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Teacher-student relationships and mental disorders of undergraduate and graduate students in online education: A moderated mediation model of mobile phone addiction and hometown setting

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ABSTRACT

To solve the problem of distance education and cope with emergencies, online education has become one of the common educational methods in recent years.

Objects: This study aimed to explore the relationship between the teacher-student relationship (TSR) and mental disorders of university students in online education.

Measures: 2032 full-time undergraduate and graduate students from a comprehensive university in China participated in the online survey. The Chinese version of the Depression, Anxiety, Stress Scale-21 Items, the Chinese version of the Mobile Phone Addiction Index (MPAI), and the 7-item Teacher-Student Relationship Perception Questionnaire were administered to the students.

Results: We found that higher quality of perceived TSR and a lower level of mobile phone addiction were associated with better mental health among undergraduate and graduate students during online education. Mobile phone addiction mediated the relationship between TSR and mental disorders, and hometown setting moderated the relationship between TSR and mobile phone addiction. Specifically, a higher quality of perceived TSR was associated with a lower level of mobile phone addiction. In addition, for students with low-quality perceived TSR, those who came from rural areas had a higher level of mobile phone addiction than those who came from urban areas. In contrast, when students had high-quality perceived TSR, the differences between students from urban and rural areas in mobile phone addiction were insignificant.

Conclusion: The results of this study are of great significance in improving the mental health and mobile phone addiction of undergraduate and graduate students during online education and reveal the urban-rural differences in the impact of TSRs during online education.

1. Introduction

Teacher-student relationship (TSR) refers to the connection between teachers and students in the process of educational communication (Xiang et al., 2022). A positive TSR is defined as students' perception that they partake in positive interactions with their teachers and that their teachers express a supportive attitude toward their educational requirements (Collie et al., 2016). A close and effective TSR can stimulate learning behavior, support young students in addressing their needs, and make them feel safe and secure in the school environment

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(Khalilzadeh & Khodi, 2021). On the contrary, unhealthy TSRs can lead to a lack of security among students and are considered to hinder and interfere with students' attempts to meet their needs in school (Hamre & Pianta, 2001).

In recent years, many schools have changed their teaching mode from traditional classroom education to online education. This shift, marked by changes in communication tools, decreased interaction frequencies, and altered classroom environments, holds profound implications for students' well-being (Hebebci et al., 2020). Online education has brought convenience to students and faculty and reduced campus conflicts (Vagos & Carvalhais, 2022). However, the advantages of traditional classroom settings, which include enhanced teacher-student interactions, a conducive environment for understanding and focus, and a pace of learning that fosters interactivity and less dependency on technology, still exist (Saurabh et al., 2021). In addition, the findings of a longitudinal study by Hewson (2018) shed light on the significance of the living environment under online education, which might lead to more inequality. Since mobile phone dependency and low academic engagement are already prevalent social and psychological issues in rural areas of China (Zhen et al., 2020), this change in the learning environment may widen the educational inequality between students from urban and rural areas. For these students from rural areas, the transition to university life, often coupled with the challenges of adapting to an urban or online educational setting, underscores the need for strong, supportive TSRs (Chen, 2022; Srinivasan et al., 2021).

However, most research samples focus on TSR and students' well-being are underage students (Daumiller et al., 2016; Kiltz et al., 2020). Due to the systematic specialty that university faculty and students always involve in various fields with roughly equal participation, findings on TSRs from the underage students' setting cannot be easily applied to the university context (Daumiller et al., 2020).

The current study examined whether undergraduate and graduate students with closer TSRs tend to have better mental health status. To our knowledge, the current paper is the first study to explore the impacts of TSR among university students of different educational levels and hometown settings under online education.

1.1. Teacher-student relationships (TSR) and mental health in online education

It is reported that mental disorders have become a serious problem among college students, and the prevalence of anxiety and depression among college students has reached 31% and 34% (Zhai & Du, 2020; Chang et al., 2021). A positive TSR has been proven to be associated with the well-being of the students (Hadi, 2020; Yao et al., 2020). Vagos and Carvalhais (2022) delved into the differences in sustaining the quality of teacher-student relationships (TSR) across online and traditional classroom contexts, revealing educators' need to leverage TSR strategically to achieve positive mental outcomes in online settings for both teachers and students. In addition, TSR might influence depressive symptoms not only directly but also through behavior-related variables and be constrained by the life background of students (Chen et al., 2021; Chirkov & Ryan, 2001).

1.2. The mediating role of mobile phone addiction

In online education, with reduced teacher supervision, young adults were reported to extended exposure to mobile devices, which would lead to a higher risk of digital distraction and internet addiction (Colomo Magaña, Cívico Ariza, Ruiz Palmero, & Sánchez Rivas, 2021; Fook et al., 2021; Sepulveda-Escobar & Morrison, 2020; Wang et al., 2020). Mobile phone addiction significantly impacts the mental state of its users. Research has shown a significant correlation between mobile phone addiction and mental disorders (Elhai et al., 2020; Sohn et al., 2019; Tao et al., 2017; Yang et al., 2019). Smartphone addiction may be a trigger for depression and anxiety (Long et al., 2016; Kwon & Paek, 2016; Demirci et al., 2015; Chen et al., 2016; Tao et al., 2017; Tavakolizadeh et al., 2014; Eyvazlou, Zarei, Rahimi, & Abazari, 2016; Chen, 2017; Hussain, Griffiths, & Sheffield, 2017; Hou, Elhai, Hu, She, & Xi, 2021).

The TSR is an influencing factor in the use of problematic mobile phones. Students' perceptions of support from teachers strongly influence their problem behavior (Vansteenkist et al., 2012). Teachers' support for students reduced the problem of mobile phone addiction among students (Peng et al., 2020). Contradictorily, in an unhealthy TSR, students will feel anxious and are more likely to turn to other environments (such as the online world of smartphones) to satisfy their psychological needs (Zhang et al., 2018). After controlling for factors such as gender, age, and grade, healthy TSRs have a negative predictive effect on problematic mobile phones (Shi et al., 2022).

1.3. Hometown setting as a moderator

Urban-rural disparities in healthcare, education, and income persist in China and have become a major problem that must be addressed in China's development (Zhou et al., 2021). Education disparities are likely the most significant of these urban-rural discrepancies (Gu, 2022; Yue et al., 2018). These discrepancies may elicit differences in emotional and motivational aspects, including the relationship between teachers and students and anxiety levels related to their academic competence (Hattie & Learning, 2009; Zhou et al., 2021).

The potential impact of TSRs may be more substantial among rural students than their urban counterparts. The offspring of Chinese rural migrants do not have access to complimentary educational opportunities in urban areas, resulting in a significant number of school-aged rural children being unable to accompany their migrating parents and remaining in their hometowns (Hong & Fuller, 2019). According to Liang et al. (2018), there is a tendency for parents residing in urban regions to exhibit a higher level of attentiveness toward their children compared to parents residing in rural areas. In urban areas, students have access to additional social-emotional support beyond the school environment, while in rural areas, teachers may serve as the mainstay of social-emotional support for students (Wang, 2023; Zhou et al., 2021).

To gain insight into students' development in online education, the interaction between students' immediate surroundings and the broader ecological system should be considered (Berk, Barr, & Principe, 2000). Bronfenbrenner's (1979) Ecological Systems Theory is well recognized as a prominent framework for understanding the various circumstances a young individual develops. The theory postulates that specific environmental elements have the potential to exert an influence on the intrapersonal traits of individuals. Therefore, to investigate the mental status of undergraduate and graduate students in online education, the hometown setting here refers to resources and immediate individual surroundings of students. The initial and proximate layer of the ecological system that engages with intrapersonal elements is referred to as students' social circles, encompassing their perception of TSR (McConney & Perry, 2010). TSR may impact depressive symptoms in a multifaceted manner: it directly affects students' emotional well-being and indirectly influences behavioral variables, with these interactions further shaped by the diverse backgrounds of the students (Chen et al., 2021; Chirkov & Ryan, 2001; Shi et al., 2022; Zhou et al., 2021). The inquiry was structured around the following research questions:

1. Is there a link between the quality of TSR and the prevalence of mental disorders among university students engaging in online education?
2. Can problematic phone use serve as a mediator in the relationship between TSR and mental disorder?
3. Does the students' hometown setting play a role in moderating the impact of TSR on problematic phone use and mental disorders?

In summary, we propose the following hypothesis: (1) TSR would be a significant negative predictor of mental disorders; (2) Mobile phone

addiction would mediate the relationship between TSR and mental disorders; (3) Hometown setting would moderate the relationships between TSR and mental disorders and TSR and mobile phone addiction (see Fig. 1 for a visual representation of our hypotheses).

2. Methods

2.1. Data sources and sample composition

From July 7 to 17, 2021, we conducted this cross-sectional study with a large sample size of Chinese undergraduate and graduate students during the spring semester of 2021. All full-time undergraduate and graduate students from a university in Shanghai province, China, were invited to participate in the online questionnaire survey. During this period, Shanghai was in a phase of relaxing quarantine requirements. Students took online courses but did not have strict travel restrictions as it was not identified as medium-high-risk areas (Health Commission of China, 2021). 2023 students answered the questionnaires from the web link. After excluding participants with inconsistent responses or incomplete demographic questionnaires, the 2009 questionnaires were deemed valid, with an average age of 22.14 ± 4.35 years old.

The Ethics Committee at Shanghai Jiao Tong University approved the study protocol (approval number: H2021158I). Each participant provided written informed consent before responding to the questionnaire and was informed of the purpose of the study.

2.2. Measures

2.2.1. Teacher-student relationship

Teacher-student relationship: For undergraduate students, TSR was assessed by the answers to the first question from the Teacher-Student Relationship Perception Questionnaire compiled by Yu et al. (2017): "I have a very good relationship with my teacher," which were rated on a 5-point Likert-type scale, ranging from 1 (Did not apply to me at all) to 5 (Applied to me very much or most of the time). The Teacher-Student Relationship Perception Questionnaire has an internal consistency coefficient of 0.945 among Chinese students (Xu et al., 2022). For graduate students, TSR was measured through all seven questions in the Teacher-Student Relationship Perception Questionnaire (e.g., "I believe my supervisor is very satisfied with my current academic performance"). In this study, we strictly handled missing data by excluding any questionnaires that were not fully completed. The average score of all items that students respond to represents the quality of the TSR, and the higher the score, the higher the quality of the TSR (Wang et al., 2022). The Cronbach α for the Teacher-Student Relationship Perception Questionnaire was 0.812 in this study.

2.2.2. Mobile phone addiction

Mobile phone addiction: This was assessed using the Mobile Phone Addiction Index (MPAI) (Huang et al., 2014). This scale's Chinese version is widely used among Chinese students and has good psychometric properties (An et al., 2022; Lian et al., 2016). Sample items included statements such as "You always feel that there is not enough time to use your Smartphone " and "You find it challenging to turn off your Smartphone." All 17 items were rated on a 5-point Likert-type scale, ranging from 1 (Never) to 5 (Always), while higher total scores indicate higher levels of mobile phone addiction. The four components of MPAI encompass the following aspects: control craving, the feeling of anxiety and being lost, withdrawal or escape, and productivity loss (CFI = 0.986, TLI = 0.957, SRMR = 0.020). Furthermore, Cronbach's alpha coefficient yielded a value of 0.90 for the overall scale. The reliability of all four dimensions was deemed satisfactory, as indicated by Cronbach's alpha coefficients of 0.851, 0.834, 0.863, and 0.823.

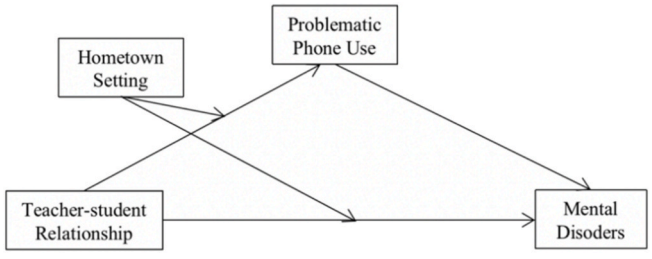

Fig. 1. Hypotheses model of the association between TSR traits and mental disorders.

2.2.3. Mental health

Since anxiety and depression were reported to be associated with mobile phone addiction and TSR and had a high prevalence among university students, we referred to anxiety and depression as mental health indicators in this study.

2.2.3.1. Depression. **Depression:** This was assessed using the Chinese version of Depression, Anxiety, and Stress Scale - 21 Items (DASS-21) (Lovibond & Lovibond, 1995; Wang et al., 2016). 7 items for depression were rated on a 4-point Likert-type scale, ranging from 0 (Did not apply to me at all) to 3 (Applied to me very much or most of the time). At the same time, higher scores indicate higher levels of depressive symptoms (total score 0–9 = minimal, 10–13 = mild, 14–20 = moderate, 21–27 = severe, 28+ = extremely Severe) (CFI = 0.971, TLI = 0.956, SRMR = 0.028). The Cronbach α for the 7 items for depression was 0.905 in this study.

2.2.3.2. Anxiety. **Anxiety:** The 7 items of anxiety from the Depression, Anxiety, and Stress Scale - 21 Items (DASS-21) were used to assess anxiety, which was rated on a 4-point Likert-type scale, ranging from 0 (Did not apply to me at all) to 3 (Applied to me very much or most of the time). Higher scores indicate higher levels of depressive symptoms (total score 0–7 = minimal, 8–9 = mild, 10–14 = moderate, 15–19 = severe, 20+ = extremely Severe) (CFI = 0.977, TLI = 0.966, SRMR = 0.026). The Cronbach α for the 7 items for anxiety was 0.896 in this study.

2.2.4. Hometown setting

Hometown setting: This was measured by asking "Where is your family residence?". Responses for the hometown indicator were 1 = ''urban,'' 2 = ''rural''.

2.3. Statistical analysis

Stata version 17.0 was used for data analysis. The quantitative data were represented using the mean ± standard deviation. The investigation of correlation analysis between the variables was conducted using the Pearson correlation analysis. $p < 0.05$ means that the difference has statistical significance. Depression and anxiety, two research focal variables, are regarded as observable mental health indicators and considered latent constructs. The study employed path analysis to examine the potential mediating and moderating effects. To further investigate the moderating effects, we used analysis of covariance (ANCOVA) controlling for gender and grade. In addition, we conducted a Bonferroni-corrected post hoc analysis to evaluate the score differences in different combinations. The variables underwent standardization during the mediating and moderating analyses.

3. Results

3.1. Scores of participants in teacher-student relationships, mobile phone addiction, anxiety, and depression

Descriptive data for participants' scores in perceived TSR, mobile

phone addiction, anxiety, depression, and hometown setting are presented in Table 1. Among them, 1439 were female (71.63 %), while 570 were male (28.37). The findings indicated that the mean score for perceived TSR was 3.52 ± 8.82, the mean score for mobile phone addiction was 37.96 ± 13.06, the mean score for anxiety was 10.61 ± 9.58, and the mean score for depression was 11.84 ± 9.77. More participants came from urban areas (67.94%) and were undergraduate students (75.26%).

3.2. The distribution of scores of participants in the teacher-student relationship, mobile phone addiction, anxiety, and depression

Fig. 2 shows the distribution of the DASS-21-anxiety score. 44.35 % of the participants had minimal anxiety, 4.93 % had mild anxiety, 19.16 % had moderate anxiety, 10.05 % had severe anxiety, and 21.05% had extremely severe anxiety. Regarding the DASS-21 depression score, this distribution was 42.71%, 10.25%, 27.82%, 12.24%, and 6.97%. Undergraduate students had the lowest prevalence of minimal anxiety (36.18%) and depression (36.51%) and the highest percentage of extremely severe anxiety (26.92%) and depression (7.87%). Moreover, the lowest average scores for TSR and the highest average scores for MPAI were also among undergraduate students. In addition, no matter their educational level, students from rural areas had lower average scores in perceived TSR (overall difference was −0.08) and higher average scores in anxiety (overall difference was 1.26) than students from urban areas. However, these differences were not statistically significant ($P > 0.05$).

3.3. Testing for mediation effects

Table 2 displays the results of the path analysis to test the hypothesized mediation model after controlling for gender and grade. Perceived TSR negatively predicted perceived MPAI among students ($\beta = -0.09$, $p < 0.001$), as well as mental health ($\beta = -0.17$, $p < 0.001$). MPAI positively predicted mental health among students ($\beta = 0.54$, $p < 0.001$). These associations were significant across all educational backgrounds (see Appendix 1).

3.4. Testing for moderated mediation effects

Table 3 presents the results of the path analysis that tested the moderating role of the hometown setting. The results indicated that the hometown setting moderated the link between TSR and mobile phone addiction ($\beta = -0.43$, $p < 0.001$). This moderation was also statistically significant among undergraduate students ($\beta = -0.43$, $p < 0.001$) and Ph.D. students ($\beta = -0.99$, $p < 0.001$). However, the moderation of hometown setting on the relationship between TSR and mental health was insignificant (Appendix 2). Fig. 3 illustrates the results of our testing of moderated mediation effects.

Table 1
Descriptive statistics of variables among 2009 participants.

	Minimum value	Maximum value	Mean	SD
Teacher-student relationship	1	5	3.52	1.04
Mobile phone addiction	17	85	37.96	13.06
Anxiety	0	42	10.61	9.58
Depression	0	42	11.84	9.77
		n		%
Sex				
Male		570		28.37
Female		1439		71.63
Hometown				
urban		1365		67.94
rural		664		32.06
Educational level				
undergraduate students		1512		75.26
graduate students		237		11.8
Ph.D. students		260		12.94

3.5. Further investigation of the moderating effects

We used analysis of covariance (ANCOVA) controlling for gender and grade to investigate the moderating effects of perceived TSR and hometown on mobile phone addiction (Table 4). Then, Bonferroni corrected post hoc tests were conducted after the ANCOVA to provide more details about differences among groups (Fig. 4) .

High-quality perceived TSR was associated with lower MPAI for students both from urban ($t = -3.59$, 95% CI = −6.07, −1.21, $P = 0.001$) and rural ($t = -4.39$, 95% CI = −7.54, −2.21, $P < 0.001$) areas. However, there is no significant difference in the MPAI between urban students with low quality and those with moderate quality of perceived TSR. Moreover, for students with low-quality perceived TSR, the MPAI of students from urban was significantly lower than that of students from rural areas. For students with moderate quality of perceived TSR, the MPAI of students from rural areas was significantly lower than that of students from urban areas. However, when the quality of perceived TSR was high, there was no significant difference between the MPAI of students from the urban and those from the rural areas.

In the subgroup analysis, we found that the moderating effect of hometown settings varied in different educational backgrounds.

For example, among urban graduate students and Ph.D. students, we found no significant difference in MPAI among students with different qualities of perceived TSR. However, among rural graduate students, those with high-quality perceived TSR had significantly lower MPAI than students with low ($p < 0.01$) or moderate ($p < 0.05$) quality of perceived TSR. For rural Ph.D. students, the higher the quality of the perceived TSR, the lower the MPAI ($p < 0.05$).

In addition, for undergraduates with low-quality perceived TSR, the MPAI of urban students was significantly lower than that of rural students ($p < 0.05$). Nonetheless, when the quality of perceived TSR was high, there was no significant difference between the MPAI of urban and rural undergraduate students. However, among graduate students, there was no significant difference in MPAI between students from urban and rural areas. Among Ph.D. students, for those with high-quality perceived TSR, those from rural areas had significantly lower MPAI than students from urban areas ($p < 0.01$).

4. Discussion

This cross-sectional study examines the association between perceived TSR and mental health in online education in China. Additionally, it investigates the role of mobile phone addiction as a mediator in the relationship between perceived TSR and mental health, as well as the moderating effect of hometown setting on the relationship between perceived TSR and mental health. The findings of the study indicate that students who exhibited a higher quality of TSR reported a lower incidence of mental disorders, such as anxiety and depression. Furthermore, the mediation model suggests that the impact of perceived TSR on mental health may be mediated by mobile phone addiction. Moreover, the association between perceived TSR and mobile phone addiction is moderated by students' hometown settings.

During this online education period, high levels of anxiety and depression were found among students. 55.65% and 57.29% of students had mild to extremely severe levels of anxiety and depression. The prevalence of mild to extremely severe levels of anxiety and depression among undergraduate students was even higher, which reached 63.82% and 63.49%, respectively. Compared to surveys conducted during the COVID-19 pandemic in 2020, the prevalence of anxiety and depression is higher in this study (Cao et al., 2020; Qi et al., 2020; Sun et al., 2021). One of the possible reasons might be the different scales used to assess mental disorders. In addition, students stayed at home during the

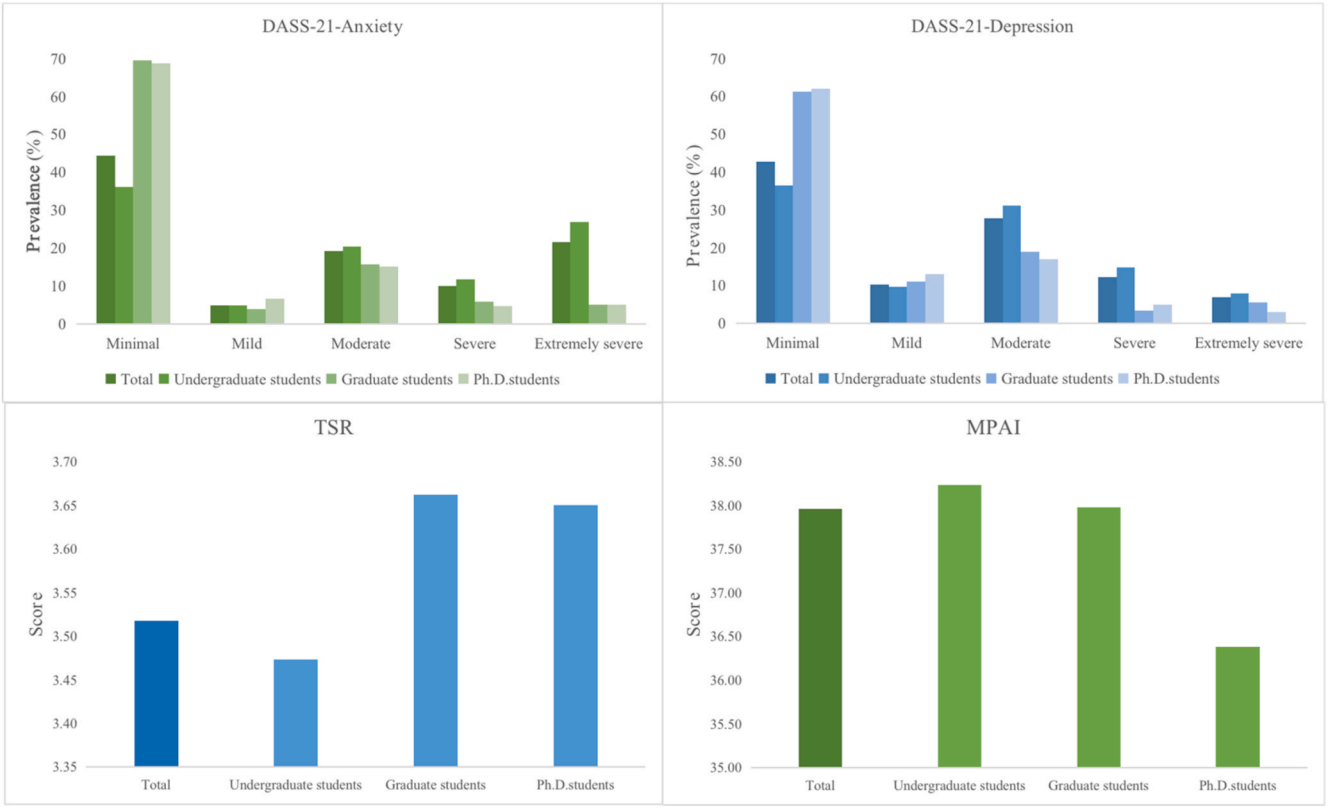

Fig. 2. The distribution of anxiety (A), depression (B), Teacher-student relationship (TSR) (C), and Mobile Phone Addiction Index (MPAI) (D) scores.

Table 2
Testing tshe mediation effect of mobile phone addiction on mental health via TSR in students.

Predictors	MPAI			Mental health		
	Est.	SE	p	Est.	SE	p
Total (N = 2009)						
Gender	0.04	0.024	0.070	−0.09	0.019	<0.001
Grade	−0.03	0.024	0.266	−0.21	0.019	<0.001
TSR	−0.09	0.024	<0.001	−0.17	0.019	<0.001
MPAI				0.54	0.018	<0.001
Inability to Control Craving	0.79	0.011	<0.001			
Feeling Anxious & Lost	0.85	0.009	<0.001			
Withdrawal/Escape	0.73	0.012	<0.001			
Productivity Loss,	0.79	0.011	<0.001			
Anxiety				0.91	0.010	<0.001
Depression				0.91	0.010	<0.001

Est. standardized coefficients, SE standard error.

Table 3
Testing the moderated mediation effect of the teacher-student relationship (TSR) on mental health.

Predictors	MPAI			Mental health		
	Est.	SE	p	Est.	SE	p
Total						
Gender	0.05	0.024	0.056	−0.09	0.019	<0.001
Grade	−0.03	0.024	0.208	−0.21	0.019	<0.001
TSR	0.18	0.071	0.010	−0.24	0.058	<0.001
Hometown setting	0.33	0.083	<0.001	−0.03	0.068	0.620
Int	−0.43	0.105	<0.001	0.10	0.086	0.251
MPAI				0.54	0.018	<0.001
Inability to Control Craving	0.79	0.011	<0.001			
Feeling Anxious & Lost	0.85	0.009	<0.001			
Withdrawal/Escape	0.73	0.012	<0.001			
Productivity Loss,	0.78	0.011	<0.001			
Anxiety				0.91	0.010	<0.001
Depression				0.91	0.010	<0.001

Int = TSR × Hometown setting, Est. standardized coefficients, SE standard error. MPAI = Mobile Phone Addiction Index (MPAI).

quarantine period in 2020, which could receive support from their family members. After going back to school but still in online education because of the risk of infection, the reduced social support might lead to a higher prevalence of mental disorders (Harandi et al., 2017; Qi et al., 2020).

Students with a higher quality of perceived TSR were associated with less anxiety and depressive symptoms regardless of their educational background. This finding aligns with previous research (Hadi, 2020; Yao et al., 2020). The results of this study suggested that the relationship between perceived TSR and mental disorders could be mediated by mobile phone addiction. Mobile phone addiction is associated with several mental disorders, including anxiety, depression, and sleep problems (Long et al., 2016; Kwon & Paek, 2016; Demirci et al., 2015; Chen et al., 2016; Tao et al., 2017; Tavakolizadeh et al., 2014; Eyvazlou et al., 2016; Chen, 2017; Hussain et al., 2017; Hou et al., 2021). Studies have shown that people who had high-quality perceived TSR and received support from their teacher were less likely to feel anxious and could always help them feel more secure (Zhang et al., 2018). This aligns with the finding that perceived support from teachers strongly influences students' problematic behaviors (Vansteenkist et al., 2012).

This study also found the moderating effect of hometown settings on the relationship between perceived TSR and mobile phone addiction. Overall, for students who came from rural areas, the higher quality of perceived TSR was associated with a lower level of mobile phone addiction compared to those who came from urban areas. In addition,

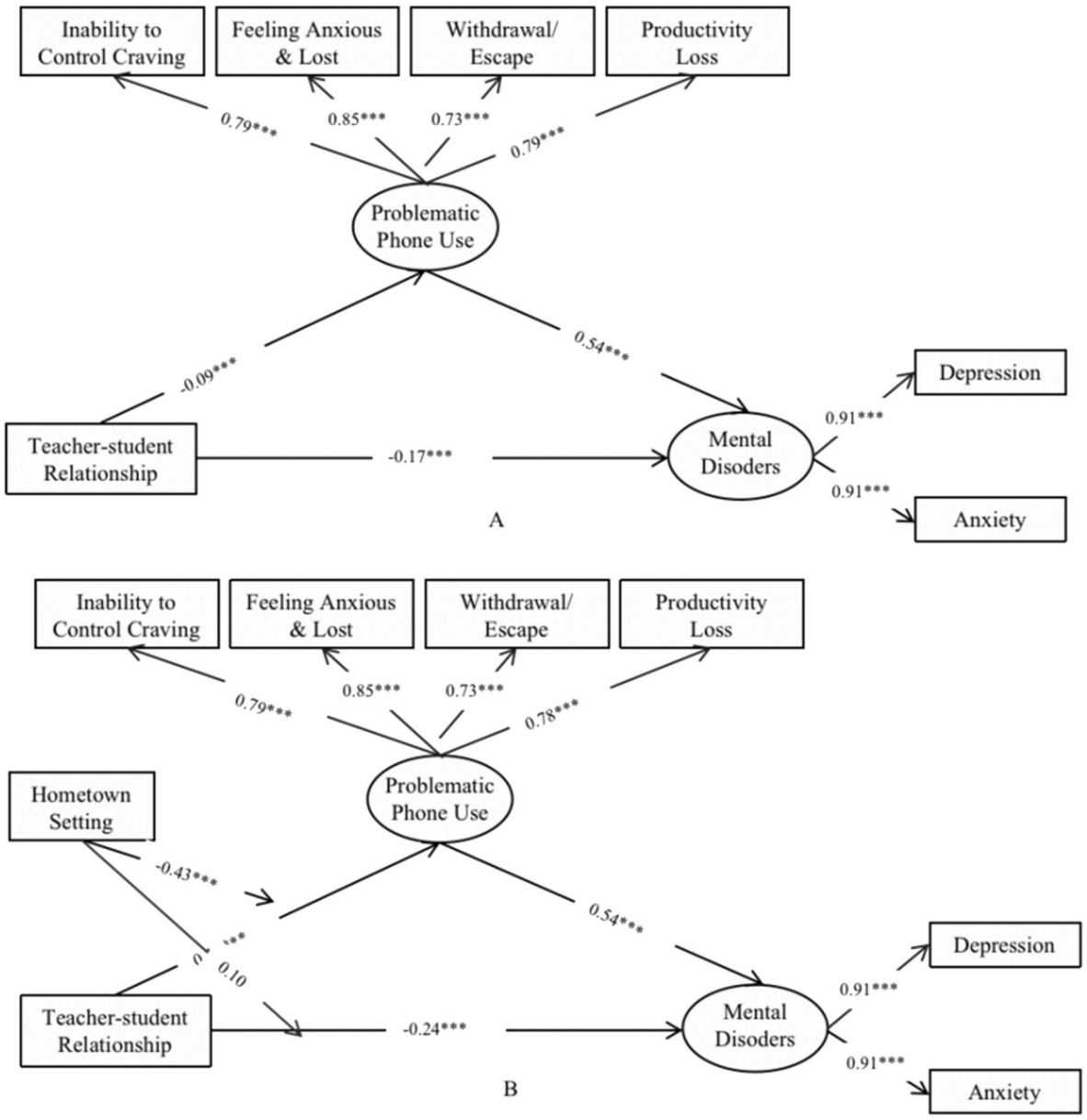

Fig. 3. The results of testing for mediation effects (A) moderated mediation effects (B).

the moderating effect of hometown settings varied between different educational backgrounds. For undergraduate students who had low quality of perceived TSR, students from rural areas reported higher levels of mobile phone addiction compared to those from urban areas. However, this difference was not significant among graduate students and Ph.D. students.

Previous studies have shown that students from urban areas are more likely to have additional support, and their parents exert more attention on their development compared to students from rural areas in China (Liang et al., 2018; Wang, 2023; Yue et al., 2018; Zhou et al., 2021; Zhou et al., 2021, 2021). With expanded social circles and resources, the influence of this disparity on problematic behaviors could diminish (Harandi et al., 2017; Qi et al., 2020). Our study found that students from rural areas had lower average scores in perceived TSR and higher average scores in anxiety than students from urban areas in all educational levels. However, among graduate students, there was no significant difference in mobile phone addiction between students from urban areas and rural areas with all levels of quality of TSR. In addition, among Ph.D. students who had high-quality TSR, rural hometown settings were associated with a lower level of problematic behaviors. The results implied the importance of TSRs in online education for students' mental health, especially for undergraduate students whose hometowns were in rural areas. Teachers who are sensitive to the diverse needs and backgrounds of their students would be more likely to help bridge the gap between rural and urban educational experiences (Cao et al., 2023; Xie & Reay, 2020).

It is true that the perspective of psychological and behavioral problems ultimately falls on the micro individual, but this does not mean that it contains no structural problems of the environment. As societies become more complex and rapidly changing, some psychological and behavioral problems are essentially expressions of social suffering (Berk et al., 2000; McConney & Perry, 2010). Our research sheds light on the relationship between perceived TSR and mental health and the role of mobile phone addiction and hometown setting in students with different educational levels in online education. Those interaction effects illustrate the ecological system that how environmental elements influence the development of individuals (Bronfenbrenner, 1979).

These findings highlight the need for educational strategies to

Table 4
Bonferroni corrected Post Hoc Comparisons of the interaction of perceived teacher-student relationship (TSR) and hometown on mobile phone addiction (MPAI).

	Hometown setting	Perceived TSR	Difference	t	P	95% Confidence Interval	
Overall	urban	Moderate vs Low	0.02	0.02	1.000	−1.88	1.91
		High vs Low	−3.64	−3.59	0.001	−6.07	−1.21
		High vs Moderate	−3.66	−3.75	0.001	−6.00	−1.32
	rural	Moderate vs Low	−4.88	−4.39	<0.001	−7.54	−2.21
		High vs Low	−9.30	−6.09	<0.001	−12.95	−5.64
		High vs Moderate	−4.42	−2.91	0.011	−8.05	−0.78
	Perceived TSR	Hometown setting	Difference	t	P	95% Confidence Interval	
	low	Rural vs Urban	2.83	2.9	0.004	0.91	4.74
	moderate	Rural vs Urban	−2.07	−2.2	0.028	−3.91	−0.22
	high	Rural vs Urban	−2.83	−1.83	0.067	−5.86	0.20
Undergraduate	Hometown setting	Perceived TSR	Difference	t	P	95% Confidence Interval	
	urban	Moderate vs Low	0.20	0.22	1.000	−2.02	2.43
		High vs Low	−4.14	−3.38	0.002	−7.08	−1.20
		High vs Moderate	−4.35	−3.5	0.001	−7.33	−1.37
	rural	Moderate vs Low	−4.74	−3.73	0.001	−7.79	−1.69
		High vs Low	−7.84	−4.42	<0.001	−12.09	−3.59
		High vs Moderate	−3.10	−1.72	0.254	−7.41	1.21
	Perceived TSR	Hometown setting	Difference	t	P	95% Confidence Interval	
	low	Rural vs Urban	2.55	2.35	0.019	0.42	4.68
	moderate	Rural vs Urban	−2.40	−2.1	0.036	−4.63	−0.16
	high	Rural vs Urban	−1.15	−0.61	0.539	−4.81	2.52
Graduate	Hometown setting	Perceived TSR	Difference	t	P	95% Confidence Interval	
	urban	Moderate vs Low	0.25	0.11	0.915	−4.45	4.96
		High vs Low	−2.29	−0.81	0.417	−7.85	3.26
		High vs Moderate	−2.55	−1.16	0.249	−6.88	1.79
	rural	Moderate vs Low	−4.17	−1.14	0.254	−11.35	3.01
		High vs Low	−13.04	−2.79	0.006	−22.26	−3.82
		High vs Moderate	−8.87	−2.18	0.030	−16.89	−0.84
	Perceived TSR	Hometown setting	Difference	t	P	95% Confidence Interval	
	low	Rural vs Urban	5.32	1.45	0.150	−1.93	12.56
	moderate	Rural vs Urban	0.89	0.38	0.702	−3.70	5.48
	high	Rural vs Urban	−5.43	−1.36	0.176	−13.32	2.46
Ph.D.	Hometown setting	Perceived TSR	Difference	t	P	95% Confidence Interval	
	urban	Moderate vs Low	−0.56	−0.27	0.788	−4.65	3.53
		High vs Low	−2.75	−1.13	0.261	−7.56	2.06
		High vs Moderate	−2.19	−1.09	0.276	−6.15	1.76
	rural	Moderate vs Low	−7.55	−2.33	0.021	−13.92	−1.17
		High vs Low	−16.39	−4.01	<0.001	−24.44	−8.35
		High vs Moderate	−8.85	−2.36	0.019	−16.22	−1.48
	Perceived TSR	Hometown setting	Difference	t	P	95% Confidence Interval	
	low	Rural vs Urban	4.18	1.37	0.173	−1.84	10.21
	moderate	Rural vs Urban	−2.80	−1.24	0.217	−7.26	1.66
	high	Rural vs Urban	−9.46	−2.63	0.009	−16.55	−2.37

nurture solid teacher-student connections, which is particularly important in online learning settings where traditional interaction avenues are limited. It is vital to address issues such as mobile phone addiction and the diverse challenges students from various backgrounds face to forge a supportive educational framework that enhances mental health (Khoirunnisa, 2022; Zhang, 2023, pp. 98–101). As the digital era transforms education, the insights from this study could serve as important guidance for educators, policymakers, and mental health experts to devise strategies that bolster mental well-being. Moreover, empowering teachers with the necessary tools to support students emphasizes the importance of enhancing teacher mental health literacy and embedding comprehensive mental health support and training within the educational framework (Miller et al., 2019; Kidger et al., 2021). Teachers have been reported to have significant stress levels due to occupational demands, including challenges such as lack of administrative support, increased workloads, and inadequate resources (Ferguson et al., 2022). Additionally, the COVID-19 pandemic has heightened mental health concerns among teachers, surpassing those in other professions and highlighting the critical need for policies focused on teacher well-being to sustain effective teaching practices (Kush, Badillo-Goicoechea, Musci, & Stuart, 2022).

Several limitations need to be considered when interpreting the results of the present study. First, causal inferences among mental health perceived TSR, mobile phone addiction, and hometown setting in online education cannot be made from these cross-sectional data. Studies using longitudinal data could provide further evidence for the mediating and moderating effects found in this study. Second, data were based on students' retrospective self-reported measures of mental disorders, TSR, and mobile phone addiction. Future studies may benefit from using technology to capture real-time patterns. Third, there are other factors besides mobile phone addiction that could be considered to have mediating effects on mental disorders. Finally, gender was only considered as a covariate, but gender differences were not considered in this study.

In summary, mobile phone addiction and hometown settings could affect the effect of the perceived TSR during online education on students' mental health. More support from teachers and better TSR might be a practicable way of maintaining and improving their mental health

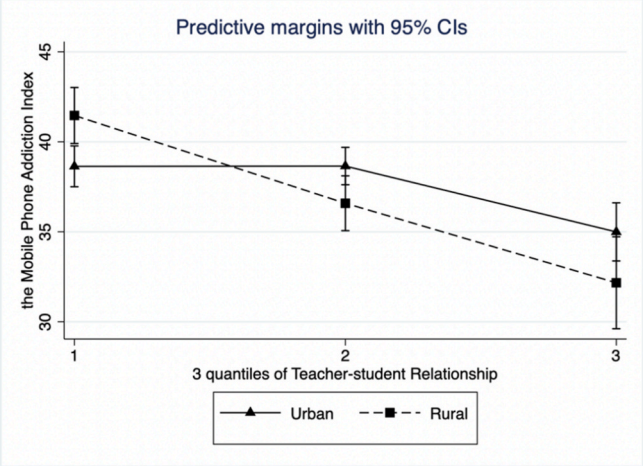

Fig. 4. Hometown setting moderated the relationship between perceived teacher-student relationships and mobile phone addiction.

during online education, especially for students from rural areas.

Ethics statement

The Ethics Committee at Shanghai Jiao Tong University approved the study protocol (approval number: H2021158I). Each participant provided written informed consent before they responded to the questionnaire. All participants provided written informed consent before they responded to the questionnaire and were informed of the purpose of the study.

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CRediT authorship contribution statement

Jingya Dong: Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Conceptualization. **Yang He:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Conceptualization. **Feng Jiang:** Writing – review & editing, Methodology, Data curation, Conceptualization. **Zuokun Liu:** Writing – review & editing, Methodology, Conceptualization. **Yuchen Ni:** Writing – review & editing, Methodology, Conceptualization. **Yilang Tang:** Writing – review & editing. **Jin Luo:** Writing – review & editing, Supervision, Data curation, Conceptualization. **Zhaoxu Zhang:** Writing – review & editing, Supervision, Funding acquisition, Conceptualization. **Yangmu Huang:** Writing – review & editing, Supervision, Funding acquisition, Conceptualization.

Declaration of competing interest

None.

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix

Appendix 1. Testing the mediation effect of mobile phone addiction on mental health via TSR in students at different educational levels

Predictors	MPAI			Mental health		
	Est.	SE	p	Est.	SE	p
Undergraduate students (N = 1512)						
Gender	0.01	0.027	0.585	−0.09	0.022	0
Grade	0.06	0.027	0.023	0.08	0.022	0
TSR	−0.08	0.027	0.004	−0.17	0.022	0
MPAI				0.58	0.02	0
Inability to Control Craving	0.79	0.011	0			
Feeling Anxious & Lost	0.87	0.009	0			
Withdrawal/Escape	0.76	0.012	0			
Productivity Loss,	0.8	0.011	0			
Anxiety				0.91	0.01	0
Depression				0.91	0.01	0
Graduate students(N = 237)						
Gender	0.17	0.067	0.013	−0.08	0.06	0.201
Grade	0.02	0.033	0.563	−0.07	0.029	0.024
TSR	−0.17	0.066	0.012	−0.13	0.059	0.025
MPAI				0.59	0.058	0
Inability to Control Craving	0.76	0.027	0			
Feeling Anxious & Lost	0.81	0.026	0			
Withdrawal/Escape	0.6	0.03	0			
Productivity Loss,	0.76	0.028	0			
Anxiety				0.91	0.027	0
Depression				0.78	0.026	0

(*continued on next page*)

(*continued*)

Predictors	MPAI			Mental health		
	Est.	SE	p	Est.	SE	p
Ph.D. students(N = 260)						
Gender	0.08	0.065	0.211	−0.06	0.059	0.277
Grade	0.02	0.04	0.648	−0.06	0.037	0.093
TSR	−0.15	0.058	0.01	−0.26	0.053	0
MPAI				0.32	0.067	0
Inability to Control Craving	0.75	0.028	0			
Feeling Anxious & Lost	0.76	0.028	0			
Withdrawal/Escape	0.63	0.03	0			
Productivity Loss,	0.72	0.029	0			
Anxiety				0.9	0.026	0
Depression				0.81	0.025	0

Est. standardized coefficients, SE standard error.

Appendix 2. Testing the moderated mediation effect of emotion regulation on mental health in students at different educational levels

Predictors	MPAI			Mental health		
	Est.	SE	p	Est.	SE	p
Undergraduate						
Gender	0.02	0.027	0.413	−0.1	0.022	0
Grade	0.07	0.027	0.014	0.07	0.022	0.001
TSR	0.21	0.076	0.005	−0.19	0.063	0.003
Hometown setting	0.33	0.084	0	0.03	0.07	0.692
Int	−0.43	0.11	0	0.03	0.092	0.773
MPAI				0.58	0.02	0
Inability to Control Craving	0.79	0.011	0			
Feeling Anxious & Lost	0.87	0.009	0			
Withdrawal/Escape	0.76	0.012	0			
Productivity Loss,	0.8	0.011	0			
Anxiety				0.92	0.01	0
Depression				0.91	0.01	0
Graduate						
Gender	0.17	0.067	0.012	−0.07	0.06	0.267
Grade	0.01	0.057	0.905	0.03	0.049	0.555
TSR	0.09	0.144	0.545	−0.34	0.124	0.006
Hometown setting	0.44	0.233	0.059	−0.43	0.206	0.038
Int	−0.48	0.261	0.065	0.44	0.231	0.058
MPAI				0.59	0.058	0
Inability to Control Craving	0.75	0.027	0			
Feeling Anxious & Lost	0.81	0.026	0			
Withdrawal/Escape	0.6	0.03	0			
Productivity Loss,	0.76	0.028	0			
Anxiety				0.92	0.028	0
Depression				0.77	0.026	0
Ph.D.						
Gender	0.04	0.065	0.504	−0.05	0.061	0.42
Grade	−0.07	0.06	0.222	−0.02	0.057	0.665
TSR	0.38	0.12	0.002	−0.25	0.116	0.033
Hometown setting	0.75	0.178	0	−0.01	0.18	0.971
Int	−0.99	0.209	0	0.01	0.217	0.961
MPAI				0.32	0.07	0
Inability to Control Craving	0.75	0.028	0			
Feeling Anxious & Lost	0.77	0.028	0			
Withdrawal/Escape	0.63	0.03	0			
Productivity Loss,	0.72	0.029	0			
Anxiety				0.91	0.026	0
Depression				0.81	0.025	0

Int = TSR × Hometown setting, Est. standardized coefficients, SE standard error.

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