ORIGINAL RESEARCH

Depression Takes a Toll on Academic Performance: Evidence from Rural Students in China

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Purpose: Depression is a growing public health concern around the world. For adolescents, depression not only impedes healthy development, but is negatively associated with academic performance. The purpose of this paper is to examine the prevalence of adolescent depressive symptoms in a sample of rural primary and junior high school students. Additionally, we examine various factors to identify subgroups within the sample that may be more vulnerable to depression. Finally, we explore the extent to which depression correlates with academic performance and conduct a series of heterogeneity analyses.

Patients and Methods: We utilize cross-sectional data derived from 30 schools in underdeveloped regions of rural China encompassing primary and junior high school students (n = 1,609).

Results: We find a high prevalence of depression, with 23% and 9% of students experiencing general depression (depression score ≥ 14) and severe depression (depression score ≥ 21), respectively. Female gender, elevated stress and anxiety levels, boarding at school, exposure to bullying, and having depressed caregiver(s) are positively correlated with depressive symptoms, while high social support exhibits a negative association. Importantly, our analyses consistently show a significantly negative link between depression and academic performance, which is measured using standardized math tests. For instance, transitioning from a non-depressed state to a state of general depression (depression score ≥ 14) is linked to a decline of 0.348–0.406 standard deviations in math scores (p < 0.01). Heterogeneity analyses reveal that this adverse relationship is more pronounced for male students, boarding students, those with lower social support, individuals with more educated mothers, and those with lower family assets.

Conclusion: Our findings underscore the high prevalence of depression in rural schools and the detrimental impact on academic performance. We advocate for the implementation of policies aimed at reducing student depression, particularly within vulnerable populations and subgroups.

Keywords: adolescent health, academic performance, rural China, developing countries

Introduction

Mental health issues can have lasting and adverse effects on a person's life, particularly when they arise during adolescence.[1] Adolescence, defined as the period from 10 to 19 years of age, has been well-documented as a transitory stage of development involving large psychological and emotional changes.[2] Negative mental health during adolescence has been closely associated with higher incidences of school dropout, self-harm, and suicide.[3,4] Furthermore, challenges from mental health issues often extend beyond individual consequences by inflicting harm to persons within their social circles.[5,6] According to a recent meta-analysis, approximately 25.0% to 31.0% of adolescents worldwide experience depressive or anxiety disorders.[7] In comparison, about 4.4% and 3.6% of the world's adult population suffers from depressive and anxiety disorders, respectively.[8]

Depression has been identified by the World Health Organization (WHO) as the third leading cause of the global burden of disease.[9] Moreover, depression experienced during adolescence is particularly concerning because it occurs within a critical period of development, and has been linked to challenges such as impaired concentration, impaired social relationships, poor school performance, reading and writing difficulties, high academic stress, and suicidal ideation.[10–12] Adolescent depressive symptoms have also been associated with multiple negative externalities.[13]

In China, recent studies using the Depression Anxiety Stress Scale (DASS-21) found that 14.4% to 19.2% of Chinese adolescents experienced general depression (depression score ≥ 14)[14–16] and 3.5% to 5.9% experienced severe depression (depression score ≥ 21).[15,16] Moreover, it has been widely acknowledged that rural Chinese students experience higher rates of depression than urban students.[17,18] Despite this, few studies internationally and within China have used the DASS-21 to explore rates of rural adolescent depression.[19] Wang et al[20] used the self-reported version of the Strengths and Difficulties Questionnaire (SDQ) to measure the mental health of Chinese rural students, but did not focus on depression. This has resulted in the incomparability of depression prevalence between rural populations and their urban counterparts.

The prevalence rates of adolescent depression within China may be influenced by a range of factors such as gender, social support, school bullying, school boarding status, and caregiver depression. Regarding gender, a large body of literature has suggested that girls experience higher levels of depression than boys.[19,21,22] However, numerous other studies suggest the opposite, making the association inconclusive.[13,23–25] With more consistency, higher levels of social support have been linked to a lower severity of depressive symptoms. This relationship has been explored among various populations in China, including college students,[23,26] left-behind children,[27,28] urban students,[29] and boarding school students.[30] In terms of school-related factors, multiple studies have established a positive relationship between bullying and adolescent depression.[29,31–36] However, most of these studies focus on urban sample[29,31–33] and high school student populations[34] with only a few examining younger students from rural areas.[35,36] Regarding school boarding, international findings have been mixed,[37–41] with very little research specifically sampling boarding students within China. Lastly, caregiver depression has been positively linked to depressive symptoms in children.[42]

This study investigates the association between gender, school boarding status, and adolescent depression within a less-studied context—underdeveloped rural areas. Existing literature offers mixed findings on these associations, yet our research provides new evidence by focusing on a rural area where socio-economic and cultural conditions differ significantly from those in more developed regions. In these poorer rural settings, girls often face systemic challenges, including discrimination,[43] which can heighten their vulnerability to depression. Furthermore, school boarding is frequently a necessity due to parental migration, leading to a lack of family support,[44] which may adversely impact students' mental health. These factors are prevalent in many underdeveloped regions, making our findings relevant for informing educational and mental health policies in similar contexts, both within China and in other developing countries.

Moreover, our study specifically addresses these relationships among younger adolescents in primary and junior high schools—a demographic that has received less attention in existing research. By exploring these associations in an underdeveloped region, this study aims to contribute to a broader understanding of how gender and school boarding status are linked to adolescent depression in rural areas.

Finally, studies from China have consistently demonstrated a negative correlation between depression and the academic performance of primary and junior high school students. These studies have examined student samples from various regions, including rural areas in northern China,[45] urban Shanghai,[24] rural Hunan Province in central China,[46] and Gansu Province in northwest China.[47] Yet despite the extensive research on the link between depression and academic performance in Chinese students, there is a lack of comprehensive heterogeneity analyses. By conducting such analyses and examining the varying degrees of the negative relationship between depression and academic performance among different vulnerable subgroups, we aim to gain more insights and develop targeted measures to aid and support these groups.

The present study examines the prevalence of adolescent depressive symptoms in a sample of rural primary and junior high school students. Additionally, we examine various factors to identify subgroups within the sample that may be more vulnerable to depression. These factors include gender, stress levels, anxiety levels, school boarding status, bullying

experiences, social support level, and caregiver depression. Finally, we explore the extent to which depression correlates with academic performance and conduct a series of heterogeneity analyses. We explore whether depression relates to academic performance differently in the case of gender, school boarding status, social support, maternal education, and family socioeconomic status.

Methods

Ethical Approval

The study received ethical clearance from the Institutional Review Board of Stanford University (Protocol Number: 58251). The IRB's goal is to protect human research participants by ensuring their rights and welfare are upheld, following the ethical principles of respect, beneficence, and justice outlined in the Belmont Report. It also ensures that research is conducted with expertise, integrity, and in compliance with all relevant laws and regulations. The IRB is part of the Human Research Protection Program (HRPP), which is accredited by AAHRPP and a member of CARE-Q. We obtained ethical approval from Stanford University's IRB due to its extensive experience in human subjects research and the local NGO's permission. Additionally, local education authorities and school principals approved our in-school surveys. Prior to the survey, we sent written consent forms to the parents or guardians of all eligible student participants. Written consent must be obtained from at least one parent or guardian of each selected student, and student participants were given verbal consent at the time of the survey, with the option to withdraw at any time.

In line with the Declaration of Helsinki, we committed to preserving data privacy and confidentiality throughout the research process. Consequently, participants were instructed not to share their survey responses either during or after completion of the survey. Additionally, we removed the names of the adolescent participants from all electronic records as part of our data encryption procedures.

Study Location and Sampling

This study uses cross-sectional data collected in October 2020 from 30 rural schools in Gansu Province, one of the poorest provinces in China. In 2022, Gansu's per capita GDP was 45,000 yuan (The data source is from the National Bureau of Statistics of China. See http://www.stats.gov.cn/ for details), positioning it at the bottom among the 31 participating provinces. A stratified random sampling method was adopted in our sample selection, so the potential selection bias associated with the sampling process is minimal. We followed a two-step random sampling method to select a study sample. In the first step, we obtained a list of all schools from the local education bureau and randomly selected 30 schools (including 20 primary schools and 10 junior high schools). All of these schools were willing to cooperate with our research. Within each school, grades 4 and 5 (10 to 11 years old) were included if it was an elementary school and grades 7 and 8 (12–13 years old) included if it was a junior high school. We then randomly selected two classes from each grade of each school. If a grade had only one or two classes, we included all the classes for that grade in our sample. In the second step, we selected a random sample of students for participation. On the day of the survey, half of the students from each sampled class were randomly selected to participate in the survey. We also conducted questionnaire surveys to classroom teachers, school principals, and the students' main caregivers. Our final analytical sample included 1,609 primary and junior high school students, with 949 elementary school students and 660 junior high school students.

We distributed informed consent forms to 1,700 students and their caregivers, receiving 1,630 completed forms in return. The response rate was nearly 96%. After excluding improperly completed questionnaires, our final sample comprised 1,609 student questionnaires. The completion rate is nearly 94.6%. Given the minimal amount of missing data, we decided not to impute missing values, as doing so could compromise the authenticity and accuracy of our data.

Measures

Academic Performance

Academic performance was measured using 30-minute standardized math tests developed by the research team in collaboration with local county education bureaus in several rural counties in China. These tests were designed to

align with the national curriculum, scheduled appropriately, and strictly supervised by the surveyors. All test scores were standardized based on the score distribution for each grade level.

Using standardized math scores to measure student academic performance has several advantages. First, math scores provide high objectivity, as students' mathematical learning is regularly evaluated through standardized testing and clear grading criteria. This reduces the influence of subjective factors, resulting in a more objective reflection of students' current academic abilities. Second, the wide use of math scores in existing research enhances comparability across studies.[48–50] Finally, the standardization of math scores facilitates the interpretation of coefficients, allowing comparisons across different grades, schools, and studies. Changes in coefficient are expressed in standard deviations, making them easier to understand and compare across studies.

Depression Anxiety and Stress Scale-21 (DASS-21)

The Depression Anxiety and Stress Scale-21 (DASS-21) was used to measure students' and their caregivers' depression, anxiety, and stress levels. The DASS-21 is a shortened version of the DASS-42 developed by Lovibond and Lovibond.[51] It is a self-reported questionnaire that measures the frequency and severity of a participant's depression, anxiety, and stress symptoms from the previous week. Although it cannot make clinical diagnoses,[51] the DASS-21 can be used to assess levels of depression, stress, and anxiety in individuals. It is one of the world's broadest measures of depressive symptoms and has been validated for use in adolescents.[25,52] Additionally, Taouk et al[53] compiled and revised the DASS-21 for use in Mandarin Chinese and the translation has shown high reliability and validity in mainland Chinese populations.[23,54–56]

The DASS-21 uses a Likert scale. The depression section of the scale consists of seven questions, each offering four response options, ranging from 0 to 3. These options correspond to levels of compliance, namely "strong noncompliance", "some compliance", "large compliance", and "strong compliance".

In addition, the DASS-21 utilizes specific cut-off scores to classify different levels of psychological symptoms. For the scale's depression section, scores can be categorized as follows: normal (0–9), mild depression (10–13), moderate depression (14–20), severe depression (21–27), and extremely severe depression (28+). This scoring system provides a more intuitive understanding of depression levels.[13,57] Finally, scores of 14 and above indicate general depression (depression score $\geq$ 14). The cut-off scores for the DASS-21 were established by its creators and have demonstrated high reliability and validity internationally, including among adolescents. For the Chinese context, Taouk et al[53] adapted the DASS-21 for use in Mandarin, with numerous studies confirming the reliability, validity, and appropriateness of the cut-off scores for mainland Chinese populations.[54,58,59] These well-established scores allow us to accurately categorize depressive symptoms in line with both international standards and Chinese cultural contexts.

School Bullying

We used the "Students Bullied at School" (SBS) scale from the Progress in Reading and Literacy Study (PIRLS) assessments to estimate the extent of bullying experienced by students. This scale has also been implemented and validated in diverse contexts, including among Chinese students.[60,61] PIRLS is a large-scale international comparative study conducted by the International Association for the Evaluation of Educational Achievement (IEA) to evaluate students' reading literacy. The scale uses a four-point Likert scale, with 0 indicating that bullying is experienced "at least once a week", and 3 indicating "never." A higher score on the scale indicates a lower frequency of school bullying experienced by the participant. Following the guidelines of the PIRLS, we categorized a bullying score above 10.1 as "almost never" experiencing bullying and was recorded as 0. A bullying score below 10.1 was categorized as experiencing bullying "approximately monthly or more often" and was recorded as 1.

Social Support

We measured social support using the Multidimensional Scale of Perceived Social Support (MSPSS), which has demonstrated good psychometric properties in Chinese samples.[62,63] This scale consists of 12 items, which are further divided into three sub-scales: significant others, family, and friends. It uses a seven-point Likert scale, where 1 indicates "strong disagreement" and 7 indicates "strong agreement." Higher scores on the scale indicate a higher perception of social support. To facilitate analysis, continuous score variables of social support were transformed into dummy variables

based on MSPSS guidelines. A score of 62 or above was considered as high social support and recorded as 1, while scores below 62 were classified as low social support and recorded as 0.

Resilience, Family Assets, and Emotion Regulation Strategies

The Connor-Davidson Resilience Scale (CD-RISC) was used to assess resilience, and it has been validated for use in Chinese populations as well.[64] Higher scores on the CD-RISC indicated higher levels of resilience. Family assets were measured by asking students whether their family possessed seven specific items identified in the National Survey of Family Income and Expenditure. Using this information, a family asset index was created and divided into tertiles, allowing for categorization based on relative levels of family assets. Lastly, we measured emotion regulation using the Emotion Regulation Questionnaire (ERQ), which assesses the frequency of cognitive reappraisal and expressive suppression. The ERQ has been widely validated across different cultural contexts, including among Chinese students.[65] Higher scores on the ERQ indicate a greater ability to regulate emotions.

Statistical Analysis

Our empirical analysis had three main stages. First, we calculated summary statistics for the main variables, including depression and academic performance, as well as for other student and family characteristics.

Second, we used class fixed effects to examine the academic performance of students within the same class but with varying levels of depression. This strategy allowed us to estimate the significant associations between individual and family characteristics and depressive symptoms. The regression uses equation (1), where $depression_{ic}$ is a variable that measures the cth class and the ith individual's depressive symptoms, $Personal_k$ and $Family_j$ represent vectors of personal and family characteristics, and λ_c means class fixed effects.

$$depression_{ic} = \alpha_0 + \sum_{k=1}^{n}\alpha_k Personal_{kic} + \sum_{j=1}^{m}\rho_j Family_{jic} + \lambda_c + \varepsilon_{ic} \tag{1}$$

Third, we continued to analyze the relationship between depression and academic performance. A participant's depression score and academic performance was plotted as a histogram for simple analysis. Then, we employed Ordinary Least Squares (OLS) regression analysis to delve deeper into the relationship between depression and academic performance. To mitigate the influence of omitted variables, we incorporated class fixed effects and included an extensive range of student and family characteristic variables. Additionally, standard errors are clustered by school, acknowledging the potential correlation among students within the same school, by employing cluster standard errors. Moreover, we conducted heterogeneity analyses to explore whether the association between depression and academic performance varies in different groups, thereby identifying potential moderating factors. The regression was performed using the following regression equation (2), and $math_{ic}$ is a variable that measures the cth class and the ith individual's academic performance, β_1 and is a coefficient of concern to us. $Personal_k$ and $Family_j$ represent vectors of personal and family characteristics, and λ_c means class fixed effects.

$$math_{ic} = \beta_0 + \beta_1 depression_{ic} + \sum_{k=1}^{n}\alpha_k Personal_{kic} + \sum_{j=1}^{m}\rho_j Family_{jic} + \lambda_c + \varepsilon_{ic} \tag{2}$$

Results

In this section, we present the prevalence of depression among rural primary and junior high school students in China, as well as descriptive statistics of their personal and family characteristics. We found that depression was associated with a student gender, boarding status, bullying experience, social support, and caregiver depression risk. Finally, we found a negative correlation between a student's academic performance and their depression risk, with the strength of this correlation varying across different characteristics, such as student gender, accommodation situation, social support, maternal education, and family assets.

Student Academic Performance and Depression Prevalence

Table 1 shows the summary statistics of students' academic performance (or their standardized math scores) and their depressive, anxiety, and stress symptoms. First, we represent student depression scores as a continuous score that

Table 1 Summary Statistics of Academic Performance and Depression Outcomes

Variables	Definition	N	Mean	S.D.	Min	Max
math_std	Standard math score	1,608	0	1	−4.016	1.902
dass_d_dum	General depression (depression score ≥ 14; 1 = yes; 0 = no)	1,609	0.232	0.422	0	1
dass_d_total	Depression score	1,609	7.682	8.542	0	42
dum_no_d	No depression (depression score < 14; 1 = yes; 0 = no)	1,609	0.768	0.422	0	1
dum_mid_d	Moderate depression (14 ≤ depression score < 21; 1 = yes; 0 = no)	1,609	0.143	0.350	0	1
dum_sev_d	Severe depression (depression score ≥ 21; 1 = yes; 0 = no)	1,609	0.089	0.285	0	1
dass_a_total	Anxiety score	1,609	9.526	8.367	0	42
dass_s_total	Stress score	1,609	10.860	8.605	0	42

Notes: Data source is author's survey.

assesses the level of depression risk, with higher scores indicating a greater degree of depression. Students had a mean depression score of 7.7 out of 42. Next, 23.2% of students were at risk of general depression (depression score ≥ 14). In more detail, 14.3% of students had moderate depression (14 ≤ depression score < 21) and 8.9% had severe depression (depression score ≥ 21).

Summary Statistics of Other Student and Family Characteristics

Panel A of Table 2 displays descriptive statistics on other student characteristics. Female students accounted for 44.6% of the sample. Nearly 15% of the students boarded at their schools, 42.6% reported experiencing bullying at school at least once per month, and 44% reported having high social support.

Panel B of Table 2 provides descriptive statistics on the students' family characteristics. The percentage of caregivers with general depression (depression score ≥ 14) is 21.0%, and the proportion of caregivers with severe depression (depression score ≥ 21) is 6.4%. In terms of parental education, 14.5% of the students' mothers and 24.1% of the students' fathers had completed high school or above. In terms of socioeconomic status, 67.6% of the students had a low or medium level of family assets.

Factors Correlated with Depression

Table 3 reveals correlations between depression outcomes and student and family characteristics. In columns (1) and (2), the explained variable is the depression score. In columns (3) and (4), the explained variable is a dummy variable indicating the presence or absence of general depression (depression score ≥ 14). To mitigate the potential bias resulting from missing variables, we systematically introduced student characteristics and family characteristics as control variables in the regression analysis. The results are consistent and robust. We emphasize the findings presented in columns (2) and (4) as the preferred results, because they contain all control variables. Standard errors are clustered by school.

In columns (2) and (4), we find that there are many student and family characteristics that are significantly associated with student depression. First, there is a higher percentage of girl students with general depression (depression score ≥ 14) than boy students ($p < 0.01$). Second, there is a positive correlation between a student's anxiety and stress scores and their depression symptoms ($p < 0.01$). Third, students who experience bullying at school at least once a month report experiencing higher levels of depressive symptoms ($p < 0.01$). Fourth, boarding students exhibit significantly higher levels of depressive symptoms compared to non-boarding students ($p < 0.05$). Fifth, high levels of social support are

Table 2 Summary Statistics of Personal and Family Characteristics

	Definition	N	Mean	S.D.	Min	Max
Panel A: Personal Characteristics						
Female	Female (1 = Yes; 0 = No)	1,609	0.446	0.497	0	1
Board_at_school	Board at school (1 = Yes; 0 = No)	1,609	0.149	0.356	0	1
Pirls_bullying_monthly	Bullying monthly (1 = yes; 0 = no)	1,609	0.426	0.495	0	1
Pirls_bullying	Bullying score	1,609	19	5.115	0	24
mspss_highsupport	High social support (1 = yes; 0 = no)	1,609	0.440	0.497	0	1
mspss_socialsupport_total	Social support score	1,609	56.850	16.880	12	84
age_year	Age (years)	1,609	11.550	1.621	7.833	15.580
han_ethnicity	Han ethnicity (1 = Yes; 0 = No)	1,609	0.964	0.186	0	1
Rural_hukou	Rural hukou (1 = Yes; 0 = No)	1,609	0.915	0.279	0	1
Only_child	Only child (1 = yes; 0 = no)	1,609	0.136	0.343	0	1
Left_behind	Left-behind child (1 = yes; 0 = no)	1,609	0.198	0.398	0	1
cd_resilience	Resilience score	1,609	59.870	14.220	0	100
erqca_cr	Cognitive reappraisal score	1,608	22.460	4.830	6	30
erqca_es	Expressive suppression score	1,608	12.350	3.753	4	20
Group_activity	Never=1; sometimes=2; Often=3; actively=4	1,604	3.014	0.916	1	4
	Never or sometimes (1 = yes; 0 = no)	1,604	0.302	0.459	0	1
	Often or actively (1 = yes; 0 = no)	1,604	0.698	0.459	0	1
Panel B: Family Characteristics						
hh_dass_d_dum	Caregiver's general depression (depression score ≥ 14; 1 = yes; 0 = no)	1,548	0.210	0.407	0	1
hh_dass_d_total	Caregiver's depression score	1,548	6.753	7.810	0	42
hh_dass_d_severe	Caregiver's severe depression (depression score ≥ 21; 1 = yes; 0 = no)	1,548	0.064	0.245	0	1
hh_dass_a_total	Caregiver's anxiety score	1,548	7.105	7.627	0	42
hh_dass_s_total	Caregiver's stress score	1,550	9.612	8.026	0	42
Mother_education	High school or above (1 = yes; 0 = no)	1,609	0.145	0.353	0	1
Father_education	High school or above (1 = yes; 0 = no)	1,609	0.241	0.428	0	1

(Continued)

Table 2 (Continued).

	Definition	N	Mean	S.D.	Min	Max
Family asset tertile	Bottom=1; middle=2; top=3	1,607	1.978	0.821	1	3
	Bottom family asset (1 = yes; 0 = no)	1,607	0.349	0.476	0	1
	Middle family asset (1 = yes; 0 = no)	1,607	0.327	0.469	0	1
	Top family asset (1 = yes; 0 = no)	1,607	0.325	0.469	0	1
Divorced_parents	Parents divorced (1 = yes; 0 = no)	1,609	0.085	0.278	0	1
hh_cd_resilience	Caregiver's resilience score	1,565	55.360	18.910	0	100

Notes: Data source is author's survey.

found to relieve depression ($p < 0.01$). Lastly, there is an inverse correlation between relying on cognitive reappraisal as an emotion regulation strategy and depression ($p < 0.05$).

Caregiver depression also has significant associations with student depression. When a student's primary caregiver has general depression (depression score $\geq$ 14), a student is more likely to have general depression themselves ($p < 0.01$).

Finally, for a more intuitive understanding, we plotted the coefficients of all variables and their 95% confidence intervals as reported in Table 3, columns (2) and (4). Results are shown by Figure 1. Several student characteristics were

Table 3 Characteristic Factors Correlated with Depression

Dependent variable:	dass_d_total				dass_d_dum			
	(1)		(2)		(3)		(4)	
Age_year	0.264	(1.12)	0.203	(0.88)	−0.002	(−0.13)	−0.004	(−0.29)
Female	0.190	(0.69)	0.257	(0.89)	0.045**	(2.66)	0.045***	(2.76)
han_ethnicity	−1.113**	(−2.27)	−1.091*	(−1.83)	−0.047	(−1.23)	−0.052	(−1.10)
Rural_Hukou	−0.238	(−0.38)	−0.305	(−0.41)	−0.006	(−0.19)	−0.007	(−0.19)
Board_at_school	1.200**	(2.19)	1.164**	(2.45)	0.094***	(3.84)	0.095***	(4.34)
Left_behind	−0.133	(−0.48)	−0.110	(−0.35)	0.000	(0.03)	0.009	(0.43)
Only_child	0.078	(0.25)	−0.149	(−0.43)	0.012	(0.55)	0.011	(0.54)
Activity often or actively	−0.044	(−0.13)	−0.037	(−0.11)	0.006	(0.34)	−0.002	(−0.15)
dass_a_total	0.333***	(11.62)	0.329***	(10.98)	0.016***	(9.22)	0.017***	(9.01)
dass_s_total	0.431***	(13.27)	0.418***	(13.05)	0.015***	(8.55)	0.014***	(8.19)
mspss_highsupport	−1.588***	(−5.58)	−1.543***	(−5.14)	−0.058***	(−3.79)	−0.056***	(−3.53)
Pirls_Bullying_Monthly	1.135***	(3.40)	1.082***	(3.26)	0.078***	(3.62)	0.069***	(3.45)
cd_resilience	−0.028***	(−2.81)	−0.019*	(−1.92)	−0.001	(−1.63)	−0.001	(−0.95)
erqca_es	0.029	(0.72)	0.039	(0.99)	−0.001	(−0.29)	−0.000	(−0.03)

(*Continued*)

Table 3 (Continued).

Dependent variable:	dass_d_total				dass_d_dum			
	(1)		(2)		(3)		(4)	
erqca_cr	−0.092**	(−2.30)	−0.112***	(−2.91)	−0.003	(−1.44)	−0.004**	(−2.24)
Father_education			0.250	(0.66)			0.037*	(1.84)
Mother_Education			−0.398	(−0.69)			−0.027	(−1.00)
Family Asset Top			−0.013	(−0.03)			0.002	(0.08)
Divorced_Parents			0.059	(0.12)			−0.025	(−0.84)
hh_cd_resilience			−0.013*	(−1.76)			−0.000	(−0.22)
hh_dass_d_total			0.047	(0.79)			−0.001	(−0.36)
hh_dass_d_dum			0.679	(1.23)			0.110***	(3.57)
hh_dass_d_severe			0.683	(0.73)			0.076	(1.38)
hh_dass_a_total			−0.037	(−1.12)			−0.002	(−1.43)
hh_dass_s_total			−0.002	(−0.05)			−0.000	(−0.18)
Observations	1,604		1,539		1,604		1,539	
R-squared	0.674		0.682		0.511		0.517	
Class FE	Yes		Yes		Yes		Yes	
Cluster	Yes		Yes		Yes		Yes	

Notes: Definitions of variables can be found in Tables 1 and 2. Personal characteristics and family characteristics are put into regression in turn. Class fixed effects are involved. Standard errors are clustered by school. T-statistics are listed in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

found to be positively associated with depressive symptoms. These characteristics include being female, experiencing regular stress or anxiety, facing monthly bullying incidents, boarding at school, and relying on cognitive reappraisal as an emotion regulation strategy. Our analysis reveals a negative association between high social support and depressive symptoms among students. Apart from a significant correlation between caregiver general depression and student general depression, family characteristics are not significantly correlated with student depression.

Association Between General Depression and Academic Performance

Figure 2 shows a simple relationship between depression and standardized math scores. The figure demonstrates a clear negative trend, indicating that as a student's depression score increases, their academic performance, as measured by standardized math scores, declines. The inflection point, where the standardized math score reaches zero, occurs around 14 points on the depression score scale (depression score ≥ 14 indicates general depression).

Table 4 presents regression results on general depression and academic performance. Student stress and anxiety score variables are added gradually to the analysis. The results presented in Table 4 indicate a significant negative association between depression and academic performance. Notably, the coefficients remain relatively consistent across different situations, suggesting that the impact of depression on academic performance is consistently negative regardless of the specific conditions or variables considered. Second, we see a significant decrease in math scores by 0.35 to 0.41 SD (p < 0.01) when students go from a state of non-general depression to general depression. Third, the stress and anxiety score variables are not significant with academic performance, with the coefficient of the depression score remaining relatively stable.
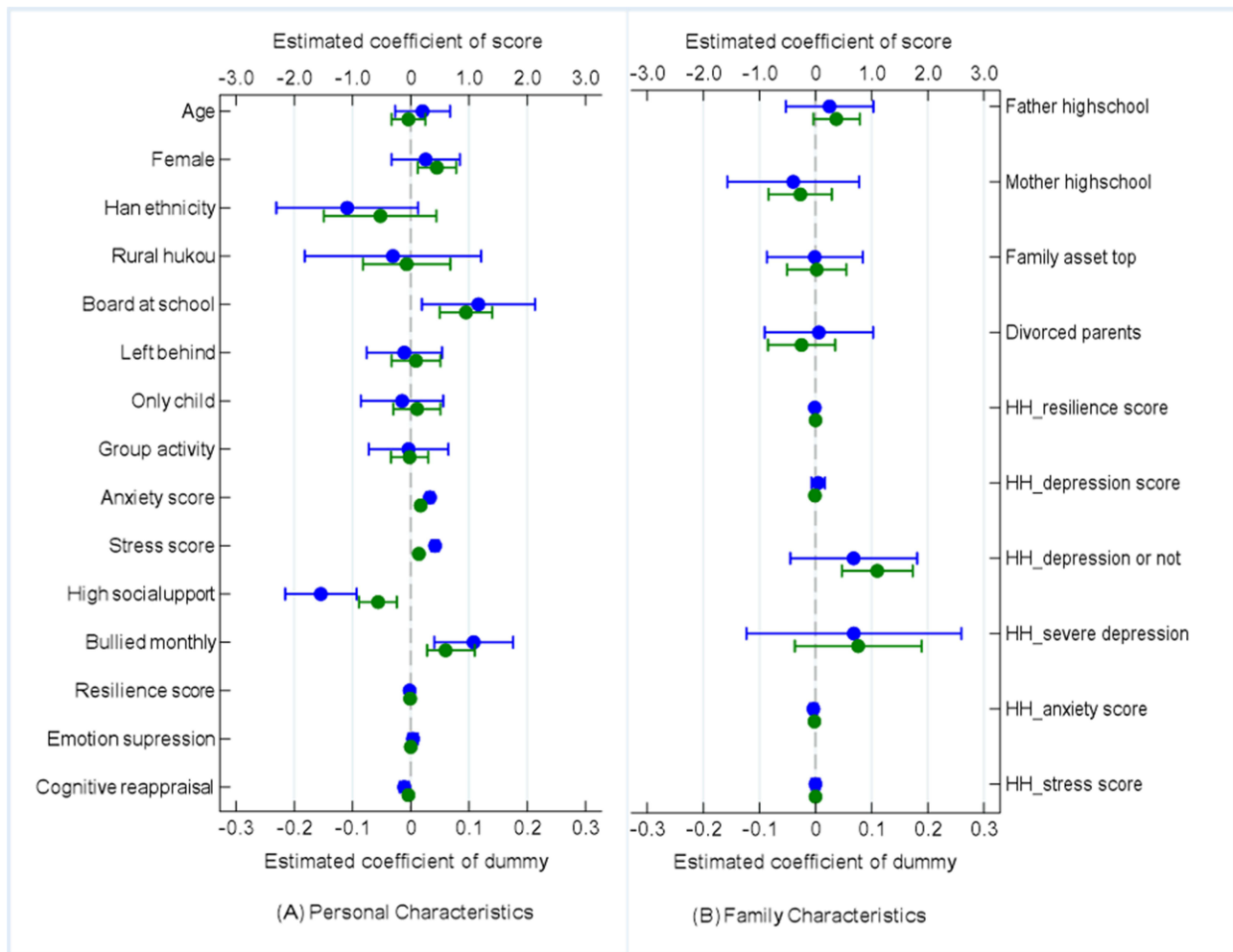
Figure 1 Personal and family characteristics correlated with depression.
Notes: Panel A depicts the estimated coefficients based on the correlation between personal characteristics and depressive symptoms. Panel B depicts the estimated coefficients based on the correlation between family characteristics and depressive symptoms. The blue solid circles denote estimated coefficients in column (2) of Table 3, and green solid circles denote estimated coefficients in column (4) of Table 3. Relative cap lines represent their 95% confidence intervals.

Although our study examines the correlation between depression and academic performance, comparing our findings with other studies in the literature can provide an intuitive understanding of the economic significance of the coefficients. Bettinger[48] found that a financial incentive program (up to a total of US $100 each year) increased mathematics test scores by approximately 0.15 standard deviations for students in grades 3–6. Liu et al[66] showed that in middle and high school, missing 10 classes can lead to a 3–4% reduction in standard deviation in math or English language arts test scores, and a 17–18% reduction in standard deviation in course grades. Our study found that transitioning from a non-depressed state to a state of general depression (depression score $\geq$ 14) is associated with a decline of 0.348–0.406 standard deviations in math scores.

Association Between Different Levels of Depression and Academic Performance

To verify the results in Table 4, we conducted two robustness tests. The results of the robustness tests are reported in Table 5. First, we replaced the binary variable of depression with a continuous scoring variable. After controlling for the same set of control variables as in column (3) of Table 4, we observed a significant negative relationship. Specifically, for every one-point increase in the depression score, the standardized math score dropped significantly by 0.02 SD ($p <$ 0.01). Second, moderate and severe depression are almost equally negatively associated with academic performance (0.37–0.38 SD, $p <$ 0.01), as shown in column (2) of Table 5.
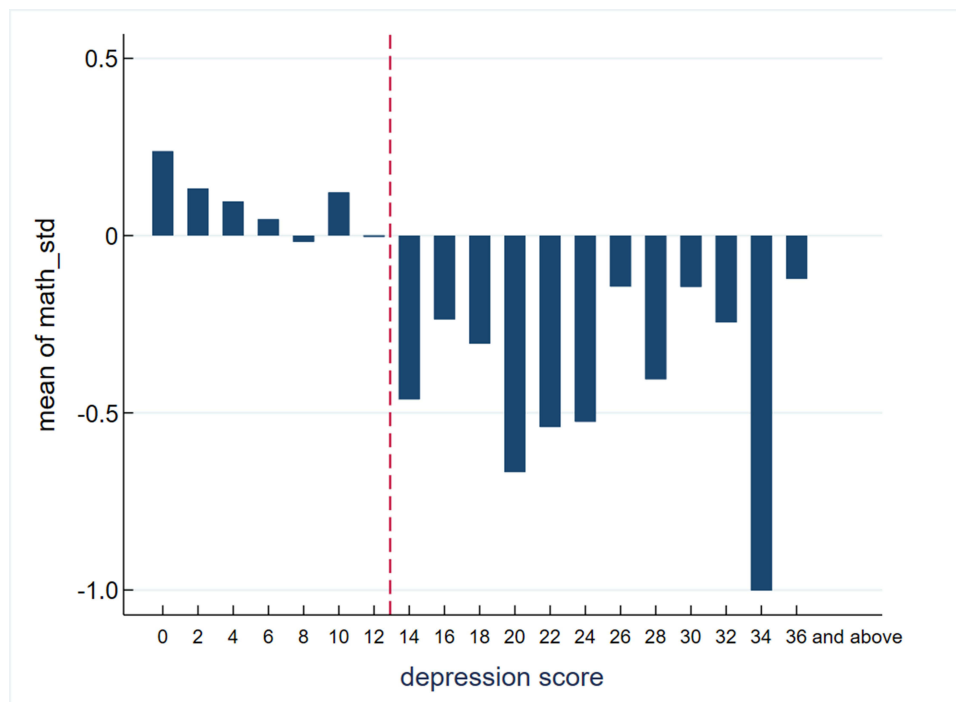
Figure 2 Academic performance varying with depression score.
Notes: The number of students with depression score between 38 and 42 is small. Due to space limitation, we combine them into 36 and above.

Heterogeneity Analyses

Table 6 displays heterogeneity analyses for student and family characteristics. Regarding the association between academic performance and depression, our findings show that the negative correlation is amplified for specific subgroups of students. Specifically, this relationship is stronger for male students, students who board at school, students with low social support, students with more educated mothers, and students from families with lower assets. Furthermore, in the correlation between general depression and academic performance, the coefficient of general depression is twice as high for boarding students compared to non-boarding students. Similarly, the coefficient of general depression is twice as high for students with low social support compared to those with high social support; for students with highly educated mothers compared to those with less educated mothers; for students from families with low or middle assets compared to those from families with high assets.

Discussion

In this study, we explored the prevalence of depressive symptoms among primary and junior high school students in the rural areas of Gansu Province, China, using the DASS-21. Additionally, we investigated the student and family factors associated with depressive symptoms, assessed the associations between student depression and academic performance, and compared the variations in this relationship among different vulnerable subgroups using data on 1609 primary and junior high school students.

Prevalence of Depression

We find a high prevalence of depression among young adolescents in rural China. The share of junior high school students with general depression was 20.3%, while for primary school students, the proportion was slightly higher at 25.2%. Overall, 23.2% of the sample experienced symptoms indicating general depression, and the mean depression score was 7.68. These results are considerably higher than those reported in previous studies conducted in urban Chinese children using the DASS-21, such as in Hunan, Shandong, Inner Mongolia Autonomous Region,[14] Guangdong,[16] Shanghai,[15] and central and southern provinces of China.[67] They are also higher than what college students suffer.[68]

Table 4 OLS Regression on General Depression and Academic Performance

	Dependent Variable: math_std		
	(1)	**(2)**	**(3)**
dass_d_dum	−0.348***	−0.380***	−0.378***
	(−4.96)	(−4.06)	(−3.81)
dass_s_total		0.003	0.003
		(0.70)	(0.74)
dass_a_total			−0.000
			(−0.10)
	(2.06)	(1.88)	(1.87)
R-squared	0.248	0.249	0.249
Personal characteristic	Yes	Yes	Yes
Family characteristic	Yes	Yes	Yes
Class *FE*	Yes	Yes	Yes
Cluster	Yes	Yes	Yes

Notes: N=1,538. Definitions of variables can be found in Tables 1 and 2. Personal characteristic includes variables such like social support score, resilience score, bullying score, bullied monthly or not, cognitive reappraisal, emotion suppression, age, gender, ethnicity, only child or not, hukou type, left-behind child or not, accommodation or not and participation in group activities. Family characteristic involves education level of father, education level of mother, marriage status, family asset tertile, caregiver's resilience score, depressive status, anxiety score and stress score, as all summarized in Tables 1 and 2. Class fixed effects are involved. Standard errors are clustered by school. T-statistics are listed in parentheses. *** p<0.01.

Compared to international findings, our results appear to be lower than those obtained using DASS-21 in other developing countries, such as Saudi Arabia,[69] Palestine,[70] Malaysia,[71] and Vietnam.[72] Nonetheless, there is a general lack of research abroad on depression in rural adolescents, despite evidence indicating that rural adolescents are at a heightened risk of experiencing severe mental illness compared to their urban counterparts.[73,74] Consequently, there is a need for increased research efforts that shed light on the high prevalence of depression in rural adolescents, with a specific emphasis on fostering international comparisons.

Factors Associated with Depression Risk

In addition, we find that depression risk varies by a student's gender, school boarding status, bullying experience, social support, and presence of depressive caregivers. First, according to our findings, female students were at a higher risk of general depression. Gender has been identified as a significant risk factor associated with depression in numerous studies conducted across various countries.[4,25,55] During adolescence, hormonal and neurodevelopmental changes can vary by sex, which may influence gender differences in depression.[75]

Second, students who boarded at their school were at a higher risk of general depression. The reason may be because boarding students are more likely to integrate with their peers and receive more support from teachers, but tend to receive less parental support than non-boarding students.[76]

Third, students who experienced school bullying at least once monthly were also at a higher risk of general depression. In a study utilizing data from two primary and secondary schools in Hebei Province, a significant association

Table 5 OLS Regression on Different Levels of Depression and Academic Performance

	Dependent variable: math_std	
	(1)	**(2)**
dass_d_total	−0.022***	
	(−3.46)	
dum_mid_d		−0.381***
		(−3.91)
dum_sev_d		−0.369**
		(−2.72)
dass_s_total	0.007	0.003
	(1.46)	(0.73)
dass_a_total	0.000	−0.001
	(0.08)	(−0.11)
R-squared	0.247	0.249
Personal characteristic	Yes	Yes
Family characteristic	Yes	Yes
Class *FE*	Yes	Yes
Cluster	Yes	Yes

Notes: N=1,538. Definitions of variables can be found in Tables 1 and 2. All model specifications in columns (1) and (2), including controls of personal and family characteristic, class fixed effects and clustering, are strictly in line with our baseline in column (3) of Table 4. T-statistics are listed in parentheses. *** $p<0.01$, ** $p<0.05$.

between boarding at school and depression was found, although the sample size was relatively small (n = 299).[77] Studies have shown that in addition to being a risk factor for adolescent depression, bullying is also a potential risk factor for suicide in adolescents.[78,79]

Fourth, our data suggests that having a greater degree of social support mitigates depression risk. Chang et al[29] finds that for adolescents from upper primary school and lower secondary school, higher social support from parents and peers is associated with lower levels of depression, with self-esteem playing a mediating role. Lu et al[80] also found that social support can improve negative emotions and enhance mental health.

Finally, our findings suggest that when students' caregivers suffer from general depression, their children have a higher risk of general depression (depression score $\geq$ 14). This aligns with findings from a Portuguese study highlighting a substantial correlation between parental mental health and that of their children.[81] Similarly, surveys involving secondary school students in Taiwan suggest that parental depression can affect adolescent depression.[82] These observations underscore the significance of caregivers not only prioritizing the mental well-being of their children but also attending to their own mental health.

Correlation Between Academic Performance and Depression

We find that students' depressive symptoms and academic performance are significantly negatively correlated. Previous research has revealed that depression can intensify the fear of exams and disrupt complex working memory processes, ultimately resulting in a decline in academic performance.[83] There are also studies suggesting that poor academic

Table 6 Heterogeneity of Personal and Family Characteristic

	Dependent variable: math_std					
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Panel A: Personal characteristics						
	Male	Female	Resident student	Day student	Low support	High support
dass_d_dum	−0.459***	−0.328**	−0.672***	−0.329***	−0.469***	−0.204
	(−3.38)	(−2.47)	(−5.40)	(−3.06)	(−3.50)	(−1.37)
Observations	839	699	237	1,301	851	687
R-squared	0.303	0.352	0.509	0.258	0.291	0.284
Differ[coef]_p-value	0.4007		0.0185		0.118	
Panel B: Family characteristics						
	mo_edu high	mo_edu low	Asset low or middle	Asset top		
dass_d_dum	−0.815**	−0.311***	−0.432***	−0.243		
	(−2.42)	(−2.88)	(−3.63)	(−1.65)		
Observations	222	1,316	1,038	500		
R-squared	0.592	0.253	0.265	0.353		
Differ[coef]_p-value	0.0426		0.2652			

Notes: Definitions of variables can be found in Tables 1 and 2. Control variables include personal and family characteristics in Table 4, as well as students' anxiety score and stress score. Other model specifications, including class fixed effects and clustering, are strictly in line with our baseline in column (3) of Table 4. T-statistics are listed in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

performance negatively impacts mental health, which may lead to the onset of depressive symptoms.[84–87] In fact, several studies have demonstrated a bidirectional and negative relationship between depression and academic achievement.[24,47]

Finally, while our study reveals a negative association between depression and academic performance, the magnitude and significance of this association varies across different factors. Specifically, the negative relationship between depression and academic performance is more pronounced for male students, those who board at school, individuals with low social support, students with highly educated mothers, and those from families with lower assets.

Regarding the heightened negative correlation between depression and academic performance among boarding students, we hypothesize that the absence of family support in their daily lives intensifies the impact of general depression (depression score ≥ 14) on academic performance. Concerning the exacerbation of the negative relationship between student depression and academic performance by higher maternal education, our hypothesis is that students with highly educated mothers generally exhibit better academic performance, especially in rural areas. Consequently, when these children experience depression, the impact on the decline in academic performance becomes more pronounced. Alternatively, high-achieving students who undergo a decline in academic performance may experience heightened levels of depression. For male students, those with lower social support and lower family assets, this adverse relationship is more pronounced, although the difference is not statistically significant.

Generalizability of Findings

The use of stratified random sampling methods ensured that our sample is representative of the broader population of rural Chinese students, increasing the potential for generalizing our results to other rural areas. The rigorous methodology we employed, including the use of the well-validated Depression Anxiety and Stress Scale-21 (DASS-21), strengthens the accuracy and reliability of our findings.

Moreover, although our findings align with previous theories, we believe that they extend upon existing knowledge by providing new insights into the specific context of rural Chinese students, a population that is often underrepresented in the literature. By confirming the association between depression and academic performance across different subgroups (eg, boarding students and students with low social support), our study supports the notion that mental health impacts are not uniform but vary based on individual and contextual factors. This finding contributes to the development of a more nuanced theoretical framework that considers the intersection of mental health and educational outcomes in under-developed regions. Additionally, our study highlights the importance of considering cultural and regional differences in understanding the relationship between mental health and academic performance, suggesting that theories in this area need to be adapted and refined to account for these contextual variations.

To further enhance the applicability of our findings, we advocate for conducting cross-regional studies in other rural areas of China and in developing countries. These studies would help validate whether the relationships we identified hold true in different contexts. Additionally, we emphasize the importance of making cultural adaptations when applying interventions based on our findings to ensure they are effective across various regions.

Policy Implications and Limitations

To enhance mental health education and support, schools can introduce specialized mental health courses to help students recognize and manage depression, anxiety, and stress, while also increasing the number of school counselors to provide timely psychological support. Given the significant association between bullying and depressive symptoms, schools need to implement anti-bullying policies and establish effective reporting and handling mechanisms to protect students. Additionally, fostering social support is also essential. Schools and communities can collaborate to organize parent education programs that enhance family and community support for students. For boarding students, improving dormitory conditions and offering more psychological support and activities can help reduce feelings of loneliness and stress. Lastly, special policies should be developed to target vulnerable groups, such as female students, those with low social support, and students with depressed caregivers, by providing regular mental health screenings and personalized support.

Our heterogeneity analysis offers important insights that can guide targeted policy interventions. The stronger negative association between depression and academic performance among boarding students suggests that the absence of daily family support exacerbates the impact of depression, indicating a need for enhanced social and emotional support within boarding schools. Additionally, the more pronounced effect of depression on students with higher maternal education levels may be due to the higher academic expectations they face, underscoring the need for targeted mental health support for this group. Finally, our findings highlight the importance of addressing gender-specific factors, low social support, and economic disparities to mitigate the adverse effects of depression on academic outcomes. These insights provide a basis for developing targeted interventions to support vulnerable student populations.

Given the limitations of our study due to the use of cross-sectional data, we acknowledge that we cannot establish causality between depressive symptoms and academic performance. Although a significant negative correlation was found, we are unable to determine whether depression leads to lower academic performance or vice versa. To address this limitation, our discussion suggested for future studies to employ longitudinal designs to track changes in students' mental health and academic performance over time, thereby providing a more robust understanding of the causal relationship.

Conclusion

This paper makes three significant contributions. First, this is one of the few papers to measure the prevalence of depression among rural primary and junior high school students in underdeveloped areas of mainland China using the DASS-21. This approach facilitates comparisons with existing domestic and international literature that applies the same scale to gauge depression levels across diverse population groups. Moreover, the use of internationally recognized standardized metrics for academic performance, depressive symptoms, and other personal and family characteristics addresses challenges in comparing data across different grades and schools, ensuring comparability and reliability in data collection. Second, we identified a range of personal and family characteristics that are associated with students' depression risk. While our cross-sectional design does not allow for establishing causality, these associations highlight

potential risk factors that warrant further investigation. Future studies using longitudinal data or experimental data are needed to establish the causal relationship and to guide the development of effective interventions aimed at reducing depression levels in students. Thirdly, we established a significant and meaningful correlation between depression and academic performance. The extensive sample size allowed us to explore correlation coefficients' magnitude across various subgroups, enhancing our analysis of heterogeneity and offering deeper insights into the varying degrees of association between depression and academic performance within different subgroups.

We find that depressive symptoms in young students are widespread in the rural areas of China. Moreover, student depressive symptoms and academic performance are highly negatively correlated. Based on these findings, we emphasize the importance of placing greater attention on identifying and addressing rural students' depressive symptoms, aiming to enhance both their mental well-being and academic performance. Measures to reduce depression should be adopted and encouraged, especially for subgroups that are more vulnerable, such as students who board at school, students who experience bullying, students with low social support, students with depressed caregivers, and students with low family assets.

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Disclosure

The authors report no conflicts of interest in this work.

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