

Temporal changes and associated factors of depressive symptoms among primary school students in Eastern China: A repeated cross-sectional study with a nested longitudinal subsample

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Abstract

Introduction

Childhood depression is an important public health concern in China, where rapid socioeconomic changes may contribute to earlier onset. However, evidence specific to primary school students remains limited. This study examined temporal trends and associated factors of depressive symptoms among Chinese primary school students.

Methods

Five survey waves were conducted among primary school students in Taizhou, Zhejiang Province, China, between May 2021 and March 2023. Depressive symptoms were assessed using the Children's Depression Inventory. The study included 36,116 person-wave observations using a repeated cross-sectional design with a nested longitudinal subsample of 9,212 students. Temporal trends were examined using Cochran-Armitage trend tests, and generalized linear mixed-effects models identified associated factors.

Results

The prevalence of depressive symptoms decreased significantly from 12.1% in May 2021 to 4.1% in March 2023 (P for trend < 0.001), with the steepest decline between the first two waves. In multivariable analyses, poor parent-child relationships showed the strongest association with depressive symptoms (OR = 6.00, 95% CI: 4.27–8.44), followed by study difficulties (OR = 3.71, 95% CI: 3.23–4.26). Excessive screen time, prolonged study time, and socioeconomic disadvantage were also significant risk factors, while regular physical activity was protective. The association between poor family economic status and depressive symptoms strengthened over time, indicating a time-varying effect of socioeconomic disadvantage.

Conclusions

Depressive symptoms among primary school students in Eastern China declined substantially from 2021 to 2023. Family relationships, academic difficulties, behavioral factors, and socioeconomic disadvantage remain key correlates, highlighting the need for multilevel interventions targeting family, school, and structural determinants.

Introduction

Mental health disorders affect approximately one in seven children and adolescents globally, imposing a substantial public health burden [1]. Among these, depression is a prevalent condition characterized by

persistent negative emotions that significantly impair psychological and social functioning [2, 3]. Globally, a meta-analysis revealed that nearly one-fifth of children and adolescents experience depression or depressive symptoms, with prevalence rates increasing over time [4]. Of particular concern is the trend towards earlier onset of depression [5], with pooled prevalence among Chinese primary school students estimated between 14.3% and 20.5% [6]. Greater attention to this younger age group is warranted [7], as primary school years represent a foundational period for cognitive, emotional, and social development [8–10], and depressive symptoms during childhood may have persistent adverse consequences across later developmental stages [11–13].

Guided by ecological systems theory, children's depressive symptoms are shaped by multiple interacting contexts, including individual behaviors, family environment, and school-related experiences [14, 15]. China's rapid socioeconomic transition and urbanization have substantially reshaped children's developmental environments, with broad implications for their psychosocial health [16]. At the individual level, increasing digital device use has altered children's daily routines and may contribute to excessive screen time and reduced physical activity [17], both of which have been linked to depressive symptoms [18–20]. At the family level, family socioeconomic conditions, parent-child relationship quality, and family structure, such as parental marital status and only-child status, may shape children's emotional well-being by influencing emotional support, parenting resources, and daily interactions [21–22]. At the school level, an examination-oriented educational culture has contributed to high academic expectations, prolonged study time, and learning-related stress among Chinese children [23]. The implementation of China's "Double Reduction" policy in July 2021, which aimed to reduce homework burden and off-campus tutoring for students in compulsory education [24], created an important policy context for examining changes in children's mental health. Meanwhile, the study period coincided with major changes in COVID-19 prevention and control measures in China, making it particularly important to monitor temporal changes in depressive symptoms among school-aged children.

Despite growing concern about childhood depression, several evidence gaps remain. First, many epidemiological studies have aggregated data across childhood and adolescence, limiting age-specific insights for primary school students [25–27]. Second, much of the existing evidence is based on single cross-sectional surveys, making it difficult to characterize population-level temporal trends or to examine whether the strength of associations between relevant factors and depressive symptoms differs across time [6, 28]. Although a few longitudinal cohort studies exist, they were often constrained by small sample sizes, high attrition rates, and the substantial financial costs of long-term follow-up [29, 30]. To address these limitations, a repeated cross-sectional design with a nested longitudinal subsample offers a practical approach for monitoring population-level trends while enabling analyses that account for repeated observations among students who participated in multiple waves [31]. Nevertheless, such evidence remains scarce for primary school students in China, particularly during periods of major educational reform and changes in COVID-19 prevention and control measures [32, 33].

Taizhou, located in Eastern China, is a rapidly urbanizing coastal prefecture-level city in Zhejiang Province. As of 2024, Taizhou had a permanent resident population of approximately 6.73 million and a

gross domestic product (GDP) of about 95.1 billion US dollars [34]. Its GDP per capita was slightly above the national average but below the Zhejiang provincial average [35, 36], representing a moderately developed coastal urban setting within one of China's most economically advanced provinces. Using five waves of repeated cross-sectional surveys with a nested longitudinal subsample, this study aimed to: (1) examine temporal changes in depressive symptoms among primary school students in Taizhou from 2021 to 2023; (2) identify individual, family, and school-related factors associated with depressive symptoms; and (3) explore whether these associations varied over time. By focusing on primary school students during a period of major educational reform and changes in COVID-19 prevention and control measures, this study provides timely evidence on how depressive symptoms changed and which groups may remain vulnerable. The findings are expected to inform interventions and strategies for promoting child mental health in similar urbanizing settings.

Methods

Study population and data collection

This study was conducted among primary school students in Taizhou City, Zhejiang Province, China, using a five-wave repeated cross-sectional design with a nested longitudinal subsample. The surveys were coordinated by the Taizhou Center for Disease Control and Prevention in collaboration with the local education bureau. Prior to data collection, class teachers explained the study objectives, procedures, and key instructions to both students and their parents. To collect complementary information and reduce potential same-source reporting bias, student and parent questionnaires were designed with distinct focuses, with students mainly reporting their own symptoms and experiences and parents providing family background information. Considering the younger age of the students, they completed the questionnaires in school computer labs under teacher supervision. On the same day, parents received the questionnaire link through class WeChat groups and completed it independently on their mobile devices. Teachers and research staff provided reminders and assistance throughout the survey period to enhance response rates and minimize missing data. All questionnaires were administered online using the Wenjuanxing platform (<https://www.wjx.cn>). The study was approved by the Ethics Committee of Taizhou Central Hospital (Approval No.: 2022L-01-17).

As shown in Fig. 1, five survey waves were conducted between May 2021 and March 2023, with each wave corresponding to one school semester. A multistage cluster sampling method was employed to select six districts or counties (two urban districts, two county-level cities, and two counties). In each area, three primary schools were randomly selected, and two classes per grade in each school were randomly sampled. In China, primary school students are in the compulsory education stage, which covers grades 1 to 6. Eligible participants were students enrolled in the selected classes who were able to complete online questionnaires under teacher guidance, for whom online informed consent was obtained from both students and their parents or legal guardians. Responses were excluded if they met any of the following criteria: (1) no online informed consent from the student or parent; (2) duplicate entries or outliers; or (3) the student's parent or guardian did not complete the corresponding

questionnaire. Following these inclusion and exclusion criteria, the number of valid responses in each survey wave was 7,753 at T1 (May 2021), 7,515 at T2 (October 2021), 7,012 at T3 (April 2022), 6,657 at T4 (September 2022), and 7,179 at T5 (March 2023), yielding a total of 36,116 person-wave observations across all five waves. From the repeated cross-sectional dataset, we further constructed an unbalanced nested longitudinal subsample by retaining students who participated in at least two survey waves. The final longitudinal subsample comprised 9,212 unique students and 28,977 person-wave observations, with 5,171, 6,208, 6,201, 5,730, and 5,667 observations contributed at T1–T5, respectively. Of these students, 3,379 participated in two waves, 2,492 in three waves, 1,962 in four waves, and 1,379 in all five waves.

Measurements

Depressive symptoms

The 27-item Children's Depression Inventory (CDI) [37] was used to measure depressive symptoms during the last 2 weeks. The CDI has demonstrated strong applicability for individuals aged 7 to 17 years, and its Chinese version has been validated in Chinese children and adolescents [38]. Because of its relatively low literacy demand, the CDI has been considered suitable for assessing depressive symptoms among primary school-aged children [39, 40]. Each of the 27 items is scored from 0 to 2 (e.g., "I get sad from time to time; I am sad many times; I am sad all the time"), yielding total scores ranging from 0 to 54. Consistent with the standard cutoff, scores ≥ 19 were classified as indicating depressive symptoms. In this study, the CDI demonstrated good internal consistency, with Cronbach's α ranging from 0.860 to 0.887 across the five survey waves.

Sociodemographic, behavioral, academic, and family-related factors

Sociodemographic information was collected using self-administered questionnaires from student and parent respectively, which were designed to provide complementary perspectives. Parent questionnaires primarily collected objective household and family information, whereas student questionnaires captured individual behaviors, study routines, and perceived experiences. Combining student- and parent-reported information provided a more comprehensive assessment of participants' individual and family characteristics and helped reduce potential same-source reporting bias [41].

Both questionnaires included personal identifiers such as student ID, date of birth, school, grade (1 to 6), and gender, which facilitated accurate matching between student and parent responses. From the parent questionnaires, we obtained information on registered residence (urban or rural), school type (public or private), only-child status (yes or no), parental marital status (married, divorced, widowed, or other), and parents' education (middle school or lower, high school or higher). Family economic status was assessed using a parent-reported subjective measure similar to those employed in previous research on subjective socioeconomic status [42]. Parents were asked, "How would you describe your family's

economic situation relative to others in your local area?" Responses were recorded on a 3-point Likert scale (1 = poor, 2 = fair, 3 = good). From the student questionnaires, we collected the following variables reflecting their behaviors and experiences over the past two weeks. Average daily screen time was assessed, excluding time spent in online classes, and dichotomized as ≥ 2 or < 2 hours per day [43]. Average daily study time was calculated by summing time spent on homework assigned by school teachers, homework assigned by parents or off-campus tutors, and off-campus tutoring related to school subjects; this variable was dichotomized as ≥ 4 or < 4 hours per day [44]. Study difficulties and regular physical exercise were assessed by asking students whether they currently experienced difficulties in their studies and whether they engaged in regular physical exercise, with response options coded as yes or no. Finally, the quality of parent-child relationships was assessed by asking students to rate their relationship with each parent separately, with response options coded as good, normal, or poor.

Statistical Analysis

Statistical analysis was conducted using R version 4.3.3. For the repeated cross-sectional data, we described participant characteristics across the five survey waves. Continuous variables were presented as mean $\pm$ standard deviation (SD), and categorical variables as counts and percentages. Differences in continuous variables across waves were assessed using one-way analysis of variance (ANOVA). For categorical variables, differences were examined using the Chi-squared test, with Fisher's exact test applied when expected cell counts were < 5 . Prevalence rates of depressive symptoms were calculated for each wave, and subgroup differences by sociodemographic, behavioral, academic, and family-related characteristics were assessed using the Chi-squared test. Unadjusted population-level temporal trends in depressive symptom prevalence across the five waves were evaluated using Cochran-Armitage trend tests.

In the nested longitudinal subsample, generalized linear mixed-effects models (GLMMs) with a binomial distribution and logit link function were used to examine factors associated with depressive symptoms. Depressive symptoms were treated as a binary outcome. In these models, survey wave was coded from 1 to 5 and included as a continuous fixed effect to account for the overall temporal trend. Student- and school-level random intercepts were included to account for repeated observations within students and clustering of students within schools. Intraclass correlation coefficients (ICCs) were estimated from an unconditional null model with student- and school-level random intercepts.

A three-step modeling strategy was applied. First, preliminary single-covariate GLMMs were fitted, each including survey wave and one candidate predictor as fixed effects (Model 1). Variables with $P < 0.05$ in these preliminary models were retained for multivariable analysis. Second, a multivariable main-effects GLMM was fitted, including survey wave and all variables significant in the preliminary models (Model 2). Multicollinearity was assessed using variance inflation factors (VIFs) from the corresponding fixed-effects logistic regression model. Model adequacy was evaluated by examining singular fit and random-effect variance components. Third, interaction terms between survey wave and predictors that remained significant in Model 2 were sequentially added to the multivariable GLMM to examine whether the

associations between predictors and depressive symptoms varied across survey waves (Model 3). Fixed-effect estimates were reported as odds ratios (ORs) with 95% confidence intervals (CIs). All statistical tests were two-sided, and statistical significance was defined as $P < 0.05$.

Results

Participant characteristics

A total of 36,116 valid person-wave observations were obtained across the five repeated cross-sectional survey waves. Across all observations, the mean age was 8.9 years (SD = 1.9), and 54.3% were male. Participant characteristics varied significantly across survey waves, particularly in behavioral, academic, and family-related factors. The proportion of students with high daily screen time (≥ 2 hours) decreased markedly from 23.3% at T1 to 5.6% at T5. The proportion reporting prolonged daily study time (≥ 4 hours) decreased from 27.9% at T1 to 13.1% at T2, followed by a gradual increase to 24.8% at T5. The proportion of students reporting study difficulties also declined from 29.7% at T1 to 17.5% at T5. The proportion of students reporting good relationships with their father and mother increased from 81.1% and 87.7% at T1 to 90.0% and 93.6% at T5, respectively. These behavioral, academic, and family-related variables differed significantly across the five waves (all $P < 0.001$). Detailed participant characteristics by survey wave are presented in Table 1.

Table 1
Participant characteristics across the five survey waves.

Variable	Waves ^a					<i>P</i> value
	T1 (N = 7753)	T2 (N = 7515)	T3 (N = 7012)	T4 (N = 6657)	T5 (N = 7179)	
Age, year	9.10 ± 2.31	8.58 ± 1.77	9.03 ± 1.80	8.49 ± 1.75	9.21 ± 1.80	< 0.001
Gender (Male)	4243 (54.7)	4091 (54.4)	3774 (53.8)	3571 (53.6)	3915 (54.5)	0.634
Grade						< 0.001
1	1200 (15.5)	1293 (17.2)	1302 (18.6)	1120 (16.8)	1088 (15.2)	
2	1248 (16.1)	1245 (16.6)	1190 (17.0)	1223 (18.4)	1219 (17.0)	
3	1347 (17.4)	1235 (16.4)	1145 (16.3)	1040 (15.6)	1091 (15.2)	
4	1324 (17.1)	1260 (16.8)	1150 (16.4)	1107 (16.6)	1249 (17.4)	
5	1366 (17.6)	1292 (17.2)	1190 (17.0)	1022 (15.4)	1251 (17.4)	
6	1268 (16.4)	1190 (15.8)	1035 (14.8)	1145 (17.2)	1281 (17.8)	
School type (Private)	788 (10.2)	483 (6.4)	499 (7.1)	125 (1.9)	145 (2.0)	< 0.001
Regular physical exercise (No)	1700 (21.9)	1282 (17.1)	1295 (18.5)	1354 (20.3)	1619 (22.6)	< 0.001
Average daily screen time (≥2h)	1809 (23.3)	1569 (20.9)	516 (7.4)	420 (6.3)	403 (5.6)	< 0.001
Average daily study time (≥4h)	2165 (27.9)	981 (13.1)	1659 (23.7)	1502 (22.6)	1782 (24.8)	< 0.001
Studying difficulties (Yes)	2305 (29.7)	1498 (19.9)	1380 (19.7)	1156 (17.4)	1256 (17.5)	< 0.001
Registered residence (Urban)	2652 (34.2)	2503 (33.3)	2278 (32.5)	2253 (33.8)	2466 (34.4)	0.116
Only-children family (No)	5584 (72.0)	5397 (71.8)	5061 (72.2)	4888 (73.4)	5252 (73.2)	0.115
Family economic status (Poor) ^b	552 (7.1)	485 (6.5)	404 (5.8)	451 (6.8)	412 (5.7)	< 0.001

Variable	Waves ^a					P value
	T1 (N = 7753)	T2 (N = 7515)	T3 (N = 7012)	T4 (N = 6657)	T5 (N = 7179)	
Parental marital status (Others) ^c	802 (10.3)	660 (8.8)	589 (8.4)	554 (8.3)	536 (7.5)	< 0.001
Father's education (Middle school or lower)	3037 (39.2)	2638 (35.1)	2363 (33.7)	2160 (32.4)	2165 (30.2)	< 0.001
Mother's education (Middle school or lower)	2947 (38.0)	2501 (33.3)	2252 (32.1)	2046 (30.7)	2074 (28.9)	< 0.001
Relationship with father						< 0.001
Good	6286 (81.1)	6570 (87.4)	6226 (88.8)	5985 (89.9)	6458 (90.0)	

Continued Table 1 Participant characteristics across the five survey waves.

Variable	Waves ^a					P value
	T1 (N = 7753)	T2 (N = 7515)	T3 (N = 7012)	T4 (N = 6657)	T5 (N = 7179)	
Normal	182 (16.5)	839 (11.2)	634 (9.0)	546 (8.2)	585 (8.1)	
Poor	185 (2.4)	106 (1.4)	77 (1.1)	63 (0.9)	57 (0.8)	
Relationship with mother						< 0.001
Good	6799 (87.7)	6931 (92.2)	6497 (92.7)	6229 (93.6)	6720 (93.6)	
Normal	859 (11.1)	523 (7.0)	389 (5.5)	327 (4.9)	336 (4.7)	
Poor	95 (1.2)	61 (0.8)	52 (0.7)	39 (0.6)	48 (0.7)	

^a T1 = May 2021, T2 = October 2021, T3 = April 2022, T4 = September 2022, and T5 = March 2023, representing five consecutive school semesters.

^b Family economic status was dichotomized (Poor vs. Fair or Good), due to small cell sizes in extreme categories.

^c Parental marital status "Others" includes all non-married categories, including divorced, widowed, or other circumstances.

Changes in depressive symptoms over time

The overall prevalence of depressive symptoms declined significantly over the five survey waves, from 12.1% at T1 to 4.1% at T5 (P for trend < 0.001), with the steepest decrease occurring between T1 and T2. Similar declining patterns were observed in both genders and across grade levels. At each wave, the prevalence of depressive symptoms increased with higher grade level (P for trend < 0.001; Fig. 2a and b).

Table 2 shows stratified prevalence of depressive symptoms across the five waves, with significant downward trends observed in all subgroups (all P for trend < 0.05). Parent-child relationship quality showed a strong and consistent gradient in depressive symptom prevalence. Students reporting poor father-child relationships had markedly higher prevalence of depressive symptoms than those reporting good father-child relationships across waves, ranging from 29.9% to 47.0% versus 2.5% to 8.4%, respectively. A similar pattern was observed for mother-child relationships, with all subgroup differences statistically significant at each wave (all P < 0.001). Higher prevalence of depressive symptoms was also consistently observed among students with study difficulties, high daily screen time, prolonged daily study time, poor family economic status, lower paternal education, and lower maternal education. In contrast, students who engaged in regular physical exercise consistently showed lower prevalence of depressive symptoms than those who did not (all P < 0.05).

Table 2

Prevalence of depressive symptoms across five survey waves by participant characteristics.

Variables	Waves ^a					<i>P</i> for trend ^b
	T1	T2	T3	T4	T5	
	(N = 7753)	(N = 7515)	(N = 7012)	(N = 6657)	(N = 7179)	
School type						
Public	851 (12.2)	398 (5.7)	275 (4.2)	243 (3.7)	284 (4.0)	< 0.001
Private	89 (11.3)	18 (3.7)	21 (4.2)	4 (3.2)	7 (4.8)	< 0.001
χ^2 value	0.567	3.230	0.000	0.093	0.228	
<i>P</i> value ^c	0.490	0.080	1.000	1.000	0.123	
Regular physical exercise						
Yes	622 (10.3)	281 (4.5)	207 (3.6)	173 (3.3)	179 (3.2)	< 0.001
No	318 (18.7)	135 (10.5)	89 (6.9)	74 (5.5)	112 (6.9)	< 0.001
χ^2 value	88.527	73.744	27.614	14.652	44.099	
<i>P</i> value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	
Average daily screen time						
< 2h	581 (9.8)	259 (4.4)	242 (3.7)	206 (3.3)	244 (3.6)	< 0.001
$\geq$ 2h	359 (19.8)	157 (10.0)	54 (10.5)	41 (6.3)	47 (11.7)	< 0.001
χ^2 value	132.019	71.799	53.706	45.950	63.562	
<i>P</i> value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	

Continued Table 2 Prevalence of depressive symptoms across five survey waves by participant characteristics.

Variables	Waves ^a					<i>P</i> for trend ^b
	T1	T2	T3	T4	T5	
	(N = 7753)	(N = 7515)	(N = 7012)	(N = 6657)	(N = 7179)	
Average daily study time						
< 4h	558 (10.0)	318 (4.9)	166 (3.1)	143 (2.8)	156 (2.9)	< 0.001
≥ 4h	382 (17.6)	98 (10.0)	130 (7.8)	104 (6.9)	135 (7.6)	< 0.001
χ2 value	85.906	42.808	70.230	65.071	75.615	
<i>P</i> value ^c	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	
Study difficulties						
Yes	582 (25.2)	236 (15.8)	168 (12.2)	132 (11.4)	166 (13.2)	< 0.001
No	358 (6.6)	180 (3.0)	128 (2.3)	115 (2.1)	125 (2.1)	< 0.001
χ2 value	530.375	373.614	268.754	232.656	328.652	
<i>P</i> value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	
Registered residence						
Rural	603 (11.8)	282 (5.6)	216 (4.6)	176 (4.0)	198 (4.2)	< 0.001
Urban	337 (12.7)	134 (5.4)	80 (3.5)	71 (3.2)	93 (3.8)	< 0.001
χ2 value	1.286	0.238	4.201	2.979	0.769	
<i>P</i> value	0.256	0.669	< 0.05	0.087	0.413	
Only-children family						
Yes	241 (11.1)	100 (4.7)	72 (3.7)	58 (3.3)	74 (3.8)	< 0.001
No	699 (12.5)	316 (5.9)	224 (4.4)	189 (3.9)	217 (4.1)	< 0.001
χ2 value	2.902	3.738	1.885	1.257	0.308	
<i>P</i> value	0.096	0.057	0.185	0.272	0.636	
Family economic status ^d						

Variables	Waves ^a					<i>P</i> for trend ^b
	T1 (N = 7753)	T2 (N = 7515)	T3 (N = 7012)	T4 (N = 6657)	T5 (N = 7179)	
Fair/Good	851 (11.8)	362 (5.2)	256 (3.9)	212 (3.4)	245 (3.6)	< 0.001
Poor	89 (16.1)	49 (10.1)	40 (9.9)	35 (7.8)	46 (11.2)	< 0.05
χ^2 value	8.920	20.684	34.204	22.212	56.838	
<i>P</i> value	< 0.05	< 0.001	< 0.001	< 0.001	< 0.001	
Parental marital status ^e						
Married	791 (11.4)	364 (5.3)	248 (3.9)	222 (3.6)	250 (3.8)	< 0.001
others	149 (18.6)	52 (7.9)	48 (8.1)	25 (4.5)	41 (7.5)	< 0.001
χ^2 value	34.975	7.597	24.539	1.089	19.257	
<i>P</i> value	< 0.001	< 0.05	< 0.001	0.290	< 0.001	
Father's education						
Middle school or lower	458 (15.1)	180 (6.8)	138 (5.8)	116 (5.4)	119 (5.5)	< 0.001
High school or higher	482 (10.2)	236 (4.8)	158 (3.4)	131 (2.9)	172 (3.4)	< 0.001
χ^2 value	40.956	12.891	23.097	24.662	16.597	
<i>P</i> value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	
Mother's education						
Middle school or lower	417 (14.1)	163 (6.5)	124 (5.5)	110 (5.4)	116 (5.6)	< 0.001
High school or higher	523 (10.9)	253 (5.0)	172 (3.6)	137 (3.0)	175 (3.4)	< 0.001
χ^2 value	18.309	6.910	13.546	22.947	17.775	

Continued Table 2 Prevalence of depressive symptoms across five survey waves by participant characteristics.

Variables	Waves ^a					<i>P</i> for trend ^b
	T1	T2	T3	T4	T5	
	(N = 7753)	(N = 7515)	(N = 7012)	(N = 6657)	(N = 7179)	
<i>P</i> value	< 0.001	< 0.05	< 0.001	< 0.001	< 0.001	
Relationship with father						
Poor	87 (47.0)	39 (36.8)	23 (29.9)	21 (33.3)	23 (40.4)	< 0.05
Normal	326 (25.4)	140 (16.7)	82 (12.9)	74 (13.6)	85 (14.5)	< 0.001
Good	527 (8.4)	237 (3.6)	185 (3.0)	149 (2.5)	177 (2.7)	< 0.001
χ^2 value	507.075	444.267	271.021	327.957	389.346	
<i>P</i> value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	
Relationship with mother						
Poor	53 (55.8)	30 (49.2)	14 (26.9)	12 (30.8)	18 (37.5)	< 0.05
Normal	275 (32.0)	110 (21.0)	78 (20.1)	61 (18.7)	63 (18.8)	< 0.001
Good	612 (9.0)	276 (4.0)	199 (3.1)	170 (2.7)	198 (2.9)	< 0.001
χ^2 value	551.195	494.388	330.122	302.418	373.363	
<i>P</i> value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	

^a T1 = May 2021, T2 = October 2021, T3 = April 2022, T4 = September 2022, and T5 = March 2023, representing five consecutive school semesters.

^b *P* for trend indicates temporal trends across the five survey waves within each subgroup.

^c *P* values indicate between-group differences within each survey wave.

^d Family economic status was dichotomized (Poor vs. Fair or Good), due to small cell sizes in extreme categories.

^e Parental marital status “Others” includes all non-married categories, including divorced, widowed, or other circumstances.

Factors associated with depressive symptoms

In the unconditional null model, ICCs showed that 50.4% and 3.8% of the variance in depressive symptoms were attributable to between-student and between-school differences, respectively,

supporting the inclusion of student- and school-level random intercepts. Multicollinearity was low, with all VIFs below 2.

As shown in Table 3, higher grade level was associated with increased odds of depressive symptoms. Compared with grade1 students, those in grades 3–6 had significantly higher odds, with adjusted ORs ranging from 1.91 to 2.97. Several behavioral and academic factors were independently associated with depressive symptoms. Regular physical exercise was associated with lower odds of depressive symptoms (OR = 0.76, 95% CI: 0.65–0.88), whereas daily screen time ≥ 2 hours (OR = 1.60, 95% CI: 1.33–1.93), daily study time ≥ 4 hours (OR = 1.62, 95% CI: 1.40–1.86), and study difficulties (OR = 3.71, 95% CI: 3.23–4.26) were associated with higher odds. Family-related factors were also significantly associated with depressive symptoms. Being an only child was associated with lower odds (OR = 0.81, 95% CI: 0.68–0.96), whereas poor family economic status (OR = 1.48, 95% CI: 1.18–1.84) and non-married parental marital status (OR = 1.28, 95% CI: 1.02–1.59) were associated with higher odds. Moreover, compared with a good father-child relationship, normal and poor father-child relationships were associated with higher odds of depressive symptoms (OR = 2.32, 95% CI: 1.95–2.77; OR = 6.00, 95% CI: 4.27–8.44, respectively), with similar patterns observed for mother-child relationships.

Most associations remained stable across survey waves. However, a significant interaction was observed for family economic status, where the association with depressive symptoms strengthened over time (interaction term OR = 1.20, 95% CI: 1.04–1.39), indicating that the relative disadvantage of students from poorer families increased across survey waves.

Table 3
Factors associated with depressive symptoms based on GLMM analyses [OR(95%CI)].

Variable	Model 1 (Crude)	Model 2 (Adjusted)	Model 3a (Main model with interactions)	Model 3b (Reported interaction effects from Model 3a)
Male (Female as Ref.)	1.07 (0.93, 1.24)	-	-	
Grade (Grade1 as Ref.)				
Grade2	1.44 (1.08, 1.91)*	1.25 (0.93, 1.69)	1.24 (0.90, 1.72)	1.04 (0.83, 1.30)
Grade3	3.09 (2.37, 4.04)***	2.24 (1.71, 2.95)***	1.91 (1.40, 2.61)***	0.81 (0.65, 0.99)*
Grade4	3.59 (2.76, 4.68)***	2.63 (2.00, 3.44)***	2.38 (1.76, 3.21)***	0.85 (0.69, 1.04)
Grade5	4.17 (3.20, 5.42)***	3.19 (2.44, 4.17)***	2.97 (2.21, 3.99)***	0.88 (0.72, 1.07)
Grade6	4.42 (3.32, 5.88)***	3.18 (2.37, 4.25)***	2.91 (2.13, 3.96)***	0.98 (0.79, 1.22)
Private school (Public school as Ref.)	1.59 (1.17, 2.16)**	1.41 (1.04, 1.91)*	1.32 (0.90, 1.93)	0.93 (0.75, 1.16)
Regular physical exercise (No as Ref.)	0.53 (0.47, 0.61)***	0.76 (0.66, 0.88)***	0.76 (0.65, 0.88)***	0.98 (0.89, 1.08)
Average daily screen time $\geq$ 2h (< 2h as Ref.)	2.28 (1.96, 2.65)***	1.57 (1.34, 1.83)***	1.60 (1.33, 1.93)***	1.02 (0.91, 1.15)
Average daily study time $\geq$ 4h (< 4h as Ref.)	2.00 (1.75, 2.28)***	1.58 (1.37, 1.81)***	1.62 (1.40, 1.86)***	1.06 (0.96, 1.17)

Variable	Model 1 (Crude)	Model 2 (Adjusted)	Model 3a (Main model with interactions)	Model 3b (Reported interaction effects from Model 3a)
Study difficulties (No as Ref.)	4.98 (4.40, 5.65)***	3.60 (3.15, 4.10)***	3.71 (3.23, 4.26)***	1.06 (0.96, 1.16)
Registered residence of urban (Rural as Ref.)	0.95 (0.80, 1.14)	-	-	-
Only-children family (No as Ref.)	0.82 (0.70, 0.97)*	0.81 (0.69, 0.96)*	0.81 (0.68, 0.96)*	0.99 (0.89, 1.10)
Poor family economic status (Fair/Good as Ref.)	1.92 (1.55, 2.37)***	1.37 (1.10, 1.70)**	1.48 (1.18, 1.84)**	1.20 (1.04, 1.39)*
Non-married parental marital status (Married as Ref.)	1.78 (1.45, 2.18)***	1.26 (1.02, 1.55)*	1.28 (1.02, 1.59)*	1.01 (0.89, 1.16)
Father's education middle school or lower (High school or higher as Ref.)	1.58 (1.36, 1.83)***	1.14 (0.96, 1.34)	-	-
Mother's education middle school or lower (High school or higher as Ref.)	1.44 (1.24, 1.67)***	0.95 (0.80, 1.13)	-	-
Relationship with father (Good as Ref.)				
Normal	4.38 (3.79, 5.08)***	2.20 (1.87, 2.60)***	2.32 (1.95, 2.77)***	1.09 (0.98, 1.21)

Continued Table 3 Factors associated with depressive symptoms based on GLMM analyses [OR(95%CI)].

Variable	Model 1 (Crude)	Model 2 (Adjusted)	Model 3a (Main model with interactions)	Model 3b (Reported interaction effects from Model 3a)
Poor	13.35 (9.80, 18.19) ^{***}	5.57 (4.04, 7.68) ^{***}	6.00 (4.27, 8.44) ^{***}	1.14 (0.92, 1.42)
Relationship with mother (Good as Ref.)				
Normal	5.70 (4.84, 6.72) ^{***}	2.46 (2.04, 2.95) ^{***}	2.51 (2.07, 3.06) ^{***}	1.04 (0.93, 1.17)
Poor	14.59 (9.96, 21.39) ^{***}	5.99 (4.04, 8.90) ^{***}	5.74 (3.82, 8.62) ^{***}	0.90 (0.69, 1.16)

Model 1 shows single-covariate GLMMs including survey wave and one predictor at a time.

Model 2 includes survey wave and all variables significant in Model 1.

Model 3a is the final multivariable GLMM including both main effects and wave-by-predictor interaction terms.

Model 3b presents the results of interaction terms from Model 3a. All models accounted for clustering at the student and school levels.

Discussion

Childhood depressive symptoms represent a critical public health concern requiring multisectoral attention [45, 46]. Using five waves of surveys conducted between May 2021 and March 2023, this study found a substantial decline in depressive symptoms among primary school students in Eastern China, decreasing from 12.1% to 4.1%, with the most pronounced reduction occurring between May and October 2021. This sharp decline coincided with the implementation of China's "Double Reduction" Policy, which was introduced in July 2021 and fully implemented locally in September 2021. The policy substantially reduced homework burden and off-campus tutoring, both of which have been identified as important sources of academic stress among Chinese children [47]. Consistent with this context, we observed a concurrent reduction in reported study time during the same period, suggesting that changes in academic pressure may have contributed to improvements in children's mental health. In addition, gradual normalization of school routines and social activities following the COVID-19 pandemic may have further supported this downward trend. Similar post-pandemic recovery patterns have been reported among Chinese children and adolescents since the winter of 2021 [48, 49]. Together, these

factors suggest that changes in both educational demands and broader social environment may have jointly contributed to the overall downward trend.

The prevalence observed in this study was generally lower than that reported in previous studies in China [50, 51] and international meta-analyses, which have documented depressive symptom prevalence ranging from approximately 15% to 25% among children and adolescents during and immediately after the COVID-19 pandemic [52, 53]. Such differences should be interpreted cautiously given variations in age composition, assessment instruments, and contextual factors [54]. Consistent with previous research [48, 55], depressive symptoms increased with grade level, rising from 1.78% in grade 1 to 9.08% in grade 6, while no significant gender differences were observed. This pattern aligns with developmental theories suggesting that marked gender differences in depression typically emerge during adolescence rather than childhood, potentially owing to pubertal, hormonal, and psychosocial changes [56–58].

Multivariable GLMM analyses, accounting for repeated observations within students and clustering within schools, identified several independent correlates of depressive symptoms. These factors spanned behavioral, academic, and family domains, supporting the notion that childhood depressive symptoms arise from multiple interacting influences rather than a single determinant. This finding aligns with previous evidence on multifactorial risk structures for childhood depression [59] and is consistent with developmental contextual perspectives, which emphasize dynamic interactions between individuals and their environments in shaping emotional development [60].

Academic-related factors were significantly associated with depressive symptoms. Among these, study difficulties exhibited the strongest association. Children reporting study difficulties had nearly fourfold higher odds of depressive symptoms after adjustment for other covariates. This finding is consistent with evidence suggesting that persistent academic struggles can undermine self-esteem, diminish perceived competence, and generate chronic stress, thereby increasing susceptibility to emotional problems [61, 62]. Together with the observed grade-related increase in depressive symptoms, these results highlight the importance of providing timely academic support and psychological assistance to students experiencing learning challenges. Similarly, longer daily study time remained a significant correlate after adjustment for other factors, suggesting that academic demands continue to play an important role in children's mental health. Although China's "Double Reduction" policy has shown promise in reducing educational pressure [63], our findings suggest that additional targeted support may be needed for students who continue to experience heavy academic burden.

Behavioral factors were also independently associated with depressive symptoms. Consistent with prior research, excessive screen time was associated with elevated odds of depressive symptoms [43, 64]. A previous Chinese meta-analysis identified two hours per day as a critical threshold for adverse mental health outcomes [65], which corresponds closely with our findings. In contrast, regular physical exercise was associated with lower odds of depressive symptoms, consistent with growing evidence that physical activity promotes psychological well-being through both physiological and psychosocial pathways [66, 67].

Family-related factors demonstrated particularly strong associations. Notably, the quality of parent-child relationships demonstrated the strongest associations observed in this study. Compared with students reporting good parent-child relationships, those reporting poor relationships with either parent had substantially elevated odds of depressive symptoms. These findings are consistent with previous research emphasizing the protective role of supportive parent-child interactions in fostering emotional security, resilience, and healthy psychological development [68, 69]. Family socioeconomic disadvantage was also associated with increased odds of depressive symptoms, corroborating evidence that economic hardship may adversely affect child mental health through material deprivation, parental stress, and reduced access to supportive resources [70, 71]. Children from non-married families exhibited modestly higher odds of depressive symptoms, while the effect size was considerably smaller than that observed for parent-child relationship quality, suggesting that family emotional functioning may be more influential than family structure itself in shaping children's mental health outcomes [72, 73]. Our findings also revealed lower odds of depressive symptoms among only children. Although this observation is consistent with some previous studies, findings in the literature remain mixed [70]. A review further highlighted context-dependent effects, suggesting that elevated depression risks may occur among certain subgroups, including girls from non-only-child families and only-children from economically disadvantaged backgrounds [74]. Potential mechanisms include differences in parental attention, educational investment, and resource allocation within families [75, 76]. Further longitudinal and mediation analyses are warranted to clarify these pathways.

Importantly, the association between poor family economic status and depressive symptoms strengthened over time, whereas most other associations remained relatively stable across survey waves. This suggests that although the overall prevalence of depressive symptoms declined during the study period, children from economically disadvantaged families may have benefited less from these broader improvements. One possible explanation is that access to educational, recreational, and psychological resources remained unequally distributed during the post-pandemic transition period. Socioeconomic disadvantage may constrain access to material and psychosocial resources that support healthy development, thereby amplifying relative vulnerability among lower-income children [77, 78]. This finding underscores the importance of targeted interventions aimed at reducing socioeconomic inequalities in child mental health outcomes.

Based on the findings of this study, several key implications can be drawn for the promotion of mental health among primary school students. First, the observed overall decline in depressive symptoms suggests that recent social and educational changes, including educational policy reform and post-pandemic recovery, may have been associated with improvements in children's mental health. However, the persistent associations between depressive symptoms and behavioral, academic, and family-related factors indicate that children's mental health is shaped by multiple and interacting contextual influences, particularly within school and family environments. Second, the strong association between parent-child relationship quality and depressive symptoms highlights the central role of family emotional functioning in child mental health. Interventions aimed at improving communication and emotional support within families may therefore be particularly important. Within the school context, significant

associations between study difficulties, academic burden, and depressive symptoms underscore the importance of providing timely academic support and reducing excessive learning pressure. Strengthening school-based mental health education and integrating psychological support into routine school activities may further benefit students' emotional development. Finally, the observed strengthening association between socioeconomic disadvantage and depressive symptoms over time suggests a potential widening mental health inequality, emphasizing the need for policies that address structural disparities in child developmental environments.

This study has several notable strengths, including the large sample size of primary school students, systematic tracking of depressive symptoms across five survey waves, and the integration of repeated cross-sectional data with a nested longitudinal subsample, which enabled examination of both population-level trends and individual-level temporal dynamics. In addition, standardized data collection procedures implemented by trained investigators in collaboration with schools helped ensure data quality and consistency across survey waves. Nevertheless, some limitations should be acknowledged. First, although the longitudinal subsample allows assessment of temporal associations, the observational design limits causal inference regarding the associations identified. Second, the reliance on self-reported measures may introduce reporting bias and potentially affect the accuracy of prevalence estimates. Third, although stratified sampling across urban and rural districts enhanced internal representativeness, caution is warranted when generalizing the findings to less urbanized or economically disadvantaged areas. Finally, despite adjustment for multiple covariates, residual confounding from unmeasured factors, such as genetic predisposition and neighborhood-level characteristics, cannot be excluded.

Conclusions

In conclusion, depressive symptoms among primary school students in Taizhou declined substantially from May 2021 to March 2023. Despite this overall improvement, several factors remained consistently associated with higher levels of depressive symptoms. Poor parent–child relationships emerged as the most prominent correlate of depressive symptoms, followed by academic-related factors (study difficulties and prolonged study time), behavioral factors (excessive screen time and physical inactivity), and socioeconomic disadvantage. Notably, the association between poor family economic status and depressive symptoms strengthened over time, suggesting that the effect of socioeconomic disadvantage on child mental health became more pronounced during the study period. These findings highlight the need for coordinated strategies that strengthen family emotional environments, reduce academic-related stress, and address socioeconomic disparities in child mental health.

Abbreviations

GDP	Gross domestic product
CDI	Children's Depression Inventory
SD	Standard deviation
ANOVA	One-way analysis of variance
ICC	Intraclass correlation coefficients
GLMM	Generalized linear mixed-effects models
VIF	Variance Inflation Factor
OR	Odds ratio
CI	Confidence interval

Declarations

Ethics approval and consent to participate

The study protocol was reviewed and approved by the Ethics Committee of Taizhou Central Hospital (2022L-01-17). These procedures were performed in accordance with the Declaration of Helsinki. Prior to participation, all participants, as well as the parents or legal guardians of minors, provided informed consent. The informed consent process was strictly followed for the collection of all study data.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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Author Contribution

Haifan Bai: Writing – review & editing, Writing – original draft, Formal analysis, Data curation, Visualization, Methodology, Conceptualization. Yunming Lin: Writing – review & editing, Investigation, Data curation, Methodology, Conceptualization. Tingting Wang: Investigation, Data curation. Yuting Yang: Methodology, Validation, Writing – review & editing. Xiaoxiao Chen: Resources, Investigation, Funding acquisition. Na Wang: Methodology, Writing – review & editing, Funding acquisition. Haijiang Lin: Resources, Investigation, Project administration, Funding acquisition. Zeyu Yu: Methodology, Formal analysis, Writing – review & editing. Qingzhi Zeng: Conceptualization, Methodology, Writing – review & editing. Jingyi Wang: Conceptualization, Methodology, Supervision, Funding acquisition, Writing – review & editing. Chaowei Fu: Conceptualization, Methodology, Supervision, Project administration, Funding acquisition, Writing – review & editing.

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Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request. The data are not publicly available due to privacy or ethical restrictions.

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Figures

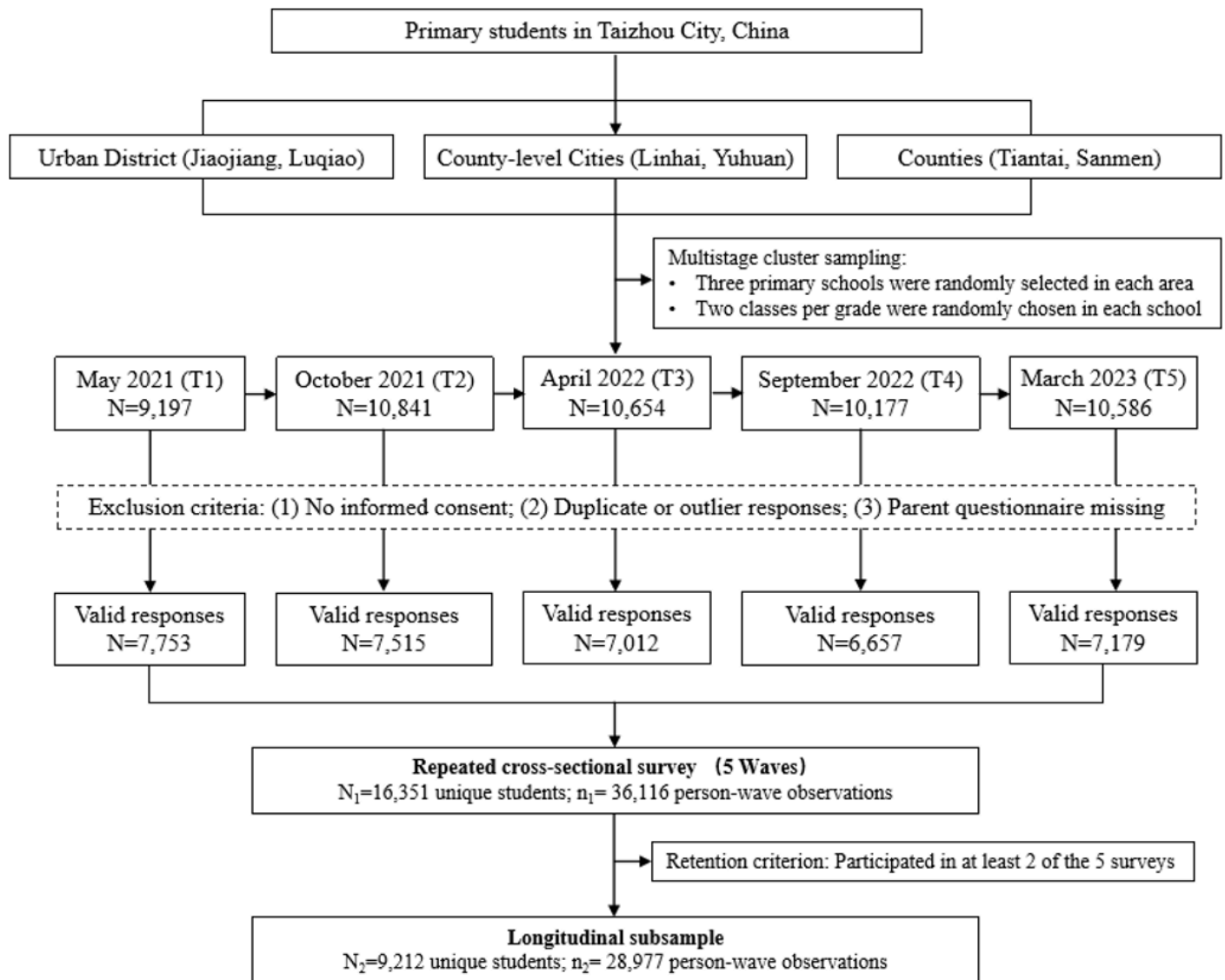


Figure 1

Participation flow chart.

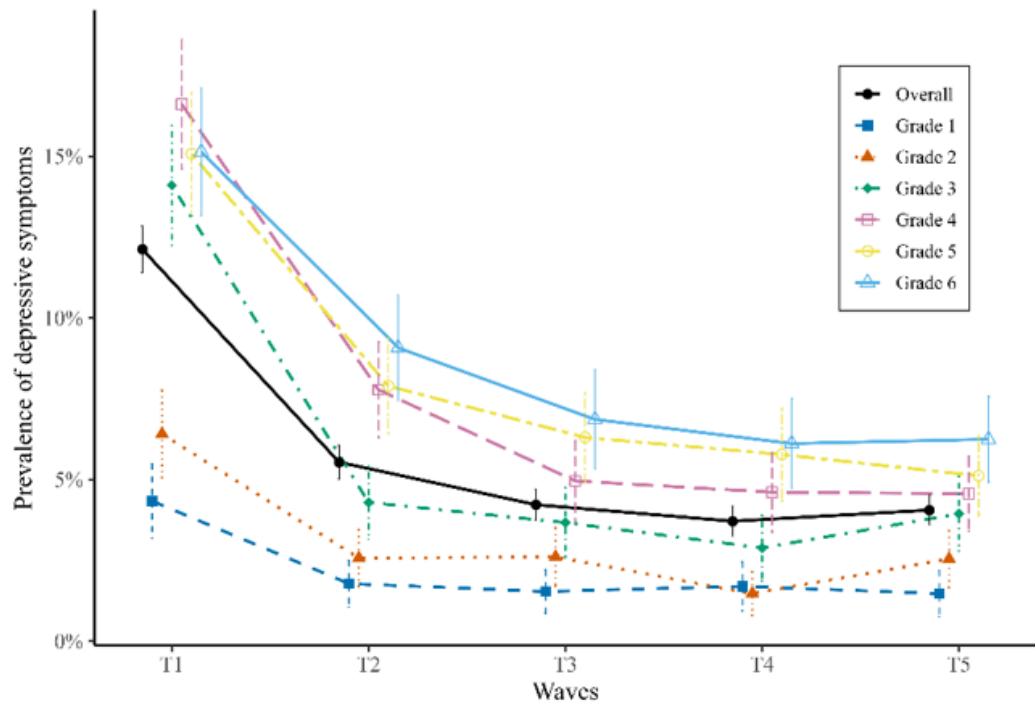
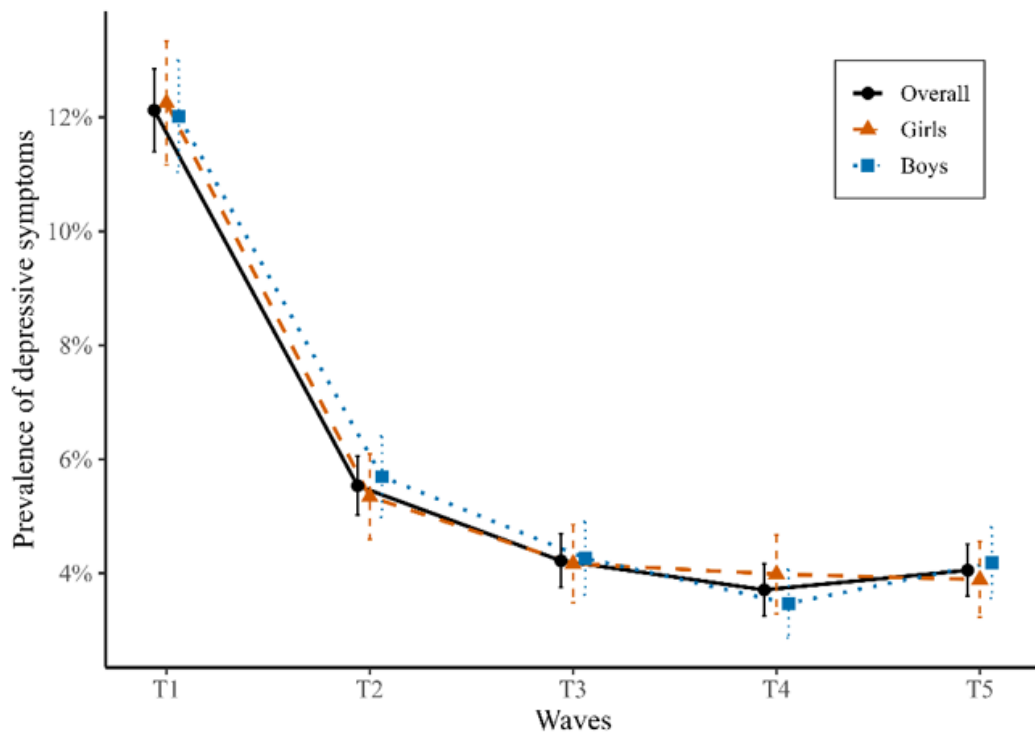


Figure 2

Temporal trends in the prevalence of depressive symptoms by gender and grade.