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Psychosocial impact of dental aesthetics in adolescent : an evaluation of a latent profile and its associated risk factors

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Abstract

Background The psychosocial impact of dental aesthetics (PIDA) has a significant effect on well-being and quality of life. This study aimed to explore the latent heterogeneous classes of the PIDA among adolescents and investigate the relationships among identified subtypes and sociodemographic variables, the status of left-behind children, and the clinical manifestations of malocclusion.

Methods A cross-sectional study on the PIDA among 1451 adolescents aged 11 to 12 years in elementary schools in a rural area in Guangxi, China, was conducted. The PIDA on adolescents was also investigated via latent profile analysis; each predictor was tested via ordinal logistic regression.

Results Three latent classes for the PIDA were identified: low-risk (48.2%), medium-risk (39.8%), and high-risk (11.9%) groups. There were significant differences among the three latent classes. The results revealed that being female, The duration of maternal employment outside the hometown, the largest anterior maxillary irregularity, the largest anterior mandibular irregularity, and the antero-posterior molar relationship (ORs of 1.737, 1.138, 1.117, 1.157, and OR = 1.242; $P < 0.001$, < 0.01, < 0.01, < 0.01 and < 0.05, respectively) had significant effects on the PIDA on adolescents.

Conclusions The occlusal features, being female and the duration of maternal employment outside the hometown are risk factors that influence the PIDA on adolescents. This provides an evidence for improving the PIDA status among rural adolescents.

Keywords Psychosocial impact, Dental aesthetics, Latent profile analysis, Adolescents

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Background

Oral aesthetics affect facial attractiveness, which is closely related to a person's self-perception and self-esteem [1, 2]. The psychosocial impact of dental aesthetics (PIDA) refers to the changes in social interactions and psychological well-being caused by dental aesthetics [1, 3], which have received much attention in recent years [4, 5]. Since facial features and appearance significantly impact adolescent self-perception [6], dental aesthetics can significantly influence adolescent well-being and self-esteem [2, 7, 8]. Compared with adults, in adolescents, dental aesthetics tend to have a more significant psychological impact on adolescents [6]. Therefore, it is necessary to accurately identify the group of adolescents at high-risk of PIDA and explore the related predictors for precise interventions for adolescent PIDA problems.

However, recent research still unable to accurately identify populations at risk for a negative PIDA, although some researchers have utilized survey respondents' scores of subjective satisfaction with dental aesthetics and threshold values of the Oral Aesthetics Subjective Impact Scale (OASIS) to identify populations at risk for poor subjective satisfaction [9, 10]. This is because these methods tend to be based on subjective scores and normative criteria and may ignore the differences in the PIDA across time and cultural contexts [10]. In addition, the PIDA questionnaire(PIDAQ), which is the scale most commonly used to assess the PIDA, does not have a risk classification threshold, and most of the studies based on this methodology only compare PIDAQ values between different populations or between the same sample groups before and after treatment [11–13]. The questionnaire designer provided a Stanine reference value for the PIDAQ on the basis of a given population [14]. Nevertheless, these "one-size-fits-all" divisions [15] may ignore possible heterogeneity in the PIDA by classifying the population at risk on the basis of the average of the sample under the assumption that the study population is homogeneous [15]. By following such an approach, it is challenging to identify the proportion of the population at risk for a negative PIDA.

Therefore, the logical next step would be to introduce the concept of precision dentistry to identify populations at risk for a negative PIDA. Precision dentistry, which is part of precision medicine, is a modern, multifaceted, data-driven approach to oral health care. This is still a relatively new concept in the dental field [16]. Latent class analysis (LCA) for categorical variables and latent profile analysis (LPA) for the continuous variables [17] are similar methods for identifying subgroups of individuals on the basis of similar responses to selected indicators [18] and assigning each participant to the most likely homogeneous subclade [15, 19]. These methods are considered a powerful tool for achieving precision dentistry [16, 20]. LPA and LCA have been used in several medical fields to improve disease diagnosis, treatment, and prognostic assessments [21–23]. To achieve precise treatment of oral diseases, some researchers have applied LCA technology for the classification of periodontal diseases [20], as well as for the exploration of oral health patterns in elderly individuals [24]. However, to our knowledge, there are no similar studies on the PIDA, particularly in southern China. In addition, studies have shown that adolescents in rural areas tend to experience more emotional problems caused by dental aesthetics due to low parental education and family income levels [25].

Therefore, our primary objectives were to utilise LPA for exploring the group heterogeneity of PIDA problems among adolescents in rural southern China, and to investigate the critical risk factors for each latent class, providing empirical evidence for accurately identifying at-risk populations.

Methods

Study design

A cross-sectional study was conducted from October to November 2022 in a rural area of Guangxi, China, and the participants were sixth-grade students in elementary schools. This survey was approved by the Ethics and Research Committee of Guangxi Medical University (2022045, 2022-6-24), and the county authorities supported it. Written informed consent was obtained from the students' guardians, and verbal consent was obtained from each student. Two examiners underwent training and calibration before data collection, including training regarding theory and practice. The baseline inter- and intraexaminer reproducibility (intraclass correlation coefficient) for the dental aesthetic index (DAI) was greater than 0.91, indicating satisfactory reproducibility between the examiners.

To obtain a representative sample size, a two-stage sampling technique was used. Five national key counties for poverty alleviation (n=28) were randomly selected in the first stage. In the second stage, two elementary schools were selected in each targeted county via a whole-group sampling method. All sixth-grade students aged 11 to 12 years from the ten selected schools were invited to participate in this study. The exclusion criteria were as follows: (1) Adolescents who could not cooperate with the investigation; (2) Adolescents with any psychological or mental disorders; (3) Adolescents with systemic diseases, a history of orthodontic treatment, or oral diseases other than caries, periodontitis, and malocclusion; and (4) Adolescents outside the age range of 11–12 years.

Two examiners collected survey data in the classroom. Oral examinations were performed according to the survey method of the DAI introduced in the World Health Organization (WHO) manual [26]. The research participants sat on school chairs and were examined in natural light by a mouth mirror and a WHO-approved periodontal probe [26, 27]. The questionnaires were completed by the students during class; the questionnaires were fully explained to the

students before they began to complete them, and the students provided written answers for all the questions. Two assistants were on site to check the questionnaires and DAI checklist for missing items. The respondents were immediately asked to fill in the blanks or undergo a new oral examination to complete the form if omissions were found. According to previous studies, to ensure that the model and the fit statistics are consistently accurate, the sample size of the LPA needs to be larger than 500 and maximized according to the study conditions [15, 28]. A total of 1598 questionnaires were collected; the questionnaires of respondents with incorrect basic information, those whose ages did not meet the inclusion criteria and those who provided contradictory answers about their parental employment outside the hometown were deleted, leaving 1451 valid questionnaires with a validity rate of 90.8%. Very few missing values in the questionnaires were interpolated via mode imputation methods.

Data collection

General information

A self-reported and structured questionnaire was included among the questionnaires, which was completed onsite. This questionnaire collected the name, age, sex, parental education level, the duration of parental employment outside the hometown and whether the adolescents were left behind when their parents worked away from the family home.

Information on experiences of parental migration

According to the UNICEF's definition and previous studies, in this study, left-behind children (LBC) were defined as children and adolescents younger than 18 years who had been separated from one or both parents for at least six months due to parental employment outside the hometown [29–31]. The following three questions were used for adolescents whose parents worked outside the home to understand the duration of parental employment outside the hometown and to determine whether the adolescents were LBC: (1) What is the duration of maternal employment outside your hometown in the past year (≤2, 2–4, 4–6, 6–8, 8–10 and 10–12 months); (2) What is the duration of paternal employment outside your hometown in the past year (≤2, 2–4, 4–6, 6–8, 8–10 and 10–12 months); and (3) has either parent taken a job outside of your hometown and been absent for over six months (yes, for one or both parents; no, for neither of the parents).

PIDA questionnaire (PIDAQ)

The PIDAQ is a valid method for estimating the PIDA on adults that was proposed by Klages et al. (2006) [32]. In 2015, by revising some of the items, the author reintroduced a version for adolescents aged 11–17 years [14]. The PIDAQ is one of the most widely used instruments to evaluate the PIDA [32, 33]. It has been shown to be valid and reliable in multiple cultural contexts [12, 33–35].

The adolescent version of the PIDAQ used in this study was developed by the authors by referring to the questionnaire translation process proposed by Brislin et al. [36], utilizing a pilot study similar to Bucci et al. [37]. We pretested the scales among 120 rural children, and the results revealed internal consistency, with a Cronbach's alpha coefficient of 0.860 for the scales and a corrected item–total correlation (CITC) ranging from 0.446 to 0.803. Four dimensions were extracted from the principal component analysis, and the loadings of each item on the dimension to which it belonged ranged from 0.599 to 0.908. The Cronbach's alpha coefficients for the four dimensions were 0.766, 0.889, 0.882 and 0.865, respectively. The results indicated that the final Chinese version of the adolescent PIDAQ had good reliability and validity.

The questionnaire is divided into four dimensions, namely, dental self-confidence (DSC, 6 items), social influence (SI, 8 items), psychological influence (PI, 6 items), and aesthetic concern (AC, 3 items). Each item is scored using a five-point Likert scale ranging from 0 to 4 to assess whether dental aesthetics positively or negatively impact an individual. Scores of 0, 1, 2, 3 and 4 represent not at all, a little, somewhat, strongly and very strongly, respectively. To ensure the reliability of the questionnaire, the items in the DSC dimension of the PIDAQ were reverse-coded. Therefore, with respect to the four dimensions of the PIDAQ, for the SI, PI and AC dimensions, the higher the score is, the worse the PIDAQ; for the DSC dimension, the higher the score, and the better the PIDAQ.

The DAI

The DAI is a malocclusion index based on socially defined global aesthetic standards [38]. It is jointly recommended by the WHO and the International Dental Federation for oral epidemiological surveys because of its simplicity, accuracy, and effectiveness [38]. The DAI checklist includes the following aesthetically relevant parameters for dentofacial anomalies: the number of visibly missing teeth, incisal segment crowding, incisal segment spacing, midline diastema, the largest anterior maxillary irregularity, the largest anterior mandibular irregularity, anterior maxillary overjet, anterior mandibular overjet, anterior openbite and the antero-posterior molar relationship.

These items are widely used to assess the subjective impact of malocclusion on oral aesthetics [10, 38]. For example, the largest anterior maxillary irregularity and the largest anterior mandibular irregularity reflect the maximum deviation of the maxillary and mandibular incisors from normal alignment, respectively. The tip of the Community Periodontal Index (CPI) probe was placed on the labial surface of the most rotated incisor while the probe was held parallel to the occlusal plane and at a right angle

to the normal line of the arch. The irregularity could then be estimated from the markings on the probe. The anteroposterior molar relationship was used to assess the extent to which the molar deviated from a Class I relationship. A score of 0 was recorded when the molar relationship was classified as Class I, a score of 1 was given when the lower first molar was located more than half a cusp but less than 1 cusp mesial or distal to the normal line, and a score of 2 was given when the mandibular first molar was one cusp or more mesial or distal to the normal line. Anterior mandibular overjet referred to the crossbite of the anterior region, and an anterior open bite referred to the largest degree of an open bite. If there was a lack of vertical overlap between any of the opposing pairs of incisors (open bite), the degree of open bite was estimated by a CPI probe.

Most studies have used the DAI to assess the need for malocclusion treatment. This need is determined by calculating a cumulative total score for each item in the DAI checklist with reference to a formula. The participants were then categorized into four classes according to the magnitude of their scores with reference to thresholds to determine the necessity for orthodontic treatment [26]. For the purpose of our study, we did not calculate the total DAI score but separately verified whether the various clinical manifestations related to aesthetics in the DAI questionnaire were associated with the PIDA on adolescents.

Statistical methods

The statistical analysis of this study was divided into three steps:

First, tests of the reliability and validity of the PIDAQ were conducted via Mplus 8.3, followed by descriptive statistics and correlation analysis with SPSS v25.0.

Then, LPA was conducted to build potential profile models for classes 1–6 using 23 PIDAQ items as observable indicators. The model's goodness-of-fit was assessed via the Akaike information criterion (AIC), Bayesian information criterion (BIC), sample-size adjusted BIC (SSABIC), entropy and Lo-Mendell-Rubin test (LMRT). On the basis of the assessment of the model's goodness-of-fit, the optimal category model was determined by considering the simplicity and practicality of the model, and the characteristics of the latent profiles were analysed.

Finally, the latent profiles of the PIDA on adolescents were analysed via univariate analysis with respect to the sex of the participant, parental education level, experience of parental migration (whether an adolescent was a left-behind child and the duration of parental employment outside the hometown) and the scores for each item of the DAI. The variables with significant results ($P<0.05$) were used as independent variables, and the latent profiles of the PIDA on adolescents were used as dependent variables in ordinal logistic regression analyses to verify the validity of the various influences as predictors of PIDA problems in adolescents.

Table 1 Characteristics of the study population

Variables	Frequency (*N*)	Percentage (%)
Sex		
Male	703	48.4
Female	748	51.6
Experience of parental migration		
Non-LBC	877	60.4
LBC	574	39.6
Paternal education level		
Elementary school and below	437	30.1
Junior High School	716	49.3
High school	201	13.9
College	58	4.0
Bachelor's degree or above	39	2.7
Maternal education level		
Elementary school and below	520	35.8
Junior High School	644	44.4
High school	200	13.8
College	46	3.2
Bachelor's degree or above	41	2.8
Total	1451	100

[1] LBC: left-behind children

Results

Sociodemographic characteristics of the participants

A total of 1451 adolescents participated in this study, including 703 boys (48.4%) and 748 girls (51.6%). Among the included adolescents, 60.4% were non-LBC, and 39.6% were LBC. The largest proportion of the adolescents had parents with a junior high school education, with 49.3% and 44.4% of fathers and mothers having a junior high school education, respectively (Table 1).

Score and correlation analysis of each PIDAQ dimension

The results of the PIDAQ reliability and validity analyses in this study were as follows: the Cronbach's alpha coefficient for each dimension was determined to be 0.818, 0.840, 0.835 and 0.846, respectively, and the value for the total scale was 0.845, indicating excellent internal consistency and reliability. The model fit results of the confirmatory factor analysis of the questionnaires were equally good ($\chi 2/df=4.780$, comparative fit index (CFI)=0.921, Tucker–Lewis index (TLI)=0.910, root mean square error of approximation (RMSEA)=0.05 and standardized root mean squared residual (SRMR)=0.051), and the standardized factor loading for each item was greater than 0.5, indicating that the structural validity was good.

Descriptive statistics and correlation analysis were performed on the four dimensions of the PIDAQ, and the results are shown in Table 2.

Table 2 Descriptive statistics and correlation analysis of the PIDAQ

	M	SD	DSC	SI	PI
DSC	1.29	0.77	-		
SI	1.02	0.74	−0.165**	-	
PI	1.25	0.82	−0.172**	0.660**	-
AC	1.24	1.07	−0.224**	0.555**	0.580**

Note: M: Mean; SD: Standard Deviation

Statistical significance: $^{+}P<0.1$, $^{*}P<0.05$, $^{**}P<0.01$, $^{***}P<0.001$

Selection of the optimal latent profile model for the PIDA on adolescents

On the basis of the fit statistics for the LPA models (Table 3), the 3-class model was determined to be the best-fit model. Although the LMRT values ranging from the 2-class model to the 5-class model were statistically significant, those of the 2-class and 3-class models were greater ($P<0.001$), and their entropy values were greater than those of all the other models. Furthermore, the values of the information criterion indicators such as the AIC, BIC and SSABIC for the 3-class model were lower than those for the 2-class model. Considering its simplicity, interpretability and practicality, the 3-class model was ultimately selected as the best model to use for subsequent analysis.

Moreover, the probability of each class being attributed to its own class in the 3-profile model ranged from 95.1 to 95.7%. The probability of each class being attributed to other classes ranged from 0.00 to 4.9%, indicating that the 3-profile model selected in this study had high accuracy and that the classification results obtained were credible.

Latent class characterization of the PIDA

The three latent classes of the PIDA on adolescents exhibited different score characteristics across the four dimensions of the PIDAQ, as shown in Table 4; Fig. 1.

The C1 category, with 700 participants (48.2% of the total sample), was the category with the best PIDA status among the three categories. In terms of the scores for each item, the C1 category had the highest score on the DSC dimension among the three categories but had the lowest scores on the other dimensions (SI, PI, and AC dimensions). For all three dimensions of the PIDAQ, except for the reverse-scored DSC dimension (where the higher the score was, the better the PIDA was), the lower the score was, the worse the PIDA was. Therefore, the C1 category had the best PIDA in all four dimensions and was named the "low-risk group." The C2 category consisted of 578 individuals, accounting for 39.8% of the total sample. The scores for all four dimensions were moderate. Therefore, this category was named the "medium-risk group". The C3 category consisted of 173 individuals, or 11.9% of the total sample, and this category had the lowest scores on the DSC dimension and the highest scores on the other three dimensions. Therefore, individuals in this category experienced the worst PIDA among the three categories, and this category was named the "high-risk group".

Table 4 The percentages and the mean values of participants in each latent class of the PIDA

Class	Frequency(%)	DSC	SI	PI	AC
C1	700(48.2)	1.46	0.48	0.66	0.55
C2	578(39.8)	1.22	1.31	1.54	1.63
C3	173(11.9)	0.86	2.22	2.66	2.78

Univariate analysis of three latent classes of the PIDA on adolescents

The results of the univariate analysis revealed that sex, left-behind status, the duration of maternal employment outside the hometown and the presence of some occlusal features, including incisal segment crowding, midline diastema, the largest anterior maxillary irregularity, the largest anterior mandibular irregularity, anterior mandibular overjet and the antero-posterior molar relationship ($P<0.05$), differed among the three latent classes.

Multivariate analysis of three latent classes of the PIDA on adolescents

As shown in Table 5, according to the results of ordinal logistic regression, sex, the duration of maternal employment outside the hometown and the presence of some occlusal features, of malocclusion had a significant effect on PIDA problems in adolescents. With respect to sex, the OR of having more severe PIDA problems was 1.737 times greater for girls than for boys (95% CI: 1.418–2.126), $P=0.000<0.001$, when boys were used as the control group). With respect to the the duration of maternal

Table 3 Summary of the fit information for the LPA model of the PIDAQ scores

Model	Np	LL	AIC	BIC	SSABIC	Entropy	LMRT
1-Class	46	-50310.70	100713.41	100956.29	100810.16	-	-
2-Class	70	-47171.93	94483.86	94853.46	94631.09	0.901	<0.001
3-Class	**94**	**-46239.89**	**92667.77**	**93164.09**	**92865.49**	**0.898**	<0.001
4-Class	118	-45684.09	91604.19	92227.23	91852.38	0.875	<0.05
5-Class	142	-45163.05	90610.09	91359.86	90908.77	0.895	<0.05
6-Class	166	-44788.86	89909.73	90786.21	90258.88	0.895	>0.05

Note: LL: log-likelihood; AIC: Akaike's information criterion; BIC: Bayesian information criterion; SSABIC: sample-size adjusted BIC; LMRT: Lo-Mendell-Rubin test

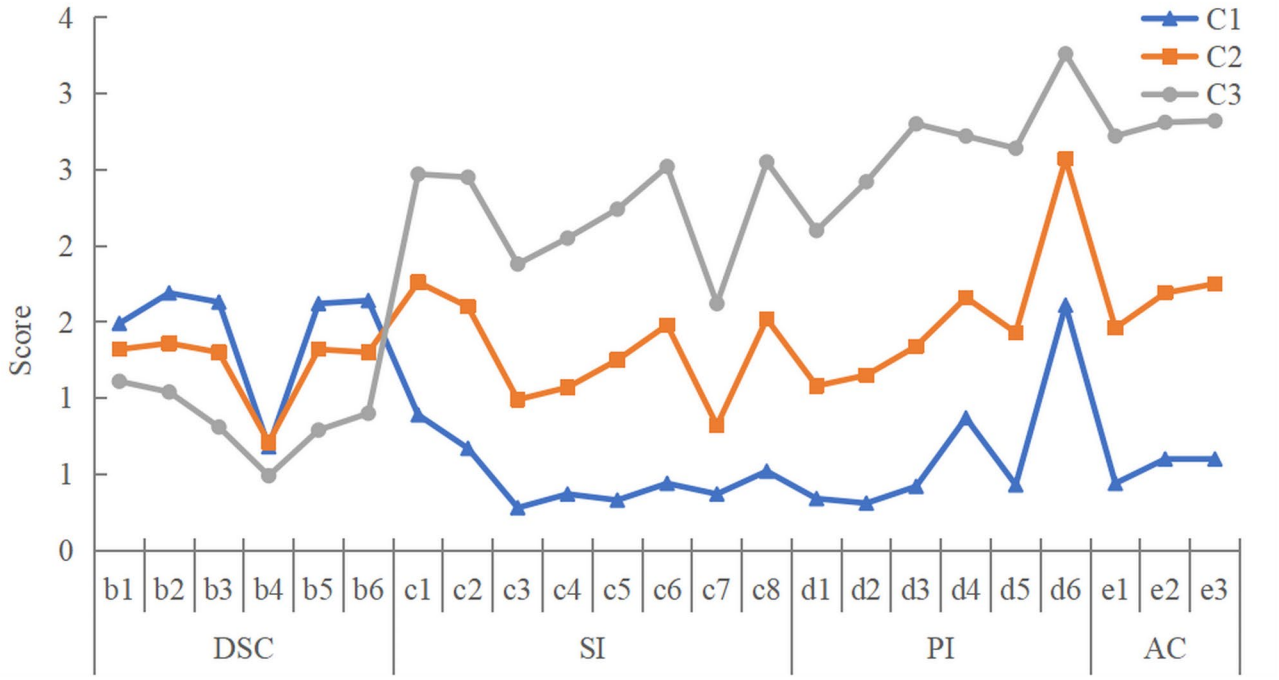

Fig. 1 Scores of the three latent classes of the PIDA with respect to the 23 different items

Table 5 Ordinal logistic regression analysis of the PIDA

	B	Std. Error	Sig.	OR	95% CI for the OR	
					Lower	Upper
Sex(male)						
female	0.552***	0.103	0.000	1.737	1.418	2.126
Experience of parental migration(LBC)						
Non-LBC	-0.165	0.146	0.259	0.848	0.636	1.129
Duration of maternal employment outside the hometown	0.130**	0.045	0.004	1.138	1.041	1.244
Incisal segment crowding	-0.122	0.091	0.182	0.885	0.740	1.059
Incisal segment spacing	0.169	0.094	0.071	1.184	0.985	1.422
Largest anterior maxillary irregularity	0.111**	0.039	0.004	1.117	1.036	1.205
Largest anterior mandibular irregularity	0.157**	0.050	0.002	1.170	1.060	1.291
Anterior mandibular overjet	0.082	0.075	0.276	1.086	0.937	1.258
antero-posterior molar relationship	0.217*	0.089	0.015	1.242	1.043	1.480

Statistical significance: + $P<0.1$, * $P<0.05$, ** $P<0.01$, *** $P<0.001$

employment outside the hometown, the OR of developing more severe PIDA problems increased by 1.138 times (95% CI: 1.041–1.244, $P=0.004<0.01$) for each 2-month increase in the duration of maternal absence from the family home.

In terms of the occlusal features of malocclusion, the largest anterior maxillary irregularity, largest anterior mandibular irregularity and antero-posterior molar relationship were significantly associated with PIDA problems. The OR of developing more severe PIDA problems was 1.117 times greater for each unit increase in the largest anterior maxillary irregularity (95% CI: 1.036–1.205, $P=0.004<0.01$). This value was 1.170 times greater for each unit increase in the largest anterior mandibular irregularity (95% CI: 1.060–1.291, $P=0.002<0.01$) and 1.242 times greater for each unit increase in the antero-posterior molar relationship (95% CI: 1.043–1.480, $P=0.015<0.05$).

Discussion

A negative PIDA significantly impacts self-esteem, well-being, and quality of life [2, 34], and people at high risk deserve attention. This study explored potential heterogeneous groups of adolescents regarding the PIDA in rural southern China via LPA, identifying three latent classes, namely, the low-risk, medium-risk, and high-risk groups. This study showed that female sex, the duration of maternal employment outside the hometown, and the

presence of some occlusal features were associated with the occurrence of PIDA problems in adolescents.

First, we found that being female was significantly associated with experiencing a negative PIDA in adolescents. This finding is consistent with most previous studies showing that women are more sensitive to dental aesthetic issues than men are [5]. Even if the severity of malocclusion that disrupts dental aesthetics is consistent, females are more likely to experience PIDA problems than males are [33]. Our study suggests that we should pay more attention to the PIDA on girls in rural areas.

As a result of economic development and urbanization, an increasing number of rural adults are migrating to cities for work, and the children of these families usually remain in rural areas. The problem of being left behind is an essential factor leading to the psychological problems in minors [30, 39–41]. In this study, the PIDA on adolescents was associated with the duration of maternal employment outside the hometown. This may be because, in rural southern China, children are usually accompanied and educated by their mothers, so they have a greater degree of attachment and psychological dependence on them [42]. The PIDA status was not related to the duration of paternal employment outside the hometown, probably because migrant fathers, as economic contributors, buffered the negative health implications of being left behind [42]. In addition, this study revealed that the PIDA on adolescents was not associated with parental education levels. This may be related to the low level of dentistry and the lack of awareness and education regarding dental aesthetics in the rural southern area. Regardless of their level of education, parents have little knowledge about dental aesthetics and malocclusion.

With respect to the clinical manifestations of malocclusion, the antero-posterior molar relationship was significantly correlated with the PIDA. This is because the higher the molar relationship score is, the greater the degree of molar deviation from Angle Class I, and the greater the likelihood of skeletal discrepancy between the maxilla and mandible. Severe skeletal deformities can have significant psychosocial effects and lead to aesthetic impairments [5, 8, 43], thus increasing the risk of PIDA problems.

Interestingly, this study revealed that the largest anterior maxillary and mandibular irregularities were significant predictors of PIDA problems, whereas crowding was not. This is because the largest anterior maxillary and mandibular irregularities are the maximum deviation of the anterior teeth from the normal alignment, and adolescents' satisfaction with their dental appearance is related mainly to the anterior aesthetic zone [9, 10], the higher the scores on these two indicators are, the greater the likelihood of a PIDA problem. However, the crowding score on the DAI reflects only the distribution of crowding in the maxilla and mandible, not the degree of crowding. A score of 1 is given when crowding is present in one segment of the maxilla and mandible, and a score of 2 is given when crowding is present in both the maxilla and mandible. The misalignment of a single tooth has a more significant effect on dental aesthetics than does a scattered distribution of crowded teeth [44]. Therefore, in this study, the largest anterior maxillary and mandibular irregularities usually had a greater effect on the PIDA than did crowding.

In this study, spacing in the incisal segments did not have a significant effect on the PIDA on adolescents, mainly because the participants in this study were adolescents aged 11 to 12 years who were still in the final stages of the transition from mixed dentition to permanent dentition. Since gaps are typical of mixed dentition, adolescents may judge them as normal occlusion [7].

Moreover, in this study, anterior maxillary overjet had no significant effect on the PIDA, which is different from the results of previous studies [45, 46]. This may be due to the different levels of acceptance of various occlusal features in different parts of the world and different ethnic groups. Typically, white Europeans have straighter facial profiles than Asian individuals and those who are of Afro-Caribbean origin. Certain lip and incisor positions that are perceived as normal by black and Asian individuals are perceived by most white individuals as being excessively protrusive [47]. In Guangxi Province, where this study was conducted, the population is predominantly Zhuang, and profile convexity is a facial feature of the Zhuang individuals [48]. As a result, people in this area may be more accustomed to deep maxillary overjet and convex facial profiles.

In addition, the findings of this study may provide some suggestions for clinical practice. With respect to the molar relationship, which can significantly affect the PIDA on adolescents, previous studies have shown that if early treatment is performed during children's growth periods, the molar relationship can be improved, the incidence of severe malocclusion can be reduced and the psychosocial well-being of children can be improved [49, 50]. Therefore, we should actively intervene in cases of severe skeletal malalignment of the maxilla and mandible during children's growth periods and actively address misalignment of the upper and lower anterior teeth during the treatment process.

Strengths and limitations

To our knowledge, this is the first LPA study on PIDA that explores for the first time the group heterogeneity of PIDA from an individual-centered perspective [23] and reveals the relationship among sociodemographic variables, parental immigrant status and clinical

manifestations of malocclusion within each latent class of the PIDA.

However, this study has several limitations. First, this was a survey of 11- to 12-year-old adolescents in rural southern China, which may limit the generalizability of the findings. Therefore, further studies should be conducted on a wider range of adolescents from different countries and regions in order to clarify whether some clinical manifestations of malocclusion, such as deep maxillary overjet and anterior tooth spacing, may have different effects on the PIDA on adolescents of different ages and from other regions. Second, this study included a limited number of possible influences that may affect the latent classes of the PIDA, and future studies should include other probable influential factors. Third, this cross-sectional study could not predict changes in each latent class over time. Thus, longitudinal studies should be conducted to track the changes in the PIDA as adolescents age.

Conclusions

Overall, by using LPA, this study explored potentially heterogeneous groups of PIDA and identified three latent risk classes for the PIDA among adolescents in rural areas of southern China. It was also found that female sex, the duration of maternal employment outside the hometown, a large anterior maxillary and mandibular irregularities, and the molar relationship were statistically associated with the likelihood of more severe PIDA problems.

Therefore, this study provides novel information on how to identify adolescents at risk for a negative PIDA, and it will help to implement targeted oral health counselling and psychological interventions for at-risk populations to improve psycho-dental aesthetics among adolescents.

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Author contributions
LJX, XJZ, and HYH conceptualized and designed the study; LJX, XJZ, HYH, WJM, and SYC developed the methods of the study; LJX, WJM, SYC, SC, and QLL coordinated and collected the data; LJX, LYT planned and conducted the data analysis; LJX, XJZ wrote the first draft of the manuscript; and LJX, XJZ, and HYH revised and prepared the final version for submission. All the authors have read and agreed to the published version of the manuscript.

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Data availability
The data that support the findings of this study are not openly available for reasons of sensitivity and are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate
The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics and Research Committee of Guangxi Medical University (2022045,2022-6-24). Written informed consent was obtained from the students' guardians, and verbal consent was obtained from each student.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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