Impact of Cleft lip and Palate on Mother-to-Infant Bonding: a Cross-Sectional Study in the Japan Environment and Children's Study

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Abstract
Background Cleft lip and/or palate (CL/P) is among the most prevalent congenital birth defects. They negatively affect maternal psychological status and may consequently result in higher prevalence of child maltreatment. However, the association of CL/P births with bonding disorders still remains unclear. To address this question, we examined the impact of CL/P birth on mother-to-infant bonding, using the nationwide birth cohort study, Japan Environment and Children's Study. Methods This study was conducted as a nationwide birth cohort study of the Japan environment and children's study (JECS), an ongoing nationwide birth cohort study in Japan. 104,065 of foetuses in fifteen regional centres in JECS were enrolled. Finally, the participants consisted of 79,140 mother-infant pairs, of which 211 mothers with CL/P infants were included in our analyses. Results First, no increased risk of bonding disorders was observed among all the mothers with CL/P births (odds ratio [95% CI]; 0.97 [0.63-1.48], p = 0.880), and advanced maternal age or multiple parity would adversely affect the associations between bonding disorders and CL/P births, respectively. Thus, after stratification with a combination of maternal age and parity, a significant association of CL/P birth with bonding disorders was found only among advanced-age multiparae (OR [95% CI] = 2.51 [1.17-5.37], p = 0.018), but it was weakened after additional adjustment for maternal depression. Conclusion CL/P birth may increase the risk of bonding disorders among advanced-age multiparae possibly through maternal depression. This finding provides valuable information for the provision of multidisciplinary cleft care.

Background
Cleft lip and/or cleft palate (CL/P), namely cleft lip with or without cleft palate (CL±P), and isolated cleft palate (CP) is among the most common birth defects and happen at a rate of approximately 1 in 700 births [1]. A nationwide survey in Japan showed that the prevalence of CL/P per 10,000 births was in a range of 14.4–24.8 [2, 3], which is slightly higher than the global prevalence. CL/P can be repaired with craniofacial plastic surgeries [2, 4]; however, parents of infants with CL/P generally suffer from childcare issues such as lower weight gain due to difficulties in direct breastfeeding and higher risk for upper respiratory infection [5–7]. Mothers of infants with CL/P, though a controversial issue, tend to show negative moods such as depression and anxiety [8, 9]. Johns et al. found a higher tendency of postpartum depression among older mothers of infants with CL/P [9].

Importantly, Van Horne et al. reported an unfortunate fact that children with CL/P have higher prevalence rates of child maltreatment compared with children with other congenital diseases [10, 11]. Furthermore, there is evidence suggesting impairment of attachment in mother-infant dyads with children with CL/P [12–14]. Boztepe et al. also indicated that, in comparison with congenital heart disease, the visibility of cleft lip was more likely to adversely affect the emotional connection between mother and infant among hospital visiting mothers [15]. Thus, CL/P birth may influence mother-infant attachment. However, the impact of CL/P birth on maternal emotional involvement with infants still remains unclear.
A mother's emotional involvements with her infant during the perinatal period has been recognized as mother-to-infant bonding [16, 17]. Bonding disorders have been acknowledged as a predictor for the impairment of infants' development due to poor childcare with lower maternal attachment and sensitivity [17–19]. Recently, the Mother-to-Infant Bonding Scale (MIBS), which is based on Kumar's Mother-Infant Bonding Questionnaire [16], has been used for quantitative screening of bonding disorders in mother-infant dyads among the general population [20]. Bonding disorders have been found to have strong relationships with maternal postpartum depression [21, 22] and lifestyle behaviours (drinking and smoking habits). The parity status impacts mother-to-infant bonding partly because of sibling competition for maternal attention [23, 24]. In particular, because congenital anomaly was one of the physiological characteristics in abuse among siblings [25–27], the parity status would confound mother-to-infant bonding with prevalence of CL/P birth. Thus, a better understanding of mother-to-infant bonding after CL/P birth will promote developments in multidisciplinary cleft care.

The aim of this study was to investigate the influence of CL/P birth on bonding disorders using a large-scale sample of the Japan Environment and Children's Study (JECS), a nationwide, multicentre, prospective birth cohort in Japan.

**Methods**

**Study design and participants**

The present study is based on the jeecs-an–20180131 dataset, which was released in March 2018. In brief, pregnant women in their first trimester were recruited at the first prenatal examination in cooperating hospitals or at local government offices from January 2011 until March 2014. After obtaining informed written consent, participants completed self-administered and medical records/transcripts, and subsequently underwent clinical measurements by medical doctors and trained nurses. To confirm the health status, check-up for both mother and infant was conducted at delivery and 1 month later. We enrolled 104,065 of foetuses in fifteen regional centres in JECS. In the fixed data of the JECS, 3,921 were miscarriages, stillbirths, and unknown; 1,889 were multiple births. Among the 98,255 mother-infant pairs, 10,045 pairs did not reply to the questionnaire sent out at 1 year after childbirth, and 9,070 pairs with other congenital disease(s) without CL/P were excluded from the analysis. A final sample size of 79,140 mother-infant pairs was included in this study (Figure. 1).

**Prevalence of CL/P (exposure measure)**

The data on CL/P and other congenital anomalies were ascertained from medical records/transcripts, which were filled by a doctor, a midwife, a nurses or a trained research coordinator at delivery and at 1 month of age onto JECS transcription forms [3, 28, 29]. The details of data processing, validation, and verification with regards to congenital anomalies were previously described [3]. There are three types of CL/P: cleft lip, cleft palate, or cleft lip with palate. A checkbox for each type was listed on the transcription
form. A tick was entered into the corresponding checkbox when any interests of CL/P were observed. Using the fixed JECS dataset, Mezawa et al. reported that total prevalence rates of CL/P per 10,000 births was 24.8 \cite{3}.

Furthermore, to examine the influence of visibility of CL/P on the mother-to-infant bonding, the mothers of infants with CL/P were divided into two groups: (1) CL±P group (mothers of infants with cleft lip with or without cleft palate) and (2) CP group (mothers of infants with isolated cleft palate).

**Mother-to-Infant Bonding Scale (MIBS: outcome measure)**

The MIBS is a self-report scale consisting of 10 items with responses based on a 4-point scale (from 0 to 3), and is used to evaluate mother-to-infant bonding at 1 year after childbirth. The total score ranges from 0 to 30, and higher scores indicate worse mother-to-infant bonding. The MIBS had been translated into Japanese and validated in a previous study \cite{20}. Cronbach's alpha of the MIBS for the current sample was 0.73. Because the optimal cut-off score is 4/5 \cite{17}, the presence of bonding disorders in mother-infant dyads was defined as \(\geq 5\) in this study.

**Covariates**

In addition to maternal smoking during pregnancy, maternal drinking habits during pregnancy was assessed with a self-administered questionnaire \cite{30}. Maternal age at delivery, parity, and infant sex were ascertained from medical records/transcripts filled by doctors, midwives, nurses, or trained research coordinators. In a follow-up questionnaire after birth, participants also reported feeding pattern and Kessler Psychological Distress Scale scores (K6) at 1 year. The design of the questionnaire has been previously described in detail \cite{28,29,31}.

Using the data from self-administered and medical records/transcripts, an advanced-age mother was defined as \(\geq 35\) years old \cite{32,33}. In addition, participants were categorized into the following groups by parity (‘primipara’ or ‘multipara’). Smoking status was divided into three categories: ‘never’, ‘stopped smoking before or during pregnancy’, or ‘current smoking’. Alcohol consumption was divided into three categories: ‘never’, ‘stopped drinking’, or ‘current drinking’. Categories for infant sex were ‘male’ or ‘female’, and categories for feeding pattern were ‘breastfeeding’, ‘formula’, or ‘mixed’.

**Statistical analysis**

Continuous variables were presented as medians with interquartile ranges, and categorical variables were presented as numbers and percentages (Table. 1). With regard to missing data, we applied the ‘missing at random’ assumption, and used multiple imputation with the multivariate normal imputation method \cite{34}. The numbers of participants with missing data in each of the variables are shown in Supplementary Table 1. An imputation model including all variables were independently applied for 10 copies of the data,
each with missing values suitably imputed. Estimates of the variables were averaged to compute a single mean estimate and adjusted standard errors using Rubin’s rule [35]. We performed crude and multivariate logistic regression analyses using the hierarchical multiple regression model for potential covariates to examine the association of bonding disorders with the prevalence of CL/P birth within each subgroup. These analyses were performed after adjustment for potential confounding factors, including maternal smoking and drinking habits, feeding pattern, and infant sex (model 1). All parameters in model 1 plus maternal depression (model 2) were included. The OR and 95% CI were calculated for bonding disorders. The results of the multiple imputation analyses are shown in Tables 2 and 3. All statistical analyses were performed using SPSS (version 24.0; IBM Corp., Armonk, NY, USA). In the analysis of the data, P values <0.05 were considered statistically significant.

Results

The median age of the participants was 31 years (interquartile range: 28–35 years), and the mean MIBS and K6 scores were 1.94 (standard deviation [SD]: 2.29) and 2.79 (SD: 3.61), respectively (Supplemental Table 1). The total numbers (%) of infants born with cleft lip with or without palate or isolated cleft palate in the present study were 64 (0.08), 90 (0.11), and 57 (0.07), respectively. Interestingly, the mean maternal MIBS scores (SD) of dyads with infants with CL/P were similar to those of the healthy infants (2.13 [2.72] vs. 1.94 [2.29] in Supplemental Table 1), but only advanced-age multiparae with CL/P births showed higher MIBS scores (SD) compared with healthy infants (3.08 [3.85] vs. 1.74 [2.21]) as well as prevalence of maternal depression (8.1% vs. 2.0%), as shown in Table 1.

No risk of bonding disorders was observed among all the mothers with infants with CL/P (odds ratio [OR] [95% confidence interval (CI)] = 0.97 [0.63–1.48], p = 0.880). After simple stratification by advanced maternal age or parity (Supplemental Table 2), ORs of association between bonding disorders and CL/P births in multivariate logistic regression analyses tended to be decreased in mothers aged <35 (OR [95% CI] = 0.71 [0.40–1.24], p = 0.222) or primiparae (OR [95% CI] = 0.58 [0.28–1.22], p = 0.152), while they tended to be increased in mothers aged ≥35 (OR [95% CI] = 1.81 [0.91–3.61], p = 0.086) or multiparae (OR [95% CI] = 1.39 [0.82–2.35], p = 0.222). Thus, the dataset was used after stratification with a combination of maternal age and parity. The characteristics of participants after stratification are shown in Table 1.

In multivariate logistic regression analysis using the imputed dataset, the adjusted ORs (95% CI) for bonding disorders of mothers with CL/P births in each group are summarized in Table 2. Compared with the reference participants with healthy infants, analyses without adjustments (crude model) or adjusted for all covariates except for maternal depression (model 1) revealed that the prevalence of bonding disorders was significantly associated with having an infant with CL/P only in the advanced-age multiparae group (OR [95% CI] = 2.51 [1.17–5.37], p = 0.018), but not in the other groups (OR [95% CI]: 0.44 [0.18–1.09], p = 0.076 in younger primiparae; 1.03 [0.51–2.07], p = 0.946 in younger multiparae; and 1.14 [0.61–2.15], p = 0.836 in advanced-age primiparae, respectively, in Table 2). However, additional adjustment for maternal depression (model 2) weakened the statistical association and resulted in no significance between bonding disorders and CL/P births among advanced-age multiparae (OR [95% CI] =
2.18 [0.96–4.95], p = 0.062). Interestingly, though no significance, CL/P birth tended to be negatively associated with bonding disorders only among young primiparae (OR [95% CI] = 0.44 [0.18–1.12], p = 0.085). Furthermore, analyses of the complete dataset (n = 75,361), excluding cases with missing values, also indicated significant association between bonding disorders and CL/P birth in crude model (OR [95% CI]; 2.39 [1.04–5.51], p = 0.040), but not in other models as shown in Supplemental Table 3. There were no significant interaction terms in the model between advanced maternal age and parity.

Moreover, with respect to the association of bonding disorders with the visibility of cleft lip, the prevalence of bonding disorders among advanced-age multiparae was significantly associated with CL±P birth in the crude model (OR [95% CI]; 2.87 [1.86–4.44], p = 0.015) or model 1 (OR [95% CI]; 2.56 [1.07–6.11], p = 0.033), but not in adjusted model for all covariates (OR [95% CI]; 2.31 [0.94–5.70], p = 0.072) as shown in Table 3. CP did not show any significant association with bonding disorders (OR [95% CI]; 1.76 [0.28–10.93], p = 0.545). In addition, there were no significant associations between bonding disorders with CL±P or CP births in the other three groups (younger primiparae, younger multiparae, or advanced-age primiparae).

**Discussion**

Our present results using the nationwide data from a large-scale birth cohort study in Japan showed no significant association between maternal bonding disorders and CL/P births among all the participants (OR [95% CI]; 0.97 [0.63–1.48], p = 0.880). However, our finding revealing the significant association of CL/P birth with maternal bonding disorders among advanced-age multiparae may serve as valuable information for multidisciplinary cleft care providers.

To the best of our knowledge, this is the first report showing the impact of CL/P birth on mother-to-infant bonding, though only among advanced-age multiparae. Maternal depression, which has been acknowledged as a predictor for bonding disorders [21, 22], statistically impacts the association of maternal bonding disorders with CL/P birth, because mothers with CL/P birth are generally troubled with more childcare issues with regards to feeding and breathing developments [5–7]. Furthermore, because the visual impacts of cleft lip possibly influence the processing of maternal-to-infant bonding, as suggested by Boztepe et al [15], we focused on whether the prevalence of cleft lip was associated with bonding disorders among advanced-age multiparae. Consequently, the significant association of bonding disorders with prevalence of CL±P birth did not remain after the adjustment using all covariates (OR [95% CI] = 2.31 [0.93–5.73], p = 0.072). Although possibly due to the smaller sample size of mothers having infants with CL/P, it would be of further interest to examine the confounding effects by visibility of cleft lip in future studies with the appropriate design.

Our results indicated that the association between bonding disorders and CL/P birth strongly varies according to parity and maternal age at delivery. Similar to the increasing trends of advanced maternal age and multiple parity on the association between bonding disorders and CL/P birth (Supplemental Table 2), their combined stratification showed a significant association between bonding disorders and
CL/P among advanced-age multiparae. A review of relevant studies indicated that the impacts of advanced maternal age and/or parity on mother-to-infant bonding are under some debate; however, several studies have reported adverse effects of older maternal age and multiparity on mother-to-infant bonding [36–39]. Because older mothers generally experience a more severe delivery and have more issues regarding childcare due to physical and psychological limitations [40, 41], advanced maternal age may impact mother-to-infant bonding among mothers of infants with CL/P. Meanwhile, as shown in our results (Table 1), multiparity generally contributes to better mother-to-infant bonding [42, 43]. Therefore, we speculated that the impact of multiparae status on mothers with CL/P birth on bonding disorders may be related to the presence of healthy siblings. The recurrence rate of nonsyndromic CL/P among siblings is reportedly very low, 2.3–4.6% [44, 45]. Tanimura et al., using nationwide data in Japan, pointed out that comparison with siblings by parents may be a common risk factor for child maltreatment [27]. The authors also found that children with congenital anomalies suffer from higher risk of maltreatment [25–27]. In order to further examine these findings, careful longitudinal observations are necessary because most mothers of infants with CL/P in other groups of this survey (younger primiparae, younger multiparae, and advanced-age primiparae) have the potential with aging to be in advanced-age multiparae when giving birth to a healthy sibling.

This study has several strengths and limitations. Since the Japanese nationwide survey covered approximately 45% of infants born in multi-subject area during 2013, our results, mostly based on the Japanese general population, allowed us to compare the experimental participants with abundant controls [28]. In terms of study limitations, first, this was a cross-sectional study using a 1-time measurement of mother-to-infant bonding as the outcome. Future longitudinal studies with more appropriate designs that consider episodes of child maltreatment are warranted. Second, this study’s data collection methods did not include a query about prenatal diagnoses. Johns et al. suggested that receiving prenatal diagnosis decreased maternal depressive symptoms among mothers of infants with CL/P [9]. Thus, our findings may be limited because the possibility of artificial abortion related to congenital anomaly after prenatal diagnosis as a selection bias cannot be ruled out.

This cross-sectional study using Japanese nationwide data indicated that mothers with CL/P births had similar rates of bonding disorders as the general population; however, advanced-age multiparae had a significantly higher risk of bonding disorders.

**Abbreviations**

CI: Confidence interval

CL/P: Cleft lip and/or cleft plate

CL±P: Cleft lip with or without cleft plate

CP: Isolated cleft palate
Declarations

Competing interests

The authors declare that they have no competing interests.

Author contributions

HM, RN, TA, and NY participated in data acquisition. ST, MT, and HM developed the study concept and participated in its design. TK, KI, and RN helped develop the study concept. ST, MT, and HM critically revised the manuscript. All authors have read and approved the final version of the manuscript.

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Ethics approval and consent to participate

This study was conducted in accordance with the World Medical Association Declaration of Helsinki. The JECS protocol was approved by the Ministry of the Environment's Institutional Review Board on Epidemiological Studies (no. 100406001), and approved by the ethics committees of all participating institutions (i.e., Asahikawa Medical College, Chiba University, Doshisha University, Fukushima Medical University, Hokkaido University, Hyogo College of Medicine, Japanese Red Cross Hokkaido College of Nursing, Kochi University, Kumamoto University, Kyoto University, Kyushu University, Nagoya City University, NCCHD, NIES, Osaka Medical Center and Research Institute for Maternal and Child Health, Osaka University, Sapporo Medical University, Shinshu University, Tohoku University, Tottori University, University of Occupational and Environmental Health, University of Miyazaki, University of the Ryukyu, University of Toyama, University of Yamanashi, and Yokohama City University). Written informed consent was obtained from all participants. The present study was conducted as a part of JECS and used anonymized data; hence, additional approval from the ethics committee was not required.

Availability of data and materials

The JECS data are not publicly available due to ethical restrictions and the legal framework of Japan. All inquiries about access to the data should be sent to the JECS Programme Office, National Institute for Environmental Studies (jeecs-en@nies.go.jp).

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Consent for publication

Not applicable.
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**Tables**
Table 1. Basic characteristics of participating mothers.

| maternal age | parity | Healthy | CL/P | | parity | Healthy | CL/P | | parity | Healthy | CL/P | | parity | Healthy | CL/P |
|--------------|--------|---------|------|---|--------|---------|------|---|--------|---------|------|---|--------|---------|------|---|
|              |        | (<35)   |      |   |        | (<35)   |     |   | (>35)  |        |    |   |
|              |        | (n =25,628) |      |   |       | (n =31,693) |     |   |       | (n =6,536) |     |   |
|              |        | (n =71)  |      |   |       | (n =85)  |     |   |       | (n =18)  |     |   |
|              |        | (n =15,072) |      |   |       | (n =37)  |     |   |
| Age, Median (IQR) | 28 (26, 31) | 28 (25.7, 31) | 30 (28, 32) | 30 (27, 33) | 37 (36, 39) | 37.5 (36, 40) | 37 (36, 39) | 37 (35.5, 38) | 1.74 (2.21) | 2.14 (2.57) | 1.74 (2.21) | 3.08 (3.85) | 1.503 (10.0) | 9 (24.3) | 2.62 (3.39) | 3.26 (4.57) |
| MIBS score, Mean (SD) | 2.23 (2.38) | 1.75 (1.90) | 1.74 (2.20) | 2.02 (2.69) | 2.21 (2.41) | 2.14 (2.57) | 1.74 (2.21) | 3.08 (3.85) | 1.503 (10.0) | 9 (24.3) | 2.62 (3.39) | 3.26 (4.57) | |
| Bonding disorders (≥5) | 3,528 (13.8) | 5 (7.0) | 3,104 (9.8) | 9 (10.6) | 2,86 (3.75) | 2.95 (4.15) | 2,63 (3.34) | 2.22 (2.71) | 3 (16.7) | 3 (16.7) | 2.62 (3.39) | 3.26 (4.57) | |
| K6 score, Mean (SD) | 2.85 (3.63) | 3.30 (4.24) | 2.86 (3.75) | 3.30 (4.24) | 2.95 (3.75) | 3.30 (4.24) | 2.95 (3.75) | 3.30 (4.24) | 3.08 (3.85) | 1.503 (10.0) | 9 (24.3) | 2.62 (3.39) | 3.26 (4.57) | |
| Bonding disorders (≥13) | 715 (2.8) | 2 (2.8) | 955 (3.0) | 3 (1.5) | 895 (13.7) | 1.74 (2.21) | 3 (16.7) | 9 (24.3) | 12 (33.3) | 12 (33.3) | 2.62 (3.39) | 3.26 (4.57) | |
| Smoking habit, n (%) | 15,988 (62.4) | 41 (57.7) | 17,665 (55.7) | 50 (58.6) | 3,983 (61.0) | 12 (66.7) | 9,153 (60.7) | 24 (64.9) | 5,311 (35.2) | 12 (34.1) | 608 (4.0) | 1 (2.7) | |
| Alcohol intake, n (%) | 8,332 (32.5) | 26 (36.6) | 11,906 (37.6) | 31 (36.5) | 2,009 (30.7) | 7 (38.9) | 5,200 (34.5) | 15 (40.5) | 7,719 (51.2) | 20 (54.1) | 2,153 (14.3) | 2 (5.4) | |
| Infant sex, n (%) | 12,957 (50.6) | 38 (53.5) | 16,076 (50.7) | 48 (56.5) | 3,359 (51.4) | 11 (61.1) | 7,809 (51.8) | 20 (54.1) | 7,263 (48.2) | 17 (45.9) | |
| Feeding pattern, n (%) | 516 (2.0) | 5 (7.0) | 7,442 (29.0) | 5 (7.0) | 11,932 (37.6) | 17 (20.0) | 1220 (18.7) | 0 (0) | 5,346 (35.5) | 5 (13.5) | |
| IQR=interquartile range; SD=standard deviation. Percentages and numbers of healthy infants and infants with CL/P may not sum to 100 or total numbers owing to rounding.

Table 2. Association of bonding disorders with the prevalence of CL/P birth.
### Table 3. Association of bonding disorders with the prevalence of childbirth with cleft lip among advanced-age multiparae.

| ≥35, Multiparae | Healthy (n = 15,072) | CL/P (n = 29) | p value | CP (n = 8) | p value |
|-----------------|----------------------|--------------|---------|-----------|---------|
| Bonding Disorders, n (%) | 1,503 (10.0) | 7 (24.1) | 0.015 | 2 (25.0) | 0.178 |
| Crude | 1.00 | 2.87 (1.86-4.44) | | 3.01 (1.33-6.81) | |
| Model 1<sup>a</sup> | 1.00 | 2.56 (1.07-6.10) | 0.033 | 2.36 (0.46-11.95) | 0.308 |
| Model 2<sup>b</sup> | 1.00 | 2.31 (0.93-5.73) | 0.072 | 1.76 (0.28-10.93) | 0.545 |

Odds ratio (95% confidence interval) (all such values) for bonding disorders were compared with the reference participants with healthy infants.

<sup>a</sup>Adjusted for maternal factors (smoking and drinking habits, feeding pattern, and infant sex).

<sup>b</sup>Additionally adjusted for maternal depression with model 1.

P values representing significant differences (<0.05) are indicated in bold.

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Odds ratio (95% confidence interval) (all such values) for bonding disorders were compared with the reference participants with healthy infants.

<sup>a</sup>Adjusted for maternal factors (smoking and drinking habits, feeding pattern, and infant sex).

<sup>b</sup>Additionally adjusted for maternal depression with model 1.

P values representing significant differences (<0.05) are indicated in bold.
Figure 1

Flow chart of the study participants. MIBS= Mother-to-Infant Bonding Scale.

Supplementary Files

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