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Social support, social cohesion and pain during pregnancy: The Japan Environment and Children's Study

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Abstract

Background: Persistent pain during pregnancy is a significant health issue, which could be correlated with psychological distress resulting from inadequate social support. This study aims to investigate whether the relationship between poor social support and antenatal pain is mediated by psychological distress. We also aimed to examine whether social cohesion moderates the influence of psychological distress on the relationship between social support and antenatal pain.

Methods: We analysed 94,517 pregnancies of women from a Japanese national birth cohort completed questionnaires assessing pain, psychological distress, social support and social cohesion. Psychological distress was assessed using the Kessler Psychological Distress Scale. Two types of models were used: the mediation model to examine whether the association between social support and pain was mediated by psychological distress; the moderated mediation model to analyse whether social cohesion buffered the negative effect of inadequate social support on pain. Demographic, socioeconomic and psychological factors were controlled for in all analyses.

Results: Psychological distress was fully mediated the association between social support and pain. Social cohesion had a focal moderation effect on the inverse association between social support and psychological distress (unstandardized regression coefficient [β] = 0.09; 95% CI, 0.07–0.11) and functioned as moderator for the indirect effect of social support on antenatal pain (index of moderated mediation = 0.006; 95% CI, 0.004–0.007).

Conclusions: Poor social support was related to antenatal pain through psychological distress, possibly buffered by social cohesion. During the antenatal period, social support and cohesion are important for women.

Significance: In this study, poor social support was found to be associated with pain intensity during pregnancy, which was mediated by psychological distress and might be buffered by desirable social cohesion. This finding could potentially help healthcare providers and policy makers to understand the importance of desirable social cohesion in preventing pain among pregnant women.

1 | INTRODUCTION

More than one fifth of pregnant women experience severe pain such as lumbopelvic pain (Mackenzie et al., 2018), pain during intercourse (Aslan et al., 2005; Elden et al., 2016; Rossi et al., 2019) and headaches (Negro et al., 2017). These pain experiences affect their psychological health, relationships with others and quality of life (Mogren, 2006; Persson et al., 2013), as well as interferes with their role of being a mother and household tasks (e.g. babysitting, cooking, cleaning) (Persson et al., 2013). However, persistent pain during pregnancy is often ignored and understudied (Ray-Griffith et al., 2018).

Social capital is a very important health determinant (Kawachi et al., 2008), and may also play a key role in the alteration of pain during pregnancy. The concept of social capital remains controversial, but social capital can be divided into two components: *structural* social capital such as social networks and *cognitive* social capital such as neighbourhood trust and reciprocity (Harpham et al., 2002). The former and the latter focused on "social support" and "social cohesion" respectively (Ehsan & De Silva, 2015).

Although the effect of these social capitals on antenatal pain has not been sufficiently investigated, poor social support at a personal level contributed to the development of lower back pain in the non-pregnant population at work and in private life (Hoogendoorn et al., 2000). This association between poor social support and the development of pain may be mediated by psychological distress despite the lack of direct evidence. As fragments of evidence, poor social support was linked to the risk of psychological distress such as depressive symptoms (Barnett & Gotlib, 1988), and the risk of psychological distress due to depression was comorbid with pain (IsHak et al., 2018). It is meaningful to figure out the mediation effect of psychological distress between poor social support and antenatal pain in order to shed light on the negative effect of poor social support on the health of pregnant women and its underlying mechanism.

As the other social capital, social cohesion at a neighbourhood-level is expected to reduce the risk of the personal-level mental health (De Silva et al., 2005; Kawachi & Berkman, 2001). Therefore, social cohesion at a neighbourhood level may buffer the negative impact of poor social support on pain mediated by psychological distress at a personal level. The evidence of this buffering effect of social cohesion at a neighbourhood level on the association between poor social support and antenatal pain via psychological distress will provide a meaningful clinical implication.

We hypothesized that poor social support (i.e. deficit practical support from individuals) leads to psychological distress in pregnant women, which, in turn, increases antenatal pain. In addition, desirable social cohesion (i.e. neighbourhood trust and reciprocity) buffers the negative effect of inadequate social support on antenatal pain through psychological distress. This study examines these hypotheses using the mediation and the moderated mediation models (Figure 1).

2 | METHODS

2.1 | Study design

The Japan Environment and Children's Study (JECS) is a government-funded birth cohort study, wherein expectant mothers in Japan who are in the first trimester of pregnancy were recruited from January 2011 to March 2014. The JECS's protocol has been published elsewhere (Kawamoto et al., 2014; Michikawa et al., 2018). Two surveys using self-report questionnaires were administered during pregnancy – in the first trimester and in the second to third trimester. We used the JECS dataset released in June 2016 and revised in October 2016 (jecs-ag-20160424).

2.2 | Study population

A total of 103,099 pregnancies were registered in the JECS; 97,678 women were registered once, 5,373 women were registered twice and 48 women were registered three times. We excluded 3,406 pregnancies with incomplete data on age or pre-pregnancy body mass index in the first trimester. Of 99,693 pregnancies, we also excluded 5,176 pregnancies with incomplete data on social cohesion, social support, pain or the Kessler Psychological Distress Scale in the second to third trimester. Ultimately, we analysed 94,517 pregnancies of women. The enrolment process of the participants is shown in Figure S1.

2.3 | Main measures

2.3.1 | Pain during pregnancy: Outcome variable (Y)

In the second survey, the SF-8 bodily pain item (SF-8 Pain) was used to assess pain intensity. Participants were asked 'How much bodily pain have you had during the past 4 weeks?' with responses on a 6-point scale: none (1), very mild (2), mild (3), moderate (4), severe (5) and very severe (6) (Fukuhara and Suzukamo, 2004; Ware JE, Kosinski M, Dewey JE, 2001). The SF-8 Pain score was treated as a consecutive variable. In addition, the SF-8 Pain could not specify the pain region, thus the current study examined the overall body pain. Our definition of "pain during pregnancy" did not include pain related to delivery.
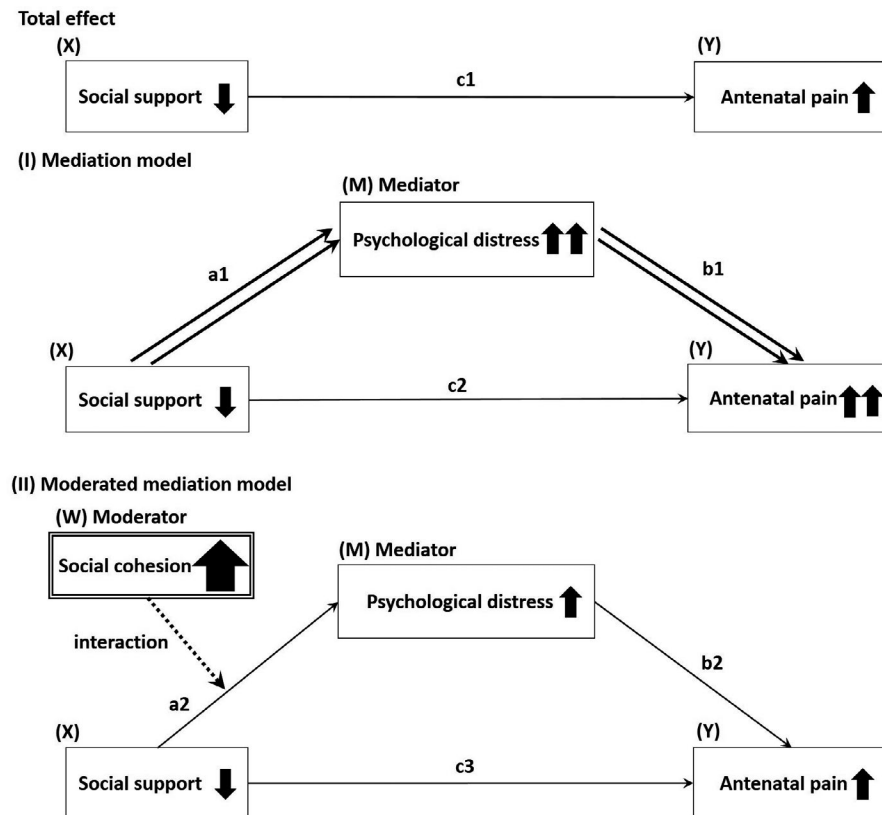
Total effect

FIGURE 1 Mediation and moderated mediation models. The total effect model examined whether social support affected antenatal pain intensity. (I) The mediation model examined whether psychological distress mediated the association between poor social support and antenatal pain intensity. (II) The moderated mediation model examined whether social cohesion interacted with social support showing the effect of antenatal pain intensity through psychological distress. X explanatory variable, Y outcome variable

2.3.2 | Psychological distress: Mediator (M)

Psychological distress during pregnancy was assessed using the Kessler Psychological Distress Scale (K6) in the second survey (Furukawa et al., 2008).

A previous study calculated the receiver operating characteristic (ROC) in the Japanese version of the K6 (<13 points or ≥13 points) versus the clinical diagnoses of mood or anxiety disorder; the ROC was shown as 0.94 (95% confidence interval [CI] = 0.88 to 0.995) (Furukawa et al., 2008). These clinical diagnoses were obtained from the structured face-to-face interviews designed to generate the criteria for mood disorder (depression and dysthymia) or anxiety disorder (panic disorder, agoraphobia, social phobia, generalized anxiety disorder and post-traumatic stress disorder) based on the Diagnostic and Statistical Manual of Mental Disorders–Fourth Edition (Furukawa et al., 2008).

2.3.3 | Social support: Explanatory variable (X)

In the second survey, three items were used to assess social support: 'Is there someone available to you who shows you love and affection?', 'Is there someone whom you can count on to provide you with emotional support (talking over

problems or helping you make a difficult decision)?' and 'How often do you have as much contact as you would like with someone you feel close to: someone in whom you can trust and confide?'. Ratings were made on a 5-point frequency scale: none of the time (0), a little of the time (1), some of the time (2), most of the time (3) and all of the time (4). These items were developed for the JECS and were not validated but had similar concept to a previously validated instrument used to assess social support (Vaglio et al., 2004). We believed that they were considered suitable for the objectives of the present study. Cronbach's alpha coefficient for internal consistency among those three items was 0.80 (Table S2).

2.3.4 | Social cohesion: Moderator (W)

In the second survey, two items were used to assess social cohesion: 'Neighbours trust each other' and 'Neighbours help each other'. Responses were on a 4-point scale: *disagree* (1), *somewhat disagree* (2), *somewhat agree* (3) and *agree* (4). Although these items were also not validated, they included the same concept of the widely quoted measures of social capital developed by Sampson et al. (Sampson et al., 1997) and the subscale for social cohesion of the previously validated Neighborhood Scale items (Mujahid et al., 2007). Cronbach's alpha coefficient for internal consistency in the three items was 0.93 (Table S2).

2.3.5 | Generating two component scores for social support and social cohesion

The original score of these five items used to assess social capital (i.e. three and two items for social support and social cohesion respectively) is shown in Table S1.

Two linearly uncorrelated primary component scores for social support and social cohesion were generated from these five items using the principal component analysis through the varimax rotation and the Anderson–Rubin methods. The primary component score with a mean of 0 and a variance of 1 was computed by multiplying the standardized variable values for each person by the component score coefficient matrix (IBM Knowledge center).

The factor loading and the item total correlation of each item are shown in Table S2.

2.4 | Potential Confounders

2.4.1 | Demographic characteristics

We included age at study entry ($\leq$19, 20–24, 25–29, 30–34, 35–39 or $\geq$40 years), body mass index (quintile), smoking status during pregnancy (never smoked, ex-smoker or current smoker), drinking status during pregnancy (never drank, ex-drinker or drinker) and physical activity during pregnancy [quintile, Metabolic Equivalents (METs) * hour].

Physical activity was measured by the International Physical Activity Questionnaire (IPAQ) (Craig et al., 2003; Murase et al., 2003).

2.4.2 | Socioeconomic factors

The included socioeconomic factors were education level (less than high school, high school, college/vocational school, university or graduate school), marital status at the first survey (married or common-law, single or divorced/widowed), and equivalized income at the second survey (quintile, Japanese yen).

Equivalized income was calculated by dividing the median value of the multiple-choice response for annual household income by the square root of the number of people living together. Based on the poverty line in Japan in 2015 (The Ministry of Health Labour & Welfare, 2016), low income was defined as less than 1.22 million Japanese yen in annual equalised income.

2.4.3 | Medical history and psychological risk factors

For medical history and psychological risk factors, we included parity $\geq$1 (*yes/no*), self-reported depth of sleep during the past month (slept quite lightly, slept lightly, normal, slept deeply or slept quite deeply), probable autism spectrum disorder (the Autism Spectrum Quotient Short Form; <7 or $\geq$7 points) (Kurita et al., 2005), history of rheumatoid arthritis (*yes/no*), history of irritable bowel syndrome (*yes/no*), history of migraine (*yes/no*), history of anxiety disorder (*yes/no*), history of depression (*yes/no*), history of schizophrenia (*yes/no*) and history of other psychological disorders (*yes/no*).

The autism spectrum disorder was considered as a probable potential confounder because previous studies reported that autism was associated with impaired social skills such as communicating with families and neighbours (American Psychiatric Association, 2013), and it was also associated with sensitivity or insensitivity to pain (Courchesne et al., 1989; Hutt et al., 1965).

Dummy variables were created for missing data when adjusting for potential confounding variables.

2.5 | Statistical Analysis

The P value for the trends of the means and the proportions of the characteristics according to the quartiles of social support and social cohesion were tested using the analysis of covariance.

2.5.1 | Total effect between social support and antenatal pain

The total effect was calculated using the multivariable regression analysis to investigate whether social support contributed to the intensity of antenatal pain (Figure 1, Total effect).

2.5.2 | Mediation model

A mediation model was used to examine whether the association between social support and antenatal pain intensity was mediated by psychological distress (Figure 1, [I] Mediation model). Indirect effect was also calculated using regression analysis to determine whether social support exerted its effect on antenatal pain through psychological distress. Bias-corrected bootstrap 95% CIs were obtained for a potential mediator (i.e. psychological distress) and were used to test the significance of the total and indirect effects based on 1,000 bootstraps. Moreover, indirect effect was considered significant if the bias-corrected bootstrap 95% CI did not include zero.

2.5.3 | Moderated mediation model

A moderated mediation model was used to examine whether social cohesion affected the focal inverse association

between social support and psychological distress protectively and the overall inverse association between social support and pain intensity during pregnancy mediated by psychological distress (Figure 1, [II] Moderated mediation model).

The conditional focal effects for the 16th and the 84th percentile of social cohesion (i.e. low and high social cohesions, respectively) on the association between social support and psychological distress were estimated using the regression analysis. The conditional indirect effects for the 16th and the 84th percentile of social cohesion on the association between social support and antenatal pain through psychological distress were also tested using the regression analysis based on 1,000 bootstraps.

Furthermore, the function of social cohesion as moderator for the indirect effect of social support on antenatal pain through psychological distress using the "index of moderated mediation" was evaluated (Hayes, 2015). The indirect effect in the moderated mediation model is presented as $(a_1 + a_3 W)$ $b = a_1 b + a_3 bW$ in the current model (a_1, regression coefficient of the predictor to the mediator; a_3, regression coefficient of the product of the predictor and the moderator to mediator; W, moderator; b, regression coefficient of the mediator to the outcome) (Hayes, 2015). The index of moderated mediation is the weight for W (i.e. $a_3 b$) (Hayes, 2015). Therefore, if $a_3 b$ does not include zero, the indirect effect depends on the moderator, and hence the mediation is considered as moderated (Hayes, 2015). The index of moderated mediation was estimated based on 1,000 bootstraps. The conditional indirect effects and the index of moderated mediation were considered significant if the bias-corrected bootstrap 95% CI did not include zero.

In the mediation and moderated mediation analyses, Model 1 was a crude model and Model 2 was adjusted for all potential confounders (demographic characteristics, socioeconomic variables, and medical history and psychological risk factors).

P values < 0.05 (two-tailed) were considered statistically significant unlike the analyses for indirect effect, the conditional indirect effect and the index of moderated mediation. The primary component analysis was performed using SPSS, Version 24.0, for Windows (IBM Corp.). Statistical analyses other than primary component analysis were performed using SAS, Version 9.4 (SAS Institute Inc.). The mediation and moderated mediation analyses were conducted using SAS macro (PROCESS version 3.4) (Preacher & Hayes, 2004).

2.6 | Sensitivity Analysis

In sensitivity analysis, the models were rerun after excluding pregnancies with medical history or psychological risk factors (*n* = 80,883) as a sensitivity analysis.

2.7 | Ethical Issues

All procedures were in accordance with the ethical standards of the Helsinki Declaration of 1975, as revised in 2010. The Japan Environment and Children's Study protocol was approved by the Institutional Review Board of the Japan National Institute for Environmental Studies (date of approval: 9 August 2010 and approval number: 2010-2R), and by the ethics committees at all participating institutions. Written informed consent was obtained from all participating women.

3 | RESULTS

The sample characteristics are shown in Table 1. Of 94,517 pregnancies, the prevalence of mild pain (SF-8 response – body pain is very mild or mild) and moderate-to-severe pain (SF-8 response – body pain is moderate, severe or very severe) during the second to third trimester of gestation was 58,370 (61.8%) and 21,126 (22.4%) respectively.

Table 2 shows the means and percentages of characteristics of the quartiles of social support and social cohesion. Compared with the first quartiles of social support and social cohesion, the second to fourth quartiles of social support and social cohesion were more likely to be older; less likely to be obese, current smokers or current drinker; less likely to have lower educational attainment; less likely to be divorced or widowed, parity, insufficient sleep and to have low income; probable autism spectrum disorder; a history of migraine, anxiety disorder or depression disorder; or other psychological disorders; and psychological distress. Compared with the first quartiles of social support, the second-to-fourth quartiles of social support were less likely to be physically active. Compared with the first quartiles of social cohesion, the second-to-fourth quartiles of social cohesion were less likely to have a history of irritable bowel syndrome or schizophrenia. The prevalence of history of rheumatoid arthritis did not vary among the quartiles of social support and social cohesion.

The effects of mediation on psychological distress and moderation on social cohesion showing the association between social support and antenatal pain are shown in Table 3. Social support was inversely associated with pain in Model 2 of the total effect model; unstandardized regression coefficient (β) = −0.03 (95% CI, −0.04 to −0.02, *p* < .001). Psychological distress fully mediated the association between poor social support and increased pain.

In the moderated mediation model, social support and social cohesion had an independent inverse association with psychological distress in Model 2; β = −0.58 (95% CI, −0.61 to −0.56, *p* < .001) and β = −0.30 (95% CI, −0.33 to −0.28, *p* < .001) respectively. The interaction between social support and social cohesion had a significant effect

TABLE 1 Sample characteristics ($n = 94,517$)

	Mean	SD
S1: Age at the study entry, years		
≤20	964	1.0
20–24	9,443	10.0
25–29	27,768	29.4
30–34	33,217	35.1
35–39	19,708	20.9
≥40	3,417	3.6
S1: Pre-pregnancy body mass index, kg/m²		
<18.5	15,204	16.1
18.5–24.9	69,344	73.4
25.0–29.9	7,618	8.1
≥30	2,351	2.5
S2: Smoking during pregnancy		
Never-smoker	54,372	57.5
Ex-smoker	35,209	37.3
Smoker	4,230	4.5
Missing	706	0.7
S2: Drinking during pregnancy		
Never-drinker	31,406	33.2
Ex-drinker	59,725	63.2
Drinker	2,649	2.8
Missing	737	0.8
S2: Amounts of physical activity, Mets*hours per day		
Q1: ≤ 0.009	21,232	22.5
Q2: 0.010–0.707	15,538	16.4
Q3: 0.708–1.744	17,335	18.3
Q4: 1.745–4.715	18,357	19.4
Q5: ≥ 4.716	17,812	18.8
Missing	4,243	4.5
S2: Educational level		
Less than high school	4,432	4.7
High school	29,400	31.1
College/vocational school	39,750	42.1
University	19,263	20.4
Graduate school	1,407	1.5
Missing	265	0.3
S1: Marital status		
Married or common-law	90,133	95.4
Single	3,214	3.4
Divorced	776	0.8
Widowed	13	0.0
Missing	381	0.4
S2: Equivalized income, million Japanese yen		

(Continues)

TABLE 1 (Continued)

	Mean	SD
Q1: ≤ 1.14	15,293	16.2
Q2: 1.15–1.65	19,844	21.0
Q3: 1.66–2.89	20,676	21.9
Q4: 2.90–4.02	13,696	14.5
Q5: ≥ 4.03	18,481	19.6
Missing	6,527	6.9
S1: Parity ≥1		
Yes	48,444	51.3
No	46,066	48.7
Missing	7	0.01
S2: Self-reported depth of sleep in the past month		
Slept quite lightly	6,852	7.2
Slept lightly	39,646	41.9
Normal	37,398	39.6
Slept deeply	8,703	9.2
Slept quite deeply	1,682	1.8
Missing	236	0.2
S2: Probable autism spectrum disorder		
Yes	2,475	2.6
No	90,015	95.2
Missing	2,027	2.1
S1: History of rheumatoid arthritis		
Yes	199	0.2
No	94,318	99.8
S1: History of irritable bowel syndrome		
Yes	1,468	1.6
No	93,049	98.4
S1: History of migraine		
Yes	5,890	6.2
No	88,627	93.8
S1: History of anxiety disorder		
Yes	2,663	2.8
No	91,854	97.2
S1: History of depression		
Yes	2,849	3.0
No	91,668	97.0
S1: History of schizophrenia		
Yes	161	0.2
No	94,356	99.8
S1: History of other psychiatric diseases		
Yes	921	1.0
No	93,596	99.0

(Continues)

TABLE 1 (Continued)

	Mean	SD
S2: Kessler psychological distress scale (K6) scores	3.5	3.8
S2: Pain intensity	n	%
Without pain	15,021	15.9
Mild pain	58,370	61.8
(Very mild)	(21,816)	(23.1)
(Mild)	(36,554)	(38.7)
Moderate-to-severe pain	21,126	22.4
(Moderate)	(16,617)	(17.6)
(Severe)	(4,133)	(4.4)
(Very severe)	(376)	(0.4)

Abbreviations: S1, Survey 1; S2, Survey 2; METs, Metabolic Equivalents; Q, Quintile; *SD*, standard deviation

on psychological distress in Model 2; β = 0.09 (95% CI, 0.07 to 0.11, $p < .001$). The effects of conditional focal moderation on social cohesion between social support and psychological distress show that individuals in high social cohesion had lower levels of psychological distress compared with those in low social cohesion; β of low social cohesion and high social cohesion = −0.73 (95% CI, −0.76 to −0.69, $p < .001$) and −0.52 (95% CI, −0.52 to −0.55, $p < .001$) respectively.

Furthermore, social cohesion functions as the moderator of the indirect effect of social support on antenatal pain that was mediated by increased psychological distress, although the effect size was small; index of moderated medication, β = 0.006 (95% CI, 0.004 to 0.007).

The sensitivity analysis excluding pregnancies with any medical history or psychological risk factors revealed results similar to the main results (Table S3).

4 | DISCUSSION AND CONCLUSIONS

The present study examined two hypotheses: (a) poor social support leads to psychological distress in pregnant women, which, in turn, increases antenatal pain, and (b) desirable social cohesion buffers the negative effect of inadequate social support on antenatal pain mediated by psychological distress. Poor social support was associated with antenatal pain, which was fully mediated by psychological distress. Strong social cohesion had a protective effect on the inverse association between social support and psychological distress, which, in turn, had a protective effect on the indirect effect of social support on antenatal pain through psychological distress. This finding was consistent with our a priori hypothesis.

Social capital such as social support and social cohesion may be important for the prevention and management of pain during pregnancy.

Before the main analyses, we examined the association of potential confounders and a mediator with explanatory variables: the quartiles of social support and social cohesion scores. The association of almost all potential confounders and a mediator with social support and social cohesion were statistically significant. Prevalence of low physical activity and histories of rheumatoid arthritis, schizophrenia and irritable bowel syndrome were not associated with one or both explanatory variables. However, these variables affected the pain experience in previous studies such that we selected these as adjusting variables (Engels et al., 2014; Geneen et al., 2017; Keefe et al., 1989; Weaver et al., 2017).

The present study provided evidence on the effect of low social support on the intensity of pain during pregnancy. A previous qualitative study of pregnant women with lumbopelvic pain reported that it was important for pregnant women to receive psychological and practical support from their partner and other family members (Persson et al., 2013). In particular, those with young children required special support from older adults such as partners, parents and other relatives for household tasks (Persson et al., 2013). Therefore, the effect of poor social support on pain in pregnant women may need to be widely examined.

The role of psychological distress as a mediator of the association between poor social support and antenatal pain was also found. Even though the study population was different from those of pregnant women, a previous research reported that social support was inversely associated with psychological distress and pain intensity among chronic pain patients (López-Martínez et al., 2008). Social support and marital quality were associated with mental health including depressive symptoms during pregnancy (Alipour et al., 2019; Bennett et al., 2004). On the other hand, psychological distress was associated with the development and continuation of persistent pain among the non-pregnant population (Edwards et al., 2016), and mental stress was a psychological risk factor for pelvic pain in pregnant women (Albert et al., 2006). Psychological distress was a key connector of these pathways, connecting poor social support and pain during pregnancy, and psychological distress in pregnant women should be reduced in order to reduce their pain intensity. A mindfulness-based cognitive therapy is one of the therapeutic options for psychological distress during pregnancy (Taylor et al., 2016; Zemestani & Fazeli Nikoo, 2020). In addition, music therapy may reduce psychological distress and pain intensity during pregnancy with relaxation (Mastnak, 2016).

On the other hand, social cohesion buffered the negative effect of poor social support on psychological distress,

TABLE 2 Mean values and proportions of sample characteristics according to the quartiles of social support and social cohesion

	Total n = 94,517		Social support									Social cohesion								
			Q1 n = 24,171		Q2 n = 23,013		Q3 n = 23,614		Q4 n = 23,719		p for trend	Q1 n = 23,568		Q2 n = 23,089		Q3 n = 23,745		Q4 n = 24,115		p for trend
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD		Mean	SD	Mean	SD	Mean	SD	Mean	SD	
S1: Age at the study entry, years	30.8	5.0	30.7	5.3	30.4	5.1	31.1	4.8	30.9	4.8	<.001	29.7	5.1	30.7	5.0	31.5	4.8	31.3	5.0	<.001
	n	%	n	%	n	%	n	%	n	%		n	%	n	%	n	%	n	%	
S1: Pre-pregnancy BMI ≥ 25 kg/m^2	9,970	10.5	2,996	13.5	2,462	10.7	2,259	9.6	2,253	9.5	<.001	2,434	10.3	2,529	11.0	2,336	9.8	2,671	11.1	<.001
S2: Smokers during pregnancy	4,230	4.5	1,392	6.3	1,237	5.4	819	3.5	782	3.3	<.001	1,399	5.9	1,142	4.9	720	3.0	969	4.0	<.001
S2: Drinkers during pregnancy	2,649	2.8	736	3.3	667	2.9	645	2.7	601	2.5	<.001	621	2.6	611	2.6	671	2.8	746	3.1	.007
S2: Low amounts of physical activity	21,232	22.5	5,706	25.7	5,106	22.2	5,146	21.8	5,274	22.2	<.001	5,378	22.8	5,086	22.0	5,263	22.2	5,505	22.8	.06
S2: Less than high school graduate	4,432	4.7	1,649	7.4	1,285	5.6	708	3.0	790	3.3	<.001	1677	7.1	1,143	5.0	596	2.5	1,016	4.2	<.001
S1: Divorce or widows	789	0.8	299	1.3	190	0.8	120	0.5	180	0.8	<.001	275	1.2	231	1.0	127	0.5	156	0.6	<.001
S2: Low income	32,189	34.1	9,980	45.0	8,188	35.6	7,140	30.2	6,881	29.0	<.001	7,432	31.5	7,852	34.0	7,376	31.1	9,529	39.5	<.001
S1: Parity ≥ 1	48,444	51.3	13,137	59.3	11,562	50.5	11,917	50.5	11,828	49.9	<.001	9,031	38.3	11,230	48.6	13,442	56.6	14,741	61.1	<.001
S2: Slept quite lightly	6,852	7.2	2,016	9.1	1,772	7.7	1,447	6.1	1,617	6.8	<.001	2,205	9.4	1645	7.1	1,343	5.7	1659	6.9	<.001
S2: Probable ASD	2,475	2.6	1,048	4.7	608	2.6	398	1.7	421	1.8	<.001	721	3.1	673	2.9	379	1.6	702	2.9	<.001
S1: History of RA	199	0.2	52	0.2	56	0.2	45	0.2	46	0.2	.58	58	0.2	54	0.2	40	0.2	47	0.2	.23
S1: History of IBS	1,468	1.6	354	1.6	383	1.7	338	1.4	393	1.7	.07	432	1.8	385	1.7	319	1.3	332	1.4	<.001
S1: History of migraine	5,890	6.2	1,631	7.4	1,460	6.3	1,376	5.8	1,423	6.0	<.001	1723	7.3	1,483	6.4	1,338	5.6	1,347	5.6	<.001
S1: History of anxiety disorder	2,663	2.8	867	3.9	721	3.1	531	2.2	544	2.3	<.001	811	3.4	694	3.0	507	2.1	651	2.7	<.001
S1: History of depression	2,849	3.0	933	4.2	756	3.3	580	2.5	580	2.4	<.001	891	3.8	726	3.1	554	2.3	678	2.8	<.001
S1: History of schizophrenia	161	0.2	48	0.2	40	0.2	34	0.1	39	0.2	.54	57	0.2	40	0.2	30	0.1	34	0.1	.01
S1: History of other psychological disorders	921	1.0	303	1.4	232	1.0	192	0.8	194	0.8	<.001	262	1.1	237	1.0	200	0.8	222	0.9	.02

(Continues)

TABLE 2 (Continued)

	Total		Social support									p for trend	Social cohesion									p for trend
	n = 94,517		Q1 n = 24,171		Q2 n = 23,013		Q3 n = 23,614		Q4 n = 23,719				Q1 n = 23,568		Q2 n = 23,089		Q3 n = 23,745		Q4 n = 24,115			
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD			Mean	SD	Mean	SD	Mean	SD	Mean	SD		
S2: K6 scores	3.5	3.8	4.5	4.3	3.7	3.8	2.9	3.3	2.8	3.3	<.001		4.0	4.2	3.8	3.8	2.7	3.1	3.3	3.7	<.001	

Note: The first quintile of amounts of physical activity was defined as low amounts of physical activity.

Poverty was defined as an equivalized income less than 1.22 million Japanese yen

Abbreviations: S1, Survey 1; S2, Survey 2; SC, social cohesion; PS, personal support; Q, Quartile; *SD*, standard deviation; BMI, body mass index; ASD, autism spectrum disorder; RA, rheumatoid arthritis; IBS, irritable bowel syndrome; K6, Kessler Psychological Distress Scale

n = 94,517.

which, in turn, social cohesion contributed as a moderator on the overall association between poor social support and antenatal pain mediated by psychological distress. Some previous researches reported that social cohesion at a neighbourhood level, the existence of mutual trust and respect between residents, had beneficial impacts on individual-level psychological distress (De Silva et al., 2005; Ehsan & De Silva, 2015; Honjo et al., 2018; O'Campo et al., 2015). However, to our knowledge, this buffering effect of social cohesion on the association between poor social support and antenatal pain through psychological distress was the novel finding.

Mechanisms explaining why social cohesion buffered the negative effect of poor social support on pain through psychological distress in pregnant women remain unclear. However, high levels of social cohesion reflected high levels of neighbourhood friendliness such as chattering and greeting with neighbours (Stansfeld, 2005), which may buffer poor social support even if their friendliness was caused by the lack of practical support from individuals. Residents with such direct and indirect neighbourhood friendliness related to social cohesion may prevent psychological distress through feeling secure and avoiding the feeling of social isolation and loneliness. A previous literature review concluded that social isolation was linked to threatened social cohesion (Cacioppo & Hawkley, 2009), and loneliness was suggested recently as a determinant of musculoskeletal pain (Smith et al., 2019). Avoiding the feeling of social isolation and loneliness, which stems from desirable social cohesion may prevent pain during pregnancy by preventing psychological distress.

Even when pregnant women live with their partners or families, their relationships with these people and the social support they receive are not always ideal. Although some socially supportive interventions for the mental care of expectant mothers existed (Striebich et al., 2018), the magnitude of the intervention was limited and it generally takes financial and personal costs to conduct these interventions for expectant mothers. The current study identified that social cohesion may be helpful to buffer the negative effect of low social support on antenatal pain. The social cohesion that exists in the communities that expectant mothers live may be important for them to consider as this is where they will be raising their children. The Council of Europe provided a strategy to build and maintain social cohesion through encouraging social participation (e.g. cultural association and voluntary activity) and encouraging family solidarity (Council of Europe, 2008). Although the buffering effect of social cohesion in the current study showed low impact compared to the effect of social support, the protective effect of social cohesion at a neighbourhood level provided a social level cue for considering antenatal pain.

TABLE 3 Mediation effect of psychological distress and moderation effect of social cohesion on the association between social support and antenatal pain

	Model 1						Model 2					
	β	95% CI LL	UL	SE	t	p value	β	95% CI LL	UL	SE	t	p value
Total effect												
Path c1: X (SS) –> Y (pain)	−0.05	−0.06	−0.04	0.004	−14.3	<.001	−0.03	−0.04	−0.02	0.004	−8.1	<.001
(I) Mediation model												
Path c2: X (SS) –> Y (pain)	0.001	−0.006	0.01	0.004	0.3	.79	0.007	−0.0004	0.01	0.004	1.8	.06
Path a1: X (SS) –> M (Distress)	−0.74	−0.76	−0.72	0.01	−61.8	<.001	−0.59	−0.61	−0.56	0.01	−50.4	<.001
Path b1: M (Distress) –> Y (pain)	0.07	0.07	0.07	0.001	74.6	<.001	0.06	0.058	0.062	0.001	61.9	<.001
	β	BC 95% CI LL	UL	B-SE			β	BC 95% CI LL	UL	B-SE		
Indirect effect												
Path a1 * Path b1: X –> M–> Y	−0.052	−0.054	−0.049	0.001			−0.035	−0.037	−0.034	0.001		
	Model 1						Model 2					
	β	95% CI LL	UL	SE	t	p value	β	95% CI LL	UL	SE	t	p value
(II) Moderated mediation model												
Path a2: X (SS) –> M (Distress)	−0.73	−0.76	−0.71	0.01	−61.5	<.001	−0.58	−0.61	−0.56	0.01	−50.2	<.001
W (SC) –> M (Distress)	−0.43	−0.45	−0.41	0.01	−36.0	<.001	−0.30	−0.33	−0.28	0.01	−25.9	<.001
X (SS)*W (SC) –> M (Distress)	0.12	0.1	0.14	0.01	10.2	<.001	0.09	0.07	0.11	0.01	8.1	<.001
Conditional focal effect for low SC	−0.92	−0.96	−0.88	0.02	−44.1	<.001	−0.73	−0.76	−0.69	0.02	−36.1	<.001
Conditional focal effect for high SC	−0.65	−0.68	−0.62	0.01	−43.6	<.001	−0.52	−0.55	−0.49	0.01	−36.3	<.001
Path b2: M (Distress) –> Y (pain)	0.069	0.068	0.071	0.001	74.6	<.001	0.060	0.058	0.061	0.001	61.9	<.001
Path c3: X (SS) –> Y (pain)	0.001	−0.006	0.008	0.004	0.3	.79	0.007	−0.0004	0.01	0.004	1.8	.06
	β	BC 95% CI LL	UL	B-SE			β	BC 95% CI LL	UL	B-SE		
Indirect effect												
Path a2*b2: X –> M –> Y	−0.051	−0.053	−0.049	0.001			−0.035	−0.037	−0.030	0.001		
Conditional indirect effect for low SC	−0.064	−0.068	−0.060	0.002			−0.044	−0.047	−0.040	0.002		

(Continues)

TABLE 3 (Continued)

	Model 1				Model 2			
	β	BC 95% CI LL	UL	B-SE	β	BC 95% CI LL	UL	B-SE
Conditional indirect effect for high SC	−0.045	−0.048	−0.043	0.001	−0.031	−0.033	−0.029	0.001
Index of moderated mediation	0.008	0.006	0.010	0.001	0.006	0.004	0.007	0.008

Note: Model 1: Crude model

Model 2: Adjusted for age, pre-pregnancy body mass index, smoking during pregnancy, drinking during pregnancy, physical activity, education, marital status, equivalized income, parity, self-reported sleep depth, probable autism spectrum disorder, history of rheumatoid arthritis, history of irritable bowel syndrome, history of migraine, history of anxiety disorder, history of depression, history of schizophrenia, and history of other psychological disorders

Social support and social cohesion were measured using primary component scores generated by the principal component analysis

Psychological distress as a mediator was measured using the Kessler Psychological Distress Scale (K6)

The 16th percentile of social cohesion (SC) score was defined as low SC, and the 84th percentile of SC score was defined as high SC

Unstandardized path coefficients for the indirect effect and the index of moderated mediation are based on 1,000 bootstrap samplings

When the bias-corrected bootstrap 95% CI of the index of moderated mediation did not include zero, social cohesion has a function of the moderator on the indirect effect.

Abbreviations: β, unstandardized path coefficient; CI, confidence interval; SE, standard error; LL, lower limit; UL, upper limit; BC 95% CI, bias-corrected bootstrap 95% confidence intervals; B-SE, bootstrap standard error; SS, social support; Distress, psychological distress; SC, social cohesion

$n = 94,517$

The strengths of the present study were that the data were from a large nationwide cohort study, and the impacts of social support and social cohesion on antenatal pain in relation to psychological distress were observed as distinct variables. Social support and social cohesion were often used together, but we could shed light on the buffering effect of social cohesion on poor social support in the pregnant population using a distinct observation of those. The study also had several limitations. First, we had no information on the causes of pain, pain sites, social capital before pregnancy and the frequency of going out during pregnancy that would have provided further clinical implications. The causes of pain and pain sites might suggest types of treatment that were required by pregnant women with pain. The information of change in social capital before and after pregnancy might suggest policy makers and healthcare professionals when they should pay attention to women regarding social capital in relation to antenatal pain. The frequency of going out may alter social support and social cohesion, and if we had examined the impact of the frequency of going out on the social capital of pregnant women, it might be a quite meaningful implication. Second, this study used a cross-sectional design, and thus the temporal aspect cannot be discussed. Pain itself may interfere with the habit of going out, which may hinder the maintenance of preferred social support and social cohesion. Third, these data were analysed approximately 6 years after the last data were collected in 2014. Therefore, the results of this study may not represent the current global social status because social environments including social capital (i.e. social support and social cohesion) are always changing and vary across countries.

In conclusion, poor social support was associated with the intensity of antenatal pain, which was fully mediated by psychological distress and was buffered by desirable social cohesion. Social support and social cohesion may be important for women during the antenatal period.

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CONFLICTS OF INTEREST

The authors report no conflicts of interest.

AUTHOR CONTRIBUTIONS

Substantial contributions to conception and design; K.Y., acquisition of data; S.I. and H.I., analysis and interpretation of data; K.Y. and Y.K, drafting the article; K.Y., revising the article for important intellectual content; T.K., M.C., Y.K., S.I. and H.I. All authors discussed the results and commented on the manuscript for final approval of the version to be published.

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