RESEARCH

Variations in the association between adverse childhood experiences (ACEs) and depression by age at first occurrence of ACEs

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Abstract

Background Adverse childhood experiences (ACEs) are known to be associated with depression. However, the extent to which such association varies by age at the first occurrence of ACEs remains unexplored. The objectives of this study are: (1) To describe the association between ACEs and depression among university students in China, and; (2) to assess the extent to which the mentioned association varied by age at first ACE.

Methods We conducted a self-administered survey among university students in southern China and analyzed the data using descriptive statistics and multivariate logistic regression.

Results We found significant associations between ACEs and depression prevalence, particularly when comparing students with three or more ACEs vs. students with no ACEs (62% vs. 36%; Adjusted OR = 3.49; 95% CI = 1.99, 6.12). Stratified analyses showed that the association was particularly strong among students who first experienced ACEs at age 0–6 years (66% vs. 36%; Adjusted OR = 4.05; 95% CI = 1.90, 8.59), but was non-significant among those who first experienced ACEs at age 13–18 years (31% vs. 36%; Adjusted OR = 0.99; 95 CI = 0.24, 4.08).

Conclusion The strength of the associations between ACEs and depression varied by the age at first ACE. However, the cross-sectional study design, potential information bias, and lack of generalizability should be considered as caveats in the interpretation of the study findings.

Keywords Adverse childhood experience, Depression, Age, University students

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Background

Adverse childhood experiences (ACEs) refer to the negative events that occur in childhood and cause harm or threat to individuals' mental and physical health [1, 2]. ACEs are a common cause of adult depression [3], as per a large number of studies [3–6]. Investigators have described variations in the association between exposure to ACEs and depression by gender and race/ethnicity [7] across states [8]. However, few studies have assessed variations in the association between ACEs and depression by the age at which the ACEs first occurred.

The biopsychosocial diathesis-stress model suggests that depression is determined by bio-genetic,

psychological, and societal factors [9]. According to John Bowlby's attachment theory, infants may develop a secure attachment style when their attachment partners during early childhood are available, sensitive, and responsive to their attempts to seek intimacy [10]. Warm, consistent, and safe environments for children to develop secure attachments can set the stage for critical developmental skills [11]. Previous studies among children aged under 6 years found an association between ACEs and mental health issues [12] with a possible dose-response relationship between the number of ACEs and adverse mental health outcomes [13]. A study among older children also yielded similar results [8]. However, previous studies did not include adults as participants and did not assess variation in the association between ACEs and mental health outcomes by age at the occurrence of the first adverse event [14, 15]. Considering that early childhood is a particularly sensitive period for the development of mental health symptoms [16], we hypothesize that the earlier ACEs occur in life, the greater the likelihood of developing depression in adulthood.

The age of traditional university undergraduate students (18–24 years) overlaps with the transition from late adolescence to young adulthood. Depression is a mental health issue that commonly occurs among undergraduate students. Undergraduate students who experienced ACEs are more likely to experience depression and depressive emotions than the students without ACEs [17–19]. However, the extent to which the association varies by the age at which ACEs first occurred is largely unexplored. Based on the above-mentioned theoretical framework, we hypothesize that the association between ACEs and depression is stronger when the event first occurs during early childhood (age 0–6 years) than during later childhood (7–12 years) or adolescence (13–18 years). Such data can provide key basic information for prioritization and resource allocation by stakeholders in public health, school and university mental health, and clinical therapists and practitioners. Thus, the objectives of this study are: (1) to describe the extent to which ACEs are associated with depression, and; (2) to assess the extent to which the mentioned association varies by age at the first occurrence of the ACE.

Methods
Study design and setting
We conducted a cross-sectional study using a self-administered questionnaire at a university in China. At the time of the study, the study university had over 20,000 students in various disciplines, including medicine, science, management, engineering, law, and literature.

Study participants and sample size calculation
Our study participants included students enrolled at the study university. The inclusion criteria were: (1) age 18 years or older, and; (2) actively enrolled in any undergraduate program. To address the primary study objective (to assess the extent to which ACEs are associated with depression), we calculated the sample size based on the assumption that 60% of the students with ACEs experienced depression ($p_1 = 0.60$) compared to 40% of students without ACEs who experienced depression ($p_2 = 0.40$) [20]. Using R statistical environment with sample size calculation command for comparison of two proportions in the *epicalc* package [21], we obtained a sample size of at least 107 participants with ACEs and 107 participants without ACEs, or 214 students in total. We then assumed a nonresponse rate of 15% and determined that we would need 125 students in each group, or 250 students in total. We then decided to enlarge the sample size by a factor of 5 to assess the extent to which the association between ACEs and depression varied by age at first ACE. Thus, we obtained a sample size of 1250 persons. We then considered that we were to invite students to participate by online invitation and assumed that an arbitrary 80% of those who received an electronic invitation would not respond to the invitation and complete the survey. Thus, the final sample size was expanded to 1562 students.

Study instruments
Our study instrument was a self-administered questionnaire that included basic characteristics, the adverse childhood experiences (ACEs) scale, and the depression scale. Basic characteristics included gender, grade, presence of siblings in the household, father's occupation, monthly family income, self-reported academic achievement, and history of visiting the university's mental health and counseling services.

Outcome: depression
To identify participants with depression in our study, we used the Chinese version of the Centre for Epidemiologic Studies Depression Scale-Short Form (C-CES-D-SF) [22, 23]. The instrument consisted of 9 self-reported depressive emotion measurement questions with 4-point Likert scales.

The total correlations for all items of the C-CES-D-SF were higher than 0.50, and the internal consistency reliability was 0.86 [22]. Participants with a C-CES-D-SF score of less than 10 were considered as having no depression, whereas those with a score of 10 or higher were considered as having prevalent depression. The cut-off point was based on a recommendation for depression screening in Chinese adults [23].

Exposure: adverse childhood experiences (ACEs)
We measured adverse childhood experiences using a standardized instrument with 10 items [1, 24–26] representing 10 types of ACEs. We used the Chinese version of the instrument [25] for our study. We assigned a score of 1 point for each reported adverse experience and 0 points otherwise, and used the sum of the 10 items as the ACEs score.

Effect modifier: age at first adverse childhood experience
We added a follow-up question to each item in the ACE measurement tool to measure the age at first adverse experience. In the survey, those who answered affirmatively to a question on the lifetime history of a type of ACE were then asked a follow-up question regarding the age when the particular ACE first occurred. For example, a question on emotional abuse was "*Did a parent or other adult in the household often or very often... Swear at you, insult you, put you down, or humiliate you? or Act in a way that made you afraid that you might be physically hurt?*" with the possible responses of "*1. Yes; 2. No*". Those who answered "*No*" were asked about the next type of ACE (i.e., physical abuse). Those who answered "*Yes*" were asked the question "*If "yes", age of onset _____ (years old)*". The English version of the study questionnaire can be found in the supplementary material section.

Data collection
We obtained the list of all undergraduate students from the study university and selected potential study participants using systematic sampling with probability proportional to size (PPS) of enrollment in each discipline. We then sent electronic invitations through the university's e-learning system and invited the students to join the study. Students who responded were invited to a meeting at a meeting hall on campus. At the meeting, research assistants provided students with more information about the study and once again invited them to join the study and answer the questionnaire. Research assistants told the students that they were free to refuse participation with no consequence. Students who decided to participate went to the classroom next to the meeting hall to complete the study questionnaire.

Study participants were asked to sign the informed consent form before filling out the survey questionnaires. However, due to the sensitive nature of the study and to respect the participant's privacy, the participants were allowed to use pseudonyms or refrain from writing their names in the consent form. Study participants were seated adequately apart (one participant in every three seats) to avoid overlooking others' responses. Participants who had finished completing the survey questionnaire were asked to put the survey in an opaque box by themselves. Additional details regarding the sampling, information, and consent processes can be found in a previous publication [27].

Data management and analysis
After receiving the questionnaires, the research assistants examined their completion and validity. Investigators considered questionnaires with less than two-thirds of the questions completed to be unfinished. Investigators excluded 9 participants (0.6%) who did not finish the ACE questionnaire and 52 participants (3.3%) who did not complete the other sections. A research assistant entered data from the remaining questionnaires into an electronic dataset using Microsoft Excel 2016.

We used descriptive statistics to describe the number of ACEs among participants with ACEs and the prevalence of depression with R 4.1.0 software. We used multivariate logistic regression to assess the associations between ACEs and depression with packages (epiDisplay) of R. We also disaggregated participants with ACEs by the age at which the first ACE occurred: 0–6 years, 7–12 years, and 13–18 years. We defined the cut-off points for these age groups based on a combination of Freud's theory of personality development and conventional age categorization in China [28, 29]. The reference group in all logistic regression analyses included those with no history of ACE. In all multivariate analyses, we adjusted the association between ACEs and depression by gender, grade, having sibling, father's occupation, and monthly family income, as we deem these to be psychosocial determinants of mental health in our study population. We also calculated the pseudo R-squared and the likelihood ratio (-2LL) values for the multivariable logistic regression models as a measure of goodness-of-fit in order to compare the models with one another. Generally, the higher the pseudo R-squared values, the better the model will be. The lower the negative likelihood ratio (-2LL) values, the more the model will be able to explain the outcome [30].

Results
We sent 1562 electronic invitations to students, 1371 of whom answered the invitation and 1310 students finished the questionnaires (survey completion rate=84%). Most participants were female and had siblings. Approximately 39% of the participants were above the cut-off point for depression at the time of the survey (Table 1).

We found that students in earlier years of study had a higher prevalence of depression than students in later years of study (Table 2). We also found that students with a previous history of contact with the university's mental health and counseling services were more likely to have depression than students who did not make contact.

We found statistically significant associations between having any ACE and depression (45% vs. 36%; Adjusted

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Table 1 Characteristics of the study participants (*n* = 1310 students)

Characteristics	Frequency (%)
Gender	
Female	722 (60.8%)
Male	517 (39.2%)
Year of study	
First year	232 (18.5%)
Second year	252 (20.1%)
Third year	438 (35.0%)
Fourth year	331 (26.4%)
Sibling	
No	329 (25.2%)
Yes	979 (74.8%)
Family income per month	
Less than 3,000 CNY	85 (6.6%)
3,000 CNY to 5,000 CNY	347 (26.8%)
5,001 CNY to 10,000 CNY	448 (34.5%)
10,001 CNY to 20,000 CNY	296 (22.8%)
More than 20,000 CNY	121 (9.3%)
Father's occupation	
Manual worker	310 (23.8%)
Low skilled workers	202 (15.5%)
High tech workers	109 (8.4%)
Managing worker	219 (16.8%)
Others	464 (35.6%)
History of Contact with University Mental Health and Counseling Services	
Yes	184 (14.1%)
No	1118 (85.8%)
History of ACEs and age at first occurrence (among those with 1 or more ACEs)	
No ACEs	831 (63.4%)
ACE(s) first occurred at age 0–6 years	142 (10.8%)
ACE(s) first occurred at age 7–12 years	222 (16.9%)
ACE(s) first occurred at age 13–18 years	115 (8.8%)
Depression at time of study	
No depression	798 (60.9%)
Depression	512 (39.1%)

Note: Those who refused to answer were excluded from the analyses

Table 2 Association between characteristics of the study participants and depression (row percents)

Characteristics	No depression	Depression	*P-value*
Gender			
Female	437 (60.5%)	285 (39.5%)	0.860
Male	316 (61.1%)	201 (38.9%)	
Year of study			
1st year	123 (53.0%)	109 (47.0%)	
2nd year	143 (56.7%)	109 (43.3%)	0.004
3rd year	274 (62.6%)	164 (37.4%)	
4th year	221 (66.8%)	110 (33.2%)	
Sibling			
No	204 (62.0%)	125 (38.0%)	0.650
Yes	592 (60.5%)	387 (39.5%)	
Family income ($/month)			
< 450	48 (56.5%)	37 (43.5%)	
450–700	215 (62.0%)	132 (38.0%)	
701–1400	265 (59.2%)	183 (40.8%)	0.640
1401–3000	186 (62.8%)	110 (37.2%)	
> 3000	78 (64.5%)	43 (35.5%)	
Father's occupation			
Manual worker	184 (59.4%)	126 (40.6%)	
Low skilled workers	123 (60.9%)	79 (39.1%)	
High tech workers	64 (58.7%)	45 (41.3%)	0.900
Managing Worker	136 (62.1%)	83 (37.9%)	
Others	289 (62.3%)	175 (37.7%)	
History of Contact with University Mental Health and Counseling Services			
Yes	91 (49.5%)	93 (50.5%)	< 0.001
No	703 (62.9%)	415 (37.1%)	

Note: Those who refused to answer were excluded from the analyses

OR = 1.45; 95% CI = 1.13, 1.85) (Table 3). However, the association was particularly strong when comparing students with three or more ACEs vs. students with no ACEs (62% vs. 36%; Adjusted OR = 3.49; 95% CI = 1.99, 6.12). Stratified analyses by age at first ACE (Table 4) showed that the association between having three or more ACEs (vs. no ACEs) and depression was particularly strong among students who first experienced ACEs at age 0–6 years (66% vs. 36%; Adjusted OR = 4.05; 95% CI = 1.90, 8.59) and strong among students who first experienced ACEs at age 7–12 years (64% vs. 36%; Adjusted OR = 3.68; 95% CI = 1.64, 8.22). However, the association between having three or more ACEs and depression was not

statistically significant among students who first experienced ACEs at age 13–18 years (31% vs. 36%; Adjusted OR = 0.99; 95 CI = 0.24, 4.08). Model fit (based on the Pseudo R^2 values) also varied by strata, with the model on the association between ACEs and depression among participants who first experienced ACE at 0–6 years (Pseudo R^2 = 0.046) having better fit than among participants who first experienced ACE at 7–12 years (Pseudo R^2 = 0.020) and participants who first experienced ACE at 13–18 years (Pseudo R^2 = 0.022). The overall patterns of these variations (Fig. 1) seemed to support the notion that age at first experience was an effect modifier in the association between ACEs and depression.

Discussions

We assessed the extent to which adverse childhood experiences (ACEs) are associated with depression, indicating a high risk of depression among university students in southern China. We also assessed the extent to which these associations varied by age at first experience of ACE, as per Freud's theory of personality development,

Table 3 Association between ACEs and depression

Number of ACEs	No depression	Depression	Crude OR (95%CI)	Adj. OR (95%CI) [§]	Pseudo-*R*-squared, and the likelihood ratio (-2LL) for Adjusted OR
None (ACE Score = 0)	525 (64.3%)	291 (35.7%)	1 (*Reference*)	1 (*Reference*)	
ACE Score > = 1	272 (55.5%)	218 (44.5%)	**1.45 (1.15,1.82)**	**1.45 (1.13,1.85)**	Pseudo R² = 0.025 -2LL = -759.72
None (ACE Score = 0)	525 (64.3%)	291 (35.7%)	1 (*Reference*)	1 (*Reference*)	
One ACE (ACE Score = 1)	184 (61.3%)	116 (38.7%)	1.14 (0.87,1.49)	1.13 (0.85, 1.51)	Pseudo R² = 0.027 -2LL = -758.64
Two ACEs (ACE Score = 2)	64 (50.4%)	63 (49.6%)	**1.78 (1.22,2.59)**	**1.67 (1.12, 2.50)**	
Three or more ACEs (ACE Score ≥ 3)	24 (38.1%)	39 (61.9%)	**2.93 (1.73,4.97)**	**3.49 (1.99, 6.12)**	

Note. CI = confidence interval; Bold numbers denote statistical significance at 95% level of confidence

[§]Adjusted for gender, grade, having sibling, father's occupation, family income/month

Table 4 Stratified analyses of the association between ACEs and depression by age at first ACE

Number of ACEs and age at first onset	No depression	Depression	Crude OR (95% CI)	Adj. OR (95% CI)[§]	Pseudo-*R*-squared, and the likelihood ratio (-2LL) for Adjusted OR
No ACE (ACE score = 0)	518 (64.3%)	287 (35.7%)	1 (*Reference*)	1 (*Reference*)	
Participants who experienced ACE, with the first experience at 0–6 years					
One ACE (ACE Score = 1)	50 (58.1%)	36 (41.9%)	1.31 (0.83,2.06)	1.25 (0.77,2.04)	Pseudo R² = 0.046 -2LL = -539.08
Two ACEs (ACE Score = 2)	17 (38.6%)	27 (61.4%)	**2.87 (1.54,5.35)**	**2.96 (1.52,5.77)**	
Three or more ACEs (ACE Score ≥ 3)	12 (34.3%)	23 (65.7%)	**3.48 (1.71,7.11)**	**4.05 (1.90,8.59)**	
Participants who experienced ACE, with the first experience at 7–12 years					
One ACE (ACE Score = 1)	92 (61.7%)	57 (38.3%)	1.12 (0.78,1.61)	1.05 (0.72,1.54)	Pseudo R² = 0.020 -2LL = -598.09
Two ACEs (ACE Score = 2)	41 (58.6%)	29 (41.4%)	1.28 (0.78,2.1)	1.26 (0.74,2.14)	
Three or more ACEs (ACE Score ≥ 3)	10 (35.7%)	18 (64.3%)	**3.27 (1.49,7.18)**	**3.68 (1.64,8.22)**	
Participants who experienced ACE, with the first experience at 13–18 years					
One ACE (ACE Score = 1)	66 (60.6%)	43 (39.4%)	1.18 (0.79,1.78)	1.05 (0.68,1.63)	Pseudo R² = 0.022 -2LL = -522.22
Two ACEs (ACE Score = 2)	13 (54.2%)	11 (45.8%)	1.53 (0.68,3.45)	1.11 (0.42,2.89)	
Three or more ACEs (ACE Score ≥ 3)	9 (69.2%)	4 (30.8%)	0.81 (0.25,2.65)	0.99 (0.24,4.08)	

Note. CI = confidence interval; Bold numbers denote statistical significance at 95% level of confidence

[§]Adjusted for gender, grade, having sibling, father's occupation, family income/month

with the hypothesis that the associations were stronger among those who first experienced ACE before age 7 than among those who first experienced ACE at an older age. Our study findings supported our hypothesis, and the findings provide potentially useful basic information for stakeholders in public health and mental health. The findings also provide insights for clinical therapists and practitioners to consider including age at first occurrence as part of the routine when asking clients to describe their history of ACEs.

The prevalence of depression among our participants was nearly 40%, much higher than the level found in the general population of China at 4.91% [23]. However, our study was conducted during the COVID-19 pandemic, and the prevalence of depression among Chinese university students varied widely with a pooled prevalence of 26% and a range from 1.8–61.9% [31]. Furthermore, depression was defined in our study with a lower cut-off point than the level used for clinical diagnosis. Thus, our study findings should be considered with caution and in the context of the test's sensitivity and specificity.
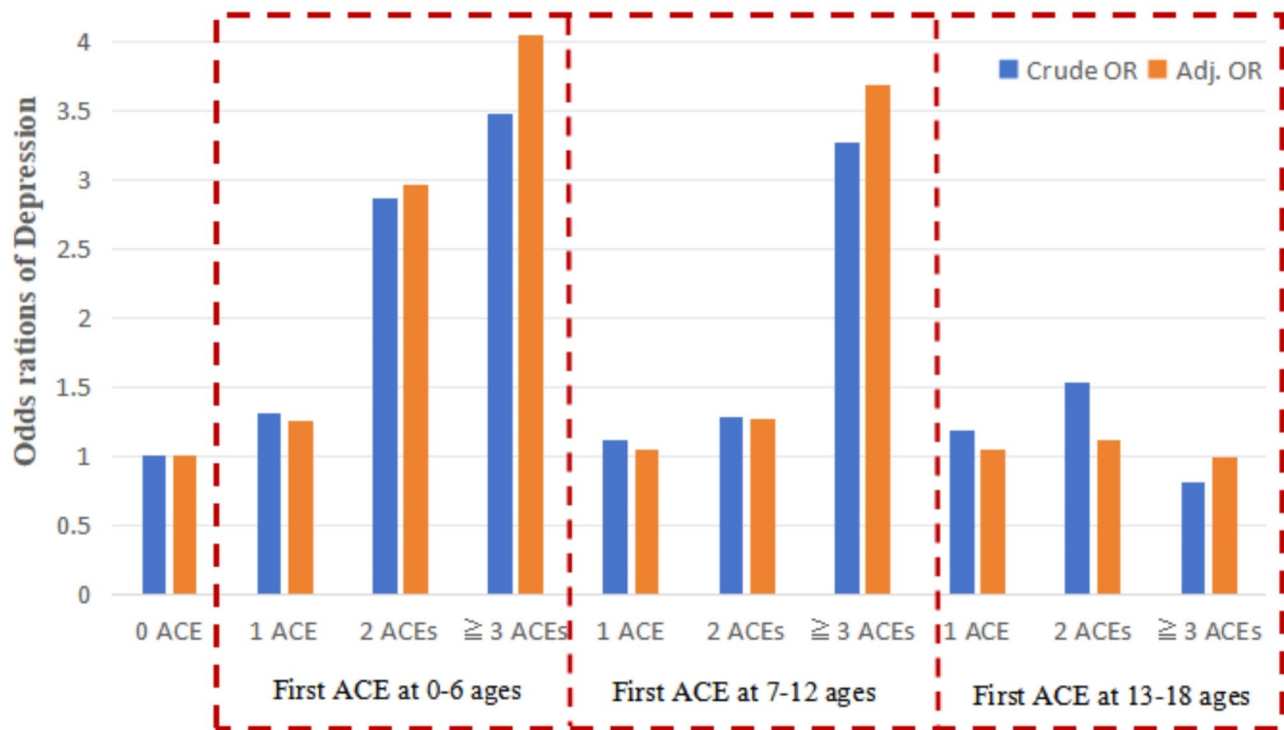
Fig. 1 Odds ratios for the association between the number of adverse childhood experiences (ACEs) and depression, stratified by age at the first occurrence of ACE

We found associations between ACEs and depression among our study participants. Our study findings were similar to those in a previous study, which found that compared to children without ACEs, the odds of risk for social-emotional delay were 2 times higher for those with one ACE, more than 2.5 times higher for those with two or three ACEs, and 6 times higher for those with four or more ACEs [13]. In our study, for those with four or more ACEs, we collapsed those with three or more ACEs in the same group to attain adequate statistical power. It is possible that in studies with larger sample sizes, we will also see an incremental strength between those with three ACEs and those with four or more ACEs.

Our hypothesis on potential effect modification in the association between ACE and depression by age at first experience seemed to be supported by our study findings. The associations were strongest among those who first experienced ACEs at the age of 0–6 years and weaker among those who first experienced ACEs at older ages. The underlying mechanisms for these findings should be further explored using the existing frameworks of psychoanalysis [29, 32, 33]. Future studies should consider collecting in-depth data from those who experienced ACEs at different ages to gain insights regarding psychological trauma [24, 25]. The study findings also supported the notion of informed care [34, 35] and suggested that the assessment of adverse childhood experiences in

counseling should also consider age at first experience to identify those who may be at a particularly elevated likelihood of depression.

Several limitations should be considered as additional caveats in the interpretation of our study findings. First, the cross-sectional study design did not allow us to make causal inferences, and correlation does not imply causation. Second, self-reports of adverse childhood experiences and the age when the experience first occurred may be subjected to both social desirability and inaccurate recall of information, potentially introducing information bias into our study findings. Third, our participants were university students in Guangdong Province, China; thus, the findings of the study might have limited generalizability to other populations. Lastly, as multiple adverse experiences measurement tools exist, the measurement of ACEs in our study should not be considered as an exhaustive measurement of all possible ACEs among our participants.

Conclusion
We described the associations between self-reported adverse childhood experiences (ACEs) and prevalent depression among university students in southern China with disaggregation by age at first occurrence of ACEs. The association between ACEs and depression were stronger among those whose first adverse experience

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occurred at the age of 0–6 years than among those whose first adverse experience occurred at later ages. The study findings can provide basic information and insights for stakeholders in public health, mental health, as well as psychologists and health practitioners. However, the lack of temporality in the measurements, social desirability and recall errors, and lack of generalizability should be considered caveats in the interpretation of the study findings.

Abbreviations
ACEs   Adverse childhood experiences

Supplementary Information
The online version contains supplementary material available at https://doi.org/10.1186/s40359-024-01998-x.

> Supplementary Material 1

Declarations

Ethics approval and consent to participate
We received ethical approval for the study from the Human Research Ethics Committee, Faculty of Medicine, Prince of Songkla University, Hat Yai, Thailand (Approval Number: REC.63-382-18-1) and the Medical Ethics Committee of the Affiliated Hospital of Guangdong Medical University (Approval number, PJ2020-097). Our study complies with the Declaration of Helsinki. Informed consent was obtained from all subjects.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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