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The impact of only-child status on adolescent mental health: a multi-center cross-sectional study using propensity score matching in Western China

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Abstract

Background Prior research on the mental well-being of adolescents has shown conflicting findings regarding the impact of only-child status. This study uses *Propensity Score Matching* (PSM) to control for confounding variables and investigate the impact of only-child status on the psychological health of adolescents.

Methods A multi-center cluster sampling approach included 7,359 students from 33 middle schools in Western China. The Depression, Anxiety, and Stress Scale-21 (DASS-21), the Childhood Psychological Abuse and Neglect Scale (CPANS), the Pittsburgh Sleep Quality Index (PSQI), the Chinese iteration of the Barratt Impulsiveness Scale (BIS-11), and the Chinese version of the Positive and Negative Affect Scale for Children (PANAS-C) were utilized to assess the adolescents' emotions, sleep, psychological abuse, and neglect. PSM was employed to address confounding variables. Univariate analysis used t-tests, chi-square tests, and Wilcoxon rank-sum tests, while multivariate analysis used GLM to compare DASS-21, PSQI, and PANAS-C scores.

Results After PSM, 980 only-child and 980 non-only-child adolescents were included. Only-child adolescents showed significantly lower levels of depression, stress, emotional neglect, and negative affect. Further scrutiny of the mean ranks of these dimensions indicated that the only-child group yielded lower scores. In the GLM analysis, after adjusting for neglect, no significant associations were observed (all $p > 0.05$). However, post adjustments for psychological abuse, the only-child group also recorded lower scores in depression, stress, and negative affect.

Conclusions This study reveals that the only-child adolescents possibly showing better psychological well-being overall in western China. This study's findings suggest that, during adolescent development, families and society should pay greater attention to the mental health of non-only children.

Keywords Adolescents, Only child, Mental health, Depressive disorder, Propensity score

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Introduction

The notion of an "only child" can be understood differently, contingent on perspective. From a parental point of view, it denotes those who bear only one offspring throughout their lifetime. From a child's standpoint, it refers to those who do not possess any siblings [1]. China's 30-year one-child policy created a substantial population of only-child families. Despite the policy's official termination at the end of 2015, many families continue to prefer having one child. Given the recent continuous decline in birth rates, it is anticipated that the proportion of only-child family will persistently rise. By the close of 2015, approximately 224.6 million only children existed in China, accounting for 43% of the total number of births during that period [2], and it keeps on growing [3, 4]. Projections suggest that by 2050, the number of only children in China will reach 303 million. As such, the mental health of only children has increasingly become a focus of societal and familial attention. Research on the mental health of only children can provide some suggestions for the family education of the next generation.

The World Health Organization (WHO) defines adolescence as spanning the ages of 10 to 19 years [5]; and mental health is a significant aspect of adolescent health [6]. The *State of the World's Children 2021* report released by the United Nations Children's Fund (UNICEF) highlights that over the last three decades, mental health issues among adolescents have been surging globally, with over 13% of adolescents diagnosed with mental disorders according to the WHO's categorization. Anxiety and depression constitute approximately 40% of these diagnosed mental disorders, with depression becoming one of the primary causes of disability amongst adolescents, and suicide ranking as the fifth most prevalent cause of adolescent mortality. The economic burden induced by the mental health of children and adolescents totals an estimated $387.2 billion per annum [7]. Globally rising adolescent mental health issues are also of particular concern in China, where the incidence of psychological and behavioral issues among adolescents has been ascending in recent years, which has become a significant public health concern. Recent survey data from China suggests an overall prevalence rate of mental disorders among children and adolescents at 17.5% [8], with the "China National Mental Health Development Report (2021–2022)" indicating that adolescents are at higher risk of depression compared to adults. In this survey, around 14.8% of surveyed adolescents were identified as at risk of depression, with 4% classified as severe depression and 10.8% as mild depression. Furthermore, the general mental health level of adolescents in western or rural areas was found to be lower [9].

While abundant literature has compared the only child population in China, the research findings exhibit inconsistency [10]. Currently, there are three viewpoints concerning the mental health of only children. The first viewpoint proposes that only children possess inferior mental health compared to non-only children: studies by Huang, Falbo, and others have detected that only children endure heightened levels of psychological distress [11, 12]; Cheng et al., identified a higher prevalence of anxiety and depression among only children [13]; Wang et al., observed a higher incidence of non-suicidal self-harm behavior among only children [14]. The second viewpoint argues that there is no discernible difference in mental health between only children and non-only children: a meta-analysis executed by Zhang et al., involving 49 domestic studies supports this conclusion [15]; Wu et al., detected no association between those of only-child status and the urban university freshmen regarding mental health [16]. The third viewpoint suggests that the mental health of only children surpasses that of non-only children: Huang et al., discovered that non-only children exhibited more extensive negative emotions, physical symptoms, interpersonal difficulties, and fewer positive emotions [10]. Liao et al., performed a meta-analysis and determined that the mental health of only children was superior to that of non-only children [17].

The marked discrepancies across previous studies could be attributed to several factors beyond the attribute of only-child status, including gender, place of origin, family economic status, experiences of being left behind, parents' marital status, and parental educational attainment, etc [16]. Therefore, traditional comparative methods using simple means (such as *t*-tests and analysis of variance) between only-child and non-only-child individuals may introduce bias, as these methods neglect the "non-random sample selection problem" crucial for making causal inferences in social science research [18]. To overcome the limitations of prior studies regarding statistical methodology, this study rigorously employs PSM, which is an alternative strategy for random allocation based on the counterfactual inference model proposed by Paul and Rubin in 1983 [18], estimates the propensity scores for all units in the treatment group and control group using a logistic or probit model. The process then identifies control group units that match the treatment group units based on predefined rules, aiming to minimize the impact of confounding factors on the results. In this study, PSM is used to strike a balance between confounding factors in the only child and non-only child groups. This method addresses the issue of non-random sampling to a certain extent, thereby allowing for a relatively pure study of the relationship between only-child status and children's mental health.

The resource dilution model suggests that as the number of children increases, the resources available to each child will decrease [19, 20]. In contrast to non-only

children, only children receive more resources, encompassing material and emotional support, resulting in a generally superior parent-child relationship in only-child families [21]. Research indicates that this advantage of only children has a positive impact on their mental health [10]. Considering these aspects, and under the premise of controlling for potential confounding factors via PSM, we propose the following two hypotheses regarding the mental health status of adolescents in western China: Hypothesis 1: There are statistically significant differences in the mental health status between adolescents from only-child families and those from non-only-child families. Hypothesis 2: Adolescents from only-child families may have better mental health status.

Methods

Participants and procedures

This study is a cross-sectional analysis intended to assess the mental health status of adolescents. For this analysis, a two-tailed test was required with an alpha (α) value set at 0.05 and a permissible error (δ) of 0.01. Based on the latest survey data from China, which revealed an overall prevalence rate of mental disorders among children and adolescents at 17.5% [8], the minimum required sample size was calculated as 5,547 cases using PASS15 software. Accounting for potential data losses due to a projected 20% data missing rate, the minimum sample size was adjusted to 6,934 cases.

$$n = \frac{z^2_{\alpha/2} \cdot p \cdot (1-p)}{\delta^2}$$

This study used random cluster sampling, conducted between November 2021 and May 2022, targeting 33 schools. Adolescents aged 10–19 years from 33 schools in western China were randomly selected as the study population, stratified by economic status. The inclusion criteria are as follows: students aged 10–19 years who are currently enrolled in middle school, those without intellectual disabilities or severe somatic diseases, and those who can independently complete the survey questionnaires. The exclusion criteria are as follows: students or their parents who refuse to participate in the questionnaire survey, and those who refuse to sign the informed consent form. A total of 7,359 questionnaires were distributed, and after removing those with missing values, blatant contradictory responses, and fabricated responses, 6,997 valid questionnaires were included in the analysis, resulting in a questionnaire validity rate of 95.1%. To ensure data quality, Mental health professional students, trained in questionnaire administration, collected the data. During data collection, the data collectors provided consistent guidance to the participants on how to complete the questionnaires. The questionnaires were handed out at the class level, with researchers and class teachers overseeing and guiding the questionnaire completion process in each class. Informed consent was obtained from all participants before they completed the questionnaires, and consent forms were signed. In the data cleaning phase, to achieve better data quality, we directly deleted the data entries with missing values.

This study was conducted on a voluntary and confidential basis, and all procedures adhered to international ethical standards and the updated Helsinki Declaration of 2008. The study received approval from the Ethics Committee of North Sichuan Medical College under the project number NSMC [2021]53. The study also passed the review of the Chinese Clinical Trial Registry with the registration number ChiCTR2200058160.

Measures

Socio-demographic data

The collected socio-demographic information in this study includes age, gender, grade level, previous experience of being left-behind, future prospect of being left-behind, current residential status, dependent status, birthplace, parental educational attainment, parental occupation, dormitory residency (live on campus, yes or no), and only-child status.

The depression anxiety stress scale (DASS-21)

Developed by Lovibond et al. in 1995, the DASS-21 is used to differentiate and define common mood disorders such as depression, anxiety, and stress [22]. It serves as a psychometric measure to assist in clinical diagnosis and provides a rapid and effective screening tool for related research. The Simplified Chinese version of DASS-21 was revised by Wen et al. in 2012 for the Chinese population [23]. The scale consists of three subscales: depression, anxiety, and stress. Higher scores on each subscale indicate a stronger experience of the corresponding emotion. The Cronbach's alpha coefficient for this study was tested and found to be 0.948.

The Childhood Psychological Abuse and Neglect Scale (CPANS)

Developed by Deng Yunlong et al. in 2005, CPANS is used to measure the psychological abuse and neglect experienced by individuals during childhood [24]. It consists of two subscales: the psychological abuse subscale and the psychological neglect subscale. The psychological abuse subscale reflects the experience of psychological abuse during childhood, including dimensions of scolding, intimidation, and interference, with a total of 14 items. The psychological neglect subscale reflects the experience of psychological neglect during childhood, including dimensions of emotional neglect, educational neglect, and supervision neglect. A higher total score on

CPANS indicates a more severe experience of psychological abuse and neglect during childhood. The Cronbach's alpha coefficient of this study was 0.951.

The Pittsburgh Sleep Quality Index (PSQI)

Developed by the Buysse team in 1989, PSQI is used to evaluate sleep quality over the past month [25]. The scale consists of a total of 24 items, including 19 self-rated items and 5 other-rated items. The 19th self-rated item and the 5 other-rated items are not scored, resulting in a total of 18 items. The scale is composed of seven dimensions: sleep latency, sleep duration, sleep quality, sleep efficiency, sleep disturbances, use of sleep medication, and daytime dysfunction. The total scale score ranging from 0 to 21. A higher total score indicates poorer sleep quality. The Cronbach's alpha coefficient in this study was 0.868.

Chinese version of the Barratt impulsiveness scale (BIS-11)

Developed by Barratt et al. in 1959, the BIS-11 is used to assess impulsivity [26, 27]. The scale consists of three subscales: non-planning impulsiveness, motor impulsiveness, and cognitive impulsiveness. The non-planning and cognitive impulsiveness subscales are reverse-scored. The total score is converted to a range of 0-100 using the provided formula, with higher scores indicating higher levels of impulsivity. The Cronbach's alpha coefficient for this study was tested and found to be 0.922.

Chinese version of the positive affect and negative affect scale for children (PANAS-C)

The original Positive Affect and Negative Affect Scale (PANAS) was developed by Watson et al., in 1988 to assess positive and negative emotions [28]. The PANAS-C, a revised version for children, was developed by Laurent et al., in 1999 to make it more accessible for children with limited language development [29]. The Chinese version of PANAS-C was further revised by Wei Huan, Chen Wei, and others in 2017 [30]. The scale consists of two subscales: positive affect and negative affect. The average score of items within each subscale serves as an index of the participant's emotional evaluation, with higher scores indicating stronger emotional experiences. The Cronbach's alpha coefficient for this study was tested and found to be 0.905.

Statistical analyses

Propensity Score Matching (PSM)

In this investigation, significant differences in demographic characteristics between adolescents of only-child and non-only-child status are observed. To eliminate potential confounding effects on our findings, we employed PSM to balance the baseline features of the two groups [31]. PSM minimizes the mismatched demographic characteristics between the experimental group (only-child status) and the control group (non-only-child status), thereby reducing potential bias in the study outcomes caused by these disparities. Confounders (or covariates) are variables that impact both the outcome and grouping variables [32]. These potential confounders are determined by analyzing relationships between variables and grouping variables, outcome variables, and by considering expert consensus and results from prior studies [18, 33]. In this investigation, ten variables were identified as potential confounders based on their relationships with grouping and outcome variables (Supplementary Tables 1 and 3–5), and previous research. The variables selected include gender, grade level, past experience of being left-behind, future prospect of being left-behind, current residential status, dependent status, birthplace, parental educational attainment, and age. The Logit model was utilized to compute the likelihood of participants being allocated to the only-child group (the propensity score). We then used a matching algorithm to pair each participant from the only-child group with a participant from the non-only-child group who had a similar propensity score, thereby balancing potential confounders between the two groups [18, 31].

In this study, the PSM portion was implemented using the R 4.2.2 packages MatchIt, tableone, and cobalt [34]. The Logit function was chosen for the matching model, and the caliper value was set to 0.2*SD [35, 36], using a 1:1 nearest neighbor matching without replacement. The caliper value refers to the range of the difference in propensity scores between two individuals that can be successfully matched. The balance of demographic characteristics after matching was assessed using the standardized mean difference (SMD) [31, 37], which is used to assess the balance of covariates between the treatment group and the control group in PSM. For an adequate balance of matching, the absolute value of SMD was set to less than 0.1 [35, 37, 38], which was standard practice in PSM of manny articles. A dot-plot of the SMD was used to represent the balance of confounders before and after matching (Fig. 1: The absolute value of SMD for all potential confounding factors being less than 0.1 shows the balance of confounding variables achieved post-matching), and a mirrored histogram displayed the distribution of propensity scores between adolescents of only-child and non-only-child status before and after matching (Fig. 2: The degree of symmetry represents the balance of confounding factors between the only-child group and the non-only-child group).

Data analysis

Data analysis was performed using SPSS 26.0 software. Univariable analyses: In the single-variable analyses conducted before and after matching, categorical variables

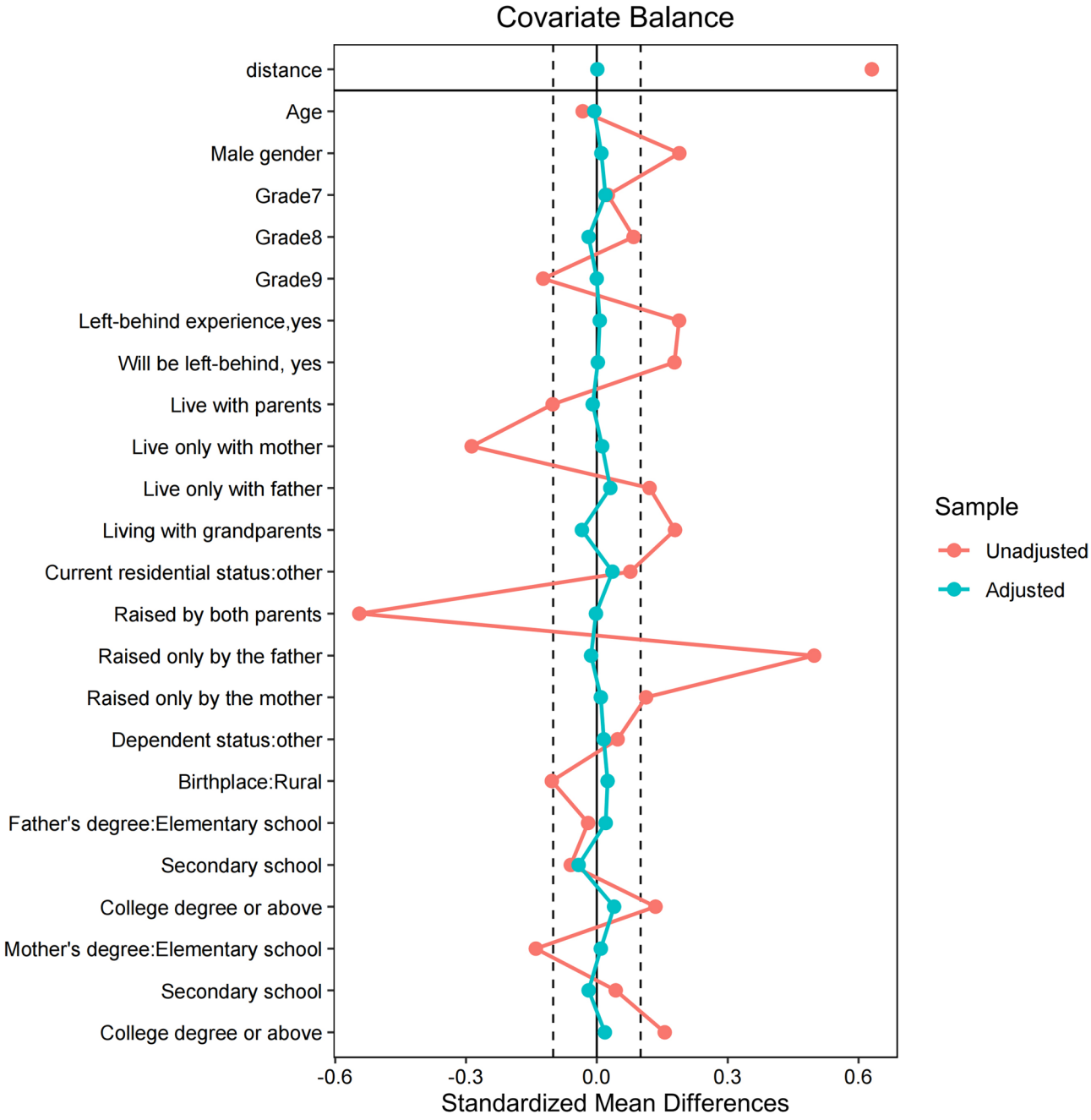

Fig. 1 Description of the SMD for each potential covariate before and after matching. Standardized Mean Difference (SMD) < 10% indicates a relatively good balance (The dotted line represents SMD = 0.1)

were represented with numbers and percentages. Significant statistical differences between adolescents of only-child and non-only-child status were determined using Pearson's Chi-square test. The normality of continuous variables was tested with the Kolmogorov-Smirnov test, and homogeneity of variance was determined with Levene's test. Continuous variables with normal distributions were represented by the mean (M) ± standard deviation (SD), while non-normally distributed variables were represented by the median (quartiles). Comparisons between normally distributed data groups were conducted using the independent samples t-test, while non-normally distributed continuous variables and ordinal variables were evaluated using the Wilcoxon rank-sum test. A two-tailed p-value < 0.05 was considered statistically significant.

Multivariable analyses: Previous studies have indicated a strong association between psychological abuse and neglect during childhood and the mental health of adolescents [39–41]. In the matched sample of this study, a

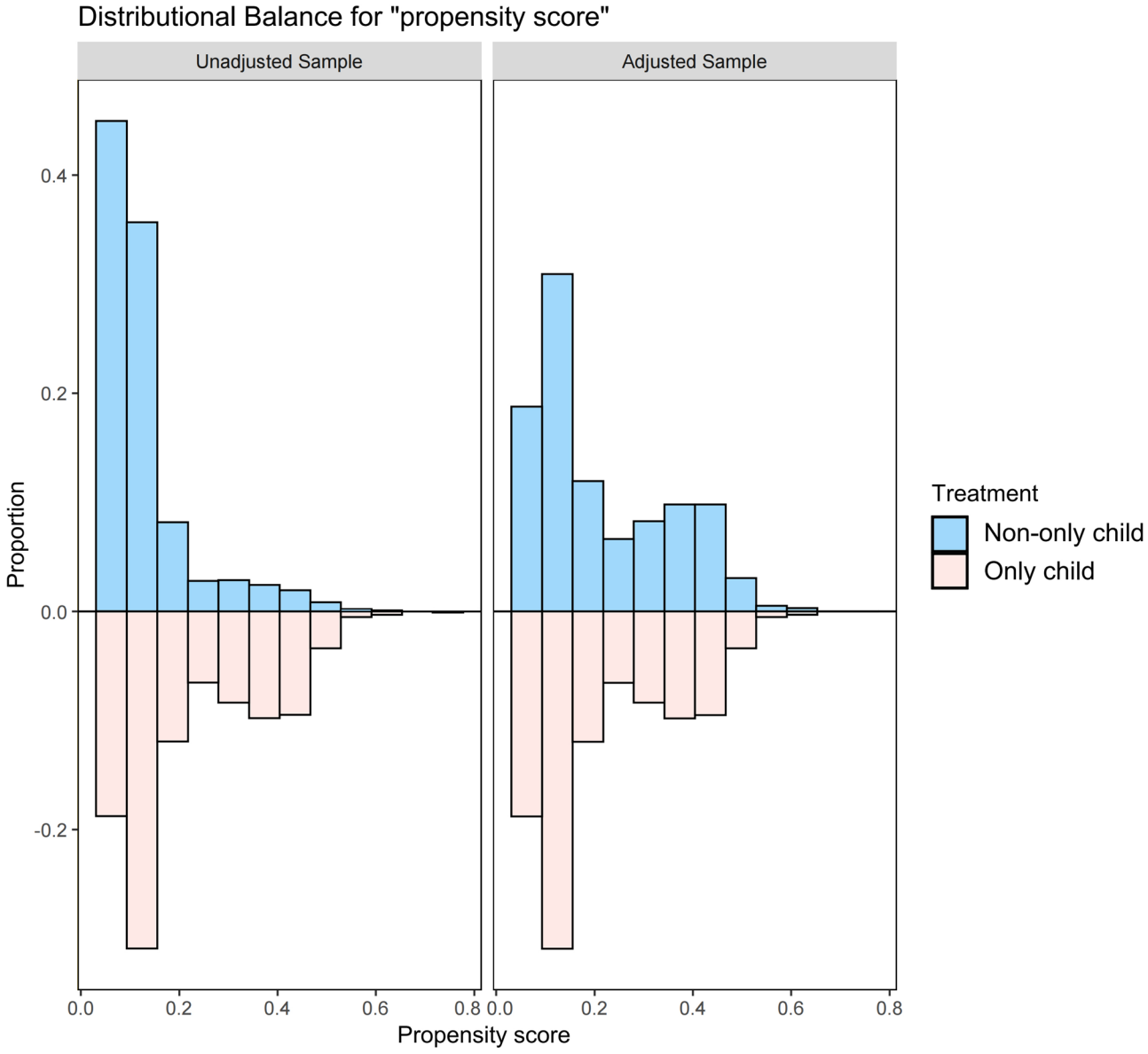

Fig. 2 Distribution of propensity scores before and after matching. The degree of symmetry represents the balance of the data

Generalized Linear Model (GLM) was applied to assess differences in DASS-21, PSQI, and PANAS-C scores between only children and non-only children, following the inclusion of the factors of psychological abuse and neglect.

Results

Demographic and clinical characteristics of the whole sample

In this study, a total of 981 adolescents of only-child status and 6,016 adolescents of non-only-child status participated and completed the required assessments. A statistical examination of the demographic factors disclosed significant disparities between the two cohorts in terms of gender, grade level, previous experience of being left-behind, future prospect of being left-behind, current residential status, dependent status, birthplace, parental educational attainment, parental occupation, dormitory residency (all $p < 0.05$, as shown in Supplementary Table 1, which summarizes the demographic characteristics of the whole sample grouped by only-child status). These findings elucidate considerable demographic discrepancies between the two cohorts.

Propensity score matching

After PSM, 980 only children and 980 non-only children were matched, resulting in a matched study sample comprising 1,960 participants. The propensity scores matched between the two groups demonstrated a

standard deviation of 0.0009, indicating a high degree of balance achieved through the matching process.

Potential confounding variables including gender, grade level, prior experiences of being left-behind, future prospect of being left-behind, current residential status, dependent status, birthplace, parental educational attainment, and age, along with other variables not specified as potential confounders, were evenly balanced between the groups (all SMD < 0.1; see Table 1, which delineates the demographic characteristics of the two matched samples). This suggests the successful matching of potential confounding factors.

Figure 1 portrays the distribution of Standardized Mean Difference (SMD) for each potential confounding variable and their respective subgroups before and after matching. Post-matching, all potential confounding variables and their subgroups achieved satisfactory balance (all SMD < 0.1; refer to Fig. 1; Table 1). Additionally, propensity score distributions became more symmetrical post-matching, indicating improved balance, corroborating enhanced comparability between these groups subsequent to matching (Fig. 2).

Demographic and clinical characteristics of the matched sample

To assess whether potential confounders interacted with only-child status after PSM, we conducted interaction analyses. Using depression, anxiety, and stress scores as dependent variables, we analyzed the interactions between only-child status and each pre-selected confounder in the post-PSM data. Few factors showed significant interactions with only-child status (see Supplementary Table 8). Univariate analysis revealed no significant disparities between the matched only child and non-only child groups in terms of gender, grade level, previous experiences of being left-behind, future prospect of being left-behind, current residential status, dependent status, birthplace, parental educational attainment, and age (all $p > 0.05$, all SMD < 0.1; Table 1). And the results showed a significant association between being an only child and lower scores on depression, stress, and negative emotions.

In terms of psychological measures, the only-child group manifested notable differences when juxtaposed with the non-only-child group. Specifically, within DASS-21, only children scored significantly lower in depression, anxiety, and stress compared to non-only children (all $p < 0.05$; see Table 2, which delineates the clinical characteristics of the matched sample grouped by only-child status). In CPANS, the only-child group exhibited statistically significant differences in the neglect dimension (Z = -2.008, $p = 0.037$, r= -0.05; Table 2), particularly in the facet of emotional neglect (Z = -2.205, $p = 0.027$, r= -0.047; Table 2). Moreover, in PANAS-C, the only-child group scored significantly lower in the negative affect dimension (Z = -2.236, $p = 0.025$, r= -0.051; Table 2). However, no substantial disparities were discerned between the groups in other dimensions of the CPANS, PANAS-C, PSQI, and the Chinese version of the Barratt Impulsiveness Scale (all $p > 0.05$; Table 2). Further comparative analysis of rank means between the two groups underscored that the only-child group demonstrated lower scores in depression, anxiety, stress, psychological neglect, total neglect, and negative affect (refer to Supplementary Table 6, which summarizes the rank mean before and after matching between the only child and non-only child groups).

Multivariable analyses

While initial univariate analyses identified significant differences in depression, anxiety, and stress, multivariable analyses revealed that these differences persisted even after adjusting for psychological abuse. Throughout the phase of adolescent development, significant correlations were observed between experiences of psychological abuse and neglect and respective scores in the domains of anxiety, depression, stress, sleep quality, impulsivity, and both positive and negative affect (all $p < 0.001$; refer to Table 3, which delineates mental health symptoms and PSQI and Only child by GLM after controlling for Experienced psychological abuse). In the generalized linear models (GLM), we incorporated experiences of psychological neglect and abuse as covariates to scrutinize whether the status of only-child status continued to be significantly associated with scores of depression, anxiety, stress, sleep quality, impulsivity, and affect, after adjusting for neglect and abuse. After adjusting for psychological abuse, only-child status was significantly linked to lower depression (b = -0.711, 95% CI: -1.296-0.126, $p = 0.017$; Table 3), stress (b = -0.674, 95% CI: -1.291-0.057, $p = 0.032$; Table 3), and negative affect scores (b = -0.932, 95% CI: -1.832-0.031, $p = 0.043$; Table 3). This infers that only-child status could potentially serve as a protective factor in these domains, when compared to non-only child status. However, subsequent to adjusting for neglect, only-child status did not demonstrate significant correlations with the aforementioned outcome variables (all $p > 0.05$; refer to Supplementary Table 7, which summarizes mental health symptoms and PSQI and Only child by GLM after controlling for Experienced neglect). These results suggest that only-child status may be a protective factor against specific mental health challenges.

Discussions

This pioneering study explores the effect of only-child status on the mental health of adolescents in Western China, employing PSM to mitigate bias. After analyzing the pre-PSM sample ($n = 6,997$), we found significant

Table 1 Demographic characteristics of the matched sample grouped by only-child status ($N = 1960$)

Variables	Non-only child		Only child		Univariable analyses			SMD
	($N_1 = 980$)		($N_2 = 980$)					
	n	%	*n*	%	c2	df	*p*	
Male gender	563	57.4	568	58	0.052	1	0.819	0.01
Grade								
Grade7	324	33.1	333	34	0.222	2	0.895	0.021
Grade8	413	42.1	404	41.2				
Grade9	243	24.8	243	24.8				
Left-behind experience, yes	654	66.7	657	67	0.021	1	0.886	0.007
Will be left-behind, yes	468	47.8	469	47.9	0.002	1	0.964	0.002
Current residential status								
Live with parents	250	25.5	246	25.1	1.484	4	0.829	0.055
Live only with mother	125	12.8	129	13.2				
Live only with father	65	6.6	73	7.4				
Living with grandparents	479	48.9	462	47.1				
Other	61	6.2	70	7.1				
Dependent status								
Raised by both parents	502	51.2	501	51.1	0.205	3	0.977	0.02
Raised only by the father	314	32	308	31.4				
Raised only by the mother	50	5.1	52	5.3				
Other	114	11.6	119	12.1				
Birthplace								
City	309	31.5	298	30.4	0.289	1	0.591	0.024
Rural	671	68.5	682	69.6				
Father's educational attainment								
Elementary school	272	27.8	281	28.7	1.219	2	0.544	0.05
Secondary school	633	64.6	613	62.6				
College degree or above	75	7.7	86	8.8				
Mother's educational attainment								
Elementary school	300	30.6	304	31	0.25	2	0.883	0.023
Secondary school	602	61.4	593	60.5				
College degree or above	78	8	83	8.5				
Father's occupation								
Farmer	226	23.1	213	21.7	2.183	3	0.535	0.067
Worker	631	64.4	660	67.3				
Businessman	100	10.2	88	9				
Public servant	23	2.3	19	1.9				
Mather's occupation								
Farmer	263	26.8	247	25.2	1.571	3	0.666	0.057
Worker	602	61.4	620	63.3				
Businessman	96	9.8	99	10.1				
Public servant	19	1.9	14	1.4				
Live on campus, yes	553	56.4	579	59.1	1.414	1	0.234	0.054
	M ± *SD*		M ± *SD*		*t*	*df*	*p*	SMD
Age	13.97 ± 0.963		13.97 ± 1.014		0.137	1958[a]	0.891	0.006

Bold values indicate statistically significant *p* values ($p < 0.05$)

df: degree of freedom, SD: standard deviation, SMD: Standardized Mean Difference

SMD < 0.1 indicates a relatively good balance in PSM

[a]: unpaired t test

group differences between only children and non-only children in factors other than age, including potential confounders (all $p < 0.05$; Supplementary Table 1). The data also exhibited poor balance (Figs. 1 and 2). However, after re-analyzing the post-PSM sample ($n = 1,960$), we observed that group differences between only children and non-only children in all factors, including potential confounders, were effectively controlled (all $p > 0.05$;

Table 2 Clinical characteristics of the matched sample grouped by only-child status ($N = 1960$)

Variables	Non-only child ($N_1 = 980$)	Only child ($N_2 = 980$)	Univariable analyses	
	Median (IQR)	Median (IQR)	Z	*p*
Score of depression	4(0–12)	4(0–10)	-2.168	**0.03**
Score of anxiety	4(2–12)	4(0–11)	-2.212	**0.027**
Score of stress	6(2–14)	6(2–12)	-2.196	**0.028**
Scold	4(1–7)	4(1–7)	-1.584	0.113
Intimidation	3(1–6)	3(1–6)	-1.459	0.145
Interference	3(1–6)	2(1–6)	-0.304	0.761
Total score of psychological abuse	10(4–19)	10(4–17)	-1.138	0.255
Emotional neglect	6(2–12)	5(1–11)	-2.205	**0.027**
Education neglects	2(0–5)	2(0–5)	-1.611	0.107
Physical neglect	2(0–5)	2(0–5)	-1.239	0.215
Total score of neglect	11(3–22)	9(3–20)	-2.088	**0.037**
Total score of the PSQI	4(2–7)	4(2–6)	-1.464	0.143
Total score of unplanned urges	50(32.5–62.5)	50(32.5–62.5)	-0.102	0.918
Total score of Impulsive behavior	30(15–45)	30(15–45)	-0.468	0.64
Total score of cognition	47.5(32.5–60)	47.5(35–60)	-1.014	0.311
Total score of BIS	43.333(31.25–52.5)	44.167(31.667–53.333)	-0.489	0.625
Total score of positive affect	36(30–42)	36(28–43)	-0.403	0.687
Total score of negative affect	29(20–36)	27(20-35.5)	-2.236	**0.025**

Bold values indicate statistically significant *p* values ($p < 0.05$)

M: mean, IQR: interquartile range. Wilcoxon rank-sum test

PSQI: Pittsburgh sleep quality index, BIS: Barratt Impulsiveness Scale

Table 3 Mental health symptoms and PSQI and only child by GLM after controlling for experienced psychological abuse (in the matched sample, $N = 1960$)

Outcome variables	Corelated factors	Wald χ2	b	95% CI	*p*
Score of depression	Only child	5.672	-0.711	(-1.296~-0.126)	**0.017**
	Experienced psychological abuse	756.813	8.464	(7.861 ~ 9.067)	< 0.001
Score of anxiety	Only child	3.289	-0.525	(-1.093 ~ 0.042)	0.07
	Experienced psychological abuse	729.755	8.068	(7.482 ~ 8.653)	< 0.001
Score of stress	Only child	4.578	-0.674	(-1.291~-0.057)	**0.032**
	Experienced psychological abuse	665.486	8.371	(7.735 ~ 9.008)	< 0.001
The total score of the PSQI	Only child	0.462	-0.096	(-0.372 ~ 0.181)	0.497
	Experienced psychological abuse	559.436	3.441	(3.155 ~ 3.726)	< 0.001
The total score of BIS	Only child	0.601	0.528	(-0.807 ~ 1.863)	0.438
	Experienced psychological abuse	285.738	11.871	(10.494 ~ 13.247)	< 0.001
The total score of positive affect	Only child	0.354	-0.262	(-1.126 ~ 0.601)	0.552
	Experienced psychological abuse	50.922	-3.241	(-4.131~-2.351)	< 0.001
The total score of negative affect	Only child	4.113	-0.932	(-1.832~-0.031)	**0.043**
	Experienced psychological abuse	634.848	11.932	(11.004 ~ 12.861)	< 0.001

Bold values indicate statistically significant *p* values ($p < 0.05$)

b: unstandardized regression coefficient, *CI*: confidence interval

PSQI: Pittsburgh sleep quality index, BIS: Barratt Impulsiveness Scale

Table 1). The post-PSM data demonstrated excellent balance (Figs. 1 and 2). This control of group differences due to potential confounders makes the two groups more comparable in subsequent statistical analyses. Prior to PSM, there were no significant differences in mental health between only-child and non-only-child adolescents in the raw data. However, only-child adolescents might be more prone to impulsivity compared to non-only-child adolescents (Supplementary Table 2). Nevertheless, after PSM - once potential confounding factors were accounted for - a significant difference in mental health surfaced between only children and non-only children. Only children possibly demonstrated superior mental health outcomes, and non-only children who suffer from psychological abuse were more likely to experience negative emotions.

This study found that there were differences in the research results before and after controlling for potential confounding factors through PSM. After controlling for confounding factors, the overall mental health of the only-child group may be better. Before PSM, there were no significant differences between the only-child and non-only-child groups in terms of depression, anxiety, stress, psychological abuse, neglect, sleep quality, and negative emotions. Differences were only observed in the BIS-11 scale, where only children may be more impulsive than non-only children (Supplementary Table 2). However, this difference in impulsivity does not seem to be significant, as no clear statistical differences were found in the three subscales of the BIS-11. In a univariate analysis of the PSM-adjusted data, considerable differences were uncovered between the two groups in terms of depression, anxiety, stress, neglect, particularly emotional neglect, and negative affect (Table 2). These findings support Hypothesis 1, highlighting significant mental health differences at the statistical level. However, in the data analysis after PSM, no significant statistical differences were found in sleep quality, impulsivity scores, and other aspects (Table 2). This indicates that the attribute of being an only child does not have a significant impact on the sleep quality and impulsivity of adolescents. Additionally, an inter-group comparison of rank means revealed that only children scored lower in depression, anxiety, stress, psychological neglect, total neglect, and negative affect relative to non-only children (Supplementary Table 6). This further supports Hypothesis 2, proposing that only children potentially have superior mental health outcomes compared to non-only children. However, we did not observe the same results for the BIS-11 total score before applying PSM (Supplementary Table 6). Additionally, even minor differences can have significant social value in large populations, particularly in the realm of adolescent education. Furthermore, in a multifactor generalized linear model (GLM) analysis, upon adjustment for psychological abuse, only-child status was associated significantly with lower scores of depression, stress, and negative affect (Table 3), thereby reinforcing Hypothesis 2. These research findings will provide valuable recommendations for families and society in the area of adolescent mental health education. During the growth process of adolescents, non-only-child families need to pay more attention to the mental health of each child. Family members should allocate more time to communicate with non-only children, provide as much companionship and care as possible, offer more affirmation, support, and encouragement, and at the same time, reduce potentially abusive behaviors such as scolding, threatening, and interfering. Schools and society should also give more attention to the mental health of non-only-child adolescents, provide help within their capabilities, and offer correct guidance. In addition, the government can also implement policy-based assistance measures within its capabilities to support families with non-only children. Previous only child status-relevant studies exploring the mental health have drawn conclusions similar to this study. Huang et al. identified non-only children as having poorer overall mental health, and sibling presence was a strong predictor of depression in adolescents [10]. A meta-analysis of 319 studies by Liao et al. found that only-child status demonstrated better mental health outcomes compared to non-only-child status among adolescents [17]. Utilizing PSM, Liu et al. examined the cognitive and non-cognitive outcomes of only children and found their peer relationships and emotional regulation to be significantly superior [42]. Cao et al. found that, during the COVID-19 pandemic, non-only children were more likely than only children to experience anxiety and depression [43]. These studies echo the findings of our research. The Resource Dilution Model proposes that as the number of children in a family increases, resources available per child decrease [19, 20]. In addition to the Resource Dilution Model, the Quantity-Quality Model offers another explanation for these findings. This model suggests that fewer children in a family allows each child to access more resources, enhancing care quality [44, 45]. In China, parents invest more emotional and material resources in their only child, which is associated with higher levels of family intimacy, better parent-child relationships, and higher levels of family functioning [10]. These positive family relationships have a beneficial impact on the mental health of only children [46–48], possibly explaining why only-child status group show better mental health outcomes than another group.

Nevertheless, we have to confront a problem: the conclusions of this study seem to differ from those encountered in clinical practice. In clinical work, it appears that only-child patients with emotional and behavioral disorders are more common. We have also carefully considered the reasons for these differences. The most likely reason is that hospitalized patients have already undergone a selection process, whereas this study was conducted in the general population, which naturally leads to certain differences. Additionally, some of these differences may arise from the limitations of the matching methods used in this study. Factors such as the personality traits of the subjects, family support, social support, and the quality of friendships may all influence their mental health; however, these were not accounted for in this study. Moreover, clinical diagnosis is comprehensive, while scales are merely auxiliary tools. We must acknowledge the inherent limitations of scales in accurately reflecting the disease.

Of course, some studies report diverging findings. Yuan et al. discovered that only-child status did not influence emotional adaptation [49]. Wu et al. reported that only-child status had no impact on the mental health of urban university freshmen, but for those from rural areas, having siblings correlated with better mental health outcomes [16]. Several reasons could explain these discrepancies. First, these studies targeted different populations; while our study focused on adolescents, the aforementioned studies examined children and university students, respectively. Some researchers have used the ecological systems theory to explain the dynamic nature of the relationship between only-child status and mental health outcomes [17, 50]. Changes in time and culture are crucial variables influencing individual development [51, 52]. On the other hand, individuals are not stationary and passively influenced by their environment. Therefore, although all the studies focus on the relationship between being an only child and mental health, they have yielded different results. These differences may be related to various factors such as individual cognition, family circumstances, and social support. These are also areas that we can continue to explore in depth in future work. Instead, they continuously change with age and actively adapt and adjust to the environment as part of their development. Second, differences in assessment tools and statistical methods could be factors. The two studies cited above used PSM to explore the relationship between only-child status and mental health outcomes, but employed different sampling methods. One used convenience sampling, and the other set the radius matching value to 0.00001, diverging from the generally recommended threshold of 0.2 * SD. Therefore, sample limitations and potential effects of overmatching should be considered when interpreting these results. The method of convenience sampling significantly impacts the representativeness of the data concerning the mental health of the entire population. The overly stringent caliper value can easily lead to the loss of some key data, further reducing the amount of successfully matched data. This approach weakens the representativeness of the matched data, thereby causing over-matching error. Therefore, adopting the current mainstream literature recommendation of setting the caliper value at 0.2 * SD is the best choice.

Strengths and limitations

A key limitation of this observational study is the inability to randomize participants into only-child or non-only-child groups using a randomized control method. However, the researcher aimed to enhance control over potential confounding factors, such as gender, age, residential environment, and parental education, by adopting the PSM approach in this study. This approach allows for effectively matching individuals with similar demographic characteristics. The strength of this study lies in its class-based design and the use of PSM, ensuring a robust analysis. Consequently, this methodology significantly enhances the accuracy and authenticity of the study findings. Furthermore, the application of PSM methods in investigating mental health among adolescent populations is relatively uncommon, making this study a valuable and pioneering endeavor.

This study's limitations rest primarily on its cross-sectional design, which precludes drawing conclusions about the evolution of mental health outcomes among only-child adolescents over time. Also, the reliance on self-reported data introduces the risk of recall bias. Moreover, the reliability of PSM depends on the observed covariates; however, it's likely some variables were omitted in the initial observational study design, leading to selection bias. Future studies should strive to include a more comprehensive range of demographic data to reduce the inherent selection bias in PSM. Longitudinal investigations utilizing a two-way panel design could illuminate changing trends in the mental health outcomes of only-child adolescents over time. Further, analyzing the relationship between birth order and mental health outcomes among non-only-child adolescents could yield valuable insights.

Conclusions

This study reveals statistically significant disparities in the mental health of only-child and non-only-child adolescents in western China, with the only-child group possibly showing better psychological well-being overall. More precisely, it pertains to the emotional and behavioral aspects of mental health. However, due to the geographical limitations of the sampling area, it is relatively difficult to predict the potential relationship between the only-child status and adolescent mental health on a national scale.

Western rural China, representing remote rural areas with economic and social conditions that are relatively underdeveloped compared to the eastern and coastal regions, also presents a lower overall education level. Western China, predominantly rural, is shaped by the deeply ingrained notion of "raising children for old age," leading many families to have more than one child. Consequently, a large proportion of non-only child populate these areas. Unlike only children, children in non-only-child families may experience an unequal distribution of family resources, such as emotional support, financial expenditures, and time spent together. The presence of these imbalances can easily lead to reduced family intimacy and poorer parent-child relationships, thereby having a negative impact on the development of adolescents' mental health. The results of this study suggest that, to minimize the incidence of mental health issues among

adolescents, families and society should pay more attention to the mental health of non-only-child adolescents during the growth process of adolescents.

Although the results of this study differ from some findings of previous scholars and have certain limitations, the recommendations proposed by this study for adolescent mental health education in the current context are valuable.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12889-025-23383-y.

Supplementary Material 1

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Author contributions
Jiaming Luo and Jinlong He: Study Design. Jing Luo, Cen Lin, Yuhang Wu, Lu Pan, Yuqin Song, Yu Cen, Jiayu Zhao, Shiya Gou, Nianjie Wang, Yao Wang, and Lei Tang: Collection of data. Jinlong He and Yunling Zhong: Analysis and interpretation of data. Jiaming Luo, Jinlong He, and Yunling Zhong: Drafting of the manuscript. Jiaming Luo, Jinlong He, Yunling Zhong, Jing Luo, and Cen Lin: Critical revision of the manuscript. Yuqin Song: Subsequent revision and data re-analysis. All authors read and approved the final manuscript.

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Data availability
The datasets used and the research protocol that support the fndings of this study are available on request from the corresponding author, Jiaming Luo. The data are not publicly available due to their containing information that could compromise the privacy of research participants.

Declarations

Ethics approval and consent to participate
This study was conducted on a voluntary and confidential basis, and all procedures adhered to international ethical standards and the updated Helsinki Declaration of 2008. The study received approval from the Ethics Committee of North Sichuan Medical College under the project number NSMC [2021]53, and written informed consents had been obtained from the students and their parents. The study also passed the review of the Chinese Clinical Trial Registry with the registration number ChiCTR2200058160.The study involved middle high school students and was questionnaire-based, so written informed consent was obtained from the participants and their legal guardians/next of kin. Detailed information about the research, including purpose, procedures, potential risks and benefits, and confidentiality measures for privacy protection, was given to participants before the questionnaire. Furthermore, participants were clearly informed that participation was voluntary and they could withdraw at any time without consequences.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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