



OPEN Psychosocial and behavioral factors linked to low oral health related quality of life in young Chinese temporomandibular disorder patients

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This cross-sectional study investigated the psychosocial and behavioral characteristics of young Chinese Temporomandibular Disorders (TMD) patients, relationships between pain intensity, depression, anxiety, oral behaviors, jaw function, and Oral Health-related Quality of Life (OHRQoL), as well as factors contributing to low OHRQoL. Youths aged 15 to 24 years were enrolled at a tertiary dental hospital. Participants were evaluated using the Diagnostic Criteria for TMDs Axis I protocol and Axis II measures, including the Patient Health Questionnaire-9, General Anxiety-7, Oral Behaviors Checklist, and Jaw Functional Limitation Scale-8. Pain intensity and OHRQoL were appraised with a visual analog scale (VAS) and the Oral Health Impact Profile for TMDs (OHIP-TMDs). Chi-square/non-parametric tests and logistic regression were employed for statistical analyses ($\alpha = 0.05$). Youths comprised 37.2% of all TMD patients seen during the study period. Of the 398 participants (75.9% female), 34.9%, 17.8%, and 47.2% were diagnosed with intra-articular (IT), pain-related (PT), and combined (CT) TMDs, respectively. Young adults (20–24 years) exhibited significantly greater depression, anxiety, sleeping-state oral activity, and lower OHRQoL ($p < 0.001$ – 0.007) compared to older adolescents (15–19 years). Significant differences were observed in pain intensity, depression, anxiety, waking-state non-functional activity, jaw functional limitation, and OHRQoL ($p < 0.001$ – 0.035) among individuals with IT, PT, and CT. OHRQoL was moderately correlated with depression, anxiety, and jaw functional limitation ($r_s = 0.53$ – 0.61). In young Chinese TMD patients, low OHRQoL was significantly associated with anxiety, pain intensity, age, jaw function, and jaw overuse behavior.

Keywords Adolescent, Jaw function, Oral behaviors, Psychological, Quality of life, Temporomandibular disorders, Young adult

Abbreviations

CT	Combined TMDs
DC/TMD	Diagnostic criteria for TMDs
GAD-7	General Anxiety Disorder-7
IT	Intra-articular TMDs
JFLS-8	Jaw Functional Limitation Scale-8
OA	Older Adolescents
OBC	Oral Behaviors Checklist
OHIP-TMDs	Oral Health Impact for TMDs

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PHQ-9	Patient Health Questionnaire-9
PT	Pain-related TMDs
SA	Sleeping-state Oral Activities
TMD/TMDs	Temporomandibular Disorder/s
WF	Waking-state Functional Oral Activities
WN	Waking-state Non-functional Oral Activities
YA	Young Adults

Background

Temporomandibular disorders (TMDs) are a cluster of medical and dental diseases characterized by pain and/or impaired function of the masticatory system¹. Based on the Diagnostic Criteria for TMDs (DC/TMD), the main symptoms of TMDs include pain in the temporomandibular joints (TMJs) and masticatory muscles, headaches, TMJ noises, and episodes of TMJ closed and open locking. Correspondingly, common TMDs can be classified into pain-related conditions (mainly TMJ arthralgia, masticatory muscle myalgia, and headache attributed to TMDs) and intra-articular conditions (primarily TMJ disc displacements, degenerative joint disease, and subluxation)². TMD symptoms tend to be more pronounced during adolescence and young adulthood, reaching their peak in middle age. They are less common in children and older adults^{3,4}. The prevalence of TMDs in East Asian populations, including China, Japan, and Korea, is around 17% in adults and 18% in adolescents⁵. However, on a global scale, the prevalence of TMDs is approximately 34% in adults and can reach up to 60% in adolescents^{6,7}. The multifaceted biopsychosocial factors implicated in TMDs include genetics, age, gender, trauma, oral behaviors, psychological distress, and somatic symptoms^{8,9}. TMDs, particularly when chronic and painful, have been shown to negatively impact patients' oral health-related quality of life (OHRQoL)^{10–12}. Conversely, therapeutic interventions for TMDs can improve patients' OHRQoL¹³.

OHRQoL is a multidimensional construct that encompasses the functional, physical, and psychosocial aspects of well-being in relation to oral health, as well as oral diseases and disorders^{14,15}. Although OHRQoL measures can be either generic or condition-specific, research on TMDs has predominantly utilized generic measures, with the Oral Health Impact Profile (OHIP) being the most widely adopted^{10,16,17}. While generic measures have broad applicability and enable comparisons across different populations, conditions, and interventions, they are not designed to address symptoms and impacts unique to specific oral diseases and disorders. Consequently, they often exhibit higher “floor effects”, where some surveyed items may not be relevant or commonly experienced, resulting in little to no reported impact^{14,15}. The OHIP for TMDs (OHIP-TMDs) was developed to fulfill the need for a TMD-specific OHRQoL measure^{18,19}. It has been translated and validated for use among Chinese patients suffering from TMDs²⁰. Additionally, the discriminative ability of the OHIP-TMDs has been confirmed in youths¹⁵.

A recent large-scale study indicated that youths or young people, defined by the United Nations as those aged 15 to 24 years, constituted 27% of TMD patients^{21,22}. However, there is limited knowledge about the OHRQoL in young TMD patients and the factors that affect it, as previous studies have largely centered on adult TMD populations^{10–12}. To date, the majority of research on OHRQoL among youths with TMDs usually involved non-patient community samples^{23–25}. These studies suggest that TMDs could be linked to psychological distress, oral behaviors, and impaired OHRQoL. Clarifying these relationships, as well as jaw function in young TMD patients, is warranted because interactions may differ from non-patient samples.

Building upon the aforementioned, the objectives of this study were to compare the psychosocial and behavioral characteristics between older adolescents and young adults, as well as among different TMD subtypes in young patients. The interrelationships among pain intensity, depression, anxiety, oral behaviors, jaw functional limitation, and OHRQoL were explored, alongside factors associated with low OHRQoL. The research hypotheses were as follows: (a) older adolescent and young adult TMD patients, as well as different TMD subtypes, display significant variations in their psychosocial and behavioral characteristics; (b) depression and anxiety exhibit a strong correlation with each other and are moderately related to pain intensity, oral behaviors, jaw function, and OHRQoL; and (c) low OHRQoL is associated with pain intensity, psychological distress, jaw overuse behavior, and jaw functional limitation in young TMD patients.

Methods

Study population

Ethics approval for this observational study was granted by the Institutional Review Board of the West China Hospital of Stomatology at Sichuan University (WCHSIRB-D-2022-212). The study adhered to the Declaration of Helsinki and was conducted in compliance with all relevant guidelines and regulations. To achieve a statistical power of 95% at a significance level of 0.05, applied in all primary analyses, a minimum sample size of 102 participants across three comparison groups was determined using G*Power (Version 3.1.9.3) and an analysis of variance model²⁶. This calculation was based on a large effect size (0.40) for OHRQoL among TMD subtypes²⁷. From January 2022 to May 2024, participants were enrolled from consecutive first-visit adolescents and young adults seeking treatment for TMDs at the West China Hospital of Stomatology. The inclusion criteria comprised individuals aged 15 to 24 years, fluency in Chinese, presence of TMD signs/symptoms, and availability of DC/TMD Axis I and II data. Exclusion criteria included a history of TMJ trauma or surgery, recent use (within the last 3 months) of central nervous system medications or analgesics, and the presence of other orofacial pain conditions such as odontogenic pain and neuralgia, severe psychiatric disorders, debilitating systemic diseases like cancer and rheumatoid arthritis, as well as cognitive impairment. Eligible patients received detailed information about the study, and if they were under 18 years old, their custodians were also briefed. Informed

consent was then obtained from either the patients or their custodians. Following this, participants completed a comprehensive survey that encompassed socio-demographic data and the Patient Health Questionnaire-9 (PHQ-9), Generalized Anxiety Disorder-7 (GAD-7), Oral Behaviors Checklist (OBC), Jaw Functional Limitation Scale-8 (JFLS-8), and the OHIP-TMDs [2, 20, 28–31]. Except for the OHIP-TMDs, all other measures were part of the DC/TMD Axis II psychosocial and behavioral assessment tools.

TMD diagnosis and participant categorization

Participants underwent a clinical examination conducted by three examiners, including a principal evaluator. The secondary examiners were trained and calibrated by the principal evaluator, who had received formal instruction in the DC/TMD methodology. Inter-examiner Cohen's kappa values ranged from 0.706 to 0.842, ensuring consistency in assessments. The examination included assessing pain locations, pain on palpation, TMJ sounds, jaw deviations, and range of jaw movements. Additionally, participants were asked to rate their current pain using a visual analog scale (VAS) where 0 = “no pain” and 10 = “most intense pain”. When significant structural pathologies were suspected, such as advanced TMJ degenerative joint disease, persistent disc displacement without reduction, or tumors, cone-beam computed tomography (CBCT) and/or magnetic resonance imaging (MRI) were performed. TMD diagnoses were founded on patient-reported symptoms, clinician-determined signs, and supplementary diagnostic imaging, utilizing the DC/TMD diagnostic algorithms². Participants were subsequently classified by age into older adolescents (OA: 15 to 19 years) and young adults (YA: 20 to 24 years)¹. They were also categorized into three TMD subtypes following the stratified reporting framework for the DC/TMD: intra-articular (IT), pain-related (PT), and combined (CT) TMDs^{1,28}. The CT subtype involves the concurrent presence of both IT and PT conditions, such as TMJ disc displacements and degenerative joint disease, along with TMJ arthralgia and masticatory muscle myalgia. While IT alone is non-painful, both PT and CT are considered painful TMDs.

Study measures

Psychological distress

Symptoms of depression and anxiety were assessed using the 9-item PHQ-9 and 7-item GAD-7, respectively^{29,30}. Both measures have demonstrated good psychometric properties in Chinese adolescents and was utilized in China's National Youth Cohort study³¹. A 4-point rating scale was used to evaluate items, ranging from 0 = “not at all” to 3 = “nearly every day.” Total sum scores were computed with higher scores indicating greater symptom severity. Depression was classified into four categories: mild (≥ 5 points), moderate (≥ 10 points), moderately severe (≥ 15 points), and severe (≥ 20 points). In contrast, anxiety was classified into three categories: mild (≥ 5 points), moderate (≥ 10 points), and severe (≥ 15 points).

Oral behaviors

Oral activities during sleep and wakefulness were assessed with the 21-item OBC³². A 5-point rating scale was used to evaluate items, ranging from 0 = “none of the time” to 4 = “4–7 nights per week” or “all of the time”. Total OBC scores, reflecting “jaw overuse behavior”, were computed and classified into three categories: normal (0 to 16 points), low (17 to 24 points), and high (25 to 84 points)³³. The OBC was also divided into three subscales: sleeping-state (SA), waking-state non-functional (WN), and waking-state functional (WF) oral activities³⁴. SA subscale scores were calculated by summing the scores of item 1 (clenching or grinding teeth while asleep) and item 2 (sleeping in a position that puts pressure on the jaw), then multiplying this total by three to align it with the WN and WF subscales. WN subscale scores were calculated by summing items 3 (grinding teeth), 4 (clenching teeth), 5 (pressing, touching, or holding teeth together other than while eating), 6 (holding, tightening, or tensing muscles without clenching or bringing teeth together), 7 (holding or jutting jaw forward or to the side), and 11 (holding jaw in rigid or tense position). Similarly, WF subscale scores, involving normal jaw functioning, were calculated by summing items 12 (biting or holding objects between the teeth), 13 (chewing gum), 17 (eating between meals), 18 (sustained talking), 19 (singing), and 20 (yawning)³⁴. Greater SA, WN, and WF subscale scores indicate elevated levels of oral activities occurring during sleep and wakefulness.

Jaw function

The functional status of the jaws was assessed using the 8-item JFLS-8³⁵. A numerical rating scale was used to evaluate items, range from 0 = “no limitation” to 10 = “extreme limitation”. Total JFLS-8 scores were computed, with higher scores indicating greater levels of “jaw function disability”³⁶.

OHRQoL

OHRQoL was assessed with the 22-item OHIP-TMDs, which comprised seven domains: functional limitation, physical pain, psychological discomfort, physical disability, psychological disability, social disability, and handicap^{18,19}. A 5-point rating scale was used to evaluate the items, ranging from 0 = “never” to 4 = “very often”. Total and domain-specific OHIP scores were computed by summing all 22 items and the designated items within each domain, accordingly. Greater OHIP scores indicated an impaired or lower OHRQoL.

Statistical analyses

The R statistical software (version 4.2.2, R Foundation for Statistical Computing, Vienna, Austria) was used for statistical assessments. Qualitative data were presented as frequencies and percentages and analyzed using the Chi-square test with Benjamini-Hochberg adjustment. Quantitative data were presented using means and standard deviations (SDs), as well as medians and interquartile ranges (IQRs). To evaluate data normality, the Shapiro-Wilk test was conducted, and results indicated that quantitative data did not follow a normal distribution. Consequently, non-parametric tests including the Kruskal-Wallis and Mann-Whitney U tests, post-

hoc Dunn test with Benjamini-Hochberg adjustment, and Spearman's rank-order correlation were employed. Correlation coefficients (r_s) among variables were classified into four categories: weak (≥ 0.1), moderate (≥ 0.4), strong (≥ 0.7), or very strong (≥ 0.9). OHRQoL was dichotomized into high and low groups using the split-median technique, based on the median total OHIP score of 30 points. As there are no universally accepted thresholds for low OHRQoL, this data-driven approach ensures balanced group distribution while maintaining statistical validity³⁷. The biopsychosocial and behavioral factors associated with low OHRQoL was established with univariate and multivariate logistic regression analyses. A stepwise variable selection procedure was applied with a significance threshold of $p < 0.10$ to exclude factors that were not statistically significant. Findings were presented as odds ratios (ORs) with corresponding 95% confidence intervals (95% CI).

Results

Youths constituted 37.2% (418/1123) of all TMD patients treated during the study period. Of the 418 young patients who met the inclusion criteria, 11 were excluded due to prior TMJ trauma or surgery, and 9 due to recent use of analgesics. The final study sample consisted of 398 individuals, predominantly female (75.9%), with a mean age of 20.0 years (SD 2.8). Among these, 34.9% were diagnosed with IT, 17.8% with PT, and 47.2% with CT. Table 1 presents the mean/median pain intensity, depression, anxiety, oral behaviors, jaw functional limitation, and OHRQoL scores for the older adolescent (OA) and young adult (YA) groups. Significant differences in depression, anxiety, sleeping-state oral activity, and OHRQoL (specifically in the psychological discomfort, psychological disability, and handicap domains) were observed (YA > OA).

Table 2 presents the mean/median scores for the various variables across TMD subtypes. Substantial differences in pain intensity, depression, anxiety, waking-state non-functional oral activity, jaw functional limitation, and OHRQoL (all domains) were discerned between individuals with painful and non-painful TMDs (CT, PT > IT). Furthermore, the CT group had substantially greater jaw overuse behavior (total OBC) and waking-state functional oral activity than the IT group (CT > IT).

Table 3 presents the correlation coefficients among various variables for all participants, as well as for older adolescents and young adults. For all participants, OHRQoL showed moderate associations with depression, anxiety, and jaw functional limitation ($r_s = 0.53$ – 0.61), while depression and anxiety exhibited strong correlations ($r_s = 0.79$). In the OA group, moderate correlations were found between OHRQoL and pain intensity, depression, anxiety, jaw overuse behavior, and jaw functional limitation ($r_s = 0.40$ – 0.55). Additionally, there was a moderate relationship between jaw overuse behavior and depression, as well as jaw functional limitations ($r_s = 0.46/0.40$). In the YA group, OHRQoL was moderately correlated with the same variables as in older adolescents, except for jaw overuse behavior ($r_s = 0.42$ – 0.66).

Table 4 presents the outcomes of the univariate and multivariate logistic regression analyses. The univariate model revealed that low OHRQoL was significantly associated with age, sex, TMD subtypes, and various psychosocial and behavioral variables. However, the multivariate model indicated that only age (OR = 1.11; 95% CI = 1.02–1.22), pain intensity (OR = 1.19; 95% CI = 1.01–1.41), anxiety (OR = 1.24; 95% CI = 1.12–1.39), jaw overuse behavior (OR = 1.04; 95% CI = 1.00–1.08), and jaw functional limitation (OR = 1.08; 95% CI = 1.05–1.11) increased the odds of low OHRQoL.

Discussion

This study is among the first to investigate the psychosocial and behavioral characteristics of young East Asian/Chinese TMD patients. It compared these aspects between older adolescents and young adults and across different TMD subtypes. Additionally, the study examined the interrelationships between depression, anxiety, oral behaviors, jaw functional limitation, and OHRQoL, as well as factors associated with low OHRQoL. The first and third hypotheses were confirmed, as significant differences in psychological distress, oral behaviors, jaw functional limitation, and OHRQoL were found between age groups and TMD subtypes, with specific psychosocial and behavioral factors related to the odds of low OHRQoL. Given that depression and anxiety exhibited strong correlations but only moderate associations with OHRQoL in both older adolescents and young adults, the second hypothesis was partially supported. Besides focusing on youths, older adolescents were also identified for the study because of the low frequency of younger adolescents (aged 10 to 14 years) presenting for TMD treatment³. The DC/TMD was used to evaluate older adolescents and young adults, taking growth and development into account. This included a -4 mm allowance for maximum mouth opening when necessary, though the adjustment was ultimately not required. While the DC/TMD for children and adolescents (ca-DC/TMD) and its distinct Axis II measures may be more suitable for assessing adolescent patients, it has not yet been translated into Chinese or validated in Chinese children and adolescents¹. Additionally, to ensure equitable comparisons, the same Axis II measures must be used for both older adolescents and young adults. Moreover, the PHQ-9 and GAD-7 are recognized as reliable and valid instruments for evaluating depressive and anxiety symptoms among Chinese adolescents^{31,38,39}. These tools are employed in the Youth Cohort Study of China, which includes 22,868 participants, thereby addressing concerns about older adolescents' cognitive capacity to comprehend and accurately report psychological and related measures³¹.

Comparison between older adolescents and young adults

Older adolescents and young adults made up around 37% of all TMD patients, highlighting considerable treatment needs for TMDs among youths, as reported in other East Asian samples⁴. As with adult TMD populations, the majority of young TMD patients (76%) were female^{22,28}. The gender disparity in TMDs has been linked to hormonal and socio-cultural factors, as well as variations in psychological distress, pain sensitivity, and treatment-seeking behaviors²⁸. Young adults had significantly higher levels of depression and anxiety, more sleeping-state oral activity, and poorer OHRQoL, particularly in the psychological discomfort,

Variables		All young TMD patients	Older adolescent (OA)	Young adult (YA)	P-value
Total, n (%)		398 (100)	158 (39.70)	240 (60.30)	
Age	Mean (SD)	20.01 (2.82)	16.99 (1.41)	22.00 (1.38)	<0.001
	Median (IQR)	20.00 (4.00)	17.00 (2.00)	22.00 (2.00)	
Sex	Male, n (%)	96 (24.12)	52 (32.91)	44 (18.33)	0.001*
	Female, n (%)	302 (75.88)	106 (67.09)	196 (81.67)	
TMD subtypes	Intra-articular, n (%)	139 (34.92)	56 (35.44)	83 (34.58)	0.985*
	Pain-related, n (%)	71 (17.84)	28 (17.72)	43 (17.92)	
	Combined, n (%)	188 (47.24)	74 (46.84)	114 (47.50)	
Pain intensity (VAS)	Mean (SD)	1.63 (1.85)	1.73 (1.81)	1.56 (1.88)	0.230
	Median (IQR)	1.00 (3.00)	1.50 (3.00)	1.00 (3.00)	
Depression (PHQ-9)	Mean (SD)	5.00 (4.87)	4.35 (4.73)	5.42 (4.93)	0.007
	Median (IQR)	4.00 (7.00)	3.00 (7.75)	4.00 (7.00)	
Anxiety (GAD-7)	Mean (SD)	4.38 (4.40)	3.48 (3.84)	4.97 (4.64)	<0.001
	Median (IQR)	3.00 (6.00)	2.00 (6.00)	4.00 (6.00)	
Jaw overuse behavior (Total OBC)	Mean (SD)	26.89 (8.29)	26.27 (8.25)	27.30 (8.30)	0.159
	Median (IQR)	27.00 (11.00)	25.00 (11.75)	27.50 (10.00)	
Sleepin-state (SA)	Mean (SD)	13.21 (5.67)	12.13 (5.39)	13.93 (5.75)	0.001
	Median (IQR)	12.00 (9.00)	12.00 (6.00)	12.00 (6.00)	
Waking-state non-functional (WN)	Mean (SD)	7.00 (3.78)	6.89 (3.87)	7.07 (3.73)	0.540
	Median (IQR)	7.00 (5.00)	7.00 (5.00)	7.00 (6.00)	
Waking-state functional (WF)	Mean (SD)	8.57 (3.01)	8.68 (3.09)	8.49 (2.96)	0.564
	Median (IQR)	8.00 (5.00)	9.00 (4.00)	8.00 (5.00)	
Jaw functional limitation (JFLS-8)	Mean (SD)	14.31 (10.20)	13.84 (9.40)	14.62 (10.71)	0.692
	Median (IQR)	13.00 (15.00)	13.00 (14.00)	13.00 (16.00)	
Overall OHRQoL (Total OHIP)	Mean (SD)	30.62 (15.95)	27.75 (14.35)	32.51 (16.67)	0.006
	Median (IQR)	30.00 (22.75)	27.00 (21.75)	32.00 (24.00)	
Functional limitation	Mean (SD)	3.67 (1.94)	3.77 (1.83)	3.60 (2.01)	0.301
	Median (IQR)	4.00 (3.00)	4.00 (2.00)	4.00 (3.00)	
Physical pain	Mean (SD)	6.17 (3.74)	6.11 (3.72)	6.20 (3.76)	0.882
	Median (IQR)	6.00 (6.00)	6.00 (6.00)	6.00 (6.00)	
Psychological discomfort	Mean (SD)	7.80 (4.08)	6.70 (3.77)	8.53 (4.12)	<0.001
	Median (IQR)	8.00 (5.75)	7.00 (5.00)	8.00 (6.00)	
Physical disability	Mean (SD)	2.99 (1.94)	2.80 (1.82)	3.12 (2.00)	0.186
	Median (IQR)	3.00 (2.00)	3.00 (2.00)	3.00 (2.00)	
Psychological disability	Mean (SD)	6.36 (4.63)	5.28 (4.04)	7.07 (4.87)	<0.001
	Median (IQR)	6.00 (6.75)	5.00 (6.00)	7.00 (8.00)	
Social disability	Mean (SD)	1.48 (1.62)	1.32 (1.56)	1.59 (1.65)	0.080
	Median (IQR)	1.00 (2.00)	1.00 (2.00)	1.00 (3.00)	
Handicap	Mean (SD)	2.14 (1.95)	1.77 (1.76)	2.38 (2.03)	0.003
	Median (IQR)	2.00 (3.00)	2.00 (3.00)	2.00 (3.00)	

Table 1. Characteristics of the older adolescent (15–19 years old) and young adult (20–24 years old) groups. SD: Standard Deviation; IQR: Interquartile Range; VAS: Visual Analog Scale; PHQ-9: Patient Health Questionnaire-9; GAD-7: General Anxiety Disorder-7; OBC: Oral Behaviors Checklist; JFLS-8: Jaw Functional Limitations Scale-8; OHIP: Oral Health Impact Profile for TMDs. Results of Chi-square* and Mann-Whitney U tests. Bold indicates $p < 0.05$.

psychological disability, and handicap domains, compared to older adolescents. Young or emerging adulthood represents a crucial period for mental health and well-being⁴⁰. It is marked by age-related experiential changes, including significant alterations in social roles, relationships, and responsibilities that are connected to the onset of depression and anxiety^{40,41}. Both depression and anxiety have been associated with TMDs, increased oral behaviors, and reduced OHRQoL^{5,8,9}. Higher levels of depression and/or anxiety may account for the significantly greater impact on the psychological and handicap domains of OHRQoL.

Comparison across TMD subtypes

Among the young TMD patients, 34.9% had IT, 17.8% had PT, and 47.2% had CT, with no significant differences in the prevalence of TMD subtypes between the older adolescent and young adult groups. This distribution differed somewhat from that of other East Asian young TMD samples (IT 48.1%, PT 6.2%, and CT 45.7%),

Variables		Intra-articular TMD (IT)	Pain-related TMD (PT)	Combined TMD (CT)	P-value Post-hoc
Total, n (%)		139 (34.92)	71 (17.84)	188 (47.24)	
Age	Mean (SD)	20.01 (2.51)	20.21 (2.86)	19.93 (3.03)	0.744
	Median (IQR)	20.00 (4.00)	21.00 (5.00)	20.00 (6.00)	
Age group	Adolescents, n (%)	56 (40.29)	28 (39.44)	74 (39.36)	0.985*
	Young adults, n (%)	83 (59.71)	43 (60.56)	114 (60.64)	
Sex	Male, n (%)	43 (30.94)	19 (26.76)	34 (18.09)	0.023*
	Female, n (%)	96 (69.06)	52 (73.24)	154 (81.91)	CT > IT
Pain intensity	Mean (SD)	0.52 (1.32)	2.13 (1.88)	2.26 (1.81)	<0.001
(VAS)	Median (IQR)	0.00 (0.00)	2.00 (2.00)	2.00 (2.00)	CT, PT > IT
Depression (PHQ-9)	Mean (SD)	3.85 (4.73)	5.92 (5.63)	5.50 (4.52)	<0.001
	Median (IQR)	3.00 (5.00)	5.00 (8.00)	5.00 (8.00)	CT, PT > IT
Anxiety (GAD-7)	Mean (SD)	3.22 (4.12)	5.08 (4.85)	4.97 (4.26)	<0.001
	Median (IQR)	2.00 (5.00)	4.00 (6.50)	4.00 (6.00)	CT, PT > IT
Jaw overuse behavior	Mean (SD)	25.51 (9.04)	27.34 (7.60)	27.75 (7.86)	0.035
(Total OBC)	Median (IQR)	25.00 (11.50)	26.00 (12.00)	28.00 (10.00)	CT > IT
Sleepin-state (SA)	Mean (SD)	12.67 (5.88)	12.93 (5.84)	13.72 (5.44)	0.455
	Median (IQR)	12.00 (9.00)	12.00 (7.50)	12.00 (9.00)	
Waking-state	Mean (SD)	6.33 (4.02)	7.72 (3.68)	7.22 (3.58)	0.007
non-functional (WN)	Median (IQR)	6.00 (6.00)	7.00 (5.00)	7.00 (4.00)	CT, PT > IT
Waking-state	Mean (SD)	8.13 (3.16)	8.38 (2.91)	8.96 (2.90)	0.023
functional (WF)	Median (IQR)	8.00 (4.00)	8.00 (4.00)	9.00 (4.00)	CT > IT
Jaw functional limitation	Mean (SD)	10.33 (9.65)	14.41 (9.48)	17.21 (9.92)	<0.001
(JFLS-8)	Median (IQR)	8.00 (13.00)	13.00 (15.00)	16.00 (14.00)	CT, PT > IT
Overall OHRQoL	Mean (SD)	23.00 (14.32)	35.03 (16.74)	34.59 (14.74)	<0.001
(Total OHIP)	Median (IQR)	22.00 (21.00)	33.00 (23.50)	34.00 (20.00)	CT, PT > IT
Functional limitation	Mean (SD)	2.91 (2.01)	3.66 (1.68)	4.23 (1.78)	<0.001
	Median (IQR)	3.00 (3.00)	4.00 (2.00)	4.00 (2.00)	CT > PT > IT
Physical pain	Mean (SD)	3.77 (3.17)	7.94 (3.32)	7.27 (3.38)	<0.001
	Median (IQR)	3.00 (5.00)	8.00 (4.00)	7.00 (4.00)	CT, PT > IT
Psychological	Mean (SD)	6.58 (3.97)	8.23 (4.23)	8.55 (3.91)	<0.001
discomfort	Median (IQR)	7.00 (6.00)	8.00 (6.00)	8.00 (5.00)	CT, PT > IT
Physical disability	Mean (SD)	2.24 (1.75)	3.28 (2.02)	3.45 (1.88)	<0.001
	Median (IQR)	2.00 (3.00)	3.00 (3.00)	3.00 (3.00)	CT, PT > IT
Psychological disability	Mean (SD)	5.05 (4.15)	7.15 (5.18)	7.03 (4.57)	<0.001
	Median (IQR)	5.00 (7.00)	6.00 (7.50)	7.00 (7.00)	CT, PT > IT
Social disability	Mean (SD)	0.98 (1.42)	1.96 (1.71)	1.68 (1.64)	<0.001
	Median (IQR)	0.00 (2.00)	2.00 (3.00)	2.00 (3.00)	CT, PT > IT
Handicap	Mean (SD)	1.48 (1.77)	2.80 (2.09)	2.38 (1.89)	<0.001
	Median (IQR)	1.00 (2.00)	3.00 (3.00)	2.00 (3.00)	CT, PT > IT

Table 2. Characteristics of participants with intra-articular, pain-related, and combined TMD conditions. SD: Standard Deviation; IQR: Interquartile Range; VAS: Visual Analog Scale; PHQ-9: Patient Health Questionnaire-9; GAD-7: General Anxiety Disorder-7; OBC: Oral Behaviors Checklist; JFLS-8: Jaw Functional Limitations Scale-8; OHIP: Oral Health Impact Profile for TMDs. Results of Chi-square test* and Kruskal-Wallis/post-hoc Dunn's test with Benjamini-Hochberg adjustment. Bold indicates $p < 0.05$.

suggesting possible ethnic and regional variations²². Individuals with CT and PT, which involved TMD pain, showed significantly higher pain intensity, depression, anxiety, more waking-state non-functional oral activity, greater jaw functional limitations, and poorer OHRQoL than those with IT conditions that were non-painful. Additionally, the CT group exhibited significantly greater jaw overuse behavior and more waking-state functional oral activity compared to the IT group. Depression and anxiety levels were mostly mild in the CT and PT groups, which also displayed high levels of jaw overuse behavior.

Findings corroborated those from previous adult TMD studies, where variables were seldom examined concurrently, demonstrating the association of painful TMDs with psychological distress, oral behaviors, jaw functional limitations, and impaired OHRQoL^{12,17,42–44}. The intricate interactions among these factors, as well as others such as somatic symptoms and sleep, remain unclear but could be linked to central sensitization (heightened responsiveness of the central nervous system to nociceptive and sensory stimuli)⁴⁵.

Groups	Variables	PI	PHQ-9	GAD-7	Total OBC	JFLS-8
All participants	PI	–				
	PHQ-9	0.22***	–			
	GAD-7	0.21***	0.79***	–		
	Total OBC	0.14**	0.35***	0.29***	–	
	JFLS-8	0.35***	0.30***	0.33***	0.24***	–
	Total OHIP	0.39***	0.54***	0.61***	0.35***	0.53***
Older adolescent (OA)	PI	–				
	PHQ-9	0.21**	–			
	GAD-7	0.21**	0.80***	–		
	Total OBC	0.21**	0.46***	0.39***	–	
	JFLS-8	0.39***	0.31***	0.32***	0.40***	–
	Total OHIP	0.40***	0.51***	0.54***	0.48***	0.55***
Young adult (YA)	PI	–				
	PHQ-9	0.23***	–			
	GAD-7	0.23***	0.77***	–		
	Total OBC	0.11	0.26***	0.19**	–	
	JFLS-8	0.32***	0.30***	0.35***	0.14*	–
	Total OHIP	0.42***	0.56***	0.66***	0.27***	0.53***

Table 3. Correlations among the various variables for all participants, older adolescent, and young adult TMD patients. PI: Pain intensity; PHQ-9: Patient Health Questionnaire-9 (depression); GAD-7: General Anxiety Disorder-7 (anxiety); WI-8: Whiteley Index-8 (health anxiety); OBC: Oral Behaviors Checklist (jaw overuse behavior); JFLS-8: Jaw Functional Limitation-8 (jaw functional limitation); OHIP: Oral Health Impact Profile for TMDs (OHRQoL). Results of Spearman's correlation with Benjamini-Hochberg adjustment. *indicates $p < 0.05$, ** indicates $p < 0.01$, *** indicates $p < 0.001$, and bold indicates correlation coefficient > 0.4 .

Variables	Univariate		Multivariate	
	Odds ratio (95% CI)	P-value*	Odds ratio (95% CI)	P-value^
Age	1.13 (1.06, 1.22)	0.001	1.11 (1.02, 1.22)	0.024
Sex				
Male	Reference		Reference	
Female	1.81 (1.14, 2.91)	0.013	1.03 (0.56, 1.90)	0.921
TMD subtype				
Intra-articular	Reference		Reference	
Pain-related	3.13 (1.74, 5.71)	<0.001	1.71 (0.80, 3.66)	0.166
Combined	3.48 (2.20, 5.56)	<0.001	1.51 (0.81, 2.80)	0.197
Pain intensity (VAS)	1.46 (1.29, 1.67)	<0.001	1.19 (1.01, 1.41)	0.037
Depression (PHQ-9)	1.25 (1.18, 1.32)	<0.001	1.02 (0.94, 1.12)	0.611
Anxiety (GAD-7)	1.36 (1.27, 1.47)	<0.001	1.24 (1.12, 1.39)	<0.001
Jaw overuse behavior (Total OBC)	1.08 (1.05, 1.11)	<0.001	1.04 (1.00, 1.08)	0.030
Jaw functional limitation (JFLS-8)	1.11 (1.08, 1.14)	<0.001	1.08 (1.05, 1.11)	<0.001

Table 4. Factors associated with low ohrqol. VAS: Visual Analog Scale; PHQ-9: Patient Health Questionnaire-9; GAD-7: General Anxiety Disorder-7; OBC: Oral Behaviors Checklist; JFLS-8: Jaw Functional Limitations Scale-8. Results of univariate* and multivariate^ logistic regression analyses. Bold indicates $p < 0.05$.

The impact of TMDs on OHRQoL may vary between young and older patients, as the young patients in this study exhibited lower overall OHRQoL scores when contrasted with mature TMD patients⁴. With higher scores in psychological discomfort and disability domains observed in both young and mature patients, psychological factors may play a more central role in the OHRQoL of TMD sufferers^{4,10}. Besides age-related experiential changes, the prevalence and severity of psychological distress tend to increase with age due to physical and cognitive changes contributing partly to the poorer OHRQoL in mature TMD patients⁴⁶.

Correlation and regression analyses

Even though depression and anxiety are distinct emotional states, their comorbidity is well-recognized¹⁷. Potential explanations for the high comorbidity and strong correlation observed include limitations in the

discriminative ability of existing measures, shared negative impacts of both emotional states, the occurrence of stressful life events, impaired cognitive functions, and common genetic or biological predispositions⁴⁸. As a whole, the OHRQoL of young Chinese TMD patients showed moderate relationships with depression, anxiety, and jaw functional limitation, with anxiety having the highest correlation. The associations of OHRQoL with pain intensity and jaw overuse behavior, albeit significant, were weaker. Correlations for both older adolescent and young adult TMD patients were generally similar and consistent with those of mature patients, supporting the use of the various Axis II measures and the OHIP-TMDs in older adolescents^{4,27}. Nevertheless, some differences were observed regarding jaw overuse behavior, which was notably high among young TMD patients. OHRQoL was moderately related to jaw overuse behavior in older adolescents, but not in young adults. Moreover, jaw overuse behavior was moderately associated with depression and jaw functional limitation in older adolescents. The exact reason for these findings remains unclear, but they may be possibly related to the use of oral behaviors as a dysfunctional coping mechanism during puberty⁴⁹. This period is characterized by physical transformation involving hormonal changes and growth, cognitive development, as well as increased social awareness, and is linked to emotional fluctuations, TMD, and somatic symptoms⁵⁰.

While low OHRQoL was related to all variables in the univariate analysis, it was only associated with age, pain intensity, anxiety, jaw overuse behavior, and jaw functional limitation in the multivariate model. However, the effect sizes were small, with ORs below 1.5. Anxiety and pain intensity had a more pronounced impact, increasing the odds of low OHRQoL by 24% and 19%, respectively, followed by age (11%), jaw functional limitation (8%) and jaw overuse behavior (4%). The greater impact of anxiety over depression on OHRQoL corresponds to the higher prevalence of anxiety disorders (6.5%) relative to depressive disorders (2.6%) in children and adolescents worldwide⁵¹. Moreover, the widespread use of social media may exacerbate negative emotions and experiences, including the Fear of Missing Out (FoMO) and cyberbullying, potentially increasing both depression and anxiety among youths^{52,53}. The impact of TMD pain on OHRQoL is well-documented and is largely attributed to jaw function limitations, psychological distress, sleep disturbances, and disruptions in daily and social activities^{10,17,54}. Age could impact OHRQoL through heightened psychological distress, whereas oral behaviors and jaw function limitations might affect it as a result of TMD pain. Effectively addressing anxiety, pain, jaw disability, and oral behaviors is essential for managing young TMD patients, as prioritizing these factors can improve OHRQoL and treatment outcomes. Additionally, integrating structured education on the masticatory system, TMD symptoms, contributing factors, and risk management into middle and high school curricula may help reduce the incidence and severity of TMDs. Early awareness and preventive strategies in educational settings can empower students to adopt healthier lifestyles and oral habits, potentially minimizing the long-term impact of these disorders⁵⁵.

Study strengths and limitations

The study focused on youths aged 15 to 24 years, a group often underrepresented in clinical TMD research. It involved a large sample of young TMD patients and employed a wide range of DC/TMD Axis II measures, along with a TMD-specific OHRQoL instrument, confirming their applicability for older adolescents. Moreover, the study distinguished between different TMD subtypes using the internationally accepted DC/TMD protocol, facilitating a nuanced understanding of how TMD conditions impact OHRQoL and enabling future cross-cultural comparisons.

Although the study possessed notable strengths, it also had its limitations. Firstly, its cross-sectional nature precludes inference of causal relationships between the variables. Furthermore, the cross-sectional design does not provide insight into changes in psychosocial/behavioral characteristics and OHRQoL over time in young TMD patients, highlighting the need for future longitudinal studies. Secondly, findings cannot be generalized to other racial and ethnic groups as the study exclusively involved young TMD patients from a single geographic region. Thirdly, while the Axis II and OHRQoL measures used are validated, they rely on self-reporting, making them susceptible to information biases such as recall and social desirability partialities. Additionally, oral activities during sleep are often unconscious and involuntary, further reducing the reliability of self-reporting. Instrument-based assessments, such as electromyography, offer more precise evaluations and are recommended when sleep bruxism is a primary focus. Lastly, the study may not have accounted for all potential confounding variables that could affect the relationships observed. These include “impact events” (such as the Coronavirus Disease 2019 pandemic), psychological well-being, social support, other physical symptoms, and sleep quality⁵⁶.

Conclusion

This study provides valuable insights into the biopsychosocial aspects of TMDs in youths, a population often underrepresented in clinical research. It found that approximately one-third of TMD patients belong to this demographic, with young adults experiencing higher levels of depression, anxiety, sleeping-state oral activity, and lower OHRQoL compared to older adolescents. This distinction underscores the unique challenges faced by these two age groups. Furthermore, this study presents a comparative analysis of painful (CT and PT) and non-painful (IT) TMDs in young patients, revealing significant differences in pain intensity, psychological distress, waking-state non-functional activity, jaw functional limitation, and OHRQoL. By identifying anxiety as the strongest factor influencing OHRQoL, alongside pain intensity, age, jaw functional limitation, and jaw overuse behavior, this research deepens understanding of the complex interplay between mental health and functional impairment in young TMD patients. These findings highlight the need for targeted, multidimensional interventions that integrate mental health support, pain management, and behavioral therapy to improve the well-being and OHRQoL of young individuals with TMD.

Data availability

The datasets generated and analyzed during the current study are not publicly accessible but can be obtained from the corresponding author upon reasonable request.

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References

- Ekberg, E. et al. Diagnostic criteria for temporomandibular disorders-InfORM recommendations: comprehensive and short-form adaptations for adolescents. *J. Oral Rehabil.* **50** (11), 1167–1180. <https://doi.org/10.1111/joor.13488> (2023).
- Schiffman, E. et al. Diagnostic criteria for temporomandibular disorders (DC/TMD) for clinical and research applications: Recommendations of the international RDC/TMD consortium network and orofacial pain special interest group. *J. Oral Facial Pain Headache.* **28** (1), 6–27. <https://doi.org/10.11607/jop.1151> (2014).
- Komiyama, O. et al. Age-related associations between psychological characteristics and pain intensity among Japanese patients with temporomandibular disorder. *J. Oral Sci.* **56** (3), 221–225. <https://doi.org/10.2334/josnusd.56.221> (2014).
- Yap, A. U., Cao, Y., Zhang, M. J., Lei, J. & Fu, K. Y. Age-related differences in diagnostic categories, psychological States and oral health-related quality of life of adult temporomandibular disorder patients. *J. Oral Rehabil.* **48** (4), 361–368. <https://doi.org/10.1111/joor.13121> (2021).
- Yap, A. U., Lai, Y. C. & Ho, H. C. W. Prevalence of temporomandibular disorders and their associated factors in Confucian heritage cultures: A systematic review and meta-analysis. *J. Oral Rehabil.* **51** (10), 2169–2194. <https://doi.org/10.1111/joor.13779> (2024).
- Zieliński, G., Pająk-Zielińska, B. & Ginszt, M. A meta-analysis of the global prevalence of temporomandibular disorders. *J. Clin. Med.* **13** (5), 1365. <https://doi.org/10.3390/jcm13051365> (2024).
- Minervini, G. et al. Prevalence of temporomandibular disorders in children and adolescents evaluated with diagnostic criteria for temporomandibular disorders: A systematic review with meta-analysis. *J. Oral Rehabil.* **50** (6), 522–530. <https://doi.org/10.1111/joor.13446> (2023).
- Slade, G. D. et al. Summary of findings from the OPFERA prospective cohort study of incidence of first-onset temporomandibular disorder: Implications and future directions. *J. Pain.* **14** (12 Suppl.), T116–T124. <https://doi.org/10.1016/j.jpain.2013.09.010> (2013).
- Warzocha, J., Gadomska-Krasny, J. & Mrowiec, J. Etiologic factors of temporomandibular disorders: A systematic review of literature containing diagnostic criteria for temporomandibular disorders (DC/TMD) and research diagnostic criteria for temporomandibular disorders (RDC/TMD) from 2018 to 2022. *Healthc. (Basel)*. **12** (5), 575. <https://doi.org/10.3390/healthcare12050575> (2024).
- Bitiniene, D. et al. Quality of life in patients with temporomandibular disorders. A systematic review. *Stomatologija* **20** (1), 3–9 (2018).
- Cao, Y., Yap, A. U., Lei, J., Zhang, M. J. & Fu, K. Y. Oral health-related quality of life of patients with acute and chronic temporomandibular disorder diagnostic subtypes. *J. Am. Dent. Assoc.* **153** (1), 50–58. <https://doi.org/10.1016/j.adaj.2021.07.011> (2022).
- Pigozzi, L. B. et al. Quality of life in young and middle age adult temporomandibular disorders patients and asymptomatic subjects: A systematic review and meta-analysis. *Health Qual. Life Outcomes.* **19** (1), 83. <https://doi.org/10.1186/s12955-021-01727-7> (2021).
- Song, Y. L. & Yap, A. U. Outcomes of therapeutic TMD interventions on oral health related quality of life: A qualitative systematic review. *Quintessence Int.* **49** (6), 487–496. <https://doi.org/10.3290/j.qi.a40340> (2018).
- Sischo, L. & Broder, H. L. Oral health-related quality of life: What, why, how, and future implications. *J. Dent. Res.* **90** (11), 1264–1270. <https://doi.org/10.1177/0022034511399918> (2011).
- Yap, A. U., Qiu, L. Y., Natu, V. P. & Wong, M. C. Functional, physical and psychosocial impact of temporomandibular disorders in adolescents and young adults. *Med. Oral Patol. Oral Cir. Bucal.* **25** (2), e188–e194. <https://doi.org/10.4317/medoral.23298> (2020).
- Allen, P. F. Assessment of oral health related quality of life. *Health Qual. Life Outcomes.* **1**, 40. <https://doi.org/10.1186/1477-7525-1-40> (2003).
- Dahlström, L. & Carlsson, G. E. Temporomandibular disorders and oral health-related quality of life. A systematic review. *Acta Odontol. Scand.* **68** (2), 80–85. <https://doi.org/10.3109/00016350903431118> (2010).
- Durham, J. et al. Creating a patient-based condition-specific outcome measure for temporomandibular disorders (TMDs): Oral health impact profile for TMDs (OHIP-TMDs). *J. Oral Rehabil.* **38** (12), 871–883. <https://doi.org/10.1111/j.1365-2842.2011.02233.x> (2011).
- Yule, P. L. et al. OHIP-TMDs: a patient-reported outcome measure for temporomandibular disorders. *Community Dent. Oral Epidemiol.* **43** (5), 461–470. <https://doi.org/10.1111/cdoe.12171> (2015).
- He, S. L. & Wang, J. H. Validation of the Chinese version of the oral health impact profile for TMDs (OHIP-TMDs-C). *Med. Oral Patol. Oral Cir. Bucal.* **20** (2), e161–e166. <https://doi.org/10.4317/medoral.20243> (2015).
- United Nations Department of Economic and Social Affairs. Young people's transition to adulthood: Progress and challenges. Published 2012. Accessed August 15, 2024. <https://desapublications.un.org/publications/young-peoples-transition-adulthood-progress-and-challenges>
- Yap, A. U. et al. Age distribution of East Asian TMD patients and age-related differences in DC/TMD axis I findings. *Cranio Published Online* **2024**:1–10. <https://doi.org/10.1080/08869634.2024.2316081>
- Natu, V. P., Yap, A. U., Su, M. H., Irfan Ali, N. M. & Ansari, A. Temporomandibular disorder symptoms and their association with quality of life, emotional States and sleep quality in South-East Asian youths. *J. Oral Rehabil.* **45** (10), 756–763. <https://doi.org/10.1111/joor.12692> (2018).
- Yang, W. et al. College students with oral habits exhibit worse psychological status and temporomandibular-related quality of life: A correlational study. *Pain Res. Manag.* 6079241. <https://doi.org/10.1155/2022/6079241> (2022).
- Yap, A. U., Marpaung, C. & Rahmadini, E. D. Self-reported symptoms of temporomandibular disorders: Relationship to psychological wellbeing, psychological distress, and oral health-related quality of life. *Int. J. Prosthodont.* **35** (1), 45–52. <https://doi.org/10.11607/ijp.7580> (2022).
- Faul, F., Erdfelder, E., Lang, A. G. & Buchner, A. G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behav. Res. Methods.* **39** (2), 175–191. <https://doi.org/10.3758/bf03193146> (2007).
- Lei, J., Yap, A. U., Zhang, M. & Fu, K. Y. Temporomandibular disorder subtypes, emotional distress, impaired sleep, and oral health-related quality of life in Asian patients. *Community Dent. Oral Epidemiol.* **49** (6), 543–549. <https://doi.org/10.1111/cdoe.12643> (2021).
- Yap, A. U. et al. DC/TMD Axis I diagnostic subtypes in TMD patients from Confucian heritage cultures: A stratified reporting framework. *Clin. Oral Investig.* **27** (8), 4459–4470. <https://doi.org/10.1007/s00784-023-05067-2> (2023).
- Kroenke, K., Spitzer, R. L. & Williams, J. B. The PHQ-9: Validity of a brief depression severity measure. *J. Gen. Intern. Med.* **16** (9), 606–613. <https://doi.org/10.1046/j.1525-1497.2001.016009606.x> (2001).
- Spitzer, R. L., Kroenke, K., Williams, J. B. & Löwe, B. A brief measure for assessing generalized anxiety disorder: the GAD-7. *Arch. Intern. Med.* **166** (10), 1092–1097. <https://doi.org/10.1001/archinte.166.10.1092> (2006).

31. Wang, M. et al. Association between comorbid anxiety and depression and health risk behaviors among Chinese adolescents: Cross-sectional questionnaire study. *JMIR Public. Health Surveill.* **9**, e46289. <https://doi.org/10.2196/46289> (2023).
32. Markiewicz, M. R., Ohrbach, R. & McCall, W. D. Jr Oral behaviors checklist: Reliability of performance in targeted waking-state behaviors. *J. Orofac. Pain.* **20** (4), 306–316 (2006).
33. Barbosa, C. et al. Are oral overuse behaviours associated with painful temporomandibular disorders? A cross-sectional study in Portuguese university students. *J. Oral Rehabil.* **48** (10), 1099–1108. <https://doi.org/10.1111/joor.13226> (2021).
34. Donnarumma, V. et al. Association between waking-state oral behaviours, according to the oral behaviors checklist, and TMD subgroups. *J. Oral Rehabil.* **48** (9), 996–1003. <https://doi.org/10.1111/joor.13221> (2021).
35. Ohrbach, R., Larsson, P. & List, T. The jaw functional limitation scale: Development, reliability, and validity of 8-item and 20-item versions. *J. Orofac. Pain.* **22** (3), 219–230 (2008).
36. Oghli, L., List, T., John, M. T., Häggman-Henrikson, B. & Larsson, P. Prevalence and normative values for jaw functional limitations in the general population in Sweden. *Oral Dis.* **25** (2), 580–587. <https://doi.org/10.1111/odi.13004> (2019).
37. DeCoster, J., Gallucci, M. & Iselin, A. M. R. Best practices for using median splits, artificial categorization, and their continuous alternatives. *J. Exp. Psychopathol.* **2** (2), 197–209. <https://doi.org/10.5127/jep.008310> (2011).
38. Leung, D. Y. P., Mak, Y. W., Leung, S. F., Chiang, V. C. L. & Loke, A. Y. Measurement invariances of the PHQ-9 across gender and age groups in Chinese adolescents. *Asia Pac. Psychiatry.* **12** (3), e12381. <https://doi.org/10.1111/appy.1281> (2020).
39. Sun, J., Lian, K., Chi, X. & Chen, S. Psychometric properties of the generalized anxiety disorder Scale-7 items (GAD-7) in a large sample of Chinese adolescents. *Healthc. (Basel).* **9** (12), 1709. <https://doi.org/10.3390/healthcare9121709> (2021).
40. Marquez, J., Katsantonis, I., Sellers, R. & Knies, G. Life satisfaction and mental health from age 17 to 21 years in a general population sample. *Curr. Psychol.* <https://doi.org/10.1007/s12144-022-03685-9> (2022).
41. Arnett, J. J. Emerging adulthood. A theory of development from the late teens through the twenties. *Am. Psychol.* **55** (5), 469–480 (2000).
42. Reis, P. H. F., Laxe, L. A. C., Lacerda-Santos, R. & Münchow, E. A. Distribution of anxiety and depression among different subtypes of temporomandibular disorder: A systematic review and meta-analysis. *J. Oral Rehabil.* **49** (7), 754–767. <https://doi.org/10.1111/joor.13331> (2022).
43. Mortazavi, N., Tabatabaei, A. H., Mohammadi, M. & Rajabi, A. Is Bruxism associated with temporomandibular joint disorders? A systematic review and meta-analysis. *Evid. Based Dent.* **24** (3), 144. <https://doi.org/10.1038/s41432-023-00911-6> (2023).
44. Yap, A. U., Kim, S., Lee, B. M., Jo, J. H. & Park, J. W. Correlates of jaw functional limitation, somatization and psychological distress among different temporomandibular disorder diagnostic subtypes. *J. Oral Rehabil.* **51** (2), 287–295. <https://doi.org/10.1111/joor.13606> (2024).
45. Ferrillo, M. et al. Pain management and rehabilitation for central sensitization in temporomandibular disorders: A comprehensive review. *Int. J. Mol. Sci.* **23** (20), 12164. <https://doi.org/10.3390/ijms232012164> (2022).
46. Hale, W. D. & Cochran, C. D. Age differences in self-reported symptoms of psychological distress. *J. Clin. Psychol.* **48** (5), 633–637. [https://doi.org/10.1002/1097-4679\(199209\)48:5<633::AID-JCLP2270480509>3.0.CO;2-H\(1992\)](https://doi.org/10.1002/1097-4679(199209)48:5<633::AID-JCLP2270480509>3.0.CO;2-H(1992)).
47. Tiller, J. W. Depression and anxiety. *Med. J. Aust.* **199** (S6), S28–S31. <https://doi.org/10.5694/mja12.10628> (2013).
48. Eysenck, M. W. & Fajkowska, M. Anxiety and depression: Roward overlapping and distinctive features. *Cogn. Emot.* **32** (7), 1391–1400. <https://doi.org/10.1080/02699931.2017.1330255> (2018).
49. Yap, A. U., Dewi, N. L., Pragustine, Y. & Marpaung, C. Oral behaviors in young adults: A multidimensional evaluation of the influence of personality, coping, and distress. *Clin. Oral Investig.* **27** (9), 5083–5093. <https://doi.org/10.1007/s00784-023-05129-5> (2023).
50. Song, Y. L., Yap, A. U. & Türp, J. C. Association between temporomandibular disorders and pubertal development: A systematic review. *J. Oral Rehabil.* **45** (12), 1007–1015. <https://doi.org/10.1111/joor.12704> (2018).
51. Polanczyk, G. V., Salum, G. A., Sugaya, L. S., Caye, A. & Rohde, L. A. Annual research review: A meta-analysis of the worldwide prevalence of mental disorders in children and adolescents. *J. Child. Psychol. Psychiatry.* **56** (3), 345–365. <https://doi.org/10.1111/jcpp.12381> (2015).
52. Weigle, P. E. & Shafi, R. M. A. Social media and youth mental health. *Curr. Psychiatry Rep.* **26** (1), 1–8. <https://doi.org/10.1007/s11920-023-01478-w> (2024).
53. Yap, A. U., Kurniawan, F., Pragustine, Y. & Marpaung, C. Temporomandibular disorder and somatic symptoms: Relations to 'fear of missing out' and other negative emotional States. *Acta Odontol. Scand.* **83**, 340–347. <https://doi.org/10.2340/aos.v83.40776> (2024).
54. Roithmann, C. C., Silva, C. A. G. D., Pattussi, M. P. & Grossi, M. L. Subjective sleep quality and temporomandibular disorders: systematic literature review and meta-analysis. *J. Oral Rehabil.* **48** (12), 1380–1394. <https://doi.org/10.1111/joor.13265> (2021).
55. Meijersjö, C., Wänman, A., Wenneberg, B. & Bergström, E. K. Can temporomandibular disorder symptoms and headaches be prevented in 13- to 15-year-old girls by information provided in a school setting? *J. Oral Rehabil.* **51** (9), 1730–1736. <https://doi.org/10.1111/joor.13773> (2024).
56. Ma, J. et al. Children and adolescents' psychological well-being became worse in heavily hit Chinese provinces during the COVID-19 epidemic. *Psychiatr Brain Sci.* **6** (5), e210020. 20900/jpbs.2010020 (2021).

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Author contributions

A.U.Y. contributed to conceptualization, methodology, visualization, formal analysis, validation, resources, project administration, and writing - original draft. Y.Z. contributed to methodology, investigation, data curation, formal analysis, validation, software, resources, and writing - review & editing. M.Y., T.L., Y.L., Y.L., and X.Z. contributed to investigation, data curation, resources, and writing - review & editing. X.X. contributed to conceptualization, methodology, investigation, data curation, formal analysis, validation, resources, project administration, funding acquisition, and writing - review & editing.

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Declarations

Competing interests

The authors declare no competing interests.

Ethics approval and consent to participant

This research was approved by the Institutional Review Board at the West China Hospital of Stomatology, Sichuan University (ID: WCHSIRB-D-2022-212). Written informed consent has been obtained from all participants.

Additional information

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