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Supplementary data related to this article can be found at the end.

Abstract

We aimed to clarify the factor structure of a bonding measure among Japanese fathers with infants and the factors associated with the subscales. Among fathers of children attending 4-month health checkups, the Japanese version of the Mother-to-Infant Bonding Scale had a two-factor structure comprising “anger” and “lack of affection”. “Anger” was associated with fathers’ work demands and poor mental condition, and “lack of affection” with fathers’ older age, poor mental condition, and interpersonal problems at home. Paternal parenting support needs to account for not only the fathers themselves, but also interpersonal communication at home and the work environment.

Keywords

Fathers, Infant, Object attachment, Japan, Parenting

Introduction

Maternal bonding toward a child starts forming during pregnancy and changes with time from birth and over the next several months (Alhusen, 2008). There are various definitions of bonding. A review by Bicking and Hupcey (2013) found that many previous studies commonly defined bonding as an emotional bond between a "mother" and a child during infancy. It is well known that maternal bonding is related to postpartum depression (Dubber et al., 2015; O'Higgins et al., 2013). Studies from Japan have reported that maternal bonding is associated with maternity blues (Nagata et al., 2000) and further with negative parenting behaviors (Choi et al., 2010). As such, Yoshida et al. (2012) defined "bonding disorder" as poor bonding to a child and impaired parenting function.

It has long been known that fathers' parenting behavior affects child development (Baumrind and Black, 1967), and more emphasis is being placed on the mental health status of fathers, as well as of mothers (Luoma et al., 2013). For example, our previous research among Japanese parents of toddlers showed that, in about 7% of the cases, both parents had poor health status (Yoshida et al., 2019). However, the focus in Japan until recently has been on mothers' bonding, and we are only starting to see studies showing that fathers also experience depression and bonding disorder. Edhborg et al. (2005) found that paternal bonding is associated with a tendency towards postpartum depression in fathers, similar to mothers. In Asia, studies of paternal-infant attachment and its effects on child development have been increasingly reported during the past decade (Rempel et al., 2017; Noh and Yeom, 2017). Further investigations are needed to promote paternal parenting in the region.

Along that line, the Japanese version of the Mother-Infant Bonding Scale (MIBS-J) that is used to evaluate maternal bonding has been proven to be potentially useful for fathers as well (Kitamura et al., 2013). However, the previous study was conducted among fathers of a wide age range of children under 11 years of age (Kitamura et al., 2013). Additionally, one study showed that paternal bonding was related to the amount of time working and parenting, but it was limited to fathers of premature infants in the neonatal intensive care unit (Murata et al., 2016). Another recent study of maternal bonding in parents at 1 month postpartum found a correlation between paternal and maternal MIBS-J (Nishigori et al., 2019). For skills needed for parenting change as a child grows and develops, further studies on Japanese fathers' bonding beyond the neonatal phase are needed.

Bonding disorders in parents are not only related to parental mental health and child health and development (Alhusen, 2008; Kitamura et al., 2013; McHale, 2007; Yoshida et al., 2012), they are also underpinned by complex family issues and social support (Camilla et al., 2014). These disorders must thus be discovered and treated early before they become more complicated. Furthermore, impaired bonding formation may lead to child abuse; therefore, it is a critical issue for the development of the next generation and preventing a negative generational chain (Valentino, 2017). In previous research (Habib and Lancaster, 2006),

bonding is presented as the basis for parenting behaviors.

The aims of the present study were to clarify the factor structure of a bonding measure among Japanese fathers with 4-month-old infants and to explore factors associated with the subscales. Fathers with 4-month-old infants were selected because it is the time of the very first child health checkups in the community. The present study was conducted in collaboration with the municipality (Fukushima City) that conducted the checkups, and based on the results, it examined ways to improve fathers' bonding with their child. The possibility of immediate application of the study findings into municipal parenting strategies can be the major strength of the present study. This study could serve as an Asian model community-based study established as a municipality-university partnership to explore strategies to promote paternal parenting.

Methods

[Figure 1 here]

Study design and participants

This was a cross-sectional study. Questionnaires were sent to 945 fathers of children who were scheduled to attend the 4-month health checkup in Fukushima City between October 2017 and March 2018. Completed questionnaires were collected at the time of the child health checkups, and responses were received from 518 (response rate of 54.8%). Figure 1 shows the selection of cases for the analyses in the present study. For the two twin cases, only one parental response was kept in the database (n=2). The analytical sample was restricted to two-parent households. The participants entered into the analyses were 500 fathers.

Study site

Fukushima City is the capital of Fukushima Prefecture, which is located in the southern part of the Tohoku region of Japan. Compared to the national figures, it has a higher rate of primary and secondary industries, and Fukushima Prefecture has the highest rate in Japan for construction, which is categorized as a secondary industry (National Statistics Center, 2015). In the Japanese time use survey by the government, the total childcare time of fathers in Fukushima Prefecture ranked 46th of all 47 prefectures in 2011 (49 minutes) and 35th in 2016 (70 minutes). For the amount of time fathers spend on household work and parenting, though it indicated that the amount of time was increasing, it was still below the national mean value (83 minutes in 2016) (National Statistics Center, 2011; National Statistics Center, 2016a). At the same time, in the 2016 survey by the Ministry of Health, Labour and Welfare (2016), Fukushima Prefecture was the highest in the country for length of working hours.

Data collection

An anonymous self-administered questionnaire for fathers, along with a letter requesting participation in the study, was included in the infant health checkup questionnaires sent by Fukushima City. Background factors of the mother, child, and household were obtained from the 4-month infant health checkup file. It should be noted that the questionnaire was completed by mothers in most cases. Fathers' questionnaires and child health checkup file data were matched using their checkup IDs, but they were immediately discarded after the match was made on the day of the checkup.

Data items

Items included in the analyses were basic information (19 items) and parenting information (4 items). Among them, father's bonding, work demands, health status, health literacy, and perceived parenting support were extracted from the questionnaires completed by the fathers. Other items were from the health checkup file.

The MIBS-J (Yoshida et al., 2012) was used to measure the level of bonding as the major outcome. Ten items about fathers' feelings towards their child were answered on a four-point scale of almost always strongly agree, sometimes strongly agree, sometimes slightly agree, and never agree. The maximum score was 30 points, and higher scores corresponded to weaker bonding. The above-mentioned previous study (Kitamura et al., 2013) of fathers of children under 11 years of age reported that there were two factors: anger and lack of affection.

Basic attributes included the following items: characteristics of the father and mother (age, health status, and employment status [employed or not] and health literacy); characteristics of the child (sex, birth order, birth weight, and temperament); and characteristics of the household (family structure, family issues, and parenting support). The ages of fathers and mothers were dichotomized by the age of 30 years (average age of women giving birth for the first time). Demographic background characteristics, parental mental health, child health, family issues, and social support have been reported to be associated with parental bonding (Alhusen, 2008; Kitamura et al., 2013; McHale, 2007; Yoshida et al., 2012). Father's health literacy was included, since mother's health literacy was reported to interact with their mental health and parenting behaviors (Smith and Moore, 2012). In addition, there was a focus on fathers' employment status because work-life conflict affects fathers' health (Kato and Yamazaki, 2009), and Fukushima Prefecture was the highest in the country for length of working hours in 2016 according to government statistics.

Parental health was examined with the questions about physical and mental conditions included in the Minami-Tama method of abuse screening (Tokyo Minamitama Health Center, 2005). "How is your health condition?" was asked, with 6 response options:

good, tired, difficult sleeping, not good, less appetite, and others. Answers other than good were classified as poor. As for mental condition, “How is your mental condition?” was asked, with 3 response options: good, not sure, and not good. Answers other than good were classified as poor. Three questions about work demands of the father were taken from Kawakami’s occupational stress measure (having an extreme amount of work; being unable to complete work within the allotted time; and having to work as hard as possible) (Kawakami et al., 1995; Kawakami et al., 2004), with 4 possible responses: strongly agree, agree, disagree, and strongly disagree. Responses were quantified, and the means of three scores were calculated. A higher score corresponded to a lower workload. As for family issues, unstable income, difference in economic sense, unemployment, change of work, gambling problem, or unplanned debt were considered financial problems. Difference in parenting styles, difficulty obtaining cooperation for parenting, lack of conversation, and difficult relationships with relatives were considered interpersonal problems. Level of health literacy was examined with the question developed by Tokuda et al. (2009), “How confident are you in completing the health status pre-checkup questionnaire filled out when receiving a doctor’s checkup?”, with 5 possible answers: not confident at all, not confident, neutral, confident, and very confident. Not confident at all, not confident, and neutral indicated a low level of health literacy.

Analysis

First, the factor structure of fathers’ bonding (MIBS-J) was examined. Exploratory factor analysis (EFA) was performed to determine the measure’s factor structure. Scores for each item used a 4-point scale, and EFA with ordered indicators was performed. Items with low factor loadings (<.50) were removed (Costello and Osborne, 2005). Confirmatory factor analysis (CFA) was performed on a one- and two-factor structures with WLSMV estimation for ordered indicators (weighted least square, promax rotation). EFA was performed with the mirt package (Chalmers, 2012), and CFA was performed with the lavaan package in R (Rosseel, 2012). Distributions of total and subscale scores are presented.

Second, to analyze associations with background factors, univariate analysis was performed on each MIBS-J subscale using Spearman’s correlation for the workload and the Mann-Whitney U test for other items. Items that were significant ($p<0.05$) were subjected to multivariate analysis with birth order using a Poisson regression model. Sub-analyses using the total score of the revised bonding measure (7 items) were also carried out.

SPSS version 24 was used for analysis, with a level of significance at 5%, excluding factor analysis. R3.5.1 and the related packages mentioned above were used for the factor analysis.

Ethical considerations

The present study was approved by the Ethics Committee of Fukushima Medical

University (No. 29085). Questionnaires for fathers were assigned numbers to be matched with the responses from the 4-month infant health checkup questionnaire. After the matching, the numbers were removed to make the questionnaires anonymous. In the cover letter of the survey addressed to the fathers, it was noted that the data will be copied from the child health checkup files as well.

Results

[Table 1 here]

Basic characteristics (Table 1)

Of all survey participants, 364 fathers (72.8%) and 309 mothers (61.8%) were aged 30 years or over. The child attending the health checkup was the first child for 264 participants (52.8%). Mean age ± standard deviation was 33.1±6.1 years for fathers and 31.0±4.8 years for mothers. The family structure was the nuclear family for 82.2%.

[Figure 2 here]

Distribution of fathers' bonding as measured by the original MIBS-J (Figure 2)

Total bonding scores measured by the original MIBS-J had a median of 2 (min 0 - max 12), kurtosis of 2.2 (standard deviation 0.22), and skewness of 1.3 (standard deviation 0.11).

[Table 2 here]

Factor structure of fathers' bonding (Table 2)

Based on the previous factor analysis study (Kitamura et al., 2013), EFA assuming a two-factor structure was performed (Table 2). Items 2, 7, and 9 were removed due to low factor loadings. After removing low loading items, the EFA was rerun. The results showed that the magnitude of the factor loadings for all items was >.50. The first factor was labelled "anger" comprising item 3, 'I feel resentful towards my baby', and item 5, 'I feel angry with my baby', and the second factor was labeled "lack of affection" comprising item 1, 'the baby is very dear to me,' item 6, 'I enjoy doing things with my baby,' item 8, 'I feel protective towards my baby,' item 4, 'I feel nothing towards the baby,' and item 10, 'I feel very close to the baby;' higher scores corresponded to weaker bonding. CFA showed that the two-factor structure from the EFA was acceptable (comparative fit index (CFI) = 0.968, root mean square error of approximation (RMSEA) = 0.040, and standardized root mean square residual (SRMR) = 0.076). Cronbach's alpha of "anger" was 0.78, and that of "lack of affection" was 0.84.

The median total score of the participants was 2 (min 0, max 12), the median score for anger was 0 (min 0, max 4), and the median score for lack of affection was 0 (min 0, max 9).

[Tables 3 and 4 here]

Factors related to fathers' bonding subscales (Tables 3 and 4)

On univariate analysis for anger, four items were significant (father's work demands, physical condition, mental condition, and mother's age). On multivariate analysis, significant items were father's work demands (β=0.38, p=0.004) and father's poor mental condition (β=0.55, p=0.006). On univariate analysis for lack of affection, five items were significant (father's age and mental condition, mother's age and physical condition, and interpersonal problems). On multivariate analysis, items that were significantly related to lack of affection were father's older age (β=0.30, p=0.04), father's poor mental condition (β=0.61, p<0.001), and interpersonal problems (β=0.42, p<0.001). Sub-analyses using the total score of 7 items provided similar results (significantly associated factors were father's age, father's mental condition, and mother's physical condition).

Discussion

The present study clarified the factor structure of fathers' bonding with 4-month-old infants in Japan and its background characteristics. Methodologically, a significant feature of this study was that the data were collected at the time of the first health checkups in the community. It should also be noted that it was based on a municipal-university collaboration.

Characteristics of participants

More than half of the participants were first-time fathers, which was higher than the average national and Fukushima Prefecture data (households with children in Japan and in Fukushima Prefecture: Japan, 46.9%; Fukushima Prefecture, 44.7%) (National Statistics Center, 2016a). According to the FY 2016 vital statistics (National Statistics Center, 2016b), the age of first-time fathers was 32.8 years for all of Japan and 31.5 years for Fukushima Prefecture, and the age of first-time mothers was 30.7 years for all of Japan and 29.4 years for Fukushima Prefecture. The mean ages of first-time parents in the present study were similar (fathers: 33.1 years, mothers: 31.0 years). The proportion of nuclear families was about 80%, which was similar to the FY 2016 national figures, but higher than figures of Fukushima Prefecture (households with children in Japan and in Fukushima Prefecture: Japan, 81%; Fukushima Prefecture, 59%). Since this area clearly has a higher proportion of nuclear families within Fukushima, cooperative parenting between parents is essential, and there is a need for support to be adjusted to the new roles of parents in the first year after the child's birth (Cowan et al., 1985; Schulz et al., 2006).

Distribution and factor structure of fathers' bonding as measured by the MIBS-J

When compared with the total scores of the original MIBS-J score, the mean score of the fathers in the present study was higher than the mean score of the mothers with infants

(mean for fathers 2.3, mean for mothers 1.7 in the previous study) (Sato et al., 2012). A two-factor structure (anger and lack of affection) was confirmed in the present fathers with 4-month-old infants. The previous study by Kitamura et al. (2013) that used the same scale for fathers also confirmed the two factors related to anger and affection. However, that study targeted children under 11 years of age, a much wider age range, while the present study focused on fathers with infants. Furthermore, some of the items included in each subscale differed from the present study. Kitamura et al. (2013) found a two-factor structure excluding items 4 and 9 ("anger and rejection" included items 2, 3, 5, and 7; and "lack of affection" included items 1, 6, 8, and 10), whereas the present study found a two-factor structure that also excluded items 2 and 7, in addition to item 9 ("anger" included items 3 and 5 and "lack of affection" included items 1, 4, 6, 8, and 10).

Factors related to fathers' bonding subscales

Anger was related to the level of the father's work demands and poor mental condition. It was noteworthy that a higher anger score was associated with lower work demands. A previous study (Kizuki et al., 2018) in Japan reported that late parental arrival at home was associated with less interaction with children. The present result thus contradicts this assumption that more time at home leads to better involvement in parenting, and this therefore highlights a need for further research into fathers' work-life balance. The present findings also suggest that the promotion of fathers' parenting is not only about improving their work environment, but also requires practical supports to facilitate daily parenting behaviors. This could be the case in Fukushima, where fathers' parenting is less of a societal norm. Although so-called "Iku-men" (men involved in childrearing) (Ministry of Health, Labour and Welfare) are becoming more common around Japan, continued efforts linked to workplaces are needed for fathers' involvement in the regular parenting routine to become the norm (Hamada, 2017). Another factor associated with anger suggests the need for parenting support that could improve father's mental condition to reduce their anger.

Lack of affection was also related to father's poor mental condition and interpersonal problems at home. Cooperation between parents has been shown to promote development of children (Cheng et al., 2009) and father's presence itself on the development of adolescents (East et al., 2006), but conventional maternal and child health services in Japan are mostly aimed at mothers. It is therefore important to approach the fathers. As an example in the present study, including a questionnaire for fathers at the time of child health checkups shows that they are included as a target for parenting support (Takehara et al., 2016; Sasaki et al., 2010). Our data further recommends that all members of the family be supported to improve their interpersonal communication. In addition, given the association of father's higher age with lack of affection, along with the recent social change of delayed marriage and parenting in Japan, attention in terms of parenting support and further research is needed regarding

older fathers in Japan.

The present results imply that separate approaches are needed for preventing anger and lack of affection among fathers. Strategies for reducing anger require a more father-centered approach, and familial supports are needed to increase affection.

Limitations and strengths of the present study

As a cross-sectional study, the present study does not prove causal associations between bonding and background factors. In addition, the response rate was 55%, and it is very likely that those with greater interest in parenting or better marital status responded. For this reason, the bonding distribution cannot be applied to the general population. That said, the internal validity of the results of the analysis of related factors is considered to be supported by the systematic data collection at the time of child health checkup and few missing values. In future studies, analyses could be further improved by including data on objective assessment of child's temperament or development through making the most of child health checkup files as data sources. Despite these limitations, the strength of the present study is that a way to develop a database from child health checkups carried out by the municipality to obtain scientific evidence to promote fathers' involvement in parenting based on municipality-university collaboration was demonstrated.

Implications for public health nursing

The results indicate the importance of both primary and secondary prevention of fathers' bonding disorder. Introduction of fathers' bonding assessment at the time of routine child health checkups, as a primary prevention measure, may help both parents and health professionals be aware of the importance of the father's involvement in parenting. Screening fathers in need of help as a secondary prevention measure could also be done at the time of child health checkups. A simple tool such as a bonding screening sheet has a potential to function as a key for promoting and supporting paternal parenting.

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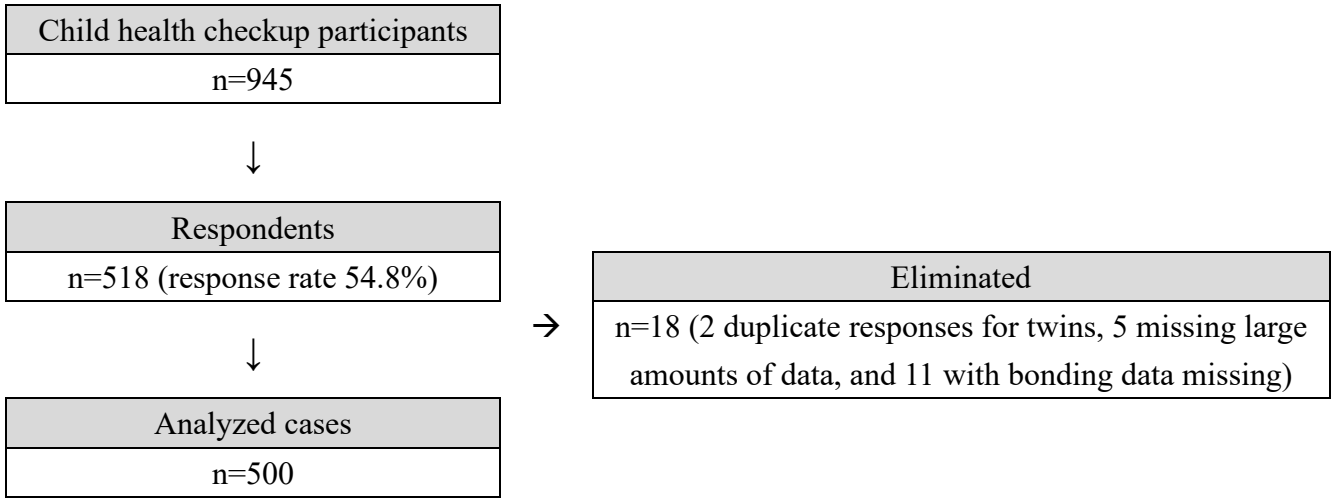

Figure 1. Flowchart of study participants

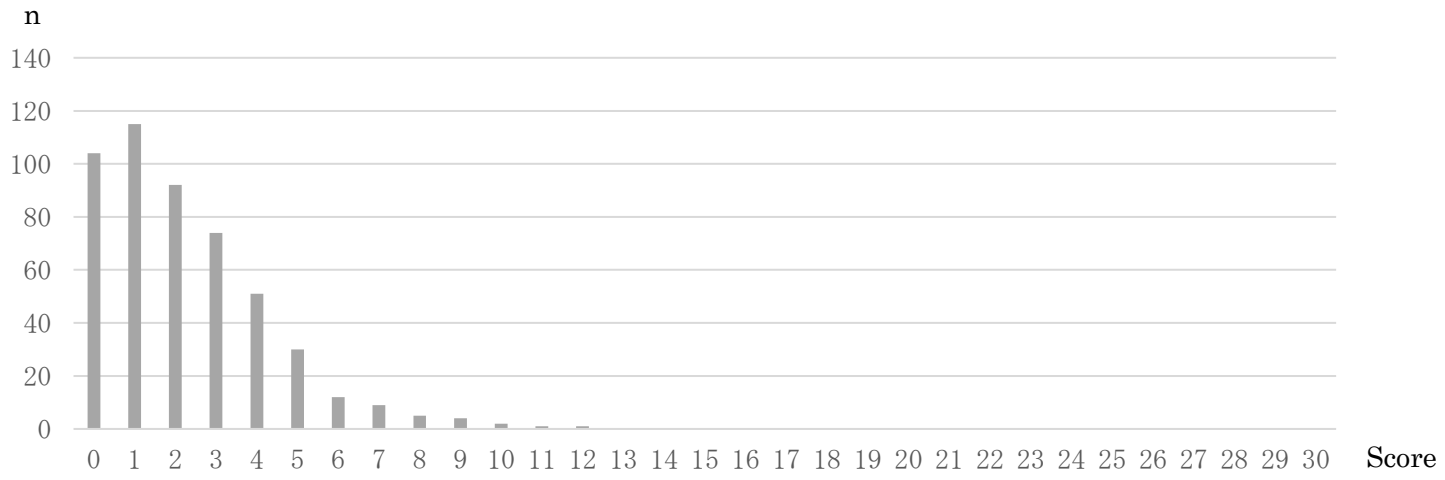

Figure 2. Fathers' bonding scores as measured by the original MIBS-J (n=500)

Median 2 (min 0 - max 12), kurtosis 2.2, skewness 1.3

Table 1. Participants' basic characteristics (n=500)

	n	(%)[a]
Characteristics of parents		
Father		
Age		
<30 years	134	(26.8)
≥30 years	364	(72.8)
Work demands [*,b]		
Median (min-max) score	2 (1-4)	
Employed		
Yes	493	(98.6)
No	4	(0.8)
Physical condition[*]		
Good	325	(65.0)
Poor	175	(35.0)
Mental condition[*]		
Good	380	(76.0)
Poor	119	(23.8)
Health literacy[*]		
High level	344	(68.8)
Low level	151	(30.2)
Mother		
Age		
<30 years	191	(38.2)
≥30 years	309	(61.8)
Employed		
Yes	273	(54.6)
No	225	(45.0)
Physical condition		
Good	359	(71.8)
Poor	141	(28.2)
Mental condition		
Good	421	(84.2)
Poor	77	(14.8)
Characteristics of family		
Family structure		
Nuclear family	411	(82.2)
Extended family	78	(15.6)
Family issues		
Financial problems[c]		
No	450	(90.0)
Yes	50	(10.0)
Interpersonal problems[d]		
No	427	(85.4)
Yes	73	(14.6)
Father's perceived social support in parenting[*]		
Have someone to talk to about concerns		
Yes	487	(97.4)
No	13	(2.6)

Have someone to ask for help		
Yes	490	(98.0)
No	9	(1.8)
Characteristics of child		
Sex		
Boy	259	(51.8)
Girl	240	(48.0)
Birth order		
Second or later	236	(47.2)
First child	264	(52.8)
Birth weight		
≥2500 g	468	(93.6)
<2500 g	32	(6.4)

*Marked items were extracted from a father's self-administered questionnaire, and others from a child health checkup file.
a. Due to missing values, totals for some items do not add up to the total number of participants in the heading.
b. A higher score corresponds to a lower workload.
c. "Unstable income", "difference in economic sense", "unemployment", "change of work", "gambling problem", or "unplanned debt" were considered financial problems.
d. "Difference in parenting styles", "difficulty obtaining cooperation for parenting", "lack of conversation", or "difficult relationships with relatives" were considered interpersonal problems.

Table 2. Factor analysis of fathers' bonding (MIBS-J) (n=500)

No.	Item	Factor loading			
		I (Anger)		II (Lack of affection)	
		EFA[a]	CFA[b]	EFA[a]	CFA[b]
3	I feel resentful towards my baby. (R)	0.98	0.95	0.00	-
5	I angry with my baby. (R)	0.66	0.67	0.03	-
1	I feel loving towards my baby.	0.25	-	0.68	0.81
6	I enjoy doing things with my baby.	0.13	-	0.72	0.79
8	I feel protective towards my baby.	-0.20	-	0.88	0.74
4	I nothing towards the baby. (R)	0.17	-	0.66	0.66
10	I feel very close to the baby.	-0.08	-	0.75	0.63
2	I feel scared or panicky when I have to do something for my baby. (R)	0.26	-	0.13	-
7	I wish my baby was different. (R)	0.36	-	0.47	-
9	I wish I did not have my baby. (R)	0.14	-	0.19	-

Factor analysis with ordered indicator was used.

a. "(R)" represents a reverse score.

b. Factor analysis with ordered indicator was used. A higher score corresponds to a weaker bonding.

c. Exploratory factor analysis (EFA)

d. Confirmatory factor analysis (CFA): items 2, 7, and 9 were removed due to low factor loadings.

Table 3. Factors related to fathers' bonding: background factors of the parents and children

Item	Anger[a] median (min-max)	Anger[a] mean(SD)[c] or *rs*	Anger[a] p value[d]	Lack of affection[b] median (min-max)	Lack of affection[b] mean(SD)[c] or *rs*	Lack of affection[b] p value[d]
Characteristics of father						
Age						
<30 years	0(0-4)	0.25(0.61)	0.31	0(0-7)	0.68(1.17)	0.01
≥30 years	0(0-2)	0.29(0.57)		1(0-9)	1.10(1.58)	
Work demands[*e]						
Score (rs)		*0.09*	0.046		*-0.02*	0.71
Physical condition[*]						
Good	0(0-2)	0.23(0.51)	0.01	0(0-9)	0.92(1.43)	0.24
Poor	0(0-4)	0.38(0.68)		1(0-7)	1.11(1.60)	
Mental condition[*]						
Good	0(0-4)	0.23(0.54)	<0.001	0(0-9)	0.80(1.35)	<0.001
Poor	0(0-2)	0.45(0.69)		1(0-7)	1.60(1.76)	
Health literacy[*]						
High level	0(0-4)	0.26(0.57)	0.08	0(0-9)	0.95(1.51)	0.23
Low level	0(0-2)	0.34(0.60)		1(0-7)	1.01(1.35)	
Characteristics of mother						
Age						
<30 years	0(0-4)	0.23(0.57)	0.049	0(0-7)	0.75(1.24)	0.01
≥30 years	0(0-2)	0.31(0.59)		1(0-9)	1.14(1.62)	
Employed[f]						
Yes	0(0-4)	0.27(0.57)	0.55	0(0-9)	1.03(1.60)	0.90
No	0(0-2)	0.30(0.60)		0(0-7)	0.94(1.35)	
Physical condition						
Good	0(0-4)	0.26(0.57)	0.06	0(0-9)	0.92(1.46)	0.02
Poor	0(0-2)	0.35(0.61)		1(0-9)	1.16(1.58)	
Mental condition						
Good	0(0-4)	0.27(0.58)	0.39	0(0-9)	0.93(1.41)	0.07

Poor	0(0-2)	0.32(0.60)		1(0-9)	1.31(1.88)	
Characteristics of family						
Family structure						
Nuclear family	0(0-4)	0.29(0.60)	0.34	0(0-9)	0.98(1.51)	0.62
Extended family	0(0-2)	0.22(0.50)		0(0-6)	1.08(1.50)	
Family issues						
Financial problems						
No	0(0-4)	0.28(0.59)	0.74	0(0-9)	0.96(1.48)	0.21
Yes	0(0-2)	0.26(0.57)		1(0-7)	1.22(1.61)	
Interpersonal problems						
No	0(0-4)	0.28(0.59)	0.80	0(0-9)	0.91(1.38)	0.03
Yes	0(0-2)	0.29(0.57)		1(0-9)	1.47(1.98)	
Father's perceived parenting support*						
Have someone to talk to about concerns						
Yes	0(0-4)	0.28(0.59)	0.98	0(0-9)	0.97(1.47)	0.28
No	0(0-1)	0.23(0.44)		1(0-7)	1.62(2.10)	
Have someone to ask for help						
Yes	0(0-4)	0.28(0.58)	0.48	0(0-9)	0.97(1.47)	0.51
No	0(0-1)	0.33(0.50)		1(0-4)	1.22(1.48)	
Child						
Sex						
Boy	0(0-4)	0.27(0.58)	0.61	0(0-9)	1.02(1.54)	0.92
Girl	0(0-2)	0.30(0.59)		0(0-9)	0.96(1.45)	
Birth order						
Second or later	0(0-4)	0.34(0.66)	0.09	0.5(0-9)	1.17(1.75)	0.09
First child	0(0-2)	0.23(0.50)		0(0-6)	0.83(1.20)	
Birth weight						
≥2500 g	0(0-4)	0.28(0.58)	0.12	0(0-9)	0.99(1.50)	0.87
<2500 g	0(0-2)	0.38(0.55)		0.5(0-7)	0.94(1.39)	

*Marked items were extracted from a father's self-administered questionnaire, and others from a child health checkup file.

a. Anger was calculated from the scores of items 3 and 5.
b. Lack of affection was calculated from the scores of items 1, 4, 6, 8, and 10.
c. Median (min-max) matched distribution, and mean (SD) was shown as reference.
d. Spearman's rank correlation was used for father’s work demands and the Mann-Whitney U test was used for all other items.
e. A higher score corresponds to a lower workload.
f. Only mother’s employment was included in the analysis, since there were only a few unemployed fathers.

Table 4. Factors related to fathers' bonding: multivariate analysis

Item	Anger[a] β	95%CI	p value	Item	Lack of affection[a] β	95%CI	p value
Father				Father			
Work demands[b] (score)	0.38	0.12 - 0.63	0.004	Age (0: <30 years, 1: ≥30 years)	0.30	0.02 - 0.58	0.04
Physical condition (0: good, 1: poor)	0.28	-0.11 - 0.66	0.16	Mental condition (0: good, 1:poor)	0.61	0.43 - 0.80	<0.001
Mental condition (0:good, 1: poor)	0.55	0.16 - 0.95	0.006	Mother			
Mother				Age (0: <30years, 1: ≥30 years)	0.19	-0.06 - 0.44	0.14
Age (0: <30 years, 1: ≥30 years)	0.16	-0.21 - 0.54	0.39	Physical condition (0: good, 1: poor)	0.11	-0.08 - 0.30	0.25
				Characteristics of family Interpersonal problems (0: No, 1: Yes)	0.42	0.20 - 0.64	<0.001

a. Multivariate analysis was carried out with Poisson regression. Birth order was used as an adjustment factor in both analyses.

b. A higher score corresponds to a lower workload.

β: partial regression coefficient; 95%CI: 95% confidence interval

Supplement 1. Score distribution of fathers' bonding (Original MIBS-J) (n=500)

No.	Items	Almost always strongly agree		Sometimes strongly agree		Sometimes slightly agree		Never agree	
		n	%	n	%	n	%	n	%
1	I feel loving towards my baby	453	90.6	45	9.0	2	0.4	0	0.0
2	I feel scared or panicky when I have to do something for my baby	18	3.6	91	18.2	221	44.2	170	34.0
3	I feel resentful towards my baby	1	0.2	0	0.0	89	17.8	410	82.0
4	I feel nothing towards the baby.	2	0.4	2	0.4	11	2.2	485	97.0
5	I feel angry with my baby.	0	0.0	0	0.0	49	9.8	451	90.2
6	I enjoy doing things with my baby.	301	60.2	146	29.2	39	7.8	14	2.8
7	I wish my baby was different.	1	0.2	1	0.2	3	0.6	495	99.0
8	I feel protective towards my baby.	468	93.6	26	5.2	3	0.6	3	0.6
9	I wish I did not have my baby	6	1.2	1	0.2	8	1.6	485	97.0
10	I feel very close to the baby.	407	81.4	72	14.4	17	3.4	4	0.8