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Periodontitis is associated with antenatal depression: a clinical study in China

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Abstract

Objectives

This study investigated the association between periodontitis severity and antenatal depression among pregnant women in China and examined whether a dose–response relationship exists.

Materials and methods

This cross-sectional study included 357 pregnant women in the second trimester in China. Periodontitis was classified according to the CDC–AAP case definitions. Antenatal depression was assessed using the Chinese version of the Edinburgh Postnatal Depression Scale, followed by psychiatrist-confirmed DSM-5 evaluation when indicated. Multivariable logistic regression, subgroup analyses, and interaction tests were performed to assess the association between periodontitis severity and antenatal depression.

Results

The prevalence of antenatal depression increased progressively from 12.1% in women without periodontitis to 27.9% with mild and 47.8% with moderate/severe periodontitis ($P < 0.001$). After full adjustment, mild and moderate/severe periodontitis were associated with higher odds of antenatal depression (odds ratio (OR) 2.980, 95% CI 1.473–6.029, $P = 0.002$; OR 3.377, 95% CI 1.348–8.460, $P = 0.009$, respectively). Each one-level increase in periodontitis severity was associated with 2.496-fold higher odds of antenatal depression (95% CI 1.651–3.772; $P < 0.001$). Smoking status and toothbrushing frequency showed significant interactions.

Conclusion

Periodontitis severity was positively associated with antenatal depression and with a significant dose–response relationship. The cross-sectional design prevents establishing causality.

Clinical relevance

Periodontal examination may represent a practical, screenable opportunity for identifying pregnant women who could benefit from further mental health assessment, highlighting the potential value of integrated oral–mental healthcare during pregnancy.

Introduction

Antenatal depression is a common mental health disorder during pregnancy and has become a major public health concern affecting both maternal and child health[1]. Evidence indicates that antenatal depression not only contributes to anxiety, insomnia, and severe psychological distress in pregnant women but is also associated with adverse outcomes such as preterm birth, low birth weight, and autism spectrum disorders in offspring[2–6]. In current clinical practice, psychological problems during pregnancy are still frequently overlooked. Some studies have shown that early identification remains particularly inadequate in resource-limited settings, and some high-risk pregnant women fail to receive timely intervention[7,8]. Given the continuity of risk between antenatal and postpartum depression, management strategies should adopt a life-course perspective[9]. Therefore, identifying modifiable risk factors and implementing early screening are of substantial clinical importance for improving maternal and neonatal health outcomes during pregnancy.

Compared with the mechanisms underlying depression in the general population, pregnant women exhibit distinct physiological characteristics in terms of hormone levels, immune regulation, and the maternal-foetal microbiome; consequently, the mechanisms underlying depression in this group also differ.[10,11]. Beyond psychosocial factors, accumulating evidence suggests that inflammatory responses and related immune mechanisms play important roles in the onset and progression of antenatal depression. Several studies have demonstrated that elevated maternal inflammatory levels during pregnancy may represent a potential risk factor for perinatal depression[12–14]. Furthermore, researchers have proposed that depression during pregnancy may constitute a distinct subtype of “inflammation-induced depression,” the underlying mechanisms of which are closely associated with the effects of cytokines and kynurenine metabolites on neuroinflammation and glutamatergic neurotransmission[15].

Periodontitis, a chronic inflammatory condition initiated by oral pathogenic bacteria, not only destroys the periodontal supporting tissues, but may also exacerbate systemic inflammatory burden through the release of specific pro-inflammatory mediators, as well as bacterial components into the circulation[16,17]. During pregnancy, substantial increases in estrogen and progesterone levels induce alterations in the oral microbiome, inflammatory factors and immune regulation, thereby increasing the risk of periodontitis development[18]. Compared with periodontitis in the general population, periodontitis during pregnancy may differ in terms of its pathogenesis and systemic spread due to the specific physiological conditions of pregnancy[19].

Recent studies have suggested an association between periodontitis and depressive symptoms. Population-based cohort studies have demonstrated significantly increased risks of depression and anxiety among individuals with periodontitis[20]. Experimental animal studies have further shown that chronic periodontitis can induce depression-like behaviors in mice through neural pathways[21]. However, direct evidence regarding the relationship between periodontitis and antenatal depression during pregnancy remains limited. The associations observed between periodontitis and depression in the general population may not be directly generalizable to pregnant populations. Therefore, further clinical

investigations are warranted to elucidate the relationship between periodontitis and antenatal depression.

Periodontitis, as a screenable, preventable, and intervenable chronic inflammatory disease, holds clinical significance regarding its potential association with antenatal depression. If such an association exists, periodontal health assessment in clinical practice could help identify pregnant women at high risk for psychological disorders, thereby providing a basis for comprehensive oral–mental health management and early intervention.

Accordingly, this study enrolled pregnant women in the second trimester and assessed the severity of periodontitis using the CDC–AAP classification criteria. Antenatal depression was evaluated using the Edinburgh Postnatal Depression Scale (EPDS) in combination with clinical diagnosis by psychiatrists. The study aimed to investigate the association between periodontitis severity and antenatal depression, and to further examine the potential dose–response relationship between them.

Materials and methods

Patient Selection

This cross-sectional clinical study was conducted from June to December 2025 at a tertiary care hospital in Changsha, Hunan Province, China. The study design and reporting followed the STROBE statement. The study was approved by the institutional ethics committee (Approval No. 20240721), and written informed consent was obtained from all participants.

A total of 426 pregnant women were enrolled in this study, all of whom were in the second trimester of pregnancy (14 weeks to 27 weeks and 6 days of gestation)[22]. Compared with the first trimester, which is characterized by pronounced early pregnancy symptoms[23,24] and a relatively higher risk of miscarriage, and the third trimester, during which physical limitations may hinder clinical examinations[25], the second trimester was considered the most appropriate period for conducting periodontal examinations and depression assessments. Therefore, all participants underwent periodontal examination and antenatal depression screening during the second trimester. Participants were excluded: 15 cases with missing periodontal examination data, 23 cases with incomplete antenatal depression assessment records, 8 cases with severe systemic diseases, 12 cases with a history of periodontal therapy before enrollment, and 11 cases with a pre-pregnancy diagnosis of depression or other psychiatric disorders. Ultimately, 357 participants were included in the final analysis (Fig. 1).

Periodontal assessment and periodontal case definition

A total of 357 participants underwent periodontal examinations. Two calibrated periodontists used a periodontal probe to measure clinical attachment loss (CAL) and probing depth (PD), recorded in millimeters (mm), at four sites per tooth for all natural teeth except third molars. Radiographic

examinations were not included in this study because pregnant women were concerned about the potential irreversible effects of X-ray exposure on the fetus.

Periodontitis severity was assessed according to the Centers for Disease Control and Prevention in partnership with the American Academy of Periodontology case definitions for surveillance of periodontitis (CDC–AAP classification). This classification system was based on CAL and PD measurements. Mild periodontitis was defined as the presence of ≥ 2 interproximal sites with CAL ≥ 3 mm, and ≥ 2 interproximal sites with PD ≥ 4 mm (not on the same tooth), or one site with PD ≥ 5 mm. Moderate periodontitis was defined as ≥ 2 interproximal sites with CAL ≥ 4 mm (not on the same tooth), or ≥ 2 interproximal sites with PD ≥ 5 mm (not on the same tooth). Severe periodontitis was defined as ≥ 2 interproximal sites with CAL ≥ 6 mm (not on the same tooth) and ≥ 1 interproximal site with PD ≥ 5 mm[26].

Among all participants, 175 were classified as non-periodontitis, 129 as mild periodontitis, 38 as moderate periodontitis, and 8 as severe periodontitis. Due to the limited number of participants with severe periodontitis, the moderate and severe periodontitis groups were combined into a moderate/severe periodontitis group for subsequent analyses to improve statistical power and reduce estimation bias[27]. In addition, two other calibrated periodontists independently repeated the periodontal examinations for all participants according to the CDC/AAP classification criteria to evaluate inter-examiner consistency and ensure the accuracy of periodontal classification.

Outcome variable

In this study, antenatal depression was assessed as the outcome variable. All 357 participants completed the Chinese version of the Edinburgh Postnatal Depression Scale (EPDS)[28]. Although originally developed as a screening tool for postpartum depression, the EPDS has also been widely used for the assessment of antenatal depression[29]. The Chinese version of the EPDS has demonstrated good reliability and validity and has been extensively applied in the Chinese population[30]. The scale consists of 10 self-reported items evaluating the participant's psychological status over the previous week. An EPDS total score ≥ 13 was considered indicative of possible depressive symptoms, scores of 10–12 were classified as borderline, and scores ≤ 9 indicated the absence of depressive symptoms[31,32].

Participants with EPDS scores ≥ 13, as well as those with borderline scores of 10–12, underwent further clinical evaluation by a psychiatrist according to the diagnostic criteria of the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5)[33], to confirm the diagnosis of antenatal depression. In addition, the diagnostic results were independently reviewed by another psychiatrist to improve diagnostic consistency and ensure diagnostic accuracy.

Covariates

In this study, multiple potential confounding factors that could influence the association between periodontitis and antenatal depression were considered. The analyzed variables included age (years), educational level (high school or below, bachelor degree or above), annual household income (≤ 100,000 RMB, 100,000–200,000 RMB, and ≥ 200,000 RMB), smoking status (yes/no), alcohol consumption status (yes/no), body mass index (BMI, kg/m²), tooth brushing frequency (≤ 1 time/day, 2 times/day, and ≥ 3 times/day), gestational age (weeks), and parity (primiparous /multiparous).

Tooth brushing frequency was included as an indicator of oral hygiene behavior to evaluate the potential influence of previous or underlying depressive status on reduced oral hygiene practices, which may subsequently increase the risk of periodontitis. Parity was included as an indicator to assess the potential impact of anxiety associated with first or subsequent pregnancies on the development of antenatal depression.

Cross-sectional analysis

Statistical analyses were performed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Categorical variables were expressed as frequencies and percentages, and comparisons between groups were conducted using the chi-square test. Continuous variables were presented as mean±standard deviation (SD), and between-group comparisons were performed using one-way analysis of variance (ANOVA).

Logistic regression models were used to evaluate the association between periodontitis and antenatal depression. Model 1 was the crude model without covariate adjustment. Model 2 was adjusted for age, educational level, and annual household income. Model 3 further adjusted for smoking status, alcohol consumption, and BMI based on Model 2. The fully adjusted model (Model 4) additionally included tooth brushing frequency, gestational age, and parity as covariates. Furthermore, subgroup analyses and interaction tests were performed.

Results were presented as odds ratio (OR) with 95% confidence interval (CI). All statistical tests were two-sided, and a P value < 0.05 was considered statistically significant.

Results

Characteristics of the study population in the clinical study

A total of 357 participants were included in this study and were categorized into non-periodontitis, mild periodontitis, and moderate/severe periodontitis groups according to periodontal status. Table 1 presents the characteristics of the study population. No significant differences were observed among the three groups with respect to annual household income, alcohol consumption, BMI, gestational age, or parity (P > 0.05). However, significant differences were found in age, educational level, smoking status, tooth brushing frequency, CAL, PD, and EPDS scores among the three groups (P < 0.001).

Table 1
Characteristics of the study population.

Characteristic	Periodontitis groups CDC/AAP classification			*P*-value
	No	Mild	Moderate/Severe	
	N = 182	N = 129	N = 46	
Age(Mean ± SD)	29.98 ± 3.932	30.88 ± 4.319	29.22 ± 3.927	0.035
Education level, n (%)				
High school or below	46 (25.3%)	73 (56.6%)	26 (56.5%)	< 0.001
Bachelor degree or above	136 (74.7%)	56 (43.4%)	20 (43.5%)	
Annual household income, n (%)				
≤ 100,000 RMB	103 (56.6%)	84 (65.1%)	29 (63.1%)	0.650
100,000-200,000 RMB	53 (29.1%)	30 (23.3%)	11 (23.9%)	
≥ 200,000 RMB	26 (14.3%)	15 (11.6%)	6 (13.0%)	
Smoking status, n (%)				
Non-smoker	166 (91.2%)	79 (61.2%)	28 (60.9%)	< 0.001
Smoker	16 (8.8%)	50 (38.8%)	18 (39.1%)	
Alcohol consumption, n (%)				
Non-drinker	145 (79.7%)	114 (88.4%)	37 (80.4%)	0.119
Drinker	37 (20.3%)	15 (11.6%)	9 (19.6%)	
BMI (Mean ± SD)	21.99 ± 2.434	22.22 ± 1.152	22.39 ± 1.159	0.347
Tooth brushing frequency, n (%)				
≤ 1 time/day	14 (7.7%)	29 (22.5%)	13 (28.3%)	< 0.001
2 times/day	131 (72.0%)	83 (64.3%)	30 (65.2%)	
≥ 3 times/day	37 (20.3%)	17 (13.2%)	3 (6.5%)	

Mean ± SD for continuous variables: the *P* value was analyzed via ANOVA; n (%) for categorical variables: the *P* value was analyzed via the chi-square test.

Abbreviation: BMI, body mass index; CAL: clinical attachment loss; PD, probing depth; EPDS, Edinburgh Postnatal Depression Scale.

Characteristic	Periodontitis groups CDC/AAP classification			*P*-value
	No	Mild	Moderate/Severe	
	N = 182	N = 129	N = 46	
Gestational age in weeks (Mean ± SD)	20.23 ± 4.061	20.11 ± 3.880	20.65 ± 3.790	0.726
Parity, n (%)				
Primiparous	130 (71.4%)	91 (70.5%)	34 (73.9%)	0.910
Multiparous	52 (28.6%)	38 (29.5%)	12 (26.1%)	
CAL (mm), Mean ± SD	0.99 ± 0.804	2.50 ± 0.502	4.70 ± 1.008	< 0.001
PD (mm), Mean ± SD	2.02 ± 0.750	4.53 ± 0.761	6.41 ± 1.066	< 0.001
EPDS total score (Mean ± SD)	7.18 ± 4.750	10.63 ± 6.738	13.50 ± 7.754	< 0.001
Antenatal depression, n (%)				
No	160 (87.9%)	93 (72.1%)	24 (52.2%)	< 0.001
Yes	22 (12.1%)	36 (27.9%)	22 (47.8%)	

Mean ± SD for continuous variables: the *P* value was analyzed via ANOVA; n (%) for categorical variables: the *P* value was analyzed via the chi-square test.

Abbreviation: BMI, body mass index; CAL: clinical attachment loss; PD, probing depth; EPDS, Edinburgh Postnatal Depression Scale.

Furthermore, the prevalence of antenatal depression was 12.1% in the non-periodontitis group, 27.9% in the mild periodontitis group, and 47.8% in the moderate/severe periodontitis group. The differences in the prevalence of antenatal depression among the three groups were statistically significant ($P < 0.001$).

Association between periodontitis and antenatal depression

Table 2 presents the results of logistic regression analyses assessing the association between periodontitis severity and antenatal depression. When periodontitis severity was analyzed as a categorical variable, the fully adjusted model (Model 4) showed that, compared with the non-periodontitis group, the odds of antenatal depression were significantly higher than groups with mild periodontitis (OR = 2.980, 95% CI: 1.473–6.029, $P = 0.002$) and moderate/severe periodontitis (OR = 3.377, 95% CI: 1.348–8.460, $P = 0.009$).

Table 2
Association of periodontitis with antenatal depression.

Exposure	Model 1	Model 2	Model 3	Model 4
	OR (95% CI)	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**
	***P* value**	***P* value**	***P* value**	***P* value**
Categorical variable				
No periodontitis	1.00	1.00	1.00	1.00
Mild periodontitis	2.815 (1.563–5.072)	2.744 (1.464–5.145)	2.677 (1.370–5.229)	2.980 (1.473–6.029)
	0.001	0.002	0.004	0.002
Moderate/Severe periodontitis	6.667 (3.212–13.838)	5.820 (2.700–12.543)	4.583 (1.967–10.680)	3.377 (1.348–8.460)
	< 0.001	< 0.001	< 0.001	0.009
P for trend	< 0.001	< 0.001	< 0.001	< 0.001
Ordinal variable				
Periodontitis	2.609(1.825–3.731)	2.576(1.771–3.748)	2.476(1.670–3.670)	2.496(1.651–3.772)
	< 0.001	< 0.001	< 0.001	< 0.001
In sensitivity analysis, periodontitis was converted from a categorical variable to an ordinal variable.				
Model 1 = No covariates were adjusted.				
Model 2 = Age, education level, and annual household income were adjusted.				
Model 3 = Age, education level, annual household income, smoking status, alcohol consumption, and BMI were adjusted.				
Model 4 = Age, education level, annual household income, smoking status, alcohol consumption, BMI, tooth brushing frequency, gestational age in weeks, and parity were adjusted.				
Abbreviation: OR, odds ratio; CI, confidence interval; BMI, body mass index.				

When periodontitis severity was further analyzed as an ordinal variable, a significant positive trend was observed across all models. In the fully adjusted model (Model 4), each one-level increase in periodontitis severity was associated with a 2.496-fold higher odds of antenatal depression (OR = 2.496, 95% CI: 1.651–3.772, $P < 0.001$). Similar associations were observed in Models 1–3, with ORs of 2.609 (95% CI: 1.825–3.731), 2.576 (95% CI: 1.771–3.748), and 2.476 (95% CI: 1.670–3.670), respectively (all $P < 0.001$).

Subgroup analysis in the clinical database

To further investigate the potential association between periodontitis severity and antenatal depression under different conditions, subgroup analyses were performed (Table 3). The interaction analyses showed that the association between periodontitis severity and antenatal depression remained consistent across subgroups stratified by education level, annual household income, alcohol consumption, and parity, with no significant interactions observed (P for interaction > 0.05). Notably, the association between periodontitis severity and antenatal depression appeared to vary according to smoking status and tooth brushing frequency (P for interaction < 0.05), suggesting that smoking status and tooth brushing frequency may influence the relationship between periodontitis severity and antenatal depression.

Table 3
Results of subgroup analysis and interaction analysis.

Subgroup	OR (95%CI)	*P*	*P* for interaction
Education level			0.066
High school or below	4.451(1.878–10.548)	0.001	
Bachelor degree or above	2.576(1.492–4.447)	0.001	
Annual household income			0.109
≤ 100,000 RMB	1.614(0.946–2.754)	0.079	
100,000-200,000 RMB	3.439(1.331–8.883)	0.011	
≥ 200,000 RMB	9.302(2.073–41.736)	0.004	
Smoking status			0.001
Non-smoker	2.403(1.510–3.824)	< 0.001	
Smoker	2.506(0.917–6.850)	0.073	
Alcohol consumption			0.929
Non-drinker	2.816(1.745–4.546)	< 0.001	
Drinker	1.608(0.571–4.529)	0.369	
Tooth brushing frequency			0.002
≤ 1 time/day	2.624(0.667–10.325)	0.167	
2 times/day	2.451(1.503–3.996)	< 0.001	
≥ 3 times/day	5.833(1.016–33.495)	0.048	
Parity			0.544
Nulliparous	2.688(1.658–4.360)	< 0.001	
Multiparous	2.456(0.915–6.592)	0.075	
Age, education level, annual household income, smoking status, alcohol consumption, BMI, tooth brushing frequency, gestational age in weeks, and parity were adjusted.			
In the subgroup analysis, the model is not adjusted for the stratification variable itself.			
Abbreviation: OR, odds ratio; CI, confidence interval.			

Discussion

This cross-sectional study conducted among pregnant women in China demonstrated a significant positive association and dose–response relationship between periodontitis severity and antenatal

depression. As the severity of periodontitis increases, the risk of antenatal depression shows a gradual upward trend. After adjustment for multiple sociodemographic, behavioral, and pregnancy-related factors, the positive association remained robust, with each one-level increase in periodontitis severity associated with 2.496-fold higher odds of antenatal depression. Subgroup analysis suggests that smoking status and tooth brushing frequency may modify the association between periodontitis and antenatal depression.

During pregnancy, fluctuations in estrogen and progesterone levels, together with alterations in periodontal microbiome and immune regulation, render periodontal tissues more susceptible to plaque-induced inflammation, thereby significantly increasing the risk of periodontitis[18]. However, current evidence regarding the association between periodontitis and antenatal depression remains limited. A prospective cohort study reported that seropositivity for IgG antibodies against the K1 serotype of Porphyromonas gingivalis (Pg) was significantly associated with moderate-to-severe depressive symptoms during pregnancy, accompanied by elevated IL-10 levels[34]. These findings suggest that specific periodontal pathogens and the immune-inflammatory responses they induce may contribute to the development and progression of antenatal depression. Nevertheless, as the study was primarily based on serological indicators, the precise biological mechanisms underlying the association between periodontitis and antenatal depression could not be fully elucidated, and further mechanistic investigations are therefore warranted.

Although research specifically examining the biological mechanisms underlying the association between periodontitis and antenatal depression remains limited. However, previous studies on the mechanisms between periodontitis and depression in general people, such as inflammatory responses, neuroimmune regulation, and neuroinflammation, may provide clues as to the association between periodontitis and antenatal depression. One study demonstrated that periodontitis may enhance monocyte/macrophage infiltration into brain tissue through CCL2-mediated systemic inflammatory responses, thereby impairing blood–brain barrier integrity and promoting anxiety-like behaviors[35]. Another study reported that periodontitis facilitates the entry of peripherally derived C-reactive protein (CRP) into the central nervous system, activating the CRP–BMP4 neuroinflammatory pathway, which subsequently impairs hippocampal neurogenesis and disrupts oligodendrocyte precursor cell function, ultimately inducing depression-like behaviors[36]. In addition, Pg and its virulence factor lipopolysaccharide (LPS) have been shown to affect the brain-derived neurotrophic factor (BDNF) signaling pathway, reduce neuronal activity, and contribute to the development of depressive disorders[37,38]. Nevertheless, whether the aforementioned mechanisms are equally applicable to pregnant women and whether the hormonal and immune environment specific to pregnancy alters the relevant inflammatory-neural pathways remains to be further investigated.

Subgroup analyses demonstrated significant interaction effects of smoking status and tooth brushing frequency on the association between periodontitis and antenatal depression. Smoking may exacerbate the severity of periodontitis and has also been associated with an increased risk of depressive

symptoms during pregnancy[39–42]; therefore, the association between periodontitis and antenatal depression may be more pronounced among pregnant smokers. In addition, oral hygiene behaviors may play a role in the relationship between periodontitis and antenatal depression. However, the subgroup analysis showed that participants who brushed their teeth ≥ 3 times/day exhibited a higher risk of depression than those who brushed ≤ 1 time/day or 2 times/day, accompanied by wide confidence intervals. This finding suggests the potential influence of limited sample size or reverse causality. Therefore, future large-scale prospective studies are warranted to further clarify the true relationship between them.

This study has several strengths. First, to our knowledge, this is the first cross-sectional study investigating the association between periodontitis during pregnancy and antenatal depression, with great clinical significance. Second, multiple confounding factors were incorporated into the statistical analyses, thereby enhancing the reliability and robustness of the findings. Nevertheless, several limitations should also be acknowledged. First, because of the cross-sectional design, causal relationships and reverse causality between periodontitis and antenatal depression could not be established. Therefore, multicenter longitudinal studies are warranted to validate these findings further. Second, inflammatory and microbiological biomarkers were not assessed in the present study. Future prospective studies incorporating these biomarkers are needed to further elucidate the potential mechanisms underlying the association between periodontitis and antenatal depression.

Conclusion

This study demonstrated a positive association between the severity of periodontitis during pregnancy and antenatal depression, with the risk of antenatal depression increasing progressively as periodontitis severity worsened. This association remained significant after adjustment for potential confounding factors, with each one-level increase associated with 2.496-fold higher odds of antenatal depression. However, given the cross-sectional design, these findings indicate an association rather than a causal relationship. As a screenable and modifiable condition, periodontitis may provide a practical opportunity for identifying pregnant women at higher risk of antenatal depression. Future multicenter longitudinal studies are warranted to determine causal relationships and elucidate the underlying biological mechanisms.

Declarations

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Author contributions

Feng-Yi Zhang and Lei Guo: Conceptualization, Supervision and Funding Acquisition. Qian Zhang: Methodology, Investigation and Formal Analysis. Jian-Nan Li: Investigation and Formal analysis. Yun-Zhi

Feng: Investigation and Visualization. All authors took part in drafting, revising, or critically reviewing the article; and gave final approval of the version to be published.

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Ethics approval

This study was approved by the hospital's ethics committee (Approval No: 20240721), and all participants provided informed consent before enrollment.

Competing interests

The authors declared no conflict interest.

Availability of data

Please contact the corresponding author for data requests.

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Figures

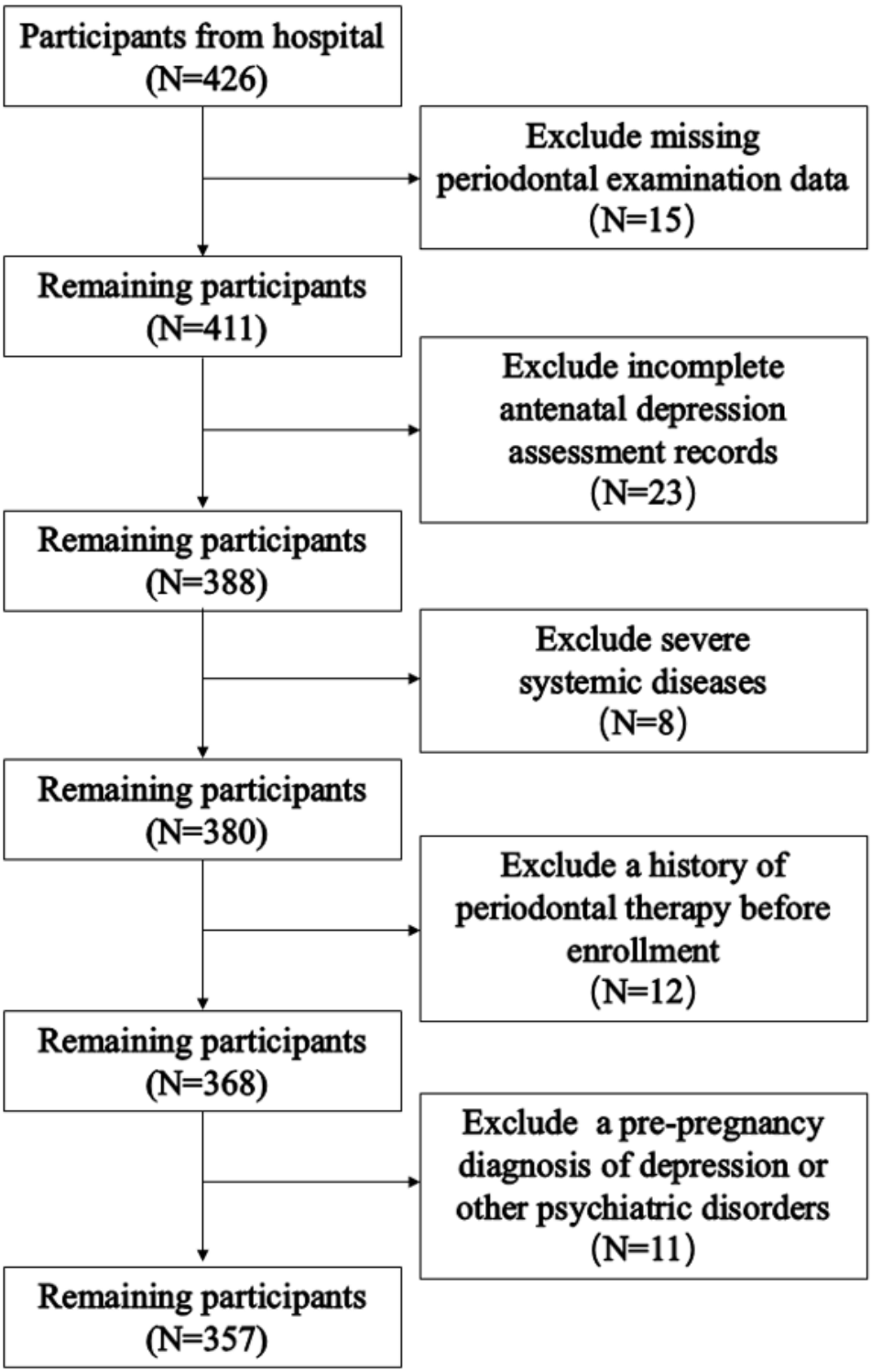


Figure 1

Flow chart of participants selection

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