the infants were boys. The mean body weight (SD) of the infants was 3,050 (347) g. Approximately 85% of the women gave birth vaginally, while the others required delivery by vacuum extraction (7%) and caesarean section (7%), respectively. Of these women, 234 (31%) had already boys and 210 (28%) had already had girls. The mean (SD) age was 3.5 (2.6) for the oldest boy child and 3.7 (2.5) for the oldest girl child. About 80% of the boys the women had already had were aged less than 5 and 76% of the girls the women had already had were aged less than 5. We were unable to obtain demographic data such as the age and parity of mothers who refrained from the study for ethical reasons.

2.2. Measurements

Postnatal depression: We used the EPDS (Cox *et al.,* 1987) [13], which consists of 10itemswith a four-point scale(0 to 3). The original English version of the EPDS had good internal consistency (Cronbach's alpha = 0.87) and reliability (split-half reliability = 0.88). The EPDS was introduced to Japan by Okano *et al.* [14] through the forward-backwards translation procedure. The Japanese version of the EPDS has good internal consistency (Cronbach's alpha = 0.78) and test-retest reliability (Spearman correlation = 0.92 [14].

Negative life events: We selected 41events that may appear after childbirth based on a report by [47]. We added a few items suitable for Japanese culture. These Negative Life Events (NLEs) were categorized into four life domains:(a) Physical Symptoms and Body Image (13 items); (b) Lifestyle Changes and Financial Problems (10 items); (c) Interpersonal Relationships and Out-of-Home Activities (10 items);and (d) Parenting and Newborn Behaviours (eight items) [48]. The participants were asked whether they had experienced any of these events since childbirth, and if so, to measure their desirable or undesirable impact using a 100-point scale. If the event was desirable, it was rated using a positive value (*e.g.*, +78), whereas if undesirable, the event was rated using a negative value (*e.g.*, – 46). If the event did not occur after childbirth, or if it did occur but caused neither a negative nor a positive impact, it was rated as zero (0).

Coping styles and behaviours: Kendler *et al.* [49] selected 14 items from the Ways of Coping Checklist (WCCL;Folkman & Lazarus, 1985 [50]) based on the highest-loading items from each of the seven subscales. Following the factor loadings of these WCCL items, Kendler *et al.* [49] grouped them into three categories. They included Turning to Others (four items, *e.g.*, 'turn to friends or relatives for advice or assistance'), Problem Solving (six items, *e.g.*, 'confront the person who caused the problem'), and Denial (three items, *e.g.*, 'try not to think about it so much'). We followed this procedure to measure both perceived coping styles and enacted coping behaviours. At fivedays after childbirth, we asked the participant how 'she usually copes with a difficult situation' using a five-point scale from 'never' (1) to 'very often' (5) (perceived coping styles). At one month after childbirth, we asked the participant how she coped with the event she rated as being the most stressful during the time since childbirth using a five-point scale (enacted coping behaviours).

Demographic and obstetric variables: We asked the participant's age and parity. We also enquired about the neonate's body weight and gender (boy – 1; girl – 2) and perceived difficulty of the current labour using a three-point scale, from 'less than expected' (1) to 'more than expected' (3).

2.3. Data Analysis

The whole sample (N = 758) was divided randomly into two parts: one (n = 380) for EFAs and another (n = 378) for CFAs. This procedure was conducted *via* SPSS 'case selection'. For the first group, we first examined the Kaiser-Meyer-Olkin (KMO) index and Bartlett's sphericity test to perform a factorability check [51] The communality and skewness of all the EPDS items were also examined. We next performed a series of EFAs by the maximum-likelihood method with PROMAX rotation from a single-factor structure and, subsequently, models with an increasingly greater number of factors (*i.e.*, two-, three-factor structures, and so on).

Next, we compared the goodness-of-fit of these models in a series of CFAs using the second halved sample. This was the cross-validation of the models derived from EFAs. Here, we also added the three-factor model proposed by Kubota *et al.* [27].The fit of models with the data was examined in terms of chi-squared (χ^2), the Comparative Fit Index (CFI), and the Root Mean Square Error of Approximation (RMSEA). Starting from the single-factor model, the subsequent model was judged better if its χ^2 value was significantly lower than that for the former model. According to conventional criteria, a good fit would be indicated by $\chi^2/df < 2$, CFI > 0.97, and RMSEA < 0.05, and an acceptable fit by $\chi^2/df< 3$, CFI >0.95, and RMSEA < 0.08 [52, 53] We also used the Akaike information criterion (AIC;Akaike, 1987 [54]), where a lower AIC was judged as being better.

Having selected the best-fit model, the second-order and bifactor models were examined. These models were reconciliation of the unidimensional and multidimensional models [28, 55 - 58]. Again, we selected the model that showed a significant decrease in χ^2 value compared with the other models.

After identifying the model that had the best fit with the data, we calculated subscale scores using this factor structure selected as the best one. The new subscales derived from such procedures were correlated with the other variables including demographic and obstetric variables, NLEs that occurred after childbirth, and coping styles and behaviours. Identifying those variables with significant correlations ($p < .001$ because of multiple comparisons) with the EPDS subscale scores, we examined the impacts of these variables in a structural regression model using a structural equation model (SEM) (Fig. **6**).

Hence, our research questions were two-fold: (1) what would be the best factor structure of the EPDS in a Japanese population, and (2) how was the construct validity of such factor structure.

2.4. Ethical Consideration

All participants asked to participate in this study were provided with a document that explained the aim and procedure of this study and the confidentiality of personal information. Participants were regarded as agreeing to participate by returning the questionnaire to the responsible researcher (T.K.) *via* postal service. This study was conducted under the approval of the Ethical Committee of the National Institute of Mental Health, Konodai Campus, where the responsible researcher (T.K.) was working while the study was conducted.

3. RESULTS

3.1. EFA

The KMO index was 0.828 and Bartlett's sphericity test showed a significant result ($p < .001$) in the first halved sample. Communalities of the EPDS items were generally good except for item 6 (Table **2**). All the EPDS items were not extremely skewed except for item 10 (suicidal idea) (Table **2**). Thus, the data were considered adequate to proceed to EFAs. A scree plot indicated a possible three-factor structure (Fig. **7**). Nevertheless, because of the idiosyncrasy of the number of the factors in EFAs, we calculated factor loadings of EPDS items in single-, two-, and three-factor structures (Table **3**).

In the single-factor structure, all the items showed factor loading > 0.3 [26]. In the two-factor model, two items of loss of interest (items 1 and 2) were loaded on the second factor, while the first factor was loaded on all the remaining items. Here, item 6 showed a slightly low factor loading (0.26). In the three-factor structure model, the first factor of the two-factor model was divided into two. In the three-factor model, items 5, 7, 9, and 10, reflecting unhappiness and suicidal thoughts,were loaded on the first factor. Items 1 and 2, reflecting the loss of interest, were loaded on the second factor. The last factor was loaded on items 3, 4, 6, and 8, reflecting anxiety and self-blame (Table **3**).

3.2. CFA

Having obtained single-, two-, and three-factor models derived from EFAs, we used the second halved sample to determine the goodness-of-fit for all three models. This was a cross-validation of the EFA-derived factor structure in order to identify the extent to which the scale's factor structure was stable. The decrease of χ^2 was significant from the single- to two-factor models (Table **4**) as well as from the two- to three-factor models. Furthermore, we calculated the fit indices of the three-factor model proposed by Kubota *et al.* (2014) [27]. This showed a significant decrease in χ^2 value from our three-factor model. The AIC of the three-factor model of Kubota *et al.* (2014) [27] was the lowest (best) among all the models. Hence, we adopted this model. In this model, items 1 and 2 reflected loss of interest; items 3, 4, and 5 reflected the anxious mood, panic, and self-blame; and items 7, 8, and 9 reflected unhappy mood and sadness (Fig. **8**). We named these three factors anhedonia, anxiety, and dysphoria. The last factor was named depression by Kubota *et al.* (2014) [27], but we renamed it to dysphoria because we reserved 'depression' as an indication of the severity of PND reflected by the total EPDS scores (see below). This model was, though the best among the first-order factor structure models, still not very good in its fit with the data: $\chi^2/df = 4.52$, CFI = 0.940, and RMSEA = 0.097.

Table 2. Mean, SD, and skewness values for each EPDS item.

Items	Mean	SD	Skewness
1	0.15	0.39	2.73
2	0.22	0.50	2.86
3	0.85	0.89	0.56

(Table 2) contd.....

Items	Mean	SD	Skewness
4	1.01	0.96	0.28
5	0.42	0.74	1.74
6	1.27	0.86	0.11
7	0.23	0.55	2.73
8	0.51	0.68	1.18
9	0.22	0.50	2.68
10	0.14	0.45	3.58

* $p< .05$; ** $p< .01$; *** $p< .001$

Table 3. EFAs of the EPDS items.

Items	Communality	1-factor	2-factor		3-factor		
		I	I	II	I	II	III
1. I have been able to laugh and see the funny side of things.	0.52	0.59	0.06	**0.77**	0.07	**0.66**	0.11
2. I have looked forward to things.	0.50	0.54	-0.07	**0.89**	-0.04	**0.98**	-0.05
3. I have blamed myself unnecessarily when things have gone wrong.	0.28	0.51	**0.47**	0.06	0.09	0.02	**0.51**
4. I have been anxious or worried for no good reason.	0.32	0.52	**0.46**	0.08	-0.17	0.00	**0.85**
5. I have felt scared or panicky for no good reason.	0.25	0.48	**0.58**	-0.12	**0.34**	-0.10	0.29
6. Things have been getting on top of me.	0.17	0.39	**0.26**	0.18	0.06	0.17	**0.26**
7. I have been so unhappy that I have had difficulty sleeping.	0.38	0.59	**0.58**	0.04	**0.84**	0.04	-0.21
8. I have felt sad or miserable.	0.48	0.74	**0.70**	0.07	0.38	0.05	**0.42**
9. I have been so unhappy that I have been crying	0.41	0.66	**0.66**	0.02	**0.64**	0.01	0.08
10.The thought of harming myself has occurred to me.	0.39	0.64	**0.69**	-0.03	**0.66**	-0.03	0.08

* $p< .05$; ** $p< .01$; *** $p< .001$. Factor loadings > .3 are in bold.

Table 4. Comparison of the models of factor structures of the EPDS items.

Model	χ^2/df	$\Delta\chi^2$ (*df*)	CFI	RMSEA	AIC
Single-factor	245.352/35 = 7.01	Ref	0.822	0.126	305.352
2-factor	167.149/34 = 4.92	78.203 (1) ***	0.887	0.102	229.149
3-factor	127.049/32 = 3.97	40.1 (2) ***	0.919	0.089	193.049
3-factor Kubota	76.837/17 = 4.52	50.212 (15) ***	0.940	0.097	130.837
3-factor Kubota with a second-order factor#	76.837/17 = 4.52	0.000 (0)	0.940	0.097	130.837
Bifactor model with 3-factor Kubota	9.637/9 = **1.07**	67.2 (8) ***	**0.999**	**0.014**	**79.637**

#, inappropriate solution; CFI, Comparative Fit Index; RMSEA, Root Mean Square Error of Approximation; AIC, Akaike Information Criteria. The best indices are in bold.

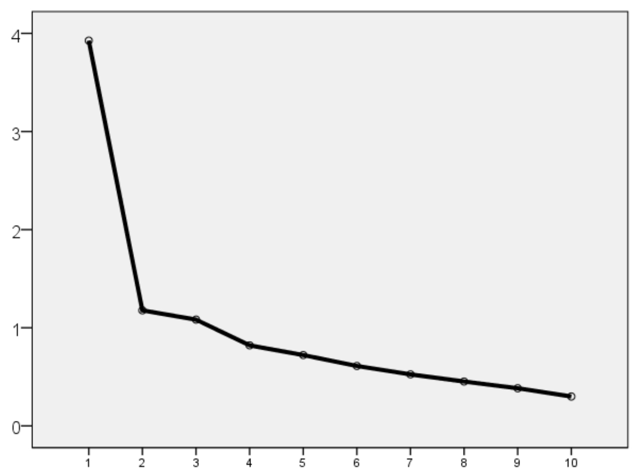

Fig. (7). Scree plot of the EFA of the EPDS items.

Next, we examined second-order (hierarchical) and bifactor models that were adapted in the three-factor model of Kubota *et al.* (2014) [27] (Table **4**). The second-order (hierarchical) model was an inappropriate solution (Fig. **4**). We found that the bifactor model showed a much better fit with data than the first-order three-factor model: χ^2/df = 1.07, CFI = 0.999, RMSEA = 0.14, and AIC = 79.637 (Fig. **5**).Therefore, we adopted the bifactor Kubota model as our final model.

3.3. Predictors of the EPDS Factors

We calculated three subscale scores-anhedonia, anxiety, and dysphoria-derived from the final bifactorial model as well as the total scores of the eight EPDS items (general depression). These subscale and general scores were correlated with the other variables (Table **5**). General depression was significantly predicted by Parenting and Newborn Behaviours, Enacted Problem Solving and Enacted Turning to Others. Anhedonia was significantly predicted by Interpersonal Relationships and Out-of-Home Activities, as well as Parenting and Newborn Behaviours. Anxiety was predicted by younger age, parity (nulliparousness), Parenting and Newborn Behaviours, enacting Problem Solving, and Turning to Others. Dysphoria was predicted by Interpersonal Relationships and Out-of-Home Activities, Parenting and Newborn Behaviours, Enacting Denial, and Enacting Problem Solving.

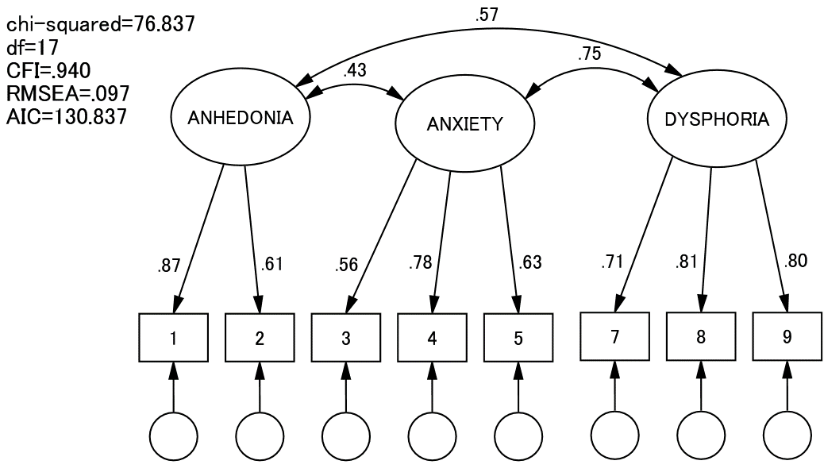

Fig. (8). Three-factor model of the EPDS items proposed by Kubota *et al.* (2014).
CFI, comparative fit index; RMSEA, root mean square error of approximation; AIC, Akaike information criteria. Paths are standardised. The names of error variables are deleted.

Table 5. Correlations of the three subscales and general scale of the EPDS with the predictor variables.

	General Depression	Anhedonia	Anxiety	Dysphoria
Demographic and Obstetrical Variables				
Age	-0.11*	0.04	-0.13***	-0.10**
Parity (nullipara – 1; multipara – 2)	-0.14**	0.02	-0.15***	-0.08*
At Delivery				
Neonate's sex (boy - 1; girl - 2)	0.01	-0.01	0.03	0.04
Neonate's body weight	-0.06	-0.05	0.04	-0.04
Perceived difficult labour (1 to 3)	0.13*	0.06	0.11**	0.08*
Perceived denial	0.08	0.04	0.03	0.01
Perceived problem solving	0.14*	0.03	0.12**	0.10**
Perceived turning to others	0.04	-0.06	0.03	-0.06
1 Month After Childbirth				
Physical symptoms and body image	0.06	-0.03	-0.04	-0.05
Lifestyle changes and financial problems	-0.07	-0.08*	-0.10**	-0.12**
Interpersonal relationships and out-of-home activities	-0.10	-0.18***	-0.07	-0.18***
Parenting and newborn behaviours	-0.21***	-0.13***	-0.17***	-0.15***
Enacted denial	0.18**	0.06	0.11**	0.14***
Enacted problem solving	0.22***	0.02	0.22***	0.15***
Enacted turning to others	0.20***	0.02	0.15***	0.03

* $p < .05$; ** $p < .01$; *** $p < .001$

We selected the variables that were significantly correlated with the EPDS subscale and general scores ($p < .001$) to build an SEM model (Figs. **9**, **10**, and **11**). Here, we examined the effects of three types of enacted coping behaviours (Enacted Denial, Enacted Problem Solving, and Enacted Turning to Others) separately.

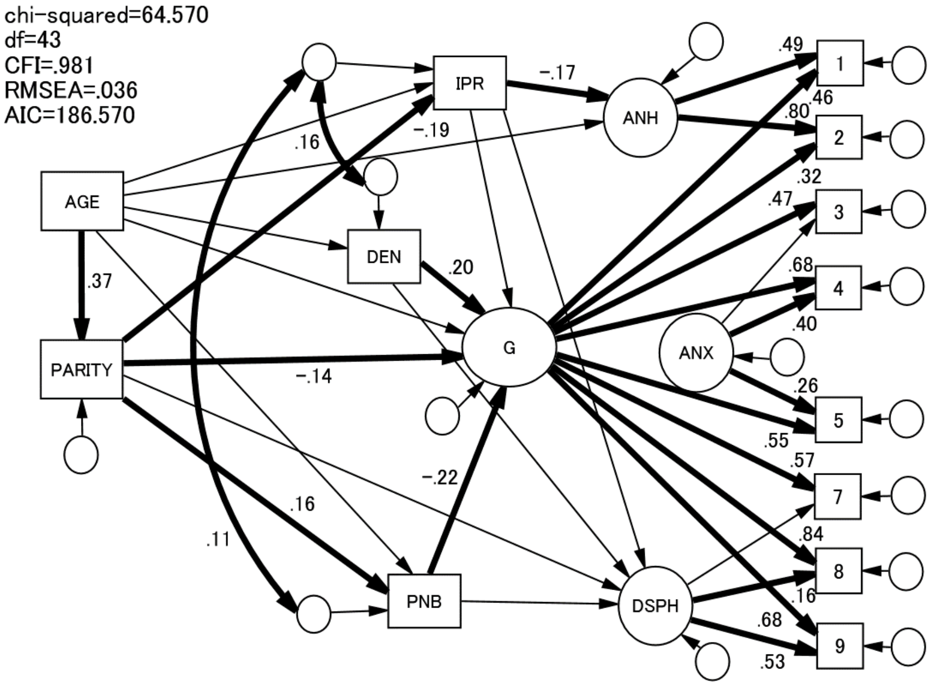

Fig. (9). Trimmed regression model with Enacted Denial as a predictor.
DEN, Enacted Denial; IPR, Interpersonal Relationships and Out-of-Home Activities; PNB, Parenting and Newborn Behaviours; G, General Depression; ANH, Anhedonia; ANX, Anxiety; DSPH; Dysphoria. The number indicates EPDS items. The names of error variables are deleted. Paths are standardised. Significant paths are in bold.

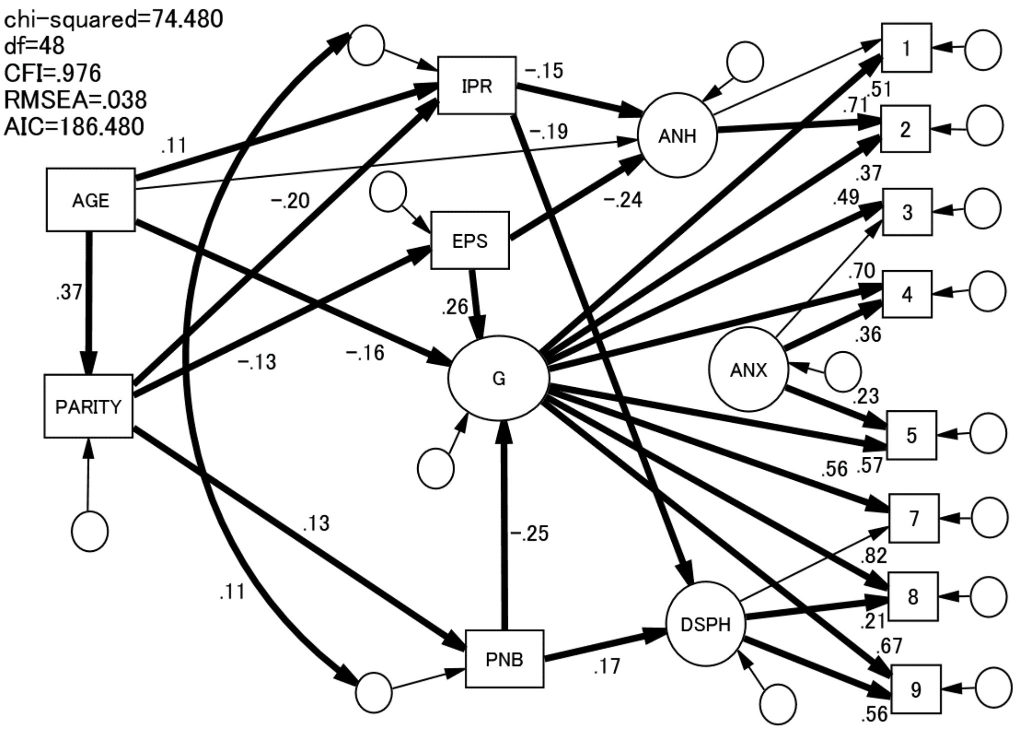

Fig. (10). Trimmed regression model with Enacted Problem Solving as a predictor.
EPS, Enacted Problem Solving; IPR, Interpersonal Relationships and Out-of-Home Activities; PNB, Parenting and Newborn Behaviours; G, General Depression; ANH, Anhedonia; ANX, Anxiety; DSPH; Dysphoria. The number indicates EPDS items. The names of error variables are deleted. Paths are standardised. Significant paths are in bold.

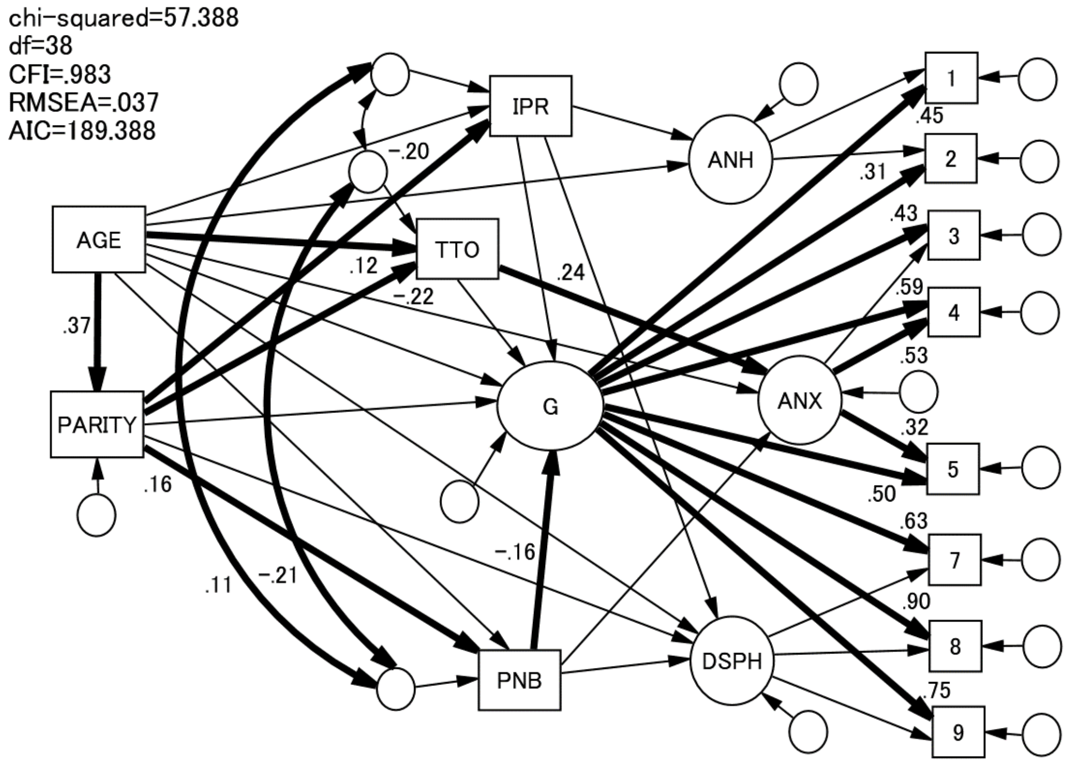

Fig. (11). Trimmed regression model with Enacted Turning to Others as a predictor.
TTO, Enacted Turing to Others; IPR, Interpersonal Relationships and Out-of-Home Activities; PNB, Parenting and Newborn Behaviours; G, General Depression; ANH, Anhedonia; ANX, Anxiety; DSPH; Dysphoria. The number indicates EPDS items. The names of error variables are deleted. Paths are standardised. Significant paths are in bold.

In SEMs, we posited that (1) age would predict parity, NLEs (*i.e.*, Interpersonal Relationships and Out-of-Home Activities, and Parenting and Newborn Behaviours), each of the enacted coping behaviours (*i.e.*, Enacted Problem Solving, Enacted Denial, Enacted Turn to Others), and the subscale and general scores of the EPDS; (2) parity would predict NLEs, coping behaviours, and the subscale and general scores of the EPDS; (3) NLEs would predict the subscale and general scores of the EPDS; (4) each coping behaviour would predict the subscale and general scores of the EPDS; (5) NLEs were correlated with each other; and (6) the coping behaviour would be correlated with NLEs.

In each of the SEMs, we trimmed models by deleting the least significant path one by one until there were no non-significant paths or the model trimming produced a statistically significant (p < .05) χ^2 increase or an inappropriate solution occurred [59].

Our final models showed a good fit with the data: enacted denial model χ^2/df = 1.502, CFI = 0.981, RMSEA = 0.036, AIC = 186.570 (before trimming:χ^2/df = 1.823, CFI = 0.976, RMSEA = 0.047, AIC = 202.156) (Fig. **9**); enacted problem solving model χ^2/df = 1.552, CFI = 0.976, RMSEA = 0.038, AIC = 186.480 (before trimming: χ^2/df = 1.799, CFI = 0.977, RMSEA = 0.046, AIC = 201.360) (Fig. **10**); enacted turning to others model χ^2/df = 1.510, CFI = 0.983, RMSEA = 0.037, AIC = 189.388 (before trimming: χ^2/df = 1.729, CFI = 0.983, and RMSEA = 0.037, AIC = 189.388) (Fig. **11**). General depression was significantly predicted by Parenting and Newborn Behaviours in each case. It was also predicted positively by Enacted Problem Solving and Enacted Denial. Anhedonia was significantly predicted by Interpersonal Relationships and Out-of-Home Activities, and (lack of) Enacted Problem Solving. Anxiety was significantly positively predicted by Enacted Turning to Others. Dysphoria was significantly predicted by Interpersonal Relationships and Out-of-Home Activities, and positively predicted by Parenting and Newborn Behaviours.

Higher age predicted parity, Interpersonal Relationships and Out-of-Home Activities, and Turning to Others. Younger age also predicted greater PND severity. Nulliparity predicted Interpersonal Relationships and Out-of-Home Activities, whereas multiparity predicted Parenting and Newborn Behaviours. Nulliparous women were likely to use Enacted Problem Solving and Turning to Others. Nulliparousness also predicted severity of PND.

4. DISCUSSION

The present study showed that among the three-factor structure models of the full EPDS—the single-, two-, and three-factor models—the three-factor model showed the best fit with the model. However, the three-factor model of Kubota *et al.* (2014) [27], which excluded items 6 'things have been getting on top of me' and 10 'thought of harming myself' fit better than ours. Item 6 showed a factor loading >0.3 in none of the three models in our study. This is in accordance with previous studies [22, 27, 60]. These results suggest that item 6 is unstable as an indicator of the EPDS. Item 10 showed a factor loading > 0.3, but it was skewed (> 3.0). Despite its clinical relevance (suicidality), its psychometric value may cast doubt on its use as a screening instrument or indicator of PND severity.

Another unique factor of our study is the application of the bifactor model. This resulted in an extremely better fit of the model with the data. Reichenheim *et al.* [61] proposed bifactor modes of EPDS using 10 items and suggested that using all EPDS items is suited to clinical practices. However, our model, which consists of eight items, showed better fit indices than the three-factor model with all 10 items. A scale that consists of fewer items is usually more useful for clinicians. Therefore, we recommend using the eight-item version. This model comprised a single general dimension alongside three distinct subfactors (anhedonia, anxiety, and dysphoria). The structural conceptualisation of PND in terms of a bifactor model should help us understand the interplay between the general condition and dimensions of symptoms of PND.

Scrutiny of the factor loadings of this bifactor model indicates characteristics of PND symptomatology (Fig. **5**). Although items 7, 8, and 9 were indicators of the dysphoria factor, their factor loadings were not significant. Items 7 and 9 were loaded on the general depression factor significantly. These findings may mean that these three items reflect the severity of PND, in general, more than the specific aspect of dysphoria. In contrast, items 3, 4, and 5 were loaded significantly on the anxiety factor but not significantly on the general depression factor. Hence, they may be more specific indicators, as are items 1 and 2, which were indicators of anhedonia. However, item 2 was significantly loaded on the general depression factor.

As we expected, a single general dimension alongside three distinct subfactors (anhedonia, anxiety, and dysphoria) was predicted by different predictor variables. We identified five variables as predictors: Interpersonal Relationships and Out-of-Home Activities, Parenting and Newborn Behaviours, Enacted Problem Solving, Enacted Denial, and Enacted Turning to Others. As reported previously [48], among the four predictors related to NLEs, two were identified: (a) Interpersonal Relationships and Out-of-Home Activities;and (b) Parenting and Neonatal Behaviours. Two other NLEs-Physical Symptoms and Body Image, and Lifestyle Changes and Financial Problems-showed no association with the EPDS subscale and general scores. Therefore, PND symptomatology has a specificity of the life event type. Furthermore, the variable Interpersonal Relationships and Out-of-Home Activities was associated with anhedonia and dysphoria, whereas Parenting and Neonatal Behaviours was associated with the general severity of PND. The inverse relationship between Parenting and Neonatal Behaviours and dysphoria is difficult to interpret (Fig. **10**). Excessive crying and feeding problems and infants' sleeping problems were associated with mothers' depression and anxiety [62 - 64]. Our results suggest that such an association is through the increased PND severity rather than direct effects on the subscale dysphoria. It may be that difficulties associated with childrearing lead to more severe PND in general and when this is controlled, focusing on childcare may prevent women from paying attention to their own mood states [65 - 68].

The effects of age and parity on the EPDS subscale and general scores were mediated by these NLEs. First-time mothers were more likely to experience interpersonal problems, whereas mothers with more than one child were more likely to experience childrearing difficulties. The role transition from being a marital partner only to having a dual role as a wife and mother may be more stressful for first-time mothers, whereas rearing more than one baby simultaneously may be more stressful for mothers with multiple babies.

Enacted coping behaviours were differentially associated with the general and subscale scores of the EPDS. Thus, the general depression factor was more severe when the participants used denial and problem solving more frequently, whereas anhedonia was more severe when the participants used problem-solving less frequently. Anxiety was more severe when the participants used Turning to Others more frequently. The association between PND severity and denial as the coping behaviour may be due to the widely held notion that denial is a maladaptive coping strategy [69]. Of interest is the negative association between problem-solving and PND severity. This coping pattern is usually regarded as adaptive in many studies [50, 70]. People using problem-solving to cope in difficult situations carefully consider the causes of the difficulty and try to solve it by themselves. However, the NLEs experienced during the postnatal period are unique and often difficult to solve singlehandedly such as a baby's cry in the night. In such a situation, the best coping strategy may be to ask for help from others. Thus, Turning to Others did not predict PND severity but, in our study, was associated with anxiety. Such behaviours may induce anxious moods, or, alternatively, anxious mothers may be likely to ask for help from others (*e.g.*, their partner). Parity was also associated with coping behaviours. Thus, experienced mothers are likely to solve problems by themselves as well as ask for help from others.

We should discuss the clinical implications of our study. Our report suggests that parenting education and support in coping behaviours would be recommended as an intervention for PND. This is because of the severity of depression, in general, was significantly predicted by Parenting and Newborn Behaviours, Enacted Denial, and Enacted Problem Solving. Careful observation of a mother's perceived difficulty with child care may encourage clinicians to provide child care assistance (*e.g.*, support from family members and relatives, and NPOs such as Home Start). It has been reported that a doula's emotional support enhances positive parenting and parent-child interactions [71, 72]. Continuous community-based support from the pregnancy to postnatal periods (*e.g.*, home visiting) by doulas would be helpful. Neither denial nor problem solving should be recommended, but mothers should be advised to ask for support from others. Mothers may hesitate to ask for help from others. Nevertheless, excessive support seeking may be linked to anxiety. Anxious mothers who seek help from others excessively may be consulted in anxiety reduction. Difficulties with interpersonal relationships are another important clinical observation among first-time mothers in particular. Approaching these difficulties with interpersonal psychotherapy may be used as a means of intervention or prevention. Such 'custom-made' care and intervention may help mothers avoid PND.

Regarding the limitations of the present study, we should be cautious because this was based on only two observation points. Confounders of the results may be found in variables during the pregnancy period. Research should be extended to the whole perinatal period. NLEs after childbirth were rated by mothers themselves one month after birth simultaneously with the EPDS. The occurrence of NLEs may be a result of depression or anxiety [73 - 75]. Mothers with anxiety or depression may perceive events as more stressful than other mothers. Neonatal behaviours should be rated independently by researchers, such as observation of a mother's neonatal temperament. We were unable to make clinical diagnoses of mood and anxiety disorders. Detection of clinical cases may yield different findings. It was desirable to conduct a diagnostic interview with the mothers. Another point which needs further research is the scale's cultural context. Obviously, we identified the factor structure of the EPDS only in Japanese culture (and language). We believe that the subscales we identified capture the different aspects of postnatal depression symptomatology. This should be compared with reports from the other cultures using different languages in the same framework of the factor structure.

CONCLUSION

Despite these drawbacks, our study expanded on a previous factor structural study of the EPDS and developed the multidimensional model. Also, this study explored different associations of the factor structure with psychological variables contributing to the construct validity of the model. The present results confirmed the presence of a general factor alongside anhedonia, anxiety, and dysphoria, presumably reflecting different aspects of the PND symptoms. Perinatal health care professionals should be encouraged to use the three subscales and the total EPDS score.

LIST OF ABBREVIATIONS

PND	=	Postnatal Depression
EPDS	=	Edinburgh Postnatal Depression Scale
SEM	=	Structural Equation Modelling
NLEs	=	Negative Life Events
PCA	=	Principal Component Analysis
RMSEA	=	Root Mean Square Error of Approximation
CFI	=	Comparative Fit Index
CFA	=	Confirmatory Factor Analysis
AN	=	Antenatal
SRMR	=	Standardised Root Mean Square Residual
TLI	=	Tucker-Lewis Index
AGFI	=	Adjusted Goodness of Fit Index
df	=	degrees of freedom
AIC	=	Akaike Information Criteria
KMO	=	Kaiser-Meyer-Olkin
DEN	=	Enacted Denial
IPR	=	Interpersonal Relationships
PNB	=	Parenting and Newborn Behaviours

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The present study was approved by the Ethical Committee of Kumamoto University School of Medical Sciences References No. 458, where the last author (TK) conducted the present research.

HUMAN AND ANIMAL RIGHTS

No animals were used for studies that are the basis of this research.

CONSENT FOR PUBLICATION

All participants asked to participate in this study were provided with a document that explained the aim and procedure of this study and the confidentiality of personal information. Participants were regarded as agreeing to participate by returning the questionnaire to the responsible researcher.

AVAILABILITY OF DATA AND MATERIALS

Not applicable.

FUNDING

None.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

ACKNOWLEDGEMENTS

We thank the following clinics for their cooperation: Okayama Central Hospital, Yamashita Clinic, Kohnan Ladies Clinic, Sunclinic, and Hashimoto Gynecologic and Obstetric Clinic.

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