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The long-term association between paternal involvement in infant care and children's psychological well-being at age 16 years: An analysis of the Japanese Longitudinal Survey of Newborns in the 21st Century 2001 cohort

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ABSTRACT

Background: Some studies conducted in the United Kingdom have shown long-term associations between paternal involvement in childcare and adolescents' mental health issues. However, findings were inconsistent, and similar epidemiologic studies have not been conducted in other countries in Europe or Asia. Thus, we aimed to examine this association using Japanese population-based cohort study data.

Methods: The Japanese Longitudinal Survey of Newborns in the 21st Century commenced in 2001. Data from 18,568 16-year-olds enrolled in the survey were analyzed. Poor psychological well-being was assessed using the WHO-5 Well-being Index. Paternal involvement in childcare—in tasks such as changing diapers—was assessed at the children's 6 months of age. We created four groups from least involvement to most active involvement based on the frequency of fathers' performing the tasks.

Results: The risk of poor psychological well-being was lower among more active involvement groups compared with the least involvement group, after adjusting for potential confounders (risk ratios = 0.90 [95 % confidence intervals: 0.85, 0.95] for the most active group).

Limitations: Due to 16 years of follow-up, loss to follow-up may have caused a selection bias.

Conclusions: Our study is the first in Asian countries to show that fathers' active involvement in childcare is associated with poor psychological well-being in adolescence. Encouraging fathers' involvement in childcare may ameliorate prevalent issues of school refusals and withdrawals in the long term in Japan.

1. Introduction

Adolescents are often assumed to be in good health; however, epidemiologic studies have shown that mental health problems are fairly common among this age group (Kieling et al., 2011). For example, one meta-analysis indicated that the prevalence of mental disorders is 13.4 % among children and adolescents worldwide (Polanczyk et al., 2015). Analysis of the global burden of disease has shown that neuropsychiatric disorders are one of the top causes of years of healthy life lost due to disability among people between the ages of 10 and 24 years (Gore et al., 2011). During the COVID-19 pandemic, the global prevalence of depressive and anxiety symptoms in children and adolescents is likely to have increased considerably (Racine et al., 2021). In Japan, adolescents' mental health issues have not been given much attention despite the high prevalence of school refusals and social withdrawals, which may be related to mental health problems (Kato et al., 2019). Suicide is one of the leading causes of death among children aged 15–19 years (Ministry of Health Labour and Welfare, n.d.).

Abbreviations: LSN, Longitudinal Survey of Newborns in the 21st Century; MHLW, Ministry of Health Labour and Welfare; RR, risk ratio; SDQ, Strengths and Difficulties Questionnaire; WHO-5, WHO-5 Well-being Index.

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There is a wide range of risk factors for adolescent mental health problems, and parental and family-related factors are often included among them (Patel et al., 2007; Shorey et al., 2022). For example, in Yap et al.'s systematic review of studies on the associations of parenting factors with depression and anxiety, some factors, such as parental warmth, were linked to young people's mental health (Yap et al., 2014). Yuen et al. (2019) reviewed studies conducted in Hong Kong and identified adolescents' relationships with their parents as one of the potential influencing factors of mental health. Another review on depressive symptoms among secondary school students in mainland China also showed that poor parent-child communication is most strongly associated with depression among 16 psychosocial risk factors examined (Tang et al., 2020).

These parental and family-related risk factors for adolescents' mental health may be rooted in parent-child relationships from children's early years (Kieling et al., 2011). Mothers often serve as primary caregivers for young children, but over the years, fathers' expected roles have shifted from moral guides to active caregivers (Lamb, 2000). Time-use studies in developed countries show that the time fathers spend on childcare has increased steadily during the last decades (Craig et al., 2014; Dotti Sani and Treas, 2016). Studies on attachment, conceptualized by Bowlby, have shown that similar to the association between mother-child relationship and children's behavior problems during subsequent years, father-child relationships fostered through early childhood years are just as important (Cabrera, 2020; Deneault et al., 2021). Some studies using longitudinal data suggest that paternal involvement in childcare may have a long-term impact on children's development. For example, using the Avon Longitudinal Study of Parents and Children data collected in the United Kingdom, Opondo et al. showed that some aspects of paternal involvement in childcare—assessed at the child's ages of 8 weeks and 8 months—were protective against depressive symptoms and behavioral issues at the ages of 9 and 11 years (Opondo et al., 2017; Opondo et al., 2016). Another study using the same cohort data showed that potential child abuse at the child's age of 21 months is associated with an increased risk of depressive symptoms at the child's age of 16 years (Scourfield et al., 2016). By contrast, Flouri et al.'s analysis of the Millennium Cohort Study data (2016) did not find much evidence of the positive effects of paternal involvement in childcare on behavioral problems during subsequent years. One meta-analysis showed that fathers' sensitive parenting is associated with children's emotional regulation but not with socio-emotional functioning or internalizing problems (Rodrigues et al., 2021). However, the absence of the latter association with socio-emotional functioning or internalizing problems may be partially attributed to a low prevalence of internalizing problems in middle childhood years. In addition to the inconsistent findings, previous studies have utilized cohort study data from the United Kingdom alone, and similar studies have not been conducted in other countries in Europe or Asia.

Therefore, in our study, we examined the association of paternal involvement in childcare at the child's age of 6 months with the child's psychological well-being at the age of 16 years, using the Japanese Longitudinal Survey of Newborns in the 21st Century 2001 cohort data. Although the results of the previous findings have not been consistent, we hypothesized that fathers' active involvement in infant care would be protective against poor psychological well-being during adolescence.

2. Method

2.1. Participants

We used data from the Longitudinal Survey of Newborns in the 21st Century (LSN), an ongoing annual household survey in Japan that commenced in 2001 and was conducted by the Ministry of Health, Labour and Welfare (MHLW). The main purpose of the LSN is for the central government to develop strategies to address the low fertility trends in Japan. Details of the LSN have been described elsewhere (Fuse et al., 2017; Kato et al., 2013).

Families with a baby or babies born during specific weeks in January or July of 2001 from all over Japan were requested to participate in the LSN. A baseline questionnaire was sent to each family when the newborns reached 6 months of age. The response rate was 88 % (47,015 out of 53,575). Follow-up questionnaires were then sent to participating families annually. Birth record information, such as date of birth, sex, and parental age, was also appended to the LSN questionnaire. We obtained data on surveys 1–15 from the MHLW and on surveys 16–18 from the Ministry of Education because the administration of the LSN had been transferred from MHLW to the Ministry of Education after the 15th survey. Permission to use these data was obtained from both ministries.

2.2. Inclusion and exclusion criteria

Of the 47,015 households, we excluded some families based on their characteristics. First, we excluded children who were born preterm or were non-singletons because they often require extra parental care. We also excluded mothers who were not married when they gave birth to the cohort child and fathers that were not living with their families. We excluded fathers who were not engaged in full-time employment or not working 40 h or more per week in the first survey. In Japan, gendered division of labor has been the norm, and fathers are expected to work full-time to meet their household needs (Tsuya et al., 2005). Thus, fathers without full-time work may have special conditions such as health problems, which may influence paternal involvement in childcare. We also limited the respondents of the first survey to mothers only. In the first survey, we retained 31,507 families (68 %). At the 16th survey, 18,727 children responded, but 217 had missing data on outcome assessments. Thus, we retained 18,510 participants for the analysis (59 %). The flow of this process is described in Fig. 1. Considering that we observed a fair amount of loss to follow-up (12,780/31507 = 41 %), we compared the participation group and loss to the follow-up group.

2.3. Psychological well-being at the child's age of 16 years

Children's psychological well-being at the age of 16 years was assessed using the Japanese version of the WHO-5 Well-being Index (WHO-5) (Blom et al., 2012; Inagaiki et al., 2013). The WHO-5 consists of five questions on psychological well-being during the past two weeks such as being in a good spirit. Children answered these questions with six ordinal responses, from “all of the time” to “at no time.” The ordinal responses were converted into a score from 5 (“all of the time”) to 0 (“at no time”). Cronbach's alpha was 0.85, and a factor analysis indicated one dimension. The scores on all items were summed to obtain the total score, ranging from 0 to 25 points. Higher scores indicate better well-being. Although the cut-off of 12 points or lower has been used to indicate poor well-being for adults, a cut-off point has not been established for adolescents (Allgaier et al., 2012). Thus, we created three dichotomized outcomes with varying cut-offs: 1) 12 points or below [conventional, 37 %], 2) 8 points or below [−1 standard deviation from the mean, 14 %], and 3) 3 points or below [−2 standard deviations from the mean, 2 %].

2.4. Paternal involvement in childcare at the child's age of 6 months

The exposure variables in this study were paternal involvement in childcare in the first survey, completed by mothers when the child was six months old. In the survey, six questions on paternal involvement in specific childcare-related tasks were assessed using four ordinal levels: “never,” “rarely,” “sometimes,” and “always.” The childcare-related tasks assessed in the survey were 1) feeding the infant, 2) changing diapers, 3) bathing the infant, 4) putting the infant to sleep, 5) playing with the infant, and 6) taking the infant outside for a walk. Cronbach's alpha was 0.75, and a factor analysis indicated one dimension. Thus, we converted the ordinal responses into a score from 3 (“always”) to

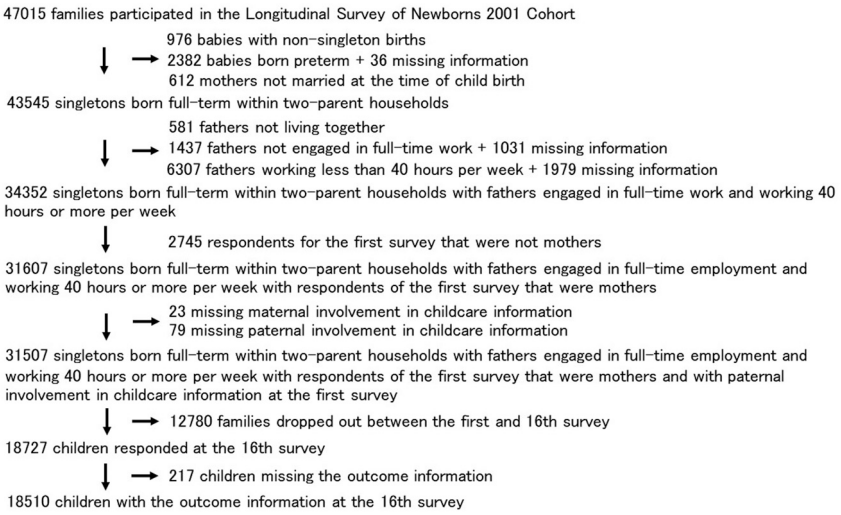

Fig. 1. The process of selecting analytical sample.

0 ("never") and combined the scores on the six tasks to obtain a childcare involvement score, ranging from 0 to 18. Based on the childcare involvement score, we created quartile groups: 1st group with scores 0–8 (least involvement), 2nd group with scores 9–11, 3rd group with a score of 12, and 4th group with scores 13–18 (most active involvement).

2.5. Potential confounders

We selected the following variables as potential confounders: child's sex, number of siblings, maternal age, maternal education, maternal involvement in childcare, father's work hours per week, living with grandparents, and total household income. Maternal age was treated as a continuous variable. Maternal education was classified into three levels: high school graduate or less, 2-year college or vocational school, and four-year college or higher. Maternal involvement in childcare in the first survey was assessed the same way as paternal involvement was assessed. Considering that most mothers answered "always" to each childcare task, there was little variation in the distribution of childcare scores. The mean score was 17 points with a standard deviation of 1 point. We treated the variable as continuous. Father's average work hours per week were ascertained with the following options: unemployed, <20 h, 20–39 h, 40–59 h, and ≥60 h. Since we excluded those working <40 h per week from the analysis, the categories of 40–59 h and ≥60 h were controlled for in the analysis. Co-residence with either or both of the grandparents was ascertained in the first survey, and we dichotomized the responses based on whether the children lived with their grandparents or not. The total household income was included as a continuous variable (in 10,000 Yen; approximately 100 US Dollars as of spring 2022). All the confounders except for maternal education were included in the first survey.

2.6. Statistical analysis

We constructed a log-binomial model to estimate the risk ratios for the association between paternal involvement in childcare and children's poor well-being. First, we estimated the strength of the association without adjusting for any other variables. Next, we re-estimated the association after adjusting for potential confounders. We analyzed only complete cases. All statistical analyses were performed using Stata 17/SE (STATA Corp., College Station, Texas, USA).

This study was approved by the Japanese National Center for Child Health and Development ethics committee (No. 2020-299).

3. Results

In Table 1, we present the socio-demographic characteristics of the participants who were classified into quartiles based on childcare involvement scores. We observed that paternal involvement was more common if the child was a male. We also observed that more active involvement was associated with fewer working hours among fathers and a fewer number of siblings in the family. Meanwhile, less involvement was associated with co-residence with grandparents. We did not observe a clear trend based on maternal education or household income. The mean WHO-5 score was 14.4 with a standard deviation of 5.4.

In Table 2, we compared those who participated in the 16th survey (59 %) and those who dropped out by the 16th survey (41 %). As previous findings have suggested, families with socially disadvantageous characteristics such as lower maternal education and low household income were more likely to drop out. For example, the proportion of mothers with a high school education or less was 38 % in the participation group and 50 % in the loss to follow-up group. The mean household income was 609.7 in the participation group and 541.5 in the loss to follow-up group. We did not observe a marked difference in paternal involvement in childcare scores in the first survey.

In Table 3, we present the crude and adjusted risk ratios (RR) with 95 % confidence intervals (95 % CI) in parentheses for the association between paternal involvement at the child's age of six months and the risk of poor well-being at the child's age of 16 years. After adjusting for potential confounders, we observed lower risks among the more active involvement groups. For example, compared to the least involvement group, the risk of poor well-being—based on the conventional cut-off point of 12 points or below—among 16-year-old children in the most active involvement group was 10 % lower (RR = 0.90 [95 % CI: 0.85, 0.95]). The risk ratios tended to be similar across the three dichotomized outcomes with varying cut-off points, although the risk ratio was not significant for the −2 standard deviations outcome (RR = 0.90 [0.85, 0.95] for conventional; 0.87 [0.79, 0.97] for −1SD; and 0.80 [0.59, 1.07] for −2SD).

4. Discussion

In this study, we examined the long-term association between paternal involvement in childcare at the child's age of 6 months and the child's psychological well-being at the age of 16 years. We observed that more active paternal involvement in infant care was protective against poor psychological well-being at an adolescent age. To our knowledge, this study is the first in Asian countries or populations to show the long-

Table 1
Socio-demographic characteristics of participants by paternal involvement in childcare group (n = 18,510).

	1st quartile* (least involvement)		2nd quartile*		3rd quartile*		4th quartile* (most active involvement)	
	(n = 4844)		(n = 6347)		(n = 2821)		(n = 4498)	
	Mean or n	SD or proportion	Mean or n	SD or proportion	Mean or n	SD or proportion	Mean or n	SD or proportion
Male child	2326	48 %	3157	50 %	1475	52 %	2370	53 %
Number of siblings								
0	1946	40 %	3105	49 %	1474	52 %	2548	57 %
1	2101	43 %	2405	38 %	1003	36 %	1493	33 %
2	686	14 %	731	12 %	305	11 %	399	9 %
≥3	111	2 %	106	2 %	39	1 %	58	1 %
Maternal age								
Mean (SD)	30.9	(4.0)	30.5	(4.0)	30.4	(4.1)	30.0	(4.2)
≤20	16	0 %	19	0 %	10	0 %	26	1 %
21–24	309	6 %	462	7 %	224	8 %	448	10 %
25–29	1692	35 %	2424	38 %	1161	41 %	1917	43 %
30–34	2085	43 %	2609	41 %	1032	37 %	1567	35 %
≥35	742	15 %	833	13 %	394	14 %	540	12 %
Maternal education								
High school or less	1785	38 %	2319	37 %	960	35 %	1739	39 %
2-year college or vocational school	2154	45 %	2820	45 %	1310	47 %	2003	45 %
4-year college or higher	821	17 %	1080	17 %	495	18 %	681	15 %
Maternal involvement in childcare								
Mean (SD)	17.4	(1.1)	17.2	(1.2)	17.1	(1.2)	16.7	(1.2)
0–14 points	126	3 %	195	3 %	105	4 %	245	5 %
15 points	180	4 %	370	6 %	184	7 %	409	9 %
16 points	362	7 %	812	13 %	392	14 %	957	21 %
17 points	923	19 %	1670	26 %	814	29 %	1598	36 %
18 points	3253	67 %	3300	52 %	1326	47 %	1289	29 %
Father's work hours at the child's age of 6 months								
40–59 h	2841	59 %	4278	67 %	2018	72 %	3567	79 %
≥60 h	2003	41 %	2069	33 %	803	28 %	931	21 %
Co-residence with grandparents	1065	22 %	1249	20 %	509	18 %	788	18 %
Household income (in 10,000 Yen = approximately 100 US dollars)**								
Mean (SD)	613.4	(334.5)	615.6	(345.5)	622.7	(362.7)	589.4	(307.8)
≤200	95	2 %	130	2 %	45	2 %	114	3 %
201–300	320	7 %	355	6 %	151	6 %	295	7 %
301–400	614	13 %	809	13 %	377	14 %	697	16 %
401–500	904	20 %	1199	20 %	472	18 %	815	19 %
501–600	795	17 %	1074	18 %	511	19 %	751	17 %
601–700	643	14 %	826	14 %	367	14 %	528	12 %
701–800	440	10 %	583	10 %	268	10 %	429	10 %
801–900	263	6 %	386	6 %	178	7 %	220	5 %
901–1000	174	4 %	274	5 %	124	5 %	165	4 %
>1000	363	8 %	435	7 %	193	7 %	282	7 %
WHO-5 score								
Mean (SD)	14.1	(5.5)	14.3	(5.4)	14.5	(5.6)	14.5	(5.4)
<13 points (conventional)	1861	38 %	2277	36 %	1030	37 %	1596	35 %
<9 points (−1SD)	748	15 %	902	14 %	392	14 %	603	13 %
<4 points (−2SD)	119	2 %	134	2 %	65	2 %	91	2 %

Note: The percentages are within each quartile group. For example, the proportion of male child within the first quartile group is 48 %.
* 1st quartile: childcare score of 0–8 points, 2nd: 9–11 points, 3rd: 12 points, 4th: 13–18 points.
** The exchange rate is as of 2022 spring.

term benefits of paternal involvement in childcare.

4.1. Comparison of current and previous findings

One study conducted in the United Kingdom, using the Avon Longitudinal Study of Parents and Children, showed that paternal confidence and enjoyment at children's age of 21 months are associated with a lower risk of depressive symptoms at children's age of 16 years, and potential paternal abuse at 21 months is associated with a higher risk of depressive symptoms (Scourfield et al., 2016). These findings corroborate our findings. Another study using the same cohort data showed that two paternal involvement factors—"emotional response to baby and parenting" and "security in role as parent and partner"—are associated with depressive symptoms, assessed using the Short Moods and Feelings Questionnaire, as well as with behavioral outcome at the child's ages of 9 and 11 years, assessed using the Strengths and Difficulties Questionnaire (SDQ), while "engagement in domestic and childcare activities" was not associated with the behavioral outcome (Opondo et al., 2017; Opondo et al., 2016). The latter finding is not consistent with our findings. Two studies using the Millennium Cohort Study data also showed that paternal involvement in childcare is mostly not associated with SDQ scores at the child's age of 7 years (Flouri et al., 2016; Kroll et al., 2016). The reason for this inconsistency is unknown, but the findings may not be directly comparable given the differences in the assessment of paternal involvement in childcare and the outcomes and timing of assessment.

4.2. Possible underlying processes

Studies on attachment suggest that the attachment formed between fathers and children during children's early years can predict children's later behavior problems (Cabrera, 2020). The ways fathers interact with

Table 2
Comparison of socio-demographic characteristics by participation group (n = 18,727) and loss to follow-up group (n = 12,780).

	Participation								Loss to follow-up							
	1st quartile* (least involvement)		2nd quartile*		3rd quartile*		4th quartile* (most active involvement)		1st quartile* (least involvement)		2nd quartile*		3rd quartile*		4th quartile* (most active involvement)	
	(n = 4904: 26 %)		(n = 6416: 34 %)		(n = 2856: 15 %)		(n = 4553: 24 %)		(n = 3426: 27 %)		(n = 4321: 34 %)		(n = 1771: 14 %)		(n = 3262: 26 %)	
	Mean or n	SD or proportion	Mean or n	SD or proportion	Mean or n	SD or proportion	Mean or n	SD or proportion	Mean or n	SD or proportion	Mean or n	SD or proportion	Mean or n	SD or proportion	Mean or n	SD or proportion
Male child	2359	48 %	3195	50 %	1498	52 %	2405	53 %	1733	51 %	2233	52 %	972	55 %	1791	55 %
Number of siblings																
0	1978	40 %	3140	49 %	1493	52 %	2580	57 %	1368	40 %	2153	50 %	918	52 %	1865	57 %
1	2121	43 %	2430	38 %	1010	35 %	1509	33 %	1430	42 %	1595	37 %	618	35 %	1059	32 %
2	693	14 %	737	11 %	313	11 %	406	9 %	527	15 %	475	11 %	189	11 %	288	9 %
≥3	112	2 %	107	2 %	40	1 %	58	1 %	101	3 %	98	2 %	46	3 %	50	2 %
Maternal age																
Mean (SD)	30.9	(4.0)	30.5	(4.0)	30.4	(4.1)	30.0	(4.2)	29.7	(4.5)	29.2	(4.4)	29.1	(4.4)	28.5	(4.3)
≤20	17	0 %	20	0 %	10	0 %	26	1 %	43	1 %	65	2 %	26	1 %	58	2 %
21–24	315	6 %	467	7 %	228	8 %	455	10 %	489	14 %	650	15 %	298	17 %	605	19 %
25–29	1710	35 %	2459	38 %	1171	41 %	1931	42 %	1274	37 %	1818	42 %	733	41 %	1454	45 %
30–34	2114	43 %	2630	41 %	1048	37 %	1591	35 %	1229	36 %	1344	31 %	537	30 %	902	28 %
≥35	748	15 %	838	13 %	399	14 %	550	12 %	391	11 %	444	10 %	177	10 %	243	7 %
Maternal education																
High school or less	1811	38 %	2350	37 %	973	35 %	1767	39 %	1480	50 %	1856	49 %	750	49 %	1468	52 %
2-year college or vocational school	2180	45 %	2844	45 %	1327	47 %	2023	45 %	1144	39 %	1537	40 %	642	42 %	1105	39 %
4-year college or higher	829	17 %	1091	17 %	499	18 %	688	15 %	323	11 %	426	11 %	153	10 %	252	9 %
Maternal involvement in childcare																
Mean (SD)	17.4	(1.1)	17.2	(1.2)	17.1	(1.2)	16.7	(1.2)	17.4	(1.1)	17.1	(1.3)	17.0	(1.2)	16.7	(1.2)
0–14 points	129	3 %	198	3 %	105	4 %	251	6 %	84	2 %	210	5 %	81	5 %	160	5 %
15 points	181	4 %	374	6 %	189	7 %	414	9 %	134	4 %	264	6 %	125	7 %	312	10 %
16 points	364	7 %	822	13 %	397	14 %	971	21 %	277	8 %	579	13 %	271	15 %	625	19 %
17 points	935	19 %	1687	26 %	821	29 %	1615	35 %	714	21 %	1134	26 %	489	28 %	1174	36 %
18 points	3295	67 %	3333	52 %	1344	47 %	1302	29 %	2217	65 %	2134	49 %	805	45 %	991	30 %
40–59 h	2877	59 %	4328	67 %	2043	72 %	3613	79 %	1933	56 %	2913	67 %	1228	69 %	2504	77 %
≥60 h	2027	41 %	2086	33 %	813	28 %	940	21 %	1493	44 %	1408	33 %	543	31 %	758	23 %
Co-residence with grandparents	1079	22 %	1262	20 %	516	18 %	803	18 %	837	24 %	841	19 %	319	18 %	601	18 %
Household income (in 10,000 Yen = approximately 100 US dollars)**																
Mean (SD)	613.4	(334.5)	615.6	(345.5)	622.7	(362.7)	589.4	(307.8)	544.0	(322.7)	546.8	(348.2)	539.6	(302.0)	532.9	(470.8)
≤200	97	2 %	132	2 %	46	2 %	115	3 %	141	4 %	166	4 %	63	4 %	133	4 %
201–300	324	7 %	363	6 %	152	6 %	298	7 %	342	11 %	427	11 %	173	11 %	333	11 %
301–400	627	13 %	815	13 %	381	14 %	709	16 %	566	18 %	736	18 %	301	18 %	605	20 %
401–500	914	20 %	1206	20 %	481	18 %	825	19 %	671	21 %	816	20 %	344	21 %	632	21 %
501–600	802	17 %	1088	18 %	519	19 %	759	17 %	510	16 %	650	16 %	261	16 %	476	16 %
601–700	654	14 %	833	14 %	372	14 %	532	12 %	310	10 %	421	10 %	187	11 %	312	10 %
701–800	441	9 %	588	10 %	269	10 %	434	10 %	216	7 %	295	7 %	125	8 %	203	7 %
801–900	265	6 %	386	6 %	178	7 %	225	5 %	123	4 %	186	5 %	58	4 %	126	4 %
901–1000	177	4 %	278	5 %	126	5 %	165	4 %	113	4 %	144	4 %	53	3 %	79	3 %
>1000	368	8 %	439	7 %	195	7 %	288	7 %	149	5 %	178	4 %	67	4 %	120	4 %
WHO-5 score																
Mean (SD)	14.1	(5.5)	14.3	(5.4)	14.5	(5.6)	14.5	(5.4)								
<13 points (conventional)	1861	38 %	2277	36 %	1030	37 %	1596	35 %								
<9 points (−1SD)	748	15 %	902	14 %	392	14 %	603	13 %								
<4 points (−2SD)	119	2 %	134	2 %	65	2 %	91	2 %								

* 1st quartile: childcare score of 0–8 points, 2nd: 9–11 points, 3rd: 12 points, 4th: 13–18 points.
** The exchange rate is as of 2022 spring.

Table 3
Crude and adjusted risk ratios with 95 % confidence intervals for the associations of paternal involvement in childcare at child's age of 6 months and risk of poor psychological well-being at child's age of 16 years.

	Poor psychological well-being					
	<13 points (conventional)		<9 points (−1 SD)		<4 points (−2 SD)	
	Crude	Adjusted	Crude	Adjusted	Crude	Adjusted
	(*n* = 18,510)	(*n* = 17,344)	(*n* = 18,510)	(*n* = 17,344)	(*n* = 18,510)	(*n* = 17,344)
Paternal involvement in childcare						
1st quartile (least)	Reference	Reference	Reference	Reference	Reference	Reference
2nd quartile	0.93 [0.89,0.98]	0.93 [0.88,0.97]	0.92 [0.84,1.01]	0.93 [0.84,1.02]	0.86 [0.67,1.10]	0.84 [0.65,1.09]
3rd quartile	0.95 [0.89,1.01]	0.95 [0.89,1.01]	0.90 [0.80,1.01]	0.90 [0.80,1.01]	0.94 [0.70,1.26]	0.94 [0.68,1.29]
4th quartile (most active)	0.92 [0.88,0.97]	0.90 [0.85,0.95]	0.87 [0.79,0.96]	0.87 [0.79,0.97]	0.82 [0.63,1.08]	0.80 [0.59,1.07]
Male child (Reference = female)		1.04 [1.00,1.08]		0.98 [0.91,1.05]		1.14 [0.93,1.40]
Number of siblings						
0		Reference		Reference		Reference
1		0.97 [0.93,1.01]		0.93 [0.85,1.01]		0.97 [0.77,1.22]
2		0.94 [0.88,1.01]		0.94 [0.83,1.07]		0.90 [0.63,1.29]
≥3		1.01 [0.87,1.17]		1.14 [0.87,1.48]		1.60 [0.83,3.07]
Maternal age		1.01 [1.00,1.01]		1.00 [0.99,1.01]		0.99 [0.96,1.02]
Maternal education						
High school or less		Reference		Reference		Reference
2-year college or vocational school		1.00 [0.96,1.04]		0.97 [0.89,1.05]		0.93 [0.75,1.16]
4-year college or higher		0.98 [0.92,1.04]		1.00 [0.89,1.11]		0.79 [0.57,1.09]
Maternal involvement in childcare score		0.98 [0.97,1.00]		1.01 [0.98,1.04]		0.99 [0.90,1.07]
Father's work hours at the first survey						
≥60 h (Reference = 40–59 h)		1.00 [0.96,1.05]		1.01 [0.93,1.09]		0.94 [0.75,1.18]
Co-residence with grandparents (Reference = no co-residence)		0.98 [0.93,1.03]		1.01 [0.92,1.11]		0.96 [0.74,1.25]
Household income		1.00 [1.00,1.00]		1.00 [1.00,1.00]		1.00 [1.00,1.00]

their children through childcare, often characterized by physically active play, may promote children's ability to regulate their emotions (e.g., fear, frustration, and excitement), although this tendency is more evident in children's externalizing behaviors than in internalizing behaviors (Deneault et al., 2021; Stgeorge and Freeman, 2017). Previous findings suggest that familial factors, such as the father–child relationship, are one of the important factors that influence adolescents' mental health problems (Tang et al., 2020; Yap et al., 2014; Yuen et al., 2019). Active involvement in childcare in the early years may help fathers build and maintain a good relationship with their children throughout childhood.

4.3. Strengths and limitations

A strength of this study is that the participants were followed-up from birth until they were 16 years of age. Birth cohorts with such a long-term follow-up are scarce worldwide, especially in Asian populations. The use of longitudinal data allowed us to identify temporal sequences of events, as paternal involvement in childcare and children's behavior may interact with each other (Flouri et al., 2016). Reverse causation, that is, children's well-being at the age of 16 years influencing paternal involvement in childcare at the age of 6 months, is improbable. With a large sample size and rich data from the LSN, we were able to account for socio-demographic characteristics such as education and household income. For the outcome assessment, we used the internationally applied WHO-5. Because paternal involvement in childcare was assessed by mothers, and psychological well-being at the age of 16 years was assessed by the children themselves, the common method variance was avoided.

A limitation of this study is the lack of validation in the assessment of the exposure variable of interest, paternal involvement in childcare, although this assessment has been used in previous studies (Fujiwara et al., 2010; Kato et al., 2018). Active involvement in childcare may indicate fathers' high commitment toward their families and children throughout their lifetimes. Further studies are needed to develop assessment tools that capture different aspects of paternal involvement in childcare (Cabrera, 2020). The proportion of loss to follow-up within the duration of 16 years was 41 %, and as previous analysis has shown (Fukuda, 2006), loss to follow-up was more common among families with disadvantageous characteristics such as lower maternal education and household income. We speculate that fragile families experiencing unstable circumstances (e.g., frequent conflicts between the father and mother) would be included in the loss to follow-up group, and children of fragile families may be at a higher risk of poor psychological well-being, biasing the association toward the null. The WHO-5 has been validated for use in the adult population, but not for use in the adolescent population. We set three cut-off points to define "poor psychological well-being," and the results were consistent. Further, we could not control for unmeasured factors such as maternal and paternal postpartum depression. However, we sought to minimize confounding bias by excluding fathers who were not working full-time when their children were 6 months old, as some of them may have had health issues.

5. Conclusions

Mental health issues among adolescents in Japan have been a neglected public health problem despite some concerning indicators, such as a high number of school refusals and social withdrawals, and an increasing number of suicide cases among young people (Dhungel et al., 2022; Fushimi, 2021; Kato et al., 2019). Our findings suggest the need to encourage fathers to become more actively involved in childcare, to ameliorate these issues in the long term.

CRediT authorship contribution statement

Takehara obtained the approval for using data from the MHLW. Kato and Kondo designed the study. Kato analyzed the data and drafted first manuscript. Kato, Kachi, Ochi, Nagayoshi, Dhungel, Kondo, and Takehara discussed the methodology and interpretation of the data. All authors reviewed the results of data analysis and revised the manuscript.

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Conflict of interest

The authors declare no potential conflict of interest with respect to the research, authorship, and/or publication of this article.

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