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Association between maternal bonding difficulty and neurodevelopmental delay in children aged 2 to 4 years: the Japan Environment and Children's Study

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Original Article

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Abstract

We aimed to determine the association between maternal bonding difficulty in the postpartum period and children's neurodevelopment, considering maternal psychological distress and child sex-specific differences. To evaluate the relationship, the dataset of the Japan Environment and Children's Study was used, as well as the Mother-to-Infant Bonding Scale (MIBS), the six-item version of the Kessler Psychological Distress Scale (K6) for mothers, and the Ages and Stages Questionnaires Third Edition for children aged 2 to 4 years. Maternal MIBS and K6 were administered at 1 year postpartum. Data from 24,798 boys and 24,025 girls were analyzed. Multivariate logistic regression analyses, with the reference groups being those with maternal MIBS scores ≤4 and K6 scores ≤4, were performed. The Benjamini–Hochberg procedure was employed to account for multiple testing. In boys, maternal bonding difficulty (MIBS score ≥5) without psychological distress (K6 score ≤4) was associated with a screen-positive result for neurodevelopmental delay in all five domains (communication, gross motor, fine motor, problem-solving, and personal-social) at ages 2 to 4 years. In girls, maternal bonding difficulty without psychological distress was associated with a screen-positive result for neurodevelopmental delay in all five domains at 2 years of age. However, at age 4 years, maternal bonding difficulty without psychological distress was no longer associated with a screen-positive result for problem-solving delay in girls. The association of maternal bonding difficulty without psychological distress at 1 year postpartum with screen-positive result for problem-solving delay persisted in boys, but at age 4 years in girls, the association no longer existed.

Introduction

Maternal bonding is the emotional and affective tie that a mother develops toward her children, beginning during pregnancy and continuing into the postnatal period.[1–3] Maternal bonding plays a critical role in establishing early relational health and supports the development of sensitive and responsive caregiving.[1–3] Postpartum maternal bonding is characterized by maternal pleasure in interacting with their children, the sense that their ability and capacity to understand and meet the children's needs are developing, and their acceptance and tolerance of the demands of the maternal role.[3,4] Previous studies suggest that maternal emotional bonding is associated with early social-affective development in children.[5,6]

Bonding difficulty, a subjective experience of emotional distance, is characterized by reduced affection and anger toward, rejection of, and impulse to harm the children.[7,8] Bonding difficulty may reflect underlying perinatal stress, mood disturbances, or unresolved relational trauma.[9] Several tools for assessing bonding difficulty have been reported, one of which is the Mother-to-Infant Bonding Scale (MIBS).[10,11] The MIBS is a self-reported instrument that captures a mother's subjective emotional experiences, such as lack of affection, anger, and rejection toward her children.[10,11]

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Importantly, maternal bonding difficulty has been associated with reduced caregiving sensitivity, maltreatment of children by mothers, as well as adverse child outcomes, including socio-emotional and developmental delays.[3,12–17] However, only a few studies have examined sex differences in children.

Maternal bonding difficulty is associated with postpartum depression.[18–20] Previous studies have shown that maternal postpartum psychological distress, including depression and anxiety, is associated with developmental delay in children[21–24] and emphasize the importance of validating maternal bonding as a confounding factor.[21,22] The association of maternal bonding difficulty or maternal postpartum psychological distress with neurodevelopmental delay has been reported in children. However, few studies have explicitly considered maternal bonding difficulty with or without concurrent psychological distress.

The Japan Environment and Children's Study (JECS), a nationwide birth cohort study in Japan, has been investigating environmental exposures and children's development.[25,26] Our study used the JECS dataset to examine the association of maternal bonding difficulty with or without psychological distress at 1 year postpartum with neurodevelopmental delay in 2-, 3-, and 4-year-old children and evaluate sex-specific differences.

Methods

Design and participants

The JECS protocol has been published elsewhere.[25,26] JECS recruited pregnant women nationwide between January 2011 and March 2014 from 15 Regional Centers. Written informed consent was obtained from all participants. The present study used the jecs-ta-20190930 and jecs-qa-20210401 datasets. This study only included children from singleton pregnancies; therefore, multiple-birth children were excluded, as were children with congenital anomalies.[27]

Maternal bonding difficulty

The JECS administered the Japanese version of the MIBS as a mailed questionnaire to assess maternal bonding difficulty at 1 year postpartum.[11] The MIBS, a self-reported scale, contains 10 items, each graded on a 4-point Likert scale. Higher scores indicate a greater severity of bonding difficulty. The optimal cut off scores were ≥5 at 1 month postpartum.[16] Because a cutoff value at 1 year postpartum has not been reported, an MIBS total score ≥5 was used in this study, in accordance with previous studies.[28,29] The MIBS has two subscales: "lack of affection (LA)" (MIBS_LA: items 1, 6, 8, and 10) and "anger/rejection (AR)" (MIBS_AR: items 2, 3, 5, and 7).[11,30] For the subscale cutoffs, we used percentile values similar to those for the MIBS total score ≥5: LA scores ≥2 and AR scores ≥3, in accordance with previous studies.[15]

Maternal psychological distress

The JECS administered the six-item Japanese version of the Kessler Psychological Distress Scale (K6) as a mailed questionnaire to assess maternal psychological distress at 1 year postpartum. The K6 is widely used to assess psychological distress during the perinatal and postnatal periods.[31,32] It is a self-administered questionnaire comprising six questions that evaluate depressive mood and anxiety according to the Diagnostic and Statistical Manual of Mental Disorders, fourth edition, over the preceding 4 weeks on a scale of 0–4. The total score, with a possible range of 0–24, is the sum of the scores for the six items. We used a cutoff of ≥5 for the K6 to identify the cases of psychological distress, according to previous population-based and affected community-based studies in Japan.[33–36]

Screening for neurodevelopmental delay in children

The Ages and Stages Questionnaires, Third Edition (ASQ-3), a screening tool for developmental delay in children aged 1–66 months, has high reliability and validity and is widely accepted in clinical settings and research.[37,38] The evaluation was performed for the following five domains: communication, gross motor, fine motor, problem-solving, and personal-social characteristics. For each domain, the parent responded "yes," "sometimes," or "not yet," for specific behaviors of the child. Scores of 10, 5, and 0, respectively, were assigned to the responses, resulting in a total score of 0–60. A score below the specific cutoff for each domain was considered screening positive for neurodevelopmental delay in that domain. The Japanese translation of the ASQ-3 was validated using adjusted cutoff scores for the five domains at ages 1–4 years, as in the study by Mezawa et al.[37] Specifically, the ASQ-3 was administered at ages 0.6, 1, 1.5, 2.0, 2.5, 3.0, 3.5, and 4.0 years. In this study, we evaluated the children at ages 2.0, 3.0, and 4.0 years. The ASQ-3 was administered as a mailed questionnaire.

Statistical analysis

Crude analyses and multivariate logistic regression analyses without / with stepwise method were performed to obtain the odds ratios (ORs) and 95% confidence intervals (CIs).

For MIBS total, mothers were classified into the following four groups: (1) MIBS total score ≤4 and K6 score ≤4, (2) MIBS total score ≤4 and K6 score ≥5, (3) MIBS total score ≥5 and K6 score ≤4, and (4) MIBS total score ≥5 and K6 score ≥5. The reference group was the "MIBS total score ≤4 and K6 score ≤4" group.

For LA, mothers were classified into the following four groups: (1) LA score ≤1 and K6 score ≤4, (2) LA score ≤1 and K6 score ≥5, (3) LA score ≥2 and K6 score ≤4, and (4) LA score ≥2 and K6 score ≥5. The reference group was the "LA score ≤1 and K6 score ≤4" group.

For AR, mothers were classified into four groups: (1) AR score ≤2 and K6 score ≤4, (2) AR score ≤2 and K6 score ≥5, (3) AR score ≥3 and K6 score ≤4, and (4) AR score ≥3 and K6 score ≥5. The reference group was the "AR score ≤2 and K6 score ≤4" group.

The multivariate logistic regression analyses were adjusted for age of the mother at the delivery, unplanned pregnancy, infertility treatment, marital status, maternal highest level of education, paternal highest level of education, maternal smoking history during pregnancy, paternal smoking history during pregnancy, maternal alcohol consumption history during pregnancy, annual household income, maternal history of neuropsychiatric disorders, psychoactive drug use during pregnancy, maternal psychological distress K6 scores ≥5 during pregnancy, psychological intimate partner violence during pregnancy, physical intimate partner violence during pregnancy, pregnancy complications, maternal autism spectrum quotient 10 Japanese version ≥7,[39] obstetric labor complications, mode of delivery, birth weight of the children, gestational age at delivery, exclusive breastfeeding for 6 months postpartum, family structure at child's age of 6 months, number of children at child's age of 6 months including current child, attendance at daycare center at age 1 year, and Regional Center at time of registration (during pregnancy). These covariates were mostly selected according to

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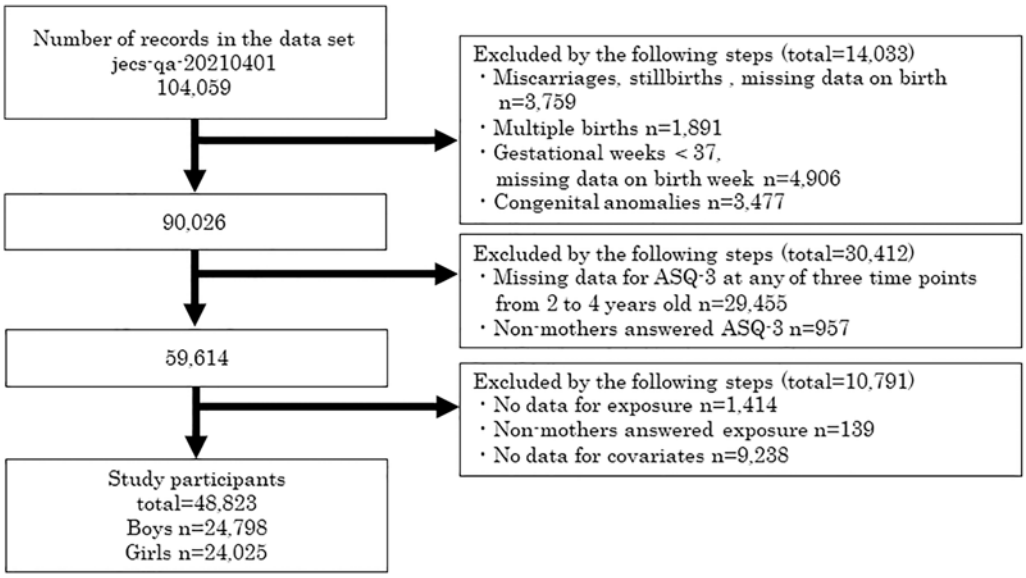


Figure 1. Flow chart depicting research participants' selection.

previous studies on postpartum depression/stress and neurodevelopment in children.[15,21,22,36] In this analysis, multicollinearity was not found. For reference, parity and number of children (including the current child) showed multicollinearity.

The multivariate logistic regression analyses were also adjusted for variables selected through a stepwise method, with the significance level ificance level of 0.05. To account for the multiple testing, the raw p-values were adjusted by methods that control the false discovery rate (FDR) were described by Benjamini and Hochberg. Raw p-values for 270 null hypotheses were collected (three exposures: MIBS, LA, and AR; three groups: (2) or (3) or (4) versus (1); five outcome domains; ages 2, 3, and 4 years; boys and girls). FDR-adjusted p-values < 0.05 was considered indicative of significance after multiplicity control.

All the analyses were performed using SAS statistical software, version 9.4 (SAS Institute Inc., Cary, NC, USA).

Results

Of 104,059 JECS dataset records, those of 24,798 boys and 24,025 girls were analyzed (Fig. 1). Table 1 shows the participants' characteristics, including those with single pregnancies and their children, evaluated using ASQ-3 (Table 1). Table 2 shows the distribution of mothers' MIBS and K6 scores.

Association between the MIBS/K6 score groups and screen-positive result for neurodevelopmental delays in children by sex (Tables 3–7 – see supplementary material)

Here, we reported only the results of groups with FDR-adjusted p-values<0.05 in multivariate logistic regression analysis fulfilling the following conditions: (I) not using the stepwise method; and (II) using the stepwise method.

MIBS total score for boys

The groups with "MIBS total score ≥5 and K6 score ≤4" and "MIBS total score ≥5 and K6 score ≥5" showed association with screen-positive result for neurodevelopmental delay in all five domains (communication, gross motor, fine motor, problem-solving, and personal-social) in boys aged 2, 3, and 4 years, compared with the reference group with "MIBS total score ≤4 and K6 score ≤4."

LA score for boys

The groups with "LA score ≥2 and K6 score ≤4" and "LA score ≥2 and K6 score ≥5" showed association with screen-positive result for neurodevelopmental delay in all five domains in boys aged 2, 3, and 4 years, compared with the reference group with "LA score ≤1 and K6 score ≤4."

AR score for boys

The groups with "AR score ≥3 and K6 score ≤4" and "AR score ≥3 and K6 score ≥5" showed association with screen-positive result for neurodevelopmental delay in all five domains in boys aged 2, 3, and 4 years, compared with the reference group with "AR score ≤2 and K6 score ≤4."

MIBS total score for girls

The group with "MIBS total score ≥5 and K6 score ≤4" showed association with (1) screen-positive result for all five domains at ages 2 years, (2) screen-positive result for gross motor, fine motor, and problem-solving at ages 3 years, (3) screen-positive result for communication, gross motor, fine motor, and personal-social delays in girls at age 4 years, compared with the reference group with "MIBS total score ≤4 and K6 score ≤4." However, the group with "MIBS total score ≥5 and K6 score ≤4" showed no significant association with screen-positive result for problem-solving delay in girls aged 4 years.

The group with "MIBS total score ≥5 and K6 score ≥5" showed association with screen-positive result for neurodevelopmental delay in all five domains in girls aged 2, 3, and 4 years, compared with the reference group with "MIBS total score ≤4 and K6 score ≤4."

LA score for girls

The group with "LA score ≥2 and K6 score ≤4" showed association with: (1) screen-positive result for all five domains at age 2 years; (2) screen-positive result for gross motor, fine motor, and

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Table 1. Characteristics of participants (total, $n = 48,823$)

		Analysis set				
		Boys ($n = 24,798$)		Girls ($n = 24,025$)		
Variables	Category	*n*	%	*n*	%	Reference for multiple regression analysis
Maternal age at delivery	Means ± SD	31.7 ± 4.7		31.7 ± 4.7		continuous variable
	<20	63	0.3	76	0.3	
	20–24	1583	6.4	1,468	6.1	
	25–34	15,845	63.9	15,607	65.0	
	> = 35	7,307	29.5	6,874	28.6	
Unplanned pregnancy	No	23,205	93.6	22,431	93.4	ref
	Yes	1593	6.4	1594	6.6	
Parity	Primipara	10,271	41.4	9,998	41.6	
	Multipara	13,952	56.3	13,479	56.1	
	No answer	575	2.3	548	2.3	
Infertility treatment	No	23,007	92.8	22,267	92.7	ref
	Yes	1791	7.2	1758	7.3	
Marital status	Married, Common-law marriage	24,515	98.9	23,787	99.0	ref
	Divorce, Widowed, Other	283	1.1	238	1.0	
Maternal highest level of education	College, University	10,944	44.1	10,512	43.8	
	Senior high school	13,161	53.1	12,797	53.3	ref
	Junior high school	693	2.8	716	3.0	
Paternal highest level of education	College, University	9,649	38.9	9,324	38.8	
	Senior high school,	13,808	55.7	13,310	55.4	ref
	Junior high school	1,341	5.4	1,391	5.8	
Maternal smoking during pregnancy	No	24,070	97.1	23,325	97.1	ref
	Yes	728	2.9	700	2.9	
Paternal smoking during pregnancy	No	14,234	57.4	13,710	57.1	ref
	Yes	10,564	42.6	10,315	42.9	
Maternal alcohol consumption during pregnancy	No	24,129	97.3	23,417	97.5	ref
	Yes	669	2.7	608	2.5	
Annual Household income (×1000 yen/ year) during pregnancy	<4,000	9,301	37.5	9,024	37.6	ref
	4,000 = < – < 6,000	8,517	34.4	8,152	33.9	
	> = 6,000	6,980	28.2	6,849	28.5	
Maternal neuropsychiatric disorders	No	22,744	91.7	21,946	91.4	ref
	Yes	2,054	8.3	2,079	8.7	
Psychoactive drugs use during pregnancy	No	24,169	97.5	23,409	97.4	ref
	yes	629	2.5	616	2.6	
Psychological IPV during pregnancy	No	21,727	87.6	21,208	88.3	ref
	Yes	3,071	12.4	2,817	11.7	
Physical IPV during pregnancy	No	24,584	99.1	23,829	99.2	ref
	Yes	214	0.9	196	0.8	

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Table 1. (*Continued*)

		Analysis set				
		Boys ($n = 24,798$)		Girls ($n = 24,025$)		
Variables	Category	*n*	%	*n*	%	Reference for multiple regression analysis
Maternal Autism Spectrum Quotient 10 Japanese version score	< = 6	24,170	97.5	23,422	97.5	ref
	> = 7	628	2.5	603	2.5	
Maternal K6; the first half of pregnancy	< = 4	17,416	70.2	16,694	69.5	ref
	> = 5	7,382	29.8	7,331	30.5	
Maternal K6; the second half of pregnancy	< = 4	18,413	74.3	17,933	74.6	ref
	> = 5	6,385	25.8	6,092	25.4	
Pregnancy complications	No	21,153	85.3	20,489	85.3	ref
	Yes	3,645	14.7	3,536	14.7	
Obstetric labor complications	No	13,715	55.3	13,360	55.6	ref
	Yes	11,083	44.7	10,665	44.4	
Mode of delivery	Vaginal	20,590	83.0	19,894	82.8	ref
	Cesarean	4,208	17.0	4,131	17.2	
Sex of children	Boy	24,798	100.0	0	0.0	
	Girl	0	0.0	24,025	100.0	
Birth weight of children (g)	Means ± SD	3,112.8 ± 364.5		3,013.0 ± 355.7		continuous variable
	0 < – < 1,500	1	0.0	2	0.0	
	1,500 = < – < 2,500	966	3.9	1554	6.5	
	2,500 = < – < 4,000	23,552	95.0	22,311	92.9	
	> = 4,000	279	1.1	158	0.7	
Gestational age at delivery (weeks)	37 = < – < 42	24,744	99.8	23,958	99.7	ref
	> = 42	54	0.2	67	0.3	
Exclusive breastfeeding for 6 months postpartum	No	15,366	62.0	14,607	60.8	ref
	Yes	9,432	38.0	9,418	39.2	
Family structure at age of 6 months	Extended family	4,903	19.8	4,794	20.0	
	Nuclear family	19,895	80.2	19,231	80.1	ref
Number of children at age of 6 months included participant	1	11,602	46.8	11,285	47.0	ref
	2	8,995	36.3	8,638	36.0	
	> = 3	4,201	16.9	4,102	17.1	
Attendance of daycare center at age 1	No	6,428	25.9	6,071	25.3	ref
	Yes	18,370	74.1	17,954	74.7	
Regional Center	Hokkaido	1903	7.7	1861	7.8	
	Miyagi	2,172	8.8	2038	8.5	
	Fukushima	3,198	12.9	3,007	12.5	ref
	Chiba	1,241	5.0	1,163	4.8	
	Kanagawa	1624	6.6	1601	6.7	
	Koshin	1562	6.3	1642	6.8	
	Toyama	1598	6.4	1553	6.5	
	Aichi	1,302	5.3	1,267	5.3	
	Kyoto	901	3.6	895	3.7	

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Table 1. (*Continued*)

		Analysis set				
		Boys ($n = 24,798$)		Girls ($n = 24,025$)		
Variables	Category	*n*	%	*n*	%	Reference for multiple regression analysis
	Osaka	2,061	8.3	2011	8.4	
	Hyogo	1,303	5.3	1,231	5.1	
	Tottori	779	3.1	789	3.3	
	Kochi	1610	6.5	1596	6.6	
	Fukuoka	2024	8.2	2021	8.4	
	South Kyusyu and Okinawa	1520	6.1	1,350	5.6	
Exposure: postpartum 1 year						
Maternal MIBS_total	Minimum	0		0		
total score [0–30]	25th percentile	0		0		
	50th percentile	1		1		
	75th percentile	3		3		
	Maximum	22		24		
Maternal MIBS_LA	Minimum	0		0		
total score [0–12]	25th percentile	0		0		
	50th percentile	0		0		
	75th percentile	1		1		
	Maximum	10		11		
Maternal MIBS_AR	Minimum	0		0		
total score [0–12]	25th percentile	0		0		
	50th percentile	1		1		
	75th percentile	2		2		
	Maximum	12		12		
Maternal K6	Minimum	0		0		
total score [0–24]	25th percentile	0		0		
	50th percentile	1		1		
	75th percentile	4		4		
	Maximum	24		24		
Maternal MIBS_total	< = 4	21,895	88.3	21,564	89.8	
	> = 5	2,903	11.7	2,461	10.2	
Maternal MIBS_LA	< = 1	21,949	88.5	21,403	89.1	
	> = 2	2,849	11.5	2,622	10.9	
Maternal MIBS_AR	< = 2	20,773	83.8	20,546	85.5	
	> = 3	4,025	16.2	3,479	14.5	
Maternal K6	< = 4	19,607	79.1	19,052	79.3	
	> = 5	5,191	20.9	4,973	20.7	
Maternal MIBS and K6	MIBS <= 4 and K6 < = 4	18,248	73.6	17,918	74.6	ref
	MIBS < = 4 and K6 > = 5	3,647	14.7	3,646	15.2	

(*Continued*)

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Table 1. (*Continued*)

		Analysis set				
		Boys ($n = 24,798$)		Girls ($n = 24,025$)		
Variables	Category	*n*	%	*n*	%	Reference for multiple regression analysis
	MIBS > = 5 and K6 < = 4	1,359	5.5	1,134	4.7	
	MIBS > = 5 and K6 > = 5	1544	6.2	1,327	5.5	
Maternal MIBS_LA and K6	MIBS_LA < = 1 and K6 < = 4	17,973	72.5	17,547	73.0	ref
	MIBS_LA < = 1 and K6 > = 5	3,976	16.0	3,856	16.1	
	MIBS_LA > = 2 and K6 < = 4	1634	6.6	1505	6.3	
	MIBS_LA > = 2 and K6 > = 5	1,215	4.9	1,117	4.7	
Maternal MIBS_AR and K6	MIBS_AR < = 2 and K6 < = 4	17,513	70.6	17,266	71.9	ref
	MIBS_AR < = 2 and K6 > = 5	3,260	13.2	3,280	13.7	
	MIBS_AR > = 3 and K6 < = 4	2,094	8.4	1786	7.4	
	MIBS_AR > = 3 and K6 > = 5	1931	7.8	1693	7.1	
Outcome: Screen-positive result for neurodevelopmental delay on the ASQ-3						
2 years old						
Communication delay (cut off point: <14.33)	No	23,466	94.6	23,569	98.1	
	Yes	1,332	5.4	456	1.9	
3 years old						
Communication delay (cut off point: < 29.95)	No	23,441	94.5	23,572	98.1	
	Yes	1,357	5.5	453	1.9	
4 years old						
Communication delay (cut off point: < 33.05)	No	23,115	93.2	23,250	96.8	
	Yes	1683	6.8	775	3.2	
2 years old						
Gross motor delay (cut off point: < 39.13)	No	23,405	94.4	22,706	94.5	
	Yes	1,393	5.6	1,319	5.5	
3 years old						
Gross motor delay (cut off point: < 39.26)	No	23,572	95.1	23,152	96.4	
	Yes	1,226	4.9	873	3.6	
4 years old						
Gross motor delay (cut off point: < 37.78)	No	23,090	93.1	22,886	95.3	
	Yes	1708	6.9	1,139	4.7	
2 years old						
Fine motor delay (cut off point: < 33.48)	No	24,236	97.7	23,588	98.2	
	Yes	562	2.3	437	1.8	

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Table 1. (*Continued*)

Variables	Category	Analysis set: Boys ($n = 24,798$)		Analysis set: Girls ($n = 24,025$)		Reference for multiple regression analysis
		n	%	*n*	%	
3 years old						
Fine motor delay (cut off point: < 27.91)	No	22,114	89.2	23,144	96.3	
	Yes	2,684	10.8	881	3.7	
4 years old						
Fine motor delay (cut off point: < 30.18)	No	22,183	89.5	23,391	97.4	
	Yes	2,615	10.6	634	2.6	
2 years old						
Problem-solving delay (cut off point: < 29.38)	No	23,605	95.2	23,195	96.6	
	Yes	1,193	4.8	830	3.5	
3 years old						
Problem-solving delay (cut off point: < 30.03)	No	22,334	90.1	22,726	94.6	
	Yes	2,464	9.9	1,299	5.4	
4 years old						
Problem-solving delay (cut off point: < 33.87)	No	23,440	94.5	23,508	97.9	
	Yes	1,358	5.5	517	2.2	
2 years old						
Personal-social delay (cut off point: < 25.22)	No	23,822	96.1	23,648	98.4	
	Yes	976	3.9	377	1.6	
3 years old						
Personal-social delay (cut off point: < 29.89)	No	23,588	95.1	23,657	98.5	
	Yes	1,210	4.9	368	1.5	
4 years old						
Personal-social delay (cut off point: < 35.01)	No	22,845	92.1	23,221	96.7	
	Yes	1953	7.9	804	3.4	

Abbreviations: intimate partner violence (IPV), The 6-item Kessler Psychological Distress Scale (K6), Japanese version of Mother-to-Infant Bonding Scale (MIBS), lack of affection (LA), anger / rejection (AR), standard deviation (SD). The Aged & Stages Questionnaires Third Edition (ASQ-3).

problem-solving delays at ages 3 years; (3) screen-positive result for communication, gross motor, fine motor, and personal-social delays at ages 4 years; compared with the reference group with "LA score ≤1 and K6 score ≤4." However, the group with "LA score ≥2 and K6 score ≤4" did not show a significant association with screen-positive result for problem-solving delay in girls aged 4 years.

The group with "LA score ≥2 and K6 score ≥5" showed association with screen-positive result for neurodevelopmental delay in all five domains in boys aged 2, 3, and 4 years, compared with the reference group with "LA score ≤1 and K6 score ≤4."

AR score for girls

The group with "AR score ≥3 and K6 score ≤4" showed association with: (1) screen-positive result for all five domains at ages 2 and 3 years; (2) screen-positive result for communication, gross motor, fine motor, and personal-social delays at ages 4 years; compared with the reference group with "AR score ≤2 and K6 score ≤4." However, the group with "AR score ≥3 and K6 score ≤4" showed no significant association with screen-positive result for problem-solving delay in girls aged 4 years.

The group with "AR score ≥3 and K6 score ≥5" showed association with screen-positive result for neurodevelopmental delay in all five domains in boys aged 2, 3, and 4 years, compared with the reference group with "AR score ≤2 and K6 score ≤4."

Discussion

Overall, our study revealed that maternal bonding difficulty at the first year postpartum period was associated with screen-positive result for neurodevelopmental delay in the children at age 2 to 4 years.

Maternal bonding difficulty without psychological distress

In boys, maternal bonding difficulty overall, LA, and AR, without psychological distress, were associated with screen-positive result

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Table 2. Maternal MIBS and K6 scores distribution at 1 year postpartum

	MIBS total				MIBS_LA				MIBS_AR				K6			
	Boys		Girls		Boys		Girls		Boys		Girls		Boys		Girls	
	n = 24,798		*n* = 24,025		*n* = 24,798		*n* = 24,025		*n* = 24,798		*n* = 24,025		*n* = 24,798		*n* = 24,025	
Score	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
0	7,870	31.7	8,046	33.5	13,980	56.4	14,123	58.8	10,675	43.1	10,728	44.7	8,876	35.8	8,652	36.0
1	5,625	22.7	5,619	23.4	7,969	32.1	7,280	30.3	6,366	25.7	6,416	26.7	3,635	14.7	3,607	15.0
2	3,860	15.6	3,770	15.7	1531	6.2	1,480	6.2	3,732	15.1	3,402	14.2	3,094	12.5	2,980	12.4
3	2,723	11.0	2,505	10.4	665	2.7	595	2.5	2,292	9.2	2036	8.5	2,227	9.0	2,126	8.9
4	1817	7.3	1624	6.8	439	1.8	361	1.5	1,063	4.3	885	3.7	1775	7.2	1687	7.0
5	1,069	4.3	900	3.8	112	0.5	104	0.4	394	1.6	342	1.4	1,291	5.2	1,194	5.0
6	651	2.6	590	2.5	58	0.2	42	0.2	171	0.7	135	0.6	957	3.9	953	4.0
7	386	1.6	323	1.3	24	0.1	16	0.1	67	0.3	51	0.2	656	2.7	662	2.8
8	286	1.2	213	0.9	8	0.0	5	0.0	27	0.1	17	0.1	551	2.2	495	2.1
9	190	0.8	157	0.7	10	0.0	18	0.1	7	0.0	5	0.0	414	1.7	395	1.6
10	133	0.5	100	0.4	2	0.0	0	0.0	1	0.0	5	0.0	302	1.2	309	1.3
11	70	0.3	68	0.3	0	0.0	1	0.0	0	0.0	1	0.0	254	1.0	250	1.0
12	39	0.2	34	0.1	0	0.0	0	0.0	3	0.0	2	0.0	206	0.8	227	0.9
13	28	0.1	22	0.1									131	0.5	122	0.5
14	23	0.1	22	0.1									115	0.5	100	0.4
15	11	0.0	11	0.1									88	0.4	65	0.3
16	5	0.0	6	0.0									51	0.2	45	0.2
17	5	0.0	3	0.0									48	0.2	38	0.2
18	2	0.0	5	0.0									32	0.1	32	0.1
19	1	0.0	3	0.0									23	0.1	22	0.1
20	0	0.0	0	0.0									23	0.1	15	0.1
21	3	0.0	0	0.0									14	0.1	15	0.1
22	1	0.0	0	0.0									6	0.0	10	0.0
23	0	0.0	1	0.0									10	0.0	11	0.1
24	0	0.0	3	0.0									19	0.1	13	0.1
25	0	0.0	0	0.0												
26	0	0.0	0	0.0												
27	0	0.0	0	0.0												

(*Continued*)

Table 2. (*Continued*)

	MIBS total				MIBS_LA				MIBS_AR				K6			
	Boys $n = 24,798$		Girls $n = 24,025$		Boys $n = 24,798$		Girls $n = 24,025$		Boys $n = 24,798$		Girls $n = 24,025$		Boys $n = 24,798$		Girls $n = 24,025$	
Score	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
28	0	0.0	0	0.0												
29	0	0.0	0	0.0												
30	0	0.0	0	0.0												

Abbreviations: Japanese version of Mother-to-Infant Bonding Scale (MIBS), lack of affection (LA), anger/rejection (AR), the 6-item Kessler Psychological Distress Scale (K6).

for all five domains of developmental delay (communication, gross motor, fine motor, problem-solving, personal-social characteristics) at ages 2, 3, and 4 years.

In girls, overall maternal bonding difficulty, LA, and AR, without psychological distress, were associated with screen-positive result for developmental delay in all five domains (communication, gross motor, fine motor, problem-solving, personal-social characteristics) at 2 years of age. However, at age 4 years, among the five domains, screen-positive result for problem-solving delay no longer showed a significant association with maternal bonding difficulty in girls. However, currently, it is unknown why in response to maternal bonding difficulty without psychological distress, only girls showed no significant screen-positive result for problem-solving delay at age 4 years. Further research and clarification are needed.

Maternal bonding difficulty with psychological distress

In both boys and girls, maternal bonding difficulty (overall, LA, and AR) with psychological distress was associated with screen-positive results for all five domains of developmental delay at ages 2, 3, and 4 years. Notably, a different pattern was observed in girls when maternal bonding difficulty occurred without psychological distress. Among them, maternal bonding difficulty (overall, LA, and AR) without psychological distress no longer showed a significant association with screen-positive results for problem-solving delay at age 4 years. This discrepancy may be explained by the potential influence of maternal psychological distress. In girls, maternal psychological distress without maternal bonding difficulty (overall, LA, and AR) was associated with screen-positive results for problem-solving delay at age 4 years (Table 6 – Supplementary material).

Previous studies about maternal bonding difficulty and neurodevelopment in children

Previous studies have revealed an association between maternal bonding difficulty and child neurodevelopment, but sex-specific differences were not examined.[3,14,15,40] In addition, these previous studies only included maternal psychological distress, including depression and anxiety, as a covariate factor. Thus, to our knowledge, this is the first report to examine sex-specific differences in the association between maternal bonding difficulty and screen-positive result for child neurodevelopmental delay and the synergistic effects of psychological distress.

Le Bas et al. studied 1,347 pairs using Maternal Postnatal Attachment Scale at 12 months postpartum and the Bayley Scales of Infant and Toddler Development, Third Edition at 12 months, in an Australian study. They reported that bonding predicted infant social-affective development, including social–emotional, behavioral, and temperamental outcomes.[14] Murakami et al. also studied 8,380 pairs using MIBS and ASQ-3 in a Japanese cohort study in the Tohoku region. They reported that maternal bonding difficulty at 1 month postpartum was associated with a screen-positive result for developmental delay in all five domains (communication, gross motor, fine motor, problem-solving, personal-social characteristics) for children aged 3.5 years.[15]

On a slightly different topic, previous studies using the MIBS reported that maternal bonding difficulty is a risk for maternal child maltreatment.[16,17] In a previous study, regarding the negative effects of physical, emotional, and sexual maltreatment and neglect, maltreatment in children was associated with changes in brain structure and function.[41]

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Limitations

First, the limitation of this study was that the mothers' self-reported all variables and the high likelihood of inter-dependence among them. The children's ASQ-3 is a maternal self-administered assessment; therefore, it was not objectively administered by trained evaluators. Thus, the result on maternal bonding difficulty may have led to an underestimation of the outcome of the children's developmental process.[3,6,14] Second, maternal bonding difficulty was not objectively measured or psychologically diagnosed. Third, psychological distress was not medically diagnosed. Fourth, an MIBS total score ≥5 at 1 year postpartum was used in this study, in accordance with previous studies.[28,29] However, there are issues regarding the significance of this range of scores when compared with the same scores at 1 month postpartum.[16] One month postpartum may reflect a time of significant adjustment, physical recovery, and fatigue. The same range score at 1 year may reflect bonding difficulty of a presumably higher magnitude. Therefore, this study has the limitation that MIBS assessments were not conducted during the early postpartum period, such as at 1 month postpartum.

Strengths of the study

To our knowledge, this is the first report to examine sex-specific differences in the association between maternal bonding difficulty and screen-positive result for child neurodevelopmental delay.

Conclusion

Overall, our study revealed that maternal bonding difficulty without psychological distress at the 1 year postpartum was associated with screen-positive result for communication, gross motor, fine motor, and personal-social domains from 2 to 4 years of age in boys and girls. The association between maternal bonding difficulty without psychological distress and screen-positive result for children's problem-solving delay persisted in boys but did not significantly exist in girls at age 4 years. However, there are limitations, and further studies are required.

Supplementary material. For supplementary material accompanying this paper visit https://doi.org/10.1017/S2040174426100476

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Ethical standard. The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national guidelines on human experimentation (Ministry of the Environment's Institutional Review Board on Epidemiological Studies) and with the Declaration of Helsinki of 1975, as revised in 2008, and was reviewed and approved by the Ministry of the Environment's Institutional Review Board on Epidemiological Studies (no. 100910001), and by the Ethics Committees of all participating institutions. Written informed consent was obtained from all participants.

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