Article

Association of Infertility Treatment with Perception of Infant Crying, Bonding Impairment and Abusive Behavior towards One’s Infant: A Propensity-Score Matched Analysis

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Abstract: Background: Although previous qualitative studies suggested the link between infertility treatment and negative emotions towards infants, few empirical population-based studies have investigated the association of infertility treatment with the perception of infant crying, bonding impairment, and abusive behavior towards one’s infant. Methods: Women who participated in a four month health-checkup program in Aichi Prefecture, Japan (n = 6590) were asked to complete a questionnaire that included infertility treatment history, perception of infant crying, maternal–infant bonding impairment assessed by the Mother to Infant Bonding Scale Japanese version, and abusive behavior towards one’s infant. Outcomes were dichotomized, and a conditional logistic regression was applied, using the propensity score match for infertility treatment exposure adjusted for known covariates. Results: A total of 690 participants (11.1%) reported infertility treatment history, and 625 cases were matched. We found that mothers with infertility treatment history were 1.36 times more likely to perceive a higher frequency of infant crying (95% confidence interval (CI): 1.05–1.78), but no association with maternal–infant bonding impairment (odds ratio (OR): 1.18; 95% CI: 0.81–1.72) and abusive behavior towards the infant (OR: 0.82; 95% CI: 0.49–1.36). Conclusions: Infertility treatment may be associated with the perception of a higher frequency of infant crying, but it is not associated with bonding impairment and abusive behavior. Further longitudinal study is needed to replicate the findings.

Keywords: infertility treatment; perception of infant crying; maternal–infant bonding impairment; abusive behavior towards infant; propensity score matching

1. Introduction

The number of cases of infertility is estimated to be 186 million around the world [1], with Japan having the highest number of infertility treatment cases [2]. The number of births by reproductive technology in Japan in 2017 stood at 56,617; that is, one out of 16 babies born in the country was through infertility treatment [3,4].

Infertility treatment might be a risk factor for child maltreatment (i.e., abusive behavior and neglect), because, in several case studies from Japan, mothers who had undergone infertility treatment were more likely to have negative emotions towards their infant than those who delivered by non-infertility treatment childbirth [5–10]. For example, the mother tended to feel her infant as a foreign body, with sentiments such as: “Because my infant has been made artificially, I feel my baby
is different from others” or “I feel my body is no longer natural since infertility treatment” [5,6]. Some other case studies reported that mothers who had undergone infertility treatment tended to be ambivalent, with both positive emotions of wanting to love their infant and negative emotions of hating their infant [8–12]. Based on these reports, some researchers proposed special care for mothers who underwent infertility treatment to prevent child maltreatment [5,13–15]. At the same time, however, there are previous reviews that reported that mothers who underwent infertility treatment may show higher maternal–fetal attachment during pregnancy [16,17].

To date, few empirical population-based studies have investigated the association of infertility treatment and child maltreatment, especially during infancy. Child maltreatment during infancy includes abusive behaviors, such as shaking and smothering [18–22], and neglect as a result of mother–child bonding impairment, which leads to poor development of attachment for the infant. Furthermore, infant crying is one of the major triggers of infant abuse [18–22] and poor bonding [23,24]. Although infant crying is an attachment behavior; that is, infant crying promotes proximity to the their primary caregiver [25], previous studies shows that infant crying is associated with maternal distress [26], which induces abusive behaviors, such as shaken baby syndrome [20,21,27]. Thus, maternal perception of infant crying needs to be investigated in the context of child maltreatment during infancy. Previous quantitative case-control studies in Australia that investigated the association between infertility treatment and mother–infant bonding at four months did not find any positive association, although the sample size was limited, and sampling was not population-based (n = 133) [28,29]. Another study reported no association between infertility treatment history and paternal bonding impairment [30], but the association between infertility treatment history and maternal bonding impairment was not revealed. Thus, there is a need to investigate the association of infertility treatment with perception of infant crying, bonding impairment, and abusive behavior towards one’s infant using a population-based sample.

In this study, we examined the association of infertility treatment with perception of infant crying, bonding impairment, and abusive behavior towards one’s infant, compared to mothers who went through non-infertility treatment childbirth, using a population-based sample in Japan.

2. Materials and Methods

2.1. Procedure and Participants

This cross-sectional study was conducted in Aichi Prefecture, Japan, between October and November 2012. Aichi Prefecture has 54 municipalities. The population was approximately 7.4 million with 67,913 births in 2012. A total of 45 municipalities, including the prefecture’s capital city Nagoya, participated in this study. The participating municipalities cover 80% of the total population in Aichi. The target subjects were all mothers (n = 9707) who were enrolled in a four-month health checkup program between October and November 2012 in participating municipalities. In accordance with the Japanese law (Maternal and Child Health Act), municipalities in Japan provide free infant health checkup at three to four months. Invitations for a health checkup are sent to eligible families. Approximately 96% of Japanese mothers participated in the health checkup [31]. Questionnaires were sent with the invitation by 3 healthcare centers to the target subjects by mail before the start of the health checkup program. Completed questionnaires were collected during the health checkup. Overall, the participation rate for the 3–4 health checkups in the prefecture was 97.9%. In total, 6590 women responded (response rate 68%).

The women who participated were asked to a complete a questionnaire including infertility treatment history of the delivered infant, perception of infant crying, the Mother to Infant Bonding Scale Japanese version (MIBS-J), and self-reported abusive behavior towards infants.

We excluded twin birth samples (n = 110; the proportion of the whole sample was 1.7%) as they increase the risk of perception of infant crying [21], mother–infant interaction [32], and abusive behavior [33–35], and causes the ambiguity of which out of the infertility treatment and the twin
was investigated. We also excluded samples with missing values for infertility treatment history, perception of infant crying, bonding impairment, abusive behavior, and parental age, as parental age is a strong predictor of infertility treatment \cite{36,37} (n = 90, 1.4% of the respondent sample). Finally, we analyzed 6213 samples.

2.2. Measurements

2.2.1. Infertility Treatment

We assessed infertility treatment history with the following the question: “Did you receive treatment for infertility for this pregnancy?”. The answer selection was “Yes” or “No”. Previous studies showed that self-reported history of infertility treatment by the mother did not differ from that of registered data \cite{38,39}.

2.2.2. Perception of Infant Crying

Perception of infant crying was assessed by the statement “My baby cries a lot” using a four-point Likert scale, with 1 indicating “not at all” and 4 indicating “yes, a lot”, based on previous studies \cite{18–22}. Since category 4 represented only a small proportion of the study population, we dichotomized the variable by categorizing responses with 1 and 2 as normal perception of infant crying, and those with 3 and 4 as high perception of infant crying.

2.2.3. Maternal–Infant Bonding Impairment

We evaluated maternal–infant bonding impairment using the 10-item version of the Mother to Infant Bonding Scale Japanese version (MIBS-J) \cite{40} with a validated cut-off point of 4/5 \cite{41}. The self-report scale consists of 10 items including four reverse items on a four-point Likert scale (from 0, “not at all” to 3, “very much”). The total score was calculated for each respondent. The range of the total score was 0–30. High scores denote bonding impairment.

2.2.4. Abusive Behavior towards Infant

We evaluated the two forms of maternal abusive behavior, self-reported shaking and smothering. Parents were asked the frequency of these behaviors over the last month with the following questions: “What is the frequency of shaking your baby violently when he/she cried or expressed frustration?” and “What is the frequency of you smothering your baby with your hands or other objects such as a cushion when he/she cried or expressed frustration?” The response items were “Never”, “1–2 times”, “3–5 times”, “6–10 times”, or “11 or more times”. “No” was assigned to those who responded “Never” while “yes” was assigned to those who responded “1–2 times”, “3–5 times”, “6–10 times”, or “11 or more times”. Furthermore, we assigned these responses as abusive behavior towards infants.

2.2.5. Covariates

We included the following covariates in our model: maternal and paternal age, maternal and paternal employment status, history of maternal depression, maternal and paternal habit during pregnancy (such as smoking), obstetric history (such as abortion), social economic status (such as subjective economic status, number of rooms in the house, and living floor), and living with grandparents. Subsequently, we included the following to control unmeasured variables in our propensity-score matching model: delivery satisfaction, delivery in maternal hometown, infant low birth weight, and feeding status.

2.3. Statistical Analysis

First, crude and multiple regressions were performed using the analytic sample (n = 6213). Covariates used for the multiple regression were the same 25 variables (See Section 2.2.5) used in propensity-score (PS) matching. Because this study was an observational study, infertility treatment was
not randomly assigned. The PS matching method was used to control by matching known covariates simultaneously [42]. PS matching was conducted using the same 25 variables to predict the propensity score for infertility treatment history. The caliper was set as 0.001. Finally, we conducted a conditional logistic regression analysis to compare the outcomes between the matched pairs. Statistical analyses were performed using STATA/SE 15.0 software (Stata Corp Drive, College Station, TX, USA).

2.4. Ethics Statement

As the data contained no personal identifiers, the requirement for informed consent was waived. Ethics approval was obtained from the institutional review board of the National Center for Child Health and Development (reference number 611).

3. Results

Table 1 shows the demographic characteristics. The average age of mothers and fathers was 31.4 and 33.3 years old, respectively. Fifty percent of the infants were firstborn. A total of 78% of mothers were not working, and 99% were married. Most fathers (98%) were in full-time employment. Almost all mothers did not smoke (97%) or drink (96%) during pregnancy, but about 14% of fathers smoked during the period. Poor economic status made up 11% of the sample.

Table 1. Distribution of background characteristics of participants.

| Continuing Variables               | Participants (n = 6213) | n | %  |
|-----------------------------------|------------------------|---|----|
| Maternal age                      |                        |   |    |
| Paternal age                      |                        |   |    |
| Categorical variables             | Response items         | n | %  |
| Maternal marital status           | Married                | 6145| 98.9|
|                                  | Unmarried              | 53 | 0.9|
|                                  | Missing                | 15 | 0.2|
| Maternal job                      | Fulltime               | 1023| 16.5|
|                                  | Part time              | 299 | 4.8|
|                                  | No work                | 4860| 78.2|
|                                  | Missing                | 31 | 0.5|
| History of depression             | No                     | 5311| 85.5|
|                                  | Yes                    | 892 | 14.4|
|                                  | Missing                | 10 | 0.2|
| Maternal smoking during pregnancy | No or quit             | 6025| 97.0|
|                                  | Yes                    | 185 | 3.0|
|                                  | Missing                | 3  | 0.1|
| Maternal drinking during pregnancy| No                     | 5961| 95.9|
|                                  | Yes                    | 244 | 3.9|
|                                  | Missing                | 8  | 0.1|
| History of abortion              | No                     | 5790| 93.2|
|                                  | Yes                    | 419 | 6.7|
|                                  | Missing                | 4  | 0.1|
| History of miscarriage           | No                     | 5097| 82.0|
|                                  | Yes                    | 1112| 17.9|
|                                  | Missing                | 4  | 0.1|
| History of stillbirth            | No                     | 6141| 98.8|
|                                  | Yes                    | 68  | 1.1|
|                                  | Missing                | 4  | 0.1|
Table 1. Cont.

| Continuing Variables                               | Participants (n = 6213) | Mean | SD |
|----------------------------------------------------|-------------------------|------|----|
| Paternal work                                      |                         |      |    |
| Fulltime                                           | 6082                    | 97.9 |    |
| Part time or no-work                               | 106                     | 1.7  |    |
| Missing                                            | 25                      | 0.4  |    |
| Paternal smoking during pregnancy                  |                         |      |    |
| No                                                 | 5303                    | 85.4 |    |
| Yes                                                | 897                     | 14.4 |    |
| Missing                                            | 13                      | 0.2  |    |
| Talk to partner about raising children              |                         |      |    |
| Yes                                                | 5814                    | 93.6 |    |
| No                                                 | 174                     | 2.8  |    |
| Missing                                            | 225                     | 3.6  |    |
| Subjective economic status                         |                         |      |    |
| Stable                                             | 2778                    | 44.7 |    |
| Afford                                             | 2553                    | 41.1 |    |
| Poor                                               | 689                     | 11.1 |    |
| Missing                                            | 193                     | 3.1  |    |
| Health insurance                                   |                         |      |    |
| Social insurance                                   | 5033                    | 81.0 |    |
| National insurance                                 | 874                     | 14.1 |    |
| Other                                              | 16                      | 0.3  |    |
| Missing                                            | 290                     | 4.7  |    |
| House type                                         |                         |      |    |
| House                                              | 2429                    | 39.1 |    |
| Apartment                                          | 3740                    | 60.2 |    |
| Missing                                            | 44                      | 0.7  |    |
| Living floor                                       |                         |      |    |
| <2F                                                | 2099                    | 33.8 |    |
| 3F–8F                                              | 1356                    | 21.8 |    |
| >9F                                                | 182                     | 2.9  |    |
| Missing                                            | 2576                    | 41.5 |    |
| Number of rooms                                    |                         |      |    |
| <2DK                                               | 810                     | 13.0 |    |
| 2LDK-3DK                                           | 2090                    | 33.6 |    |
| 3LDK-4DK                                           | 1221                    | 19.7 |    |
| >4DK                                               | 1877                    | 30.2 |    |
| Missing                                            | 215                     | 3.5  |    |
| Live with grandmother                              |                         |      |    |
| No                                                 | 5521                    | 88.9 |    |
| Yes                                                | 692                     | 11.1 |    |
| Live with grandfather                              |                         |      |    |
| No                                                 | 5678                    | 91.4 |    |
| Yes                                                | 535                     | 8.6  |    |
| Delivery satisfaction                              |                         |      |    |
| Satisfaction                                       | 5356                    | 86.2 |    |
| Slightly satisfied                                 | 697                     | 11.2 |    |
| Slightly not satisfied                             | 108                     | 1.7  |    |
| Not satisfies                                      | 34                      | 0.6  |    |
| Missing                                            | 18                      | 0.3  |    |
| Delivery in maternal hometown                      |                         |      |    |
| Yes                                                | 2614                    | 42.1 |    |
| No                                                 | 3580                    | 57.6 |    |
| Missing                                            | 19                      | 0.3  |    |
| Number of children                                 |                         |      |    |
| Second child or more                               | 3084                    | 49.6 |    |
| First child                                        | 3112                    | 50.1 |    |
| Missing                                            | 17                      | 0.3  |    |
| Feeding at 4 months                                |                         |      |    |
| Breast-feed                                        | 3782                    | 60.9 |    |
| Mix-feed                                           | 1395                    | 22.5 |    |
| Bottle-feed                                        | 649                     | 10.5 |    |
| Missing                                            | 387                     | 6.2  |    |
| Low birth weight                                   |                         |      |    |
| <2500                                              | 454                     | 7.3  |    |
| ≥2500                                              | 5736                    | 92.3 |    |
| Missing                                            | 23                      | 0.4  |    |
Table 2 shows the distribution of outcomes. More than 22.8% of mothers perceived their infant to cry a lot \((n = 1415)\). The prevalence of bonding impairment with a cut-off score over 5 was 8.6\% \((n = 537)\), and the prevalence of abusive behavior was 5.3\% \((n = 372)\).

**Table 2. Distribution of outcomes of participants.**

| Variables                      | Response | Participants \((n = 6213)\) | \(\text{N}^a\) | \%     |
|-------------------------------|----------|-------------------------------|-----------------|--------|
| Perception of infant crying   | No       | 4798                          | 77.2            |
|                               | Yes      | 1415                          | 22.8            |
| Bonding impairment            | No       | 5676                          | 91.4            |
|                               | Yes      | 537                           | 8.6             |
| Abusive behavior towards infant | No    | 5881                          | 94.7            |
|                               | Yes      | 332                           | 5.3             |

\(^a\) Number of observations.

Table 3 shows the distribution of covariates before and after PS matching by infertility treatment. Among the women who underwent infertility treatment, 83\% \((n = 625)\) were matched with similar women who went through non-infertility treatment childbirth. The balance of potential confounders within the matched pairs was evaluated using standardized bias. Before PS matching, those who underwent infertility treatment were more likely to be older (34.3 vs. 31.0 years, \(p < 0.01\)); were in full-time employment (21.2\% vs. 15.9\%, \(p < 0.01\)); had a lower prevalence of depression before pregnancy (10.6\% vs. 14.8\%, \(p < 0.01\)); had a partner who smoked during the pregnancy period (15.1\%, vs. 9.3\%, \(p < 0.01\)); had higher economic status, such as stable economic status (55.9\% vs. 43.3\%, \(p < 0.01\)); and had the child as a firstborn (66.7\% vs. 48.0\%, \(p < 0.01\)). After PS matching, these variables became nonsignificant, and the bias of these covariates became less than 10\%, suggesting that covariates were balanced between the infertility treatment group and the non-infertility treatment group.

We conducted the odds ratio of crude, multiple logistic before PS matching, and conditional logistic regression after PS matching to examine the association between infertility treatment and maternal perception of crying, maternal–infant bonding impairment, and abusive behavior (Table 4). Before PS matching, mothers with infertility treatment showed a higher risk of the perception of a higher frequency of crying in the crude model (odds ratio (OR): 1.24; 95\% confidence interval (CI): 1.03–1.48) but no significance was observed in the multiple logistic regression (OR: 1.20; 95\% CI: 0.99–1.46). As for bonding impairment and abusive behavior, no association with infertility treatment was observed. After PS matching, mothers with infertility treatment still showed a higher odds ratio of the perception of a higher frequency of crying (OR: 1.36; 95\% CI: 1.05–1.78). As for maternal–infant bonding impairment (OR: 1.18; 95\% CI: 0.81–1.72) and abusive behavior towards one’s infant (OR: 0.82; 95\% CI: 0.49–1.36), no association was found, which was similar to the result before PS matching.
Table 3. Distribution of characteristic covariates for the history of infertility treatment before and after propensity score (PS) matching (outcome is “Maternal perception of crying”).

| Variables                        | n = 6213 Before PS Matching | n = 1250 After PS Matching |
|----------------------------------|-------------------------------|-----------------------------|
|                                  | (Number of samples, proportions) |                          | (Number of samples, proportions) |                          |
|                                  | No (5523, 88.9%) | Yes (690, 11.1%) | p a | Mean (SD) | No (n = 625) | Yes (n = 625) | p a | Mean (SD) |
| Maternal age                     | 31.0 (4.7) | 34.3 (4.3) | <0.01 | 73.5 | 33.9 (4.4) | 33.8 (4.2) | 0.9 | 35.5 (5.5) | 35.6 (4.9) | 0.8 |
| Paternal age                     | 33.0 (5.5) | 36.0 (5.1) | <0.01 | 57.4 | 36.8 (4.9) | 36.9 (4.2) | 0.9 | 35.5 (5.5) | 35.6 (4.9) | 0.8 |
| Maternal marital status          | Unmarried 51 (0.9) | 2 (0.3) | 0.2 | Reference | 3 (0.5) | 2 (0.3) | 0.8 | Reference |
|                                  | Married 5459 (98.8) | 686 (99.4) | Reference | 621 (99.4) | 621 (99.4) | Reference |
|                                  | Missing 13 (0.2) | 2 (0.3) | 1.1 | Reference | 1 (0.2) | 2 (0.3) | 3.1 |
| Maternal job                     | Fulltime 877 (15.9) | 146 (21.2) | <0.01 | Reference | 135 (21.6) | 127 (20.3) | 0.3 | Reference |
|                                  | Part timer 263 (4.8) | 36 (5.2) | 2.1 | Reference | 37 (5.9) | 31 (5.0) | −4.4 |
|                                  | No work 4355 (78.9) | 505 (73.2) | −13.3 | Reference | 453 (72.5) | 464 (74.2) | 4.1 |
|                                  | Missing 28 (0.5) | 3 (0.4) | −1.1 | Reference | 0 (0) | 0 (0) | 0.5 |
| History of depression            | No 4695 (85.0) | 616 (89.3) | 0.01 | Reference | 559 (89.4) | 556 (89.0) | 0.8 | Reference |
|                                  | Yes 819 (14.8) | 73 (10.6) | Reference | 64 (10.2) | 68 (10.9) | 1.9 |
|                                  | Missing 9 (0.2) | 1 (0.1) | −0.5 | Reference | 2 (0.3) | 1 (0.2) | −4.1 |
| Maternal smoking during pregnancy| No or quit 5345 (96.8) | 680 (98.6) | 0.04 | Reference | 608 (97.3) | 616 (98.6) | 0.1 | Reference |
|                                  | Yes 175 (3.2) | 10 (1.5) | −3.3 | Reference | 17 (2.7) | 9 (1.4) | −8.5 |
|                                  | Missing 3 (0.1) | 0 (0) | −3.3 | Reference | 0 (0) | 0 (0) | 0.0 |
| Maternal drinking during pregnancy| Yes 216 (3.9) | 28 (4.1) | 0.6 | Reference | 29 (4.6) | 24 (3.8) | 0.5 | Reference |
|                                  | No 5299 (95.9) | 662 (95.9) | Reference | 596 (95.4) | 601 (96.2) | 4.1 |
|                                  | Missing 8 (0.1) | 0 (0) | Reference | 5 (0.1) | 6 (0.1) | 0.0 |
| History of abortion              | No 5127 (92.8) | 663 (96.1) | <0.01 | Reference | 600 (96.0) | 601 (96.2) | Reference |
|                                  | Yes 392 (7.1) | 27 (3.9) | −14.0 | Reference | 25 (4.0) | 24 (3.8) | −0.7 |
|                                  | Missing 4 (0.1) | 0 (0) | −3.8 | Reference | 0 (0) | 0 (0) | 0.0 |
| History of miscarriage           | No 4594 (83.2) | 503 (72.9) | <0.01 | Reference | 465 (74.4) | 467 (74.7) | Reference |
|                                  | Yes 925 (16.8) | 187 (27.1) | 25.2 | Reference | 160 (25.6) | 158 (25.3) | −0.8 |
|                                  | Missing 4 (0.1) | 0 (0) | −3.8 | Reference | 0 (0) | 0 (0) | 0.0 |
| Variables | Response Items | \( n = 6213 \) Before PS Matching | \( n = 1250 \) After PS Matching | \( \rho ^{a} \) | Bias (%) | \( \rho ^{a} \) | Bias (%) |
|-----------|----------------|---------------------------------|---------------------------------|---------|----------|---------|----------|
| History of stillbirth | No | 5461 (98.9) | 680 (98.6) | 0.5 | Reference | 618 (98.9) | 615 (98.4) | 0.5 | Reference |
| | Yes | 58 (1.1) | 10 (1.5) | | | 7 (1.1) | 10 (1.6) | | |
| | Missing | 4 (0.1) | 0 (0) | | | | | | |
| Paternal work | Fulltime | 5400 (97.8) | 682 (98.8) | 0.2 | Reference | 619 (98.7) | 617 (98.9) | 0.8 | Reference |
| | part time or no-work | 100 (1.8) | 6 (0.9) | | | 4 (0.6) | 6 (1.0) | | |
| | Missing | 23 (0.4) | 2 (0.3) | | | 2 (0.3) | 2 (0.3) | | |
| Paternal smoking during pregnancy | Yes | 833 (15.1) | 64 (9.3) | <0.01 | Reference | 57 (9.1) | 59 (9.4) | 0.6 | Reference |
| | No | 4678 (84.7) | 625 (90.6) | | | 568 (90.9) | 565 (90.4) | | |
| | Missing | 12 (0.2) | 1 (0.1) | | | 0 (0) | 1 (0.2) | | |
| Talk to partner about raising children | Yes | 5156 (93.4) | 658 (95.4) | 0.1 | Reference | 586 (93.8) | 595 (95.2) | 0.4 | Reference |
| | No | 160 (2.9) | 14 (2.0) | | | 14 (2.2) | 13 (2.1) | | |
| | Missing | 207 (3.8) | 18 (2.6) | | | 25 (4.0) | 17 (2.7) | | |
| Subjective economic status | stable | 2392 (43.3) | 386 (55.9) | <0.01 | Reference | 321 (51.4) | 341 (54.6) | 0.6 | Reference |
| | afford | 2308 (41.8) | 245 (35.5) | | | 235 (37.6) | 227 (36.3) | | |
| | poor | 645 (11.7) | 44 (6.4) | | | 50 (8.0) | 43 (6.9) | | |
| | Missing | 178 (3.2) | 15 (2.2) | | | 19 (3.0) | 14 (2.2) | | |
| Health insurance | Social insurance | 4446 (80.5) | 587 (85.1) | 0.02 | Reference | 514 (82.2) | 528 (84.5) | 0.6 | Reference |
| | National insurance | 803 (14.5) | 71 (10.3) | | | 76 (12.2) | 67 (10.7) | | |
| | Other | 15 (0.3) | 1 (0.1) | | | 3 (0.5) | 1 (0.2) | | |
| | Missing | 259 (4.7) | 31 (4.5) | | | 32 (5.1) | 29 (4.6) | | |
| House type | House | 2116 (38.3) | 313 (45.4) | <0.01 | Reference | 281 (45.0) | 281 (45.0) | 0.9 | Reference |
| | Apartment | 3366 (61.0) | 374 (54.2) | | | 340 (54.4) | 341 (54.6) | | |
| | Missing | 41 (0.7) | 3 (0.4) | | | 4 (0.6) | 3 (0.5) | | |
| Living floor | <2F | 1911 (34.6) | 188 (27.3) | <0.01 | Reference | 181 (29.0) | 177 (28.3) | 0.8 | Reference |
| | 3F-5F | 1209 (21.9) | 147 (21.3) | | | 134 (21.4) | 133 (21.3) | | |
| | >9F | 150 (2.7) | 32 (4.6) | | | 18 (2.9) | 24 (3.8) | | |
| | Missing | 2253 (40.8) | 323 (46.8) | | | 292 (46.7) | 291 (46.6) | | |

\( a \): Bias calculated.
Table 3. Cont.

| Variables                  | Response Items | $n = 6213$ | Before PS Matching | After PS Matching |
|----------------------------|----------------|------------|--------------------|-------------------|
|                            |                | $n$ | History of Infertility Treatment | $p^a$ | Bias (%) | $n$ | History of Infertility Treatment | $p^a$ | Bias (%) |
| Number of rooms            |                |     |                        |            |          |     |                        |            |          |
| <2DK                       |                | 760 | (13.8)                  | 50 (7.3)   | <0.01 Reference | 42 (6.7) | 48 (7.7) | 0.8 | Reference |
| 2LDK-3DK                   |                | 1885 | (34.1)                  | 205 (29.7) | -9.5 | 205 (32.8) | 192 (30.7) | -4.5 |
| 3LDK-4DK                   |                | 1052 | (19.1)                  | 169 (24.5) | 13.2 | 143 (22.9) | 148 (23.7) | 1.9  |
| >4DK                       |                | 1629 | (29.5)                  | 248 (35.9) | 13.8 | 221 (35.4) | 219 (35.0) | -0.7 |
| Missing                    |                | 197  | (3.6)                   | 18 (2.6)   | -5.5 | 14 (2.2)   | 18 (2.9)   | 3.7  |
| Live with grandmother      |                |     |                        |            |          |     |                        |            |          |
| No                         |                | 4913 | (89.0)                  | 608 (88.1) | 0.5 | Reference | 538 (86.1) | 552 (88.3) | 0.2 | Reference |
| Yes                        |                | 610  | (11.0)                  | 82 (11.9)  | 2.6 | 87 (13.9)  | 73 (11.7)  | -7.0 |
| Live with grandfather      |                |     |                        |            |          |     |                        |            |          |
| No                         |                | 5047 | (91.4)                  | 631 (91.5) | 1.0 | Reference | 564 (90.2) | 573 (91.7) | 0.4 | Reference |
| Yes                        |                | 476  | (8.6)                   | 59 (8.6)   | -0.2 | 61 (9.8)   | 52 (8.3)   | -5.1 |
| Delivery satisfaction      |                |     |                        |            |          |     |                        |            |          |
| Satisfaction               |                | 4788 | (86.7)                  | 568 (82.3) | 0.02 | Reference | 511 (81.8) | 519 (83.0) | 0.7 | Reference |
| Slightly satisfied         |                | 595  | (10.8)                  | 102 (14.8) | 12.0 | 100 (16.0) | 88 (14.1)  | -5.8 |
| Slightly not satisfied     |                | 97   | (1.8)                   | 11 (1.6)   | -1.3 | 7 (1.1)    | 11 (1.8)   | 5.0  |
| Not satisfied              |                | 28   | (0.5)                   | 6 (0.9)    | 4.4  | 5 (0.8)    | 4 (0.6)    | -1.9 |
| Missing                    |                | 15   | (0.3)                   | 3 (0.4)    | 2.7  | 2 (0.3)    | 3 (0.5)    | 2.7  |
| Delivery in maternal hometown |            |     |                        |            |          |     |                        |            |          |
| Yes                        |                | 2326 | (42.1)                  | 288 (41.7) | 0.4 | Reference | 258 (41.3) | 254 (40.6) | 0.9 | Reference |
| No                         |                | 3182 | (57.6)                  | 398 (57.7) | 0.1  | 363 (58.1) | 368 (58.9) | 1.6  |
| Missing                    |                | 15   | (0.3)                   | 4 (0.6)    | 4.7  | 4 (0.6)    | 3 (0.5)    | -2.5 |
| Number of children         |                |     |                        |            |          |     |                        |            |          |
| Second chil or more        |                | 2857 | (51.7)                  | 227 (32.9) | <0.01 | Reference | 224 (35.8) | 224 (35.8) | 0.9 | Reference |
| First child                |                | 2652 | (48.0)                  | 460 (66.7) | 38.4 | 398 (63.7) | 399 (63.8) | 0.3  |
| Missing                    |                | 14   | (0.3)                   | 3 (0.4)    | 3.1  | 3 (0.5)    | 2 (0.3)    | -2.7 |
| Feeding at 4 months        |                |     |                        |            |          |     |                        |            |          |
| Breast-feed                |                | 3396 | (61.5)                  | 386 (55.9) | <0.01 | Reference | 359 (57.4) | 362 (57.9) | 0.9 | Reference |
| Mix-feed                   |                | 1200 | (21.7)                  | 195 (28.3) | 15.1  | 162 (25.9) | 169 (27.0) | 2.6  |
| Bottle-feed                |                | 583  | (10.6)                  | 66 (9.6)   | -3.3 | 63 (10.1)  | 59 (9.4)   | -2.1 |
| Missing                    |                | 344  | (6.2)                   | 43 (6.2)   | 0.0  | 41 (6.6)   | 35 (6.6)   | -4.0 |
| Low birth weight           |                |     |                        |            |          |     |                        |            |          |
| ≥2500                      |                | 5112 | (92.6)                  | 624 (90.4) | 0.1  | Reference | 563 (90.1) | 569 (91.0) | 0.8 | Reference |
| <2500                      |                | 392  | (7.1)                   | 62 (9.0)   | 0.1  | 58 (9.3)   | 52 (8.3)   | -3.5 |
| Missing                    |                | 19   | (0.3)                   | 4 (0.6)    | 3.5  | 4 (0.6)    | 4 (0.6)    | 0.0  |

*a* $p$-value for that continuous variables were calculated using a t-test, categorical variables were calculated using a chi-square test.
4. Discussion

We found that mothers who went through infertility treatment may have the perception of a higher frequency of infant crying, but not bonding impairment and abusive behavior, using propensity-score matching analysis which reduces the bias by unknown variables on the allocation of exposure—in this case, infertility treatment history.

One possible explanation as to why mothers who had infertility treatment history showed a higher risk of the perception of a higher frequency of infant crying might be due to a heightened sensitivity towards their infants. A systematic review reported that mothers who had infertility treatment history were more likely to experience difficulties in parenting [17]. Another study found that mothers who had infertility treatment history were more likely to feel that their infant had a difficult temperament [29]. Thus, the current study adds to the literature that mothers with infertility treatment history may be in more distress due to the perception of a higher frequency of infant crying. Nonetheless, further study is needed to confirm the association between infertility treatment and the actual amount of infant crying.

Alternatively, because of the lack of association between infertility treatment and bonding impairment and abusive behavior, the perception of infant crying might be indicative of maternal attentiveness to the infant due to infertility treatment, but not a marker of distress. That is, the response “My baby cries a lot” may not reflect the mother’s attitude towards the infant crying, but the attentiveness to the infant.

To the best of our knowledge, this is the first study to find no association between infertility treatment and bonding impairment and abusive behavior towards one’s infant using a population-based study. Although this is inconsistent with previous Japanese case studies reporting the anecdotal notes from women who underwent infertility treatment and risk of abusive behavior towards infants [5–15,43,44], the findings of the current study are consistent with those of previous quantitative studies [28,29]. A possible reason for this contradiction is that qualitative study is more likely to capture negative emotion towards infants, which might be due to selection bias. If we employ a population-based quantitative study, which has less sampling bias, no association between infertility treatment and bonding impairment and abusive behavior towards one’s infant using a population-based study.
treatment and bonding impairment is found. Similarly, in this study, mothers who went through infertility treatment showed no bonding impairment and abusive behavior.

This study has several limitations. Because the evaluation of infertility treatment was self-reported, we could not identify the type of infertility treatment (e.g., in vitro fertilization and artificial insemination) and the period of infertility treatment, as well as the differences between them. Abusive behavior was also self-reported. Hence, there was a possibility of underestimating our results. Due to the limited sample location, the results may not be generalized for the whole of Japan. Furthermore, some of the confounding variables, such as maternal educational background and income, were not assessed. Since this is a cross-sectional study, the direction of influence of the relations was unknown.

5. Conclusions

In conclusion, infertility treatment may be associated with the perception of a higher frequency of infant crying, but it is not associated with bonding impairment and abusive behavior. To validate the findings, further longitudinal study is needed to investigate the association of infertility treatment with perception of infant crying, maternal–infant bonding impairment, and abusive behavior towards one’s infant.

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References
1. Inhorn, M.C.; Patrizio, P. Infertility around the globe: New thinking on gender, reproductive technologies and global movements in the 21st century. Hum. Reprod. Update 2015, 21, 411–426. [CrossRef] [PubMed]
2. Dyer, S.; Chambers, G.M.; de Mouzon, J.; Nygren, K.G.; Zegers-Hochschild, F.; Mansour, R.; Ishihara, O.; Banker, M.; Adamson, G.D. International Committee for Monitoring Assisted Reproductive Technologies world report: Assisted Reproductive Technology 2008, 2009 and 2010. Hum. Reprod. Oxf. Engl. 2016, 31, 1588–1609. [CrossRef] [PubMed]
3. Japan Society of Obstetrics and Gynecology. Assisted Reproductive Technology; ART. Available online: https://plaza.umin.ac.jp/~|jsog-art (accessed on 16 July 2020).
4. Ministry of Health, Labour and Welfare. Vital Statistics. Available online: https://www.mhlw.go.jp/toukei/list/81-1a (accessed on 16 July 2020).
5. Okajima, H.; Kabeyama, K. Problems on child rearing of mothers who received infertility treatment, literature review in Japan. Annu. Rep. Sch. Health Sci. Fac. Med. Kyoto Univ. 2006, 2, 61–66.
6. Othuki, Y. From the analysis result of the interview survey of 8 psychological cases of pregnancy childbirth after infertility treatment. Jpn. J. Matern. Health 2003, 44, 110–120.
7. Tachikawa, H.; Ozawa, M.; Kusakawa, I.; Hosoya, R. Investigation of perception toward their child in parents who received infertility treatment. J. Jpn. Pediatric Soc. 2004, 108, 1217–1221.
8. Ghima, K.; Owatari, K.; Omine, F.; Miyaghi, M.; Thujino, K.; Kazue, I.; Shimajiri, S. Anxiety and feelings toward their infant for pregnant women and mother who were undergoing infertility treatment. Jpn. J. Matern. Health 1999, 40, 203.
9. Mizuno, C.; Shimada, M. Study on mother-child relationship in pregnant women and mothers after infertility treatment. J. Jpn. Soc. Womens Health 2004, 3, 15–16.
10. Omine, F.; Gima, T.; Miyagi, M.; Nakamura, M.; Shimajiri, S.; Sakamoto, K.; Sugishita, T. Anxiety of women who underwent infertility treatment and emotional feeling toward their child. *Ipn. J. Matern. Health* 2000, 41, 439–443.

11. Nakazawa, N.; Hotta, M.; Yokoyama, H.; Iwasaki, K. Longitudinal survey of maternal perception in women after infertility treatment. *Kanagawa J. Matern. Health* 2004, 7, 19–22.

12. Herai, H.; Kanbayashi, R.; Nishiwaki, M. A study on anxiety, self-acceptance and fetal emotion change of a woman after infertility treatment. A longitudinal study on puerperal compared with spontaneous mother. *Ipn. J. Matern. Health* 2002, 43, 113.

13. Saito, Y. Infertility treatment and perinatal period. Pregnancy and maternal and child health after infertility treatment (mental care). *Perinat. Med.* 2001, 31, 803–806.

14. Takenori, K. The role of perinatal care in prevention of child abuse. *Perinat. Med.* 2002, 32, 693–697.

15. Gourounti, K. Psychological stress and adjustment in pregnancy following assisted reproductive technology and spontaneous conception: A systematic review. *Women Health* 2016, 56, 98–118. [CrossRef] [PubMed]

16. Hammarberg, K.; Fisher, J.R.; Wynter, K.H. Psychological and social aspects of pregnancy, childbirth and early parenting after assisted conception: A systematic review. *Hum. Reprod. Update* 2008, 14, 395–414. [CrossRef] [PubMed]

17. Barr, R.G.; Rivara, F.P.; Barr, M.; Cummings, P.; Taylor, J.; Lengua, L.J.; Meredith-Benitz, E. Effectiveness of educational materials designed to change knowledge and behaviors regarding crying and shaken-baby syndrome in mothers of newborns: A randomized, controlled trial. *Pediatrics* 2009, 123, 972–980. [CrossRef] [PubMed]

18. Fujiwara, T.; Yamaoka, Y.; Morisaki, N. Self-Reported Prevalence and Risk Factors for Shaking and Smothering Among Mothers of 4-Month-Old Infants in Japan. *J. Epidemiol. Ipn. Epidemiol. Assoc.* 2016, 26, 6–13. [CrossRef] [PubMed]

19. Lee, C.; Barr, R.G.; Catherine, N.; Wicks, A. Age-related incidence of publicly reported shaken baby syndrome cases: Is a crying trigger for shaking? *J. Dev. Behav. Pediatrics* 2007, 28, 288–293. [CrossRef] [PubMed]

20. Talvik, I.; Alexander, R.C.; Talvik, T. Shaken baby syndrome and a baby’s cry. *Acta Paediatr.* 2008, 97, 782–785. [CrossRef] [PubMed]

21. Dias, M.S.; Smith, K.; DeGuehery, K.; Mazur, P.; Li, V.; Shaffer, M.L. Preventing abusive head trauma among infants and young children: A hospital-based, parent education program. *Pediatrics* 2005, 115, e470–e477. [CrossRef]

22. Lehtonen, L.; Korhonen, T.; Korvenranta, H. Temperament and sleeping patterns in colicky infants during the first year of life. *J. Dev. Behav. Pediatrics* 1994, 15, 416–420. [CrossRef]

23. Yurdakök, K. Why are they having infant colic? A nested case-control study. *Paediatr. Perinat. Epidemiol.* 2000, 14, 693–697. [CrossRef] [PubMed]

24. Miller, A.R.; Barr, R.G.; Eaton, W.O. Crying and motor behavior of six-week-old infants and postpartum maternal mood. *Pediatrics* 1993, 92, 551–558. [PubMed]

25. Barr, R.G.; Trent, R.B.; Cross, J. Age-related incidence curve of hospitalized Shaken Baby Syndrome cases: Convergent evidence for crying as a trigger to shaking. *Child Abus. Negl.* 2006, 30, 7–16. [CrossRef]

26. Mcmahon, C.A.; Tennant, C.; Ungerer, J.; Saunders, D. “Don’t count your chickens”: A comparative study of the experience of pregnancy after IVF conception. *J. Reprod. Infant Psychol.* 1999, 17, 345–356. [CrossRef]

27. Mcmahon, C.A.; Ungerer, J.A.; Tennant, C.; Saunders, D. Psychosocial adjustment and the quality of the mother-child relationship at four months postpartum after conception by in vitro fertilization. *Fertil. Steril.* 1997, 68, 492–500. [CrossRef]

28. Nishigori, H.; Obara, T.; Nishigori, T.; Metoki, H.; Mizuno, S.; Ishikuro, M.; Sakurai, K.; Hamada, H.; Watanabe, Z.; Hoshiai, T.; et al. Mother-to-infant bonding failure and intimate partner violence during pregnancy as risk factors for father-to-infant bonding failure at 1 month postpartum: An adjunct study of the Japan Environment and Children’s Study. *J. Matern. Fetal Neona. Med.* 2020, 33, 2789–2796. [CrossRef]
31. Ministry of Health, Labour and Welfare. Overview of Community Health and Health Promotion Report. Available online: https://www.mhlw.go.jp/toukei/saikin/hw/c-hoken/17/dl/gaikyo.pdf (accessed on 16 July 2020).

32. Rocha, N.; Silva, F.P.D.; dos Santos, M.M.; Dusing, S.C. Impact of mother-infant interaction on development during the first year of life: A systematic review. J. Child Health Care 2015, 57, 40. [CrossRef]

33. Dhanani, R.M.; Nield, L.S.; Ogershok, P.R. Traumatized twins: A case report and discussion of the maltreatment of multiples. Clin. Pediatr. 2006, 45, 173–176. [CrossRef]

34. Ooki, S. Fatal child maltreatment associated with multiple births in Japan: Nationwide data between July 2003 and March 2011. Environ. Health Prev. Med. 2013, 18, 416–421. [CrossRef]

35. Yokoyama, Y.; Oda, T.; Nagai, N.; Sugimoto, M.; Mizukami, K. Child Maltreatment Among Singleton and Multiple Births in Japan: A Population-Based Study. Twin Res. Hum. Genet. 2015, 18, 806–811. [CrossRef]

36. Baird, D.T.; Collins, J.; Egozcue, J.; Evers, L.H.; Gianaroli, L.; Leridon, H.; Sunde, A.; Templeton, A.; van Steirteghem, A.; Cohen, J.; et al. Fertility and ageing. Hum. Reprod. Update 2005, 11, 261–276. [CrossRef]

37. Homan, G.F.; Davies, M.; Norman, R. The impact of lifestyle factors on reproductive performance in the general population and those undergoing infertility treatment: A review. Hum. Reprod. Update 2007, 13, 209–223. [CrossRef]

38. Herbert, D.; Lucke, J.; Dobson, A. Agreement between self-reported use of in vitro fertilization or ovulation induction, and medical insurance claims in Australian women aged 28-36 years. Hum. Reprod. Oxf. Engl. 2012, 27, 2823–2828. [CrossRef]

39. Buck Louis, G.M.; Druschel, C.; Bell, E.; Stern, J.E.; Luke, B.; McLain, A.; Sundaram, R.; Yeung, E. Use of assisted reproductive technology treatment as reported by mothers in comparison with registry data: The Upstate KIDS Study. Fertil. Steril. 2015, 103, 1461–1468. [CrossRef]

40. Yoshida, K.; Yamashita, H.; Conroy, S.; Marks, M.; Kumar, C. A Japanese version of Mother-to-Infant Bonding Scale: Factor structure, longitudinal changes and links with maternal mood during the early postnatal period in Japanese mothers. Arch. Womens Ment. Health 2012, 15, 343–352. [CrossRef]

41. Matsunaga, A.; Takauma, F.; Tada, K.; Kitamura, T. Discrete category of mother-to-infant bonding disorder and its identification by the Mother-to-Infant Bonding Scale: A study in Japanese mothers of a 1-month-old. Early Hum. Dev. 2017, 111, 1–5. [CrossRef]

42. Rosenbaum, P.R.; Rubin, D.B. The central role of the propensity score in observational studies for causal effects. Biometrika 1983, 70, 41–55. [CrossRef]

43. Hikari, S. The choosing infertility treatment put the mother under a curse, who abuse their baby after their birth. J. Jpn. Acad. Midwifery 2005, 18, 74.

44. Sei, C.; Sasaki, A.; Chifumi, S. Anxiety and emotion toward baby of pregnant women who received infertility treatment and the treatment background. J. Jpn. Soc. Womens Health 2006, 20, 99–106.

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