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Long-Term Effects of the COVID-19 Open Strategy on the Mental Health of Chinese University Students: A Prospective Cohort Study

Xiu Yang[1,2] | Na Luo[3] | Ya Yang[1,2] | Wenyi Jiang[1,2] | Jingjing Zhang[1,2] | Lingli Hou[1,2] | Jieqiong Zhang[4] | Congxia Hu[1,2] | Jihui Lin[1,2]

[1]Department of Nursing, The Affiliated Hospital, Southwest Medical University, Luzhou, China | [2]Wound Healing Basic Research and Clinical Application Key Laboratory of LuZhou, School of Nursing, Southwest Medical University, Luzhou, China | [3]Department of Operation Room, Xijing Hospital, Fourth Military Medical University, Xi'an, China | [4]School of Nursing, Shaanxi University of Chinese Medicine, Xianyang, China

Correspondence: Congxia Hu (congxiahu0606@sjtu.edu.cn) | Jihui Lin (linjihui@swmu.edu.cn)

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Keywords: COVID-19 | mental health | open policy | psychological trajectory | university students

ABSTRACT

Background: In December 2022, the Chinese government shifted its COVID-19 prevention and control policy to full openness, leading to a widespread pandemic within a short period. This study aimed to examine the trajectories of stress, anxiety, and depressive symptoms among Chinese university students within 1 year after the implementation of the open policy. Additionally, it investigated the influence of sleep quality, psychological resilience, and medical specialization on these psychological trajectories.

Methods: A cohort study was conducted among Chinese university students using stratified sampling. Follow-up assessments were conducted at three time points: T1 (December 2022–January 2023), T2 (May–June 2023), and T3 (December 2023–January 2024). Generalized Estimating Equations were used to estimate mean differences in symptom levels over time and to examine the influence of sleep quality, psychological resilience, and medical specialization on these changes.

Results: At T1, a total of 2,062 university students were recruited. By T3, the follow-up rate was 63.43%, resulting in a final analytical cohort of 1,308 participants. Among them, 769 (58.8%) were female, and 539 (41.2%) were male. The majority (54.7%, $n = 716$) were between 19 and 22 years old. Stress, anxiety, and depression levels were highest among Chinese university students at the beginning of the open policy and gradually decreased over the following year. Students with poor sleep quality and poor psychological resilience exhibited worsening psychological trajectories, which showed more severe and persistent symptoms. Medical and Nonmedical students consistently exhibited similar psychological trajectories.

Conclusions: Collectively, the present study indicated that the change of COVID-19 prevention and control policy had more serious negative impacts on the mental health of Chinese university students than the epidemic itself. Thus, strengthening psychological treatments and psychosocial interventions for university students would be crucial in the context of a protracted infectious disease epidemic.

Abbreviations: CD-RISC-10, the Connor-Davidson Resilience Scale Simplified; COVID-19, coronavirus disease 2019; GEE, generalized estimating equations; PSQI, The Pittsburgh Sleep Quality Index; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2; SOR, stimulus-organism-response.

Xiu Yang and Na Luo contributed equally to this study.

1 | Introduction

Coronavirus disease 2019 (COVID-19), caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), has prompted various measures from governments worldwide to slow its spread since the outbreak initiation in December 2019 [1]. As one of the first countries to experience the outbreak of COVID-19, China's response policy has several distinguishing features. Firstly, China implemented an exceptionally stringent "dynamic clearance" policy, maintaining a delicate balance between prevention and daily life [2]. Consequently, China's infection and mortality rates are significantly lower than those reported by the World Health Organization [3]. However, with the mutation of the SARS-CoV-2 virus and changes in the global epidemiological landscape, the Chinese government announced the "10 New Measures" on December 7, 2022 [4, 5]. Before this, local governments strictly adhered to previous epidemic prevention and control strategies. The sudden announcement of the policy to lift lockdowns was highly unexpected. This shift marks a transition from the "dynamic clearance" policy to a "Category B management" policy for the COVID-19 outbreak, reducing the stringency of outbreak management measures accordingly. From March 2020 to December 2022, China did not experience any large-scale infections due to its rigorous COVID-19 prevention measures [6, 7]. However, the sudden announcement of the "10 New Measures", without giving the public and the government sufficient time to prepare, inevitably led to large-scale infections and a heavy burden of epidemics [8, 9].

University students received widespread attention as a vulnerable group in terms of mental health during the COVID-19 epidemic [10, 11]. A cross-sectional study of university students in mainland China following the mass quarantine that began on January 23, 2020, noted that over 46% of university students exhibited depressive symptoms, and 34% experienced anxiety symptoms [12]. Similarly, an online survey in the United States found that 32.68% of university students suffered from moderate to severe anxiety [13]. In Europe, over 40% of university students in Germany reported increased stress and fear of the future due to the epidemic, while in France and Spain, the proportion of university students experiencing stress and anxiety reached 60% [14, 15]. Further longitudinal studies indicated that poor sleep quality was a key risk factor for deteriorating mental health among university students compared to before the pandemic [16]. Poor sleep quality is a common and growing problem in this population, impeding emotion regulation and further impairing positive emotions after disruptive events [17, 18]. Additionally, data from two follow-up studies in China suggested that good psychological resilience could help university students reduce stress, anxiety, and depression associated with the epidemic [19]. However, there are few reports on the long-term effects of these two factors on university students' psychological well-being following a specific epidemic event. On the other hand, the open policy led to a shortage of hospital staff, significantly increasing the workload of medical students [20]. Studies showed that persistent work pressure could lead to psychological syndromes, such as exhaustion, anxiety, and depersonalization, which might cause medical students to develop more serious psychological problems compared to their nonmedical counterparts [20].

Poor sleep quality and poor psychological resilience are receiving widespread attention as risk factors for university students' mental health [21, 22]. However, the long-term effects of these factors on university students' mental health during the COVID-19 open policy period remains unclear. Additionally, almost all cohort studies focused on changes in mental health before and after the onset of the COVID-19 pandemic, neglecting the effects of specific epidemic policy changes on the mental health of university students [23]. Therefore, new evidence is needed to assess the impact of policy changes during major public health events on the mental health of university students.

Here, a 1-year follow-up study was conducted to investigate the trajectories of stress, anxiety, and depressive symptoms among Chinese university students after the implementation of the open policy in China. Furthermore, the influence of sleep quality, psychological resilience, and medical specialty on the trajectories of stress, anxiety, and depression was also analyzed. This study would be beneficial for investigating the long-term effects of COVID-19 policies on university students, and also provide valuable insights for handling mental health issues among university students during future public health emergencies.

2 | Methods

2.1 | Design and Study Population

As a prospective cohort study, stratified random sampling was employed to ensure a representative and broad sample. Participants were drawn from universities across different regions of China: Sichuan, Guangdong, Hubei, Shaanxi, and Zhejiang. One class was randomly selected from each major, spanning freshman to junior years. To account for the follow-up period, only university students with at least 1 year remaining until degree completion were eligible for selection. All participants were assessed using a standardized questionnaire to collect data on socio-demographic and lifestyle factors, as well as mental health scores. Access links to the study questionnaires were distributed via the Questionnaire Star platform or by email. Participants who did not respond to the follow-up received a single reminder via email, text message, and phone call. All participants were required to complete an electronic informed consent form at the beginning of the study.

2.2 | Data Collection

The collected data were divided into three time periods: the early stage of policy announcement (T1; December 17, 2022 to January 17, 2023), the first follow-up (T2; May 17, 2023 to June 17, 2023), and the second follow-up (T3; December 17, 2023 to January 17, 2024). The campus experienced a large-scale outbreak of COVID-19 after the implementation of the policy on December 7, 2022. The T2 period was chosen because it was a high-risk period for secondary COVID-19 infections [24]. The T3 period was chosen because it marked 1 year of follow-up time.

2.3 | Outcomes

A total of three mental health outcomes were examined in this study: stress, anxiety, and depression, which were measured using the DASS-21. DASS-21 consists of three subscales (stress, anxiety, and depression) with 21 questions in total, 7 questions per subscale. The scale is rated on a 4-point scale from 0 (Did not apply to me at all) to 3 (Applied to me very much, or most of the time). Scores for each subscale are the sum of the 7 subscale-specific items multiplied by 2, resulting in a score range of 0–42. Higher scores indicate more severe symptoms. Previous studies demonstrated that the DASS-21 had good reliability and validity among Chinese university students, making it well-suited as a rapid screening tool for both research and clinical purposes [25]. The Chinese version of the DASS-21 had reliable psychometric properties [26–28]. In this study, the Cronbach's α values for the stress, anxiety, and depression subscales ranged from 0.89 to 0.92.

2.4 | Independent Variable

The Pittsburgh Sleep Quality Index (PSQI) was used to distinguish between good and poor sleep quality. This scale has been widely used in studies related to the sleep quality of Chinese university students. The PSQI score ranges from 0 to 21, with higher scores indicating poorer sleep quality. A score of 5 was chosen as the cut-off value; scores > 5 represents poor sleep quality, and scores ≤ 5 represents good sleep quality. The specificity and sensitivity of this cut-off value are 86.5% and 89.6%, respectively [29].

Psychological resilience refers to an individual's positive adaptive capacity in the face of significant adversity [30]. In this study, psychological resilience was assessed using the 10-item Connor-Davidson Resilience Scale (CD-RISC-10). This scale employs a 5-point Likert response format, with scores ranging from 0 (never) to 4 (almost always). The total score ranges from 0 to 40, with higher scores indicating better psychological resilience. The CD-RISC-10 was proved to have excellent psychometric properties in Chinese university students [31]. According to previous studies, a score of ≥ 30 would be defined as good psychological resilience, while a score of < 30 would be considered poor psychological resilience [32]. In this study, the Cronbach's α value of the scale was 0.97, indicating good reliability.

Participants were classified as medical or nonmedical students based on their reported specializations during the T1 period. The definition of medical specializations followed the catalog of specializations published by the Chinese Ministry of Education [33].

2.5 | Covariates

Covariates were collected using a standardized questionnaire which included demographic status, health characteristics, and lifestyle factors. Demographic characteristics comprised age, gender, education level, and annual household income. Based on data from the National Bureau of Statistics of China in 2023, annual household income was categorized into low-income and high-income groups, with a cut-off point of 50,000 ¥ (≈ 6860 $) per year [34]. Health characteristics included the presence of chronic diseases (yes or no), COVID-19 infection status (yes or no), and COVID-19 vaccination status (yes or no). Lifestyle factors encompassed four behaviors: smoking, alcohol consumption, outdoor activities, and time spent on electronic devices. Previous studies indicated that university students spent a median of 1.04 h per day outdoors and 3 h per day using electronic devices [35]. Therefore, outdoor activity time was categorized into ≤ 1 h and > 1 h groups, and electronic device usage time into ≤ 3 h and > 3 h groups.

2.6 | Statistical Analysis

For normally distributed continuous variables, data were presented as means and standard error of the mean, while categorical variables were described using frequencies and percentages. This study employed generalized estimating equations (GEE) to model the mental health of university students across three time periods. First, three independent models were developed for stress, anxiety, and depressive symptoms to assess the overall mean differences in symptoms across three time periods. These models included only the time period as a predictor to estimate the mean differences in symptom levels across the entire group with respect to the T1 period. Subsequently, after adjusting for covariates, differences between various independent variable groups and reference groups at different time points were analyzed. Finally, to assess trends in symptom trajectories over time at different independent variables (poor sleep quality, poor psychological resilience, and nonmedical students), nine independent models were constructed. By analyzing the interaction between the independent variable and time period, the trajectory of mean symptom levels over time for both the independent variable and reference groups were observed, and the difference in mean symptom levels between these groups were calculated. All models used exchangeable work-related matrices.

Two sensitivity analyses were performed to assess the robustness of the results: (1) repeating all analyses using the entire data set of 2062 participants; and (2) evaluating the magnitude of effect size changes before and after adjusting for all model covariates. The findings from these sensitivity analyses were compared with those from the main analyses. IBM SPSS Statistics 26 was utilized for all analyses, with a significance level set at $\alpha = 0.05$, and all tests were two-tailed.

2.7 | Ethics Approval and Consent to Participate

Based on the principle of anonymity and informed consent of the participants, data was collected. All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and/or national research committee, and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The participants would see the purpose of the study and their

personal rights clearly on the first page of the questionnaire. The formal questionnaire would only be administered after reading and signing the electronic consent. Electronic informed consent was obtained from each respondent. The study was approved by the Ethics Committee of Southwest Medical University (Ethics Approval ID: No. SWMUIRBTX-202404-0015).

3 | Results

3.1 | Demographic Characteristics of Participants

A total of 2062 participants were initially recruited for the T1 time period of this study. Subsequently, 752 participants either withdrew or declined to participate in the follow-ups during the T2 and T3 time periods. Therefore, 1308 participants were ultimately included in the analyses. There were no significant differences at T1 between participants who were included in the analysis and those who were not included (Supporting Information S1: Table S1). The distribution of demographic characteristics, health characteristics, lifestyle factors, psychological resilience, and sleep quality across the three time periods is shown in Table 1. Overall, stress, anxiety, and depression levels declined over time, with the highest anxiety scores at T1, followed by depression and stress (Figure 1).

3.2 | Stress, Anxiety and Depression Outcomes in the Independent Variable and Reference Groups at Three Time Points

After adjusting for covariates such as gender and age, differences in scores of stress, anxiety and depression levels between the independent variable and reference groups were analyzed at three time points. Students with poor sleep quality and low psychological resilience had significantly higher stress levels at T1 and T2 compared to their counterparts (Table 2). Anxiety and depression differences were most pronounced at T2. In addition, there were no significant differences in stress, anxiety, and depression levels between medical and Nonmedical students at any of the three assessed time points (Table 2).

3.3 | Longitudinal Impacts of Sleep Quality, Psychological Resilience, and Specialization on Psychological Symptoms

The results of the adjusted GEE showed a decrease in the mean level of stress symptoms by 4.19 points (95% CI: −4.637 to −3.738) at time T2 and 8.77 points (95% CI: −9.274 to −8.260) at time T3 compared to that of T1 (Table 3). In addition, significant interaction terms (group * time) indicated an additional increase of 4.06 points ($B = 4.06$, $p < 0.001$) and 3.15 points ($B = 3.15$, $p < 0.001$) in stress scores for students with poor sleep quality and poor psychological resilience, respectively (Figure 2A and Table 3). Anxiety levels followed a similar trend as stress levels, with a significant decline from T1 to T3 (Table 3). However, students with poor sleep quality and low psychological resilience showed less improvement, as indicated by significant interaction effects (group * time) (Figure 2B and Table 3). For depressive symptoms, the adjusted GEE showed a significant decline from T1 to T3 (Table 3). However, students with poor sleep quality and low psychological resilience exhibited less improvement, as indicated by significant interaction effects (group * time) (Figure 2C and Table 3).

Overall, participants with poor sleep quality and poor psychological resilience at time T1 had higher levels of stress, anxiety, and depression. At T2 and T3 periods, except for the factor of nonmedical students, the mean differences of stress, anxiety, and depression between the independent variable and reference group were smaller than that of T1 period, with none of the confidence intervals crossing zero. This suggested different trajectories between the independent variable and reference groups. The results remained consistent after conducting two sensitivity analyses, indicating robust findings (Supporting Information S1: Tables S2 and S3).

4 | Discussion

This study analyzed how stress, anxiety, and depression trajectories changed among 1,308 university students over 1 year following the implementation of the open policy in China. It focused uniquely on understanding the effects of specific policy changes on university students' mental health during a public health event. The impact of government pandemic control policies on society was reported to be more immediate than that of the COVID-19 outbreak itself [36]. A study from China on emotions and behaviors identified three pivotal moments and four distinct periods following the announcement of the "10 New Measures," during which public negativity was particularly pronounced [7]. The chain of reactions triggered by these policies constituted the primary driver of public sentiment. Previous studies primarily focused on the period before and after the "epidemic blockade" or the COVID-19 outbreak, which did not adequately provide evidence of robust mental health support for university students following the openness of the epidemic [37, 38]. Therefore, a longitudinal study employing a time-series development perspective would be essential in the context of the open policy [7]. The main finding was that university students with poor sleep quality and low psychological resilience exhibited significantly different psychological trajectories compared to those in the reference group.

Notably, there was no significant difference in the psychological health trajectories between medical students and nonmedical students. These two groups were very similar, which was different from our previous assumption. The reasons could be divided into two aspects. On one hand, before the policy liberalization, stringent control measures had successfully prevented widespread COVID-19 infections in universities [39]. The implementation of the "10 New Measures" policy marked the first instance when Chinese university students encountered an outbreak on university campus. At the onset of the outbreak, a meta-analysis indicated that anxiety and depression prevalence among Chinese university students stood at 24% and 22%, respectively [40]. However, following the policy liberalization, these figures increased to 27% and 34% [41]. The open policy heightened university students' perception of COVID-19 risk, leading to elevated levels of stress, anxiety, and

TABLE 1 | Distribution of participants' characteristics on T1, T2, T3 time periods.

	T1 ($n = 2062$)	T2 ($n = 1519$)	T3 ($n = 1308$)
DASS-21 Stress, mean (SEM)	11.52 (0.19)	7.06 (0.20)	2.22 (0.06)
DASS-21 Anxiety, mean (SEM)	15.57 (0.22)	7.49 (0.22)	2.32 (0.06)
DASS-21 Depression, mean (SEM)	12.06 (0.18)	6.26 (0.17)	2.30 (0.06)
Gender, *n* (%)			
Male	915 (44.4%)	673 (44.3%)	539 (41.2%)
Female	1147 (55.6%)	846 (55.7%)	769 (58.8%)
Age, *n* (%)			
< 19	392 (19.0%)	281 (18.5%)	244 (18.7%)
19–22	1115 (54.1%)	799 (52.6%)	716 (54.7%)
> 22	555 (26.9%)	439 (28.9%)	348 (26.6%)
Educational levels, *n* (%)			
College degree	235 (11.4%)	173 (11.4%)	161 (12.3%)
Bachelor's degree	1199 (58.1%)	860 (56.6%)	747 (57.1%)
≥ Master's degree	628 (30.5%)	486 (32%)	400 (30.6%)
Average annual family income (RMB), *n* (%)			
< 50,000	780 (37.8%)	597 (39.3%)	458 (35.0%)
≥ 50,000	1282 (62.2%)	922 (60.7%)	850 (65.0%)
Major, *n* (%)			
Medical specialty	582 (28.3%)	445 (29.3%)	375 (28.7%)
Nonmedical specialty	1478 (71.7%)	1074 (70.7%)	933 (71.3%)
Chronic conditions, *n* (%)			
Yes	147 (7.1%)	126 (8.3%)	118 (9.0%)
No	1915 (92.9%)	1393 (91.7%)	1190 (91.0%)
Infected with COVID-19, *n* (%)			
Yes	1395 (67.7%)	1465 (96.4%)	1282 (98.0%)
No	667 (32.3%)	54 (3.6%)	26 (2.0%)
COVID-19 vaccination, *n* (%)			
Yes	1981 (96.1%)	1471 (96.8%)	1268 (96.9%)
No	81 (3.9%)	48 (3.2%)	40 (3.1%)
Smoke, *n* (%)			
Yes	301 (14.6%)	157 (10.3%)	130 (9.9%)
No or occasional	1761 (85.4%)	1362 (89.7%)	1178 (90.1%)
Drink alcohol, *n* (%)			
Yes	133 (6.5%)	153 (10.1%)	59 (4.5%)
No or occasional	1929 (93.5%)	1366 (89.9%)	1249 (95.5%)
Time spent outdoors, *n* (%)			
≤ 1 h	1532 (74.3%)	286 (18.8%)	258 (19.7%)
> 1 h	530 (25.7%)	1233 (81.2%)	1050 (80.3%)
Time spent on electronic equipment, *n* (%)			
≤ 3 h	200 (9.7%)	975 (64.2%)	834 (63.8%)
> 3 h	1862 (90.3%)	544 (35.8%)	474 (36.2%)
Sleep quality, *n* (%)			
Good	1352 (65.6%)	1167 (76.8%)	1012 (77.4%)

(Continues)

TABLE 1 | (Continued)

	T1 ($n = 2062$)	T2 ($n = 1519$)	T3 ($n = 1308$)
Poor	710 (34.4%)	352 (23.2%)	296 (22.6%)
Psychological resilience, *n* (%)			
Good	1586 (76.9%)	1184 (77.9%)	994 (76.0%)
Poor	476 (23.1%)	335 (22.1%)	314 (24.0%)

Note: DASS-21, depression, anxiety and stress scale; SEM, standard error of the mean; RMB, Chinese Yuan; T1, December 17, 2022–January 17, 2023. T2, May 17, 2023–June 17, 2023. T3, December 17, 2023–January 17, 2024.

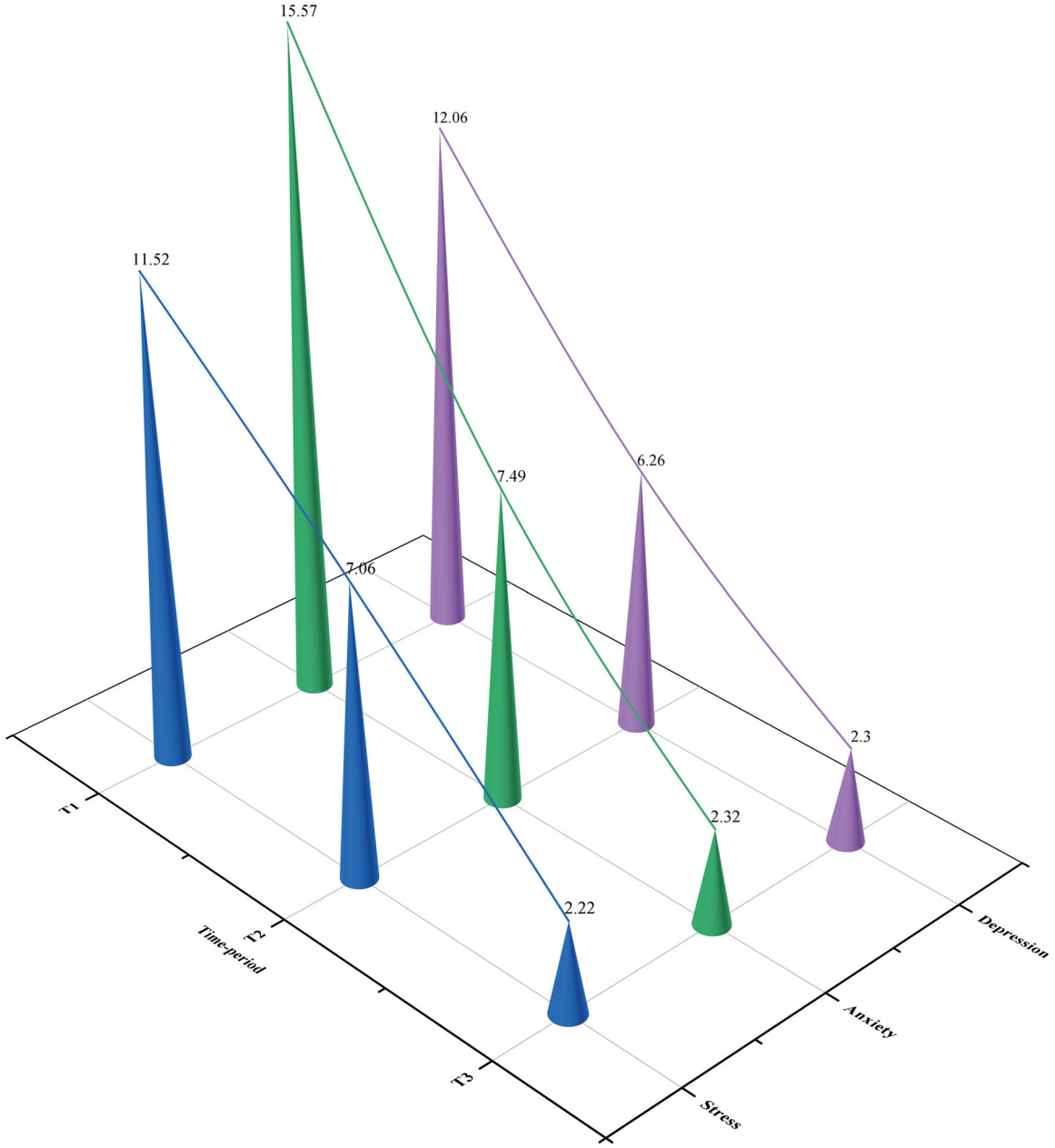

FIGURE 1 | Mean scores on the depression, anxiety and stress scale (DASS-21) subscales over the three time periods. T1, December 17, 2022–January 17, 2023. T2: May 17, 2023–June 17, 2023. T3, December 17, 2023–January 17, 2024.

depression [42]. A subsequent survey established a longitudinal causal relationship between COVID-19 risk perception and mental health, indicating that higher risk perception correlates with more pronounced mental health issues among university students [43]. Thus, within the context of the open policy, the COVID-19 epidemic adversely impacted the mental health of university students across all majors, rather than specific majors exclusively. On the other hand, owing to their medical

TABLE 2 | Group differences between independent variable and reference groups at three time points.

	T1			T2			T3		
Outcome by group	**Mean ± SEM**	**Adjust mean (95% CI)**	***p***	**Mean ± SEM**	**Adjust mean (95% CI)**	***p***	**Mean ± SEM**	**Adjust mean (95% CI)**	***p***
Stress									
Good sleep quality	10.04 ± 0.24	2.91 (1.726 to 4.084)	< 0.001	4.47 ± 0.16	6.96 (5.724 to 8.200)	< 0.001	2.30 ± 0.97	−0.09 (−0.424 to 0.244)	0.599
Poor sleep quality	12.96 ± 0.56			11.44 ± 0.62			2.22 ± 0.13		
Good psychological resilience	9.66 ± 0.21	6.39 (4.756 to 8.025)	< 0.001	4.80 ± 0.16	9.54 (7.775 to 11.299)	< 0.001	2.21 ± 0.09	0.26 (−0.146 to 0.664)	0.211
Poor psychological resilience	16.09 ± 0.81			14.37 ± 0.89			2.50 ± 0.18		
Medical specialty	11.03 ± 0.48	−0.02 (−1.121 to 1.086)	0.963	7.06 ± 0.47	−0.33 (−1.429 to 0.778)	0.563	2.25 ± 0.15	−0.04 (−0.364 to 0.357)	0.984
Nonmedical specialty	11.04 ± 0.29			6.77 ± 0.29			2.28 ± 0.09		
Anxiety									
Good sleep quality	14.14 ± 0.29	2.22 (1.035 to 3.421)	< 0.001	4.51 ± 0.18	8.07 (6.746 to 9.390)	< 0.001	2.23 ± 0.09	0.27 (−0.055 to 0.595)	0.103
Poor sleep quality	16.40 ± 0.54			12.61 ± 0.66			2.53 ± 0.13		
Good psychological resilience	13.76 ± 0.26	5.33 (3.729 to 6.927)	< 0.001	5.12 ± 0.18	10.05 (8.16 to 11.944)	< 0.001	2.32 ± 0.08	0.02 (−0.353 to 0.39)	0.921
Poor psychological resilience	19.12 ± 0.78			15.20 ± 0.95			2.37 ± 0.16		
Medical specialty	15.24 ± 0.51	−0.49 (−1.676 to 0.688)	0.412	7.22 ± 0.52	0.06 (−1.132 to 1.244)	0.927	2.56 ± 0.14	−0.34 (−0.686 to −0.003)	0.052
Nonmedical specialty	14.78 ± 0.32			7.30 ± 0.32			2.24 ± 0.09		
Depression									
Good sleep quality	10.97 ± 0.25	1.73 (0.716 to 2.737)	< 0.001	4.20 ± 0.15	5.94 (4.897 to 6.918)	< 0.001	2.27 ± 0.10	0.14 (−0.186 to 0.466)	0.399
Poor sleep quality	12.71 ± 0.46			10.16 ± 0.51			2.43 ± 0.13		
Good psychological resilience	10.75 ± 0.22	3.78 (2.429 to 5.125)	< 0.001	4.44 ± 0.15	8.37 (6.918 to 9.814)	< 0.001	2.32 ± 0.08	−0.03 (−0.415 to 0.352)	0.872
Poor psychological resilience	14.56 ± 0.66			12.84 ± 0.72			2.33 ± 0.17		
Medical specialty	11.73 ± 0.43	−0.21 (−1.229 to 0.751)	0.557	6.23 ± 0.41	0.11 (−0.927 to 0.949)	0.982	2.41 ± 0.15	−0.132 (−0.487 to 0.224)	0.528
Nonmedical specialty	11.50 ± 0.27			6.24 ± 0.25			2.29 ± 0.08		

Note: SEM, standard error of the mean; adjust mean, The adjusted effect size was calculated after controlling for covariates; T1, December 17, 2022–January 17, 2023. T2, May 17, 2023–June 17, 2023. T3, December 17, 2023–January 17, 2024.

TABLE 3 | Generalized estimating equations' model coefficients on mean level depression, anxiety and stress symptoms over the three time periods.

	Stress		Anxiety		Depression	
	β (95% CI)	***p***	**β (95% CI)**	***p***	**β (95% CI)**	***p***
Models with only time periods						
T1	REF		REF		REF	
T2	−4.19 (−4.637 to −3.738)	< 0.001	−7.63 (−8.190 to −7.077)	< 0.001	−5.33 (−5.777 to −4.879)	< 0.001
T3	−8.77 (−9.274 to −8.260)	< 0.001	−12.58 (−13.131 to −12.023)	< 0.001	−9.24 (−9.712 to −8.772)	< 0.001
Models with sleep quality and time period						
Good sleep quality	REF		REF		REF	
Poor sleep quality	2.91 (1.726 to 4.084)	< 0.001	2.23 (1.035 to 3.421)	< 0.001	1.73 (0.716 to 2.737)	0.001
Time						
T1	REF		REF		REF	
T2	−5.57 (−6.140 to −5.008)	< 0.001	−9.63 (−10.336 to −8.923)	< 0.001	−6.77 (−7.342 to −6.194)	< 0.001
T3	−7.74 (−8.238 to −7.249)	< 0.001	−11.908 (−12.527 to −11.290)	< 0.001	−8.70 (−9.224 to −8.177)	< 0.001
Group*time						
Group*T1	REF		REF		REF	
Group*T2	4.06 (3.181 to 4.933)	< 0.001	5.84 (4.788 to 6.892)	0.002	4.21 (3.358 to 5.068)	< 0.001
Group*T3	−3.00 (−4.214 to −1.776)	< 0.001	−1.96 (−3.290 to −0.706)	< 0.001	−1.59 (−2.651 to −0.521)	0.004
Models with psychological resilience and time period						
Good psychological resilience	REF		REF		REF	
Poor psychological resilience	6.39 (4.756 to 8.025)	< 0.001	5.33 (3.729 to 6.927)	< 0.001	3.78 (2.429 to 5.125)	< 0.001
Time						
T1	REF		REF		REF	
T2	−4.86 (−5.371 to −4.351)	< 0.001	−8.65 (−9.279 to −8.01)	< 0.001	−6.31 (−6.821 to −5.799)	< 0.001
T3	−7.45 (−7.887 to −7.022)	< 0.001	−11.44 (−11.983 to −10.899)	< 0.001	−8.43 (−8.899 to −7.955)	< 0.001
Group*time						
Group*T1	REF		REF		REF	
Group*T2	3.15 (2.121 to 4.172)	< 0.001	4.72 (3.499 to 5.948)	< 0.001	4.86 (3.637 to 5.541)	< 0.001
Group*T3	−6.13 (−7.825 to −4.438)	< 0.001	−5.31 (−6.959 to −3.66)	< 0.001	−3.81 (−5.180 to −2.438)	< 0.001
Models with medical specialty and time period						
Medical specialty	REF		REF		REF	
Nonmedical specialty	−0.03 (−1.121 to 1.068)	0.963	−0.49 (−1.676 to 0.688)	0.412	−0.24 (−1.229 to 0.751)	0.636

(Continues)

TABLE 3 | (Continued)

	Stress		Anxiety		Depression	
	β **(95% CI)**	***p***	***β*** **(95% CI)**	***p***	***β*** **(95% CI)**	***p***
Time						
T1	REF		REF		REF	
T2	−3.97 (−4.783 to −3.164)	< 0.001	−8.03 (−9.076 to −6.978)	< 0.001	−5.51 (−6.344 to −4.669)	< 0.001
T3	−8.78 (−9.772 to −7.793)	< 0.001	−12.69 (−13.716 to −11.657)	< 0.001	−9.32 (−10.198 to −8.440)	< 0.001
Group*time						
Group*T1	REF		REF		REF	
Group*T2	−0.30 (−1.272 to 0.673)	0.546	0.55 (−0.688 to 1.787)	0.384	0.25 (−0.742 to 1.242)	0.840
Group*T3	0.02 (−1.129 to 1.174)	0.970	0.15 (−1.069 to 1.374)	0.807	0.11 (−0.933 to 1.147)	0.621

Note: REF, reference; all models were adjusted for covariates; T1, December 17, 2022–January 17, 2023. T2, May 17, 2023–June 17, 2023. T3, December 17, 2023–January 17, 2024.

background, medical students usually have a higher level of understanding of COVID-19 and are relatively less susceptible to the influence of news and internet information concerning COVID-19 [44, 45]. Medical students demonstrated higher mental resilience compared to nonmedical students, effectively using their knowledge to self-regulate and manage stress levels. Meanwhile, in the postpandemic era, several studies employed the stimulus-organism-response (SOR) model to train medical students in infectious disease prevention and control, alongside lectures on COVID-19 [46]. These initiatives effectively enhanced the integration of clinical and preventive medicine, thereby bolstering medical students' preparedness to respond to public health emergencies [47]. Overall, the convergence of increased mental health challenged among university students, and the proactive responses of medical students to COVID-19 within the open policy resulted in similar psychological trajectories for both groups.

The relationship between sleep quality and the mental health of university students was extensively studied, but the trajectory of this impact within the context of the open policy remains unclear [48–50]. This study found that university students with poor sleep quality experienced higher levels of stress, anxiety, and depressive symptoms under the open policy. Consequently, the psychological trajectories of students with poor sleep quality differed significantly from those with good sleep quality. Five months after the implementation of the open policy, secondary infections of COVID-19 became prevalent. Although most university students had returned to school, the epidemic continued to significantly disrupt their lives. Over time, this disruption consumed substantial physical and mental resources, affecting students' sleep patterns and quality [51].

More importantly, the adjustment of the epidemic prevention and control policy occurred in December, a period when Chinese university students faced significant academic pressure. During this time, students are required to prepare for important exams, such as final exams, postgraduate entrance exams, and English proficiency tests. The sudden outbreak of COVID-19 on campus disrupted their study plans and social activities, which led to disturbances in their sleep cycles [52]. Research showed that disruptions to the biological clock could increase stress responses, which contribute to heightened levels of anxiety and stress [53]. The combination of academic demands and public health concerns exacerbated negative emotions, further worsening sleep disorders and creating a vicious cycle [54]. In the T2 period, although the direct impact of the epidemic was alleviated, the long-term adverse effects of poor sleep quality persisted. Students with poor sleep quality continued to experience ongoing mental health challenges. Therefore, we recommend that universities implement sleep education and mental health interventions, such as cognitive behavioral therapy, during public health crises to help students manage their sleep and emotional responses more effectively [55].

Psychological resilience usually has been considered as a potential factor influencing the mental health of university students. However, its underlying mechanisms remain controversial. Although psychological resilience was reported to minimize and alleviate the impact of COVID-19 stress on the mental health of university students, another study reported

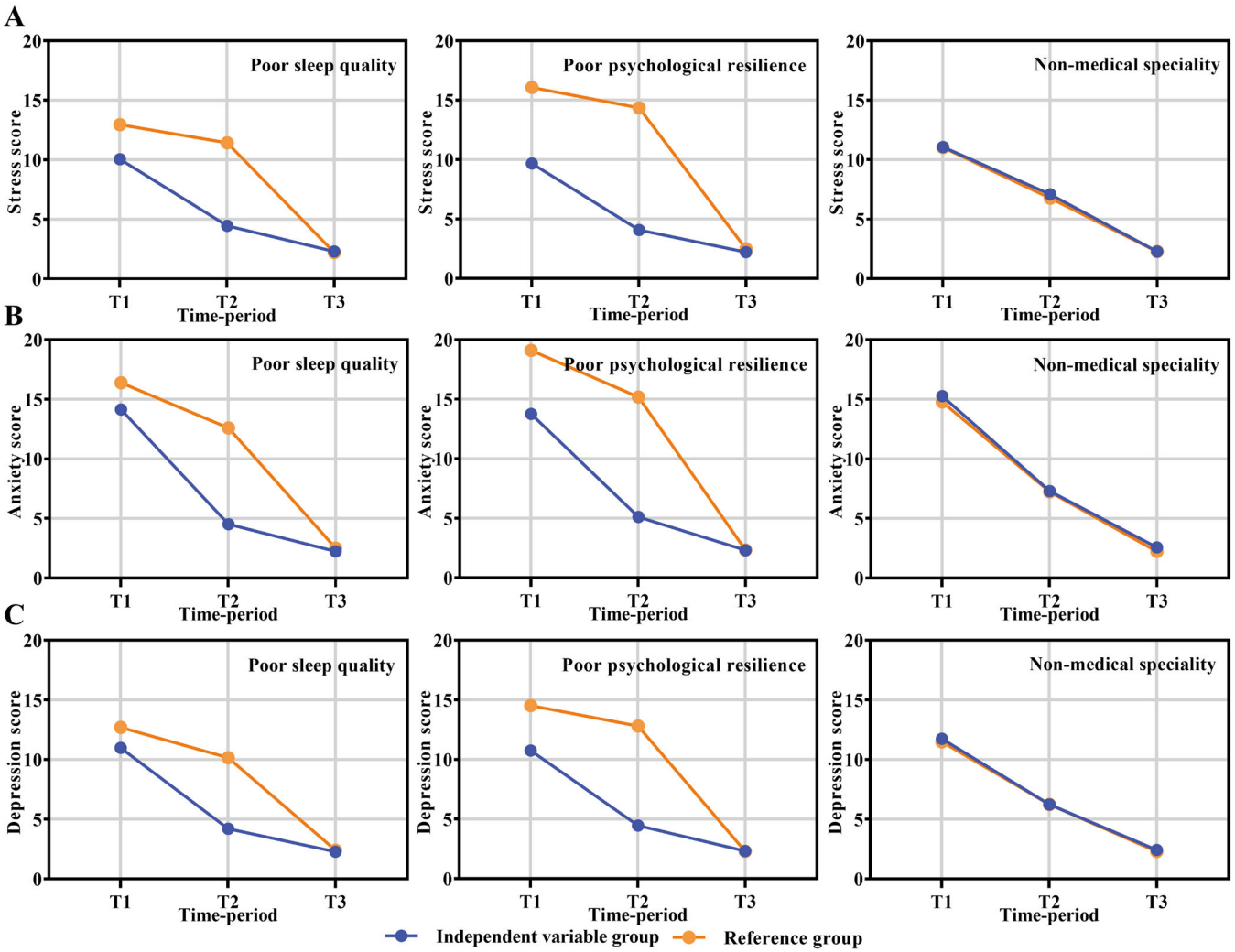

FIGURE 2 | Estimated mean of depression, anxiety and stress scale (DASS-21) scores over time stratified by sleep quality, psychological resilience and medical specialty. Adjusted for covariates. Independent variable were poor sleep quality, poor psychological resilience and nonmedical specialty, respectively. (A) Trajectories of scores on stress outcomes for three independent variables. (B) Trajectories of scores on anxiety outcomes for three independent variables. (C) Trajectories of scores on depression outcomes for three independent variables. T1, December 17, 2022–January 17, 2023. T2: May 17, 2023–June 17, 2023. T3, December 17, 2023–January 17, 2024.

that it was not a predictive variable and did not show a statistically significant correlation with their emotions [56, 57]. The limitations of these studies, such as insufficient sample size and the singular choice of subjects, might constrain the interpretation of psychological resilience. This study found that university students with poor psychological resilience and good psychological resilience had markedly different psychological trajectories. University students with poor psychological resilience were more likely to experience severe stress, anxiety, and depressive symptoms. A randomized controlled trial demonstrated that enhancing psychological resilience in university students significantly improved outcomes related to anxiety, depression, low self-esteem, paranoia, obsessive-compulsive behaviors, social withdrawal, and psychosexual aspects [58]. At the onset of the open policy, most students were shocked by the unprecedented situation, experiencing various psychological symptoms due to COVID-19-related stress [2]. Subsequently, the protective effect of psychological resilience alleviated these symptoms, allowing a new equilibrium to be restored [56]. However, students with poor psychological resilience delayed or even failed to achieve a new psychological equilibrium, resulting in persistent and severe psychological problems [59]. These findings suggest that good psychological resilience can mitigate stress, anxiety, and depression among university students.

This study first investigated the long-term effects of the open policy on the mental health of Chinese university students. We successfully analyzed the psychological trajectories of university students postpolicy and evaluated the impacts of sleep quality and psychological resilience on these trajectories. Our findings highlighted the necessity of enhancing psychological care for vulnerable university students during major public health events. Additionally, understanding differences in psychological distress among university students across time, sleep quality, and profession will be crucial for informing college health promotion programs and policies. The study has the following limitations: (1) due to the specificity of China's policy, the results should be cautiously generalized to other countries; (2) there might be some response bias in the questionnaire responses; and (3) due to the sudden announcement of the open

policy, we were unable to obtain data before its implementation, which limited the interpretation of the independent variable on the psychological trajectories.

5 | Conclusion

After the implementation of the open policy, stress, anxiety, and depression symptoms of Chinese university students were significantly higher, and gradually declined over the following year. University students with poor sleep quality and poor psychological resilience developed more severe and persistent symptoms of stress, anxiety, and depression. Medical students and nonmedical students followed similar psychological trajectories. These results indicated that the change of COVID-19 prevention and control policy had more serious negative impacts on the mental health of Chinese university students than the epidemic itself. Thus, strengthening psychological treatments and psychosocial interventions for university students would be crucial in the context of a protracted infectious disease epidemic.

Author Contributions

Xiu Yang: methodology, data curation, formal analysis, investigation, writing – original draft. **Na Luo:** conceptualization, methodology, formal analysis, investigation, writing – original draft. **Ya Yang:** conceptualization, formal analysis, investigation, writing – review and editing. **Wenyi Jiang:** data curation, formal analysis, investigation, writing – review and editing. **Jingjing Zhang:** conceptualization, data curation. **Lingli Hou:** conceptualization, writing – original draft. **Jieqiong Zhang:** conceptualization, writing – original draft. **Congxia Hu:** conceptualization, methodology, validation, writing – review and editing. **Jihui Lin:** conceptualization, methodology, validation, supervision, project administration, writing – review and editing.

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Consent

The authors have nothing to report.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The datasets used and/or analysed during the current study are available from the corresponding author upon reasonable request. All authors have read and approved the final version of the manuscript, corresponding author had full access to all of the data in this study and takes complete responsibility for the integrity of the data and the accuracy of the data analysis.

Transparency Statement

The lead author Congxia Hu, Jihui Lin affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

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