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Longitudinal influence of quarantine and COVID-19 surge after quarantine was released on behavioral and mental problems among Chinese university students

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Abstract

Objective This study examines the longitudinal influence of quarantine and the COVID-19 surge after quarantine was released on behavioral and mental problems among the Chinese university students.

Methods A longitudinal observation design was utilized. There were 10 waves of surveys including the pre-quarantine period, the quarantine period, and the quarantine releasing period. The non-parametric linear mixed-effects model and generalized estimating equations were used to examine the association between the dependent and independent variables.

Results Two-hundred and two (88.21%) participants completed 10 waves of the survey. The COVID-19 surge was positively associated with perceived severity for COVID-19 infection (β: 0.2162, $p < 0.01$), the quarantine period was negatively associated with perceived risk (β: -0.3632, $p < 0.01$). The quarantine was negatively associated with both behavior belief (β: -0.6164, $p < 0.01$) and outcome belief for lockdown (β: -0.0976, $p < 0.01$). The COVID-19 surge was only positively associated with behavior belief for the lockdown (β: 0.1073, $p < 0.01$). Both the COVID-19 surge and the quarantine periods were positively associated with mental disorders, and the standard β values were 0.2611 and 0.3846. The quarantine also had an influence on short sleep duration (β: 0.2681, $p < 0.05$).

Conclusion This study yielded new information about the influence of the COVID-19 surge, the quarantine period and the period after quarantine was released on the behavioral and mental problems among Chinese university students. Policy changes and health education are essential for minimizing the adverse health effects of these responses. This may have important implications for policies and disease prevention strategies targeted at controlling COVID-19.

Keywords COVID-19, Quarantine, Perceived risk, Behavior quarantine beliefs, Short sleep, Mental disorders

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Introduction

During the COVID-19 epidemic, people suffered from dual stressors: the risk of COVID-19 infection and the reality of quarantine. On the one hand, COVID-19 infection or fear of infection is a stimulus that plausibly induces people to strong mental responses with potentially severe health consequences. Different from general sporadic infections, the surge of COVID-19 may be a stronger stimulus for most people, and thus lead to more severe mental health problems. At the same time in order to curb the rapid spread of COVID-19, a quarantine or "lock down" policy was implemented in many places [1–4]. Many studies found that quarantine was positively associated with mental and behavioral problems [4–8]. Quarantine is a direct stimulant, which may induce people's mental and behavioral problems [9]. Since both the surge of COVID-19 and the quarantine can lead to mental and behavioral issues at the same time, reducing the COVID-19 pandemic by mandatory quarantine is a dilemma for public health decision-makers. It is necessary to compare the difference between the effects of quarantine and the COVID-19 surge on leading mental and behavior problems. However past studies were implemented separately to examine this effect. Due to the two factors being experienced simultaneously in China, large-scale quarantine and the COVID-19 surge after quarantine, it is possible to compare differences in mental response and mental and behavioral problems. This is the main purpose of this study.

Many studies have found that students were a particularly vulnerable population during the COVID-19 pandemic, with related mental and behavioral problems [10]. Due to living together in close proximity, university students are more susceptible to the spread of COVID-19 between people. Additionally, they can be exposed to an increased range of emotional and behavioral issues to make them more prone to COVID-19 infection [11]. Under normal circumstances, university students experience high levels of hassles, anxiety, and depressive symptoms. A systematic review including 48 articles from different parts of the world showed a prevalence of 26.1% for depressive symptoms and 24.5% for anxiety among 56,816 students [12]. Similarly, the surge of COVID-19 increased the prevalence and severity of mental health problems among university students [13–17].

According to Stimulus, Cognition and Mental Health (SCM) theory, a good research framework should include stimulus, intermediate variables (cognition, mental response), and outcome variables (mental and behavioral problems). This ecological model is helpful in understanding the effects of the COVID-19 surge and quarantine on mental and behavioral problems. It is also important to determine the causal relationships between them. However, most prior research, especially during quarantine, was limited from stimulus to mental and behavioral consequences [5–8]. This study will include more aspects, stimulus (quarantine, the COVID-19 infection and COVID-19 surge), behavior and perceived beliefs, mental response, and outcomes (mental disorder, and sleep deprivation).

In this study, cognition covered two aspects, the perceived risk for the COVID-19 and the behavior belief for lockdown. According to Health Belief Model (HBM), individual health behavior is motivated and influenced by several well-defined core belief variables [18, 19]. Previous studies have examined people's strong risk and threat perceptions for COVID-19 under COVID-19 epidemic and quarantine [3, 9, 20]. This study will examine how the COVID-19 surge and the quarantine have influenced people's perceived risk and perceived severity of COVID-19 infection.

Theory of Reasoned Action (TRA) argues that intentions arise from one's considerations of behavioral beliefs and behavioral consequences [18, 19]. Some studies have examined people's behavioral belief about prevention for COVID-19 [21, 22]. This study will examine how the COVID-19 surge and quarantine influence people's behavioral beliefs about lockdown.

Many studies found COVID-19 infection, and just living through the pandemic [9, 23] and the resulting quarantine induced mental stress [24, 25]. This study will compare differences in mental stress based on the COVID-19 surge and quarantine.

Mental disorders may be referred to as poor mental health conditions. Studies found that not only COVID-19 infections or just living through the pandemic to be associated with mental disorders [26], but also the quarantine was associated with mental disorders [27, 28]. In this study we will compare effects of COVID-19 surge and quarantine on mental disorders.

Sleep is an integral part of proper human function [29]. When facing COVID-19, many people experienced sleep problems [30, 31]. We hypothesized that the quarantine may have affected sleep and circadian rhythms. Studies found that mandatory quarantine markedly changed people's sleep time and quality of sleep [32, 33]. Sleep deprivation is considered be a behavior problem, and contributes to many health problems, including obesity, diabetes, increased rates of work accidents and it seriously affects people's quality of life [34, 35]. In general, sleep deprivation results in lower general health status and higher mortality [36, 37]. In this study we will examine the association between surge of COVID-19 and quarantine on short sleep duration (SSD), which was considered an aspect of sleep deprivation. Many studies have found that SSD is associated with significant health outcomes, including not only mortality but also various diseases [36, 38].

Most studies conducted during quarantine, were cross-sectional studies [5–8], which do not determine causal relationships. This study will overcome this limitation by utilizing a prospective longitudinal observation design from the SCR ecological perspective. It will better determine causal relationships and help understand the impact of the quarantine and pandemic on mental and behavioral problems among university students. These results should assist in formulating public health policy and intervention programs to mitigate COVID-19 as well as future pandemics.

Materials and methods

Study design

A prospective longitudinal observation study was designed to examine temporal trends and changes in series variables from quarantine to non-quarantine in relation to mental and behavioral problems over a 10-week period of time. Associations with two key stimulus, the COVID-19 surge and quarantine, were observed in relation to cognition, behavior and perceived beliefs, mental stress, mental disorder, and SSD among university students.

Participants

All areas of Haizhu district and partial areas of Panyu and Tianhe district in Guangzhou imposed quarantine on 24 October 2022, and ended quarantine on 27 November 2022. All areas of Guangzhou were released on 30 November 2022, and the whole nation was released 1 January 2023. The study participants are from several universities located in the Haizhu, Tianhe and Panyu districts of Guangzhou. These universities enforced and ended quarantine in compliance with Guangzhou's policy. University students located on these campuses were quarantined, and restricted to their residential buildings. They were unable to freely enter or exit from these places. Sporadic cases of COVID-19 occurred before quarantine and during the period of quarantine where the students lived. Soon after quarantine ended the COVID-19 reached pandemic status, with large increases in case numbers from 8 December until the end of December. Our observation time covered one wave before quarantine, three waves in the period of quarantine, three waves after the quarantine, COVID-19 surge, then subsided, and three waves in the period of sporadic COVID-19 infection. Following are the dates of each wave: Wave 1 (23 October 2022), Wave 2 (19 November 2022), Wave 3 (24 November 2022), Wave 4 (1 December 2022), Wave 5 (8 December 2022), Wave 6 (16 December 2022), and Wave 7 (23 December 2022), Wave 8 (15 February 2023), Wave 9 (16 February 2023), and Wave 10 (2 March 2023).

Participants were recruited via an advertisement on the Campus Bulletin Board System (BBS), which was the most popular social media platform in the university. Inclusion criteria included: (1) quarantined university students; (2) having access to a smartphone; and (3) willing to provide follow-up information. Participants were excluded if they refused to provide this information or had a medical condition that could limit or preclude their participation. Upon consent with an electronic informed consent letter, participants received an electronic questionnaire and instructions on how to proceed. After reading the instructions, they were asked to provide an e-consent by tapping the 'Confirmation and Authorization' button and then directed to the questionnaire. A special administrative WeChat group was established to manage the follow-up data collection, using a unique QR code for each respondent [39].

The online questionnaire link was posted to the respondent group and accessible every Thursday from 10:30 a.m. to 4:30 p.m. All responses were anonymous. The same survey protocol was used for each wave of the survey to assure homogeneity of data administration and collection. As appropriate, a token of appreciation, 35 RMB ($5.00) was given to those participants who completed all 10 questionnaires.

Measurement

Dependent variable

This observation included pre-quarantine period, the quarantine period, and quarantine releasing period. A COVID-19 surge period and the sporadic period occurred during the releasing period. The quarantine period refers to the period during which people were quarantined by the implementation of lockdown measures. The COVID-19 surge period refers to when the COVID-19 infection prevalence was at a high level after the lockdown was lifted, which occurred in Wave 5, Wave 6, and Wave 7. It should be mentioned that the data in first wave was obtained through a retrospective survey where participants were required to answer their mental and behavioral status questions as they were within a day before they were quarantined. The data was collected during Wave 2 on 18 November 2022. In order to assist respondents in recalling specific details, this study established the context for each section of the survey by an introductory statement: *We aim to understand your behavioral and mental performance prior to quarantine. Please take a moment to reflect on Sunday, 23 October, which was the day before the official announcement of a lockdown across the entire region*. Each question is carefully framed to reference the period preceding the quarantine, for instance, *Before the quarantine, did you […]*. Furthermore, data collected in all subsequent waves will reflect the current status at the time of the survey.

Independent variables

Perceived risk and perceived severity of COVID-19 These measures came from two key concepts in HBM. Perceived risk was measured by a question, *do you always feel at risk of being infected by COVID-19?* Perceived severity was measured by a question, *infection with COVID-19 has serious health consequences*. Responses were on a 5-point Likert-type from *strongly disagree* to *strongly agree*.

Behavioral belief for the COVID-19 epidemic lockdown Two variables were included behavioral beliefs in this study. The first variable was general behavioral belief (behavior belief for the lockdown), it was measured by the question, *COVID-19 has become like influenza, so lockdown is unnecessary*. The second variable was belief about adverse outcomes of the lockdown (outcome belief for the lockdown). It was measured by a question; *lockdown would produce serious secondary hazards*. Both responses were on a 5-point Likert-type from *strongly disagree* to *strongly agree*.

Mental stress This variable was measured by the Chinese version of the Perceived Stress Scale (CPSS) [40], which has been widely used and has demonstrated good reliability and validity [7, 41, 42]. This scale was comprised of 14 items that addressed perceptions of stress during the month prior to the survey. Items were rated on a 5-point Likert-type scale that ranged from 0 (never) to 4 (very often). Item scores were summed to yield a total stress level, with higher scores indicating higher perceived levels of stress. In this study, the Cronbach's alpha of CPSS ranges from 0.81 to 0.87 among 10 waves and it indicated strong reliability in measurement.

Mental disorders Mental health status was measured by the Chinese Health Questionnaire (CHQ), which was derived from the General Health Questionnaire (GHQ), and has widely been used to screen for mental disorders in community settings [43–47]. This questionnaire has been widely used to assess mental disorders in China and has been shown to be an appropriate indicator of mental health status. The CHQ is a self-administered, 12-item instrument designed for detecting mental disorders in the community. It has a four-point scale for responses: *not at all* and *same as usual* both = 0 and r*ather more than usual* and *much more than usual* = 1. A cut-off score of 3 or more was classified as signified mental disorders. In this study, CHQ had acceptable reliability and validity, and the Cronbach's alpha ranges from 0.88 to 0.91 each wave.

Short sleep duration (SSD) Participants were asked about their usual sleep duration via the question, *how many hours of sleep do you usually get per night?* Responses were coded into five categories (< 6, 6–, 7–, 8–, and ≥ 9 h). SSD was defined as less than six hours of sleep [35, 38].

New infectious for the COVID-19 This variable was obtained by asking whether they were currently infected with COVID-19 at each survey time. In this study we used newly infected persons as the confounding variable for adjusting parameter values from analyzing the relationship between quarantine and the dependent variables.

Data analysis

All data were imported into SAS (9.4version) for the statistical analysis. As all of the continuing variables included in this study were not normally distributed, non-parametric testing methods were utilized to conduct the analysis. The Friedman test was used to examine the differences of variables across the 10 observation points, and the mixed-effect model was used to assess changing trends. The parameters for statistical testing were χ^2 and T value respectively. This study analyzed the impact of the COVID-19 surge and quarantine on mental and behavioral problems. However, they are in different stages of this observation. To show their different effects, it was necessary to categorize stages into different observation periods. For quarantine wave 2, wave 3, and wave 4 were combined into the quarantine group, other waves were categorized as control group, including the prior quarantine period and the later period of quarantine. For the COVID-19 surge period with high level infection wave 5, wave 6, and wave 7 were categorized as the surge group, other waves were categorized as control group. The non-parametric linear mixed effects model was used to examine the association between the COVID-19 surge and the quarantine period. It was also used to examinethe behavioral beliefs, the perceived risk and severity, and mental stress. Generalized estimating equation was used to examine the association between the COVID-19 surge, quarantine, and mental disorders, and SSD.

Results

We recruited 229 participants at baseline, with 202 (88.21%) participants remaining for all repeated waves. Most of respondents were Han Chinese (97.5%), 76.7% were female. 57.9% were science, engineering, and medicine majors; and 42.1% majored in the humanities and social sciences (See Table 1).

Table 2 displays the changing trends for all variables. Both perceived risk (T: 76.35, $p < 0.01$) and perceived severity (T: -12.33, $p < 0.01$) for COVID-19 infection had a statistically significant time trend across the total observation period. There were statistically significant differences between observation periods in them, χ^2 was 315.70($p < 0.01$) for the former, 96.05($p < 0.01$) for the latter, see Fig. 1. Behavior belief for the lockdown showed

Table 1 Sample characteristics (*N* = 202)

	N	%
Age(year)		
< 22	28	13.9
22	47	23.3
23	48	23.8
24	36	17.8
24-	43	21.3
Ethnicity/ethnicity		
Han	197	97.5
Minority	5	2.4
Gender		
Male	47	23.3
Female	155	76.7
Monthly expenditure (RMB)		
< 1000	24	11.9
1000–1499	84	41.6
1500–1999	47	23.3
2000 and over	47	23.3
Major		
Science and engineering, and medicine	117	57.9
Humanities and social sciences	85	42.1
Father's education level		
Primary school and low	54	26.7
Junior school	50	24.8
High school	43	21.3
Junior college	23	11.4
College and more	32	15.8
Father's occupation		
Operation	138	68.3
Administration, commercial and service	52	25.7
Science, technology and education	12	5.9
Others	16	7.2
Mother's education level		
Primary school and low	57	28.2
Junior school	51	25.2
Highschool	41	20.3
Junior college	22	10.9
College and more	31	15.4
Mother's occupation		
Operation and others	130	64.4
Administration, commercial and service	48	23.8
Science, technology and education	24	11.9

statistically significant upward trend (T: 99.92, $p < 0.01$) with differences among waves (χ^2: 356.00, $p < 0.01$). Outcome belief for lockdown showed a statistically significant time trend (T: 3.87, $p < 0.01$), but there was no difference within each wave ((χ^2: 13.30, $p > 0.05$), see Fig. 2. Mental stress (T: -5.18, $p < 0.01$) and SSD (T: -2.73, $p < 0.01$) showed statistically significant downwards trend across the observation period. Mental disorders prevalence increased with time (T: 2.69, $p < 0.01$) and with significantly difference among waves, see Fig. 3. During the observation periods, time trend was not found in newly

Table 2 Time change trend in perceived risk and severity for COVID-19 infection, negative belief and evaluation of consequences for quarantine, new COVID-19 infection persons, mental stress, short sleepduration, and mental disorders

Observation wave	Perceived risk for COVID-19 infection (Median, 95%C.I)	Perceived severity for COVID-19 infection (Median, 95%C.I)	Behavior belief for the lockdown (Median, 95%C.I)	Outcome belief for the lockdown (Median, 95%C.I)	Mental stress (Median, 95%C.I)	New infectious persons (Median, 95%C.I)	SSD (%,95%C.I)	Mental disorders (%,95%C.I)
1	2.36(2.19,2.44)	2.46(2.34,2.58)	2.89(2.76,3.03)	3.43(3.30,3.56)	29.46(28.36,30.57)	1.7	8.4(4.6,12.2)	41.1(34.3,47.9)
2	2.37(2.26,2.48)	2.52(2.34,2.64)	2.92(2.78,3.06)	3.45(3.32,3.59)	29.21(28.03,30.41)	3.5	5.9(2.6,8.8)	40.1(33.3,46.9)
3	2.53(2.40,2.66)	2.39(2.29,2.49)	3.27(3.14,3.40)	3.61(3.53,3.76)	29.70(28.63,30.78)	3.5	5.9(2.6,8.8)	41.1(34.4,48.0)
4	2.95(2.81,3.08)	2.49(2.27,2.50)	3.57(3.45,3.67)	3.64(3.53,3.76)	29.73(28.58,30.89)	4.6	6.9(3.3,10.4)	29.7(23.4,36.0)
5	3.52(3.37,3.67)	2.49(2.37,2.60)	3.54(3.43,3.67)	3.60(3.48,3.71)	29.55(28.32,30.77)	17.2	2.9(0.6,5.2)	36.6(30.0,43.2)
6	3.37(3.03,3.90)	2.76(2.63,2.89)	3.44(3.31,3.57)	3.45(3.32,3.58)	29.38(28.30,30.47)	42.0	5.9(2.6,9.2)	45.0(38.1,51.9)
7	3.12(2.87,3.17)	2.51(2.40,2.62)	4.05(3.95,4.14)	3.69(3.57,3.81)	29.46(28.35,30.58)	9.8	3.0(0.7,3.2)	32.7(26.2,39.2)
8	3.02(2.87,3.17)	2.50(2.39,2.61)	3.91(3.79,4.01)	3.60(3.48,3.78)	29.14(28.08,30.20)	0	3.5(0.8,6.3)	33.2(26.6,39.7)
9	2.99(2.85,3.14)	2.51(2.39,2.63)	3.93(3.39,4.08)	3.57(3.51,3.59)	28.89(27.75,30.03)	0	4.4(1.6,7.2)	31.7(25.3,38.1)
10	2.32(2.19,2.43)	2.11(2.01,2.29)	2.87(2.74,3.15)	2.47(2.32,3.62)	27.20(26.10,28.31)	0.6	3.5(0.98,6.0)	31.7(25.3,38.1)
Overall prevalence or median	2.91(2.87,2.96)	2.47(2.43,2.50)	3.44(3.40,3.48)	3.55(3.51,3.59)	29.18(28.82,29.53)	8.31	5.1(4.1,6.1)	35.9(33.4,38.5)
Difference among waves(χ^2)	315.70**	96.05**	356.00**	13.30*	11.50	20.00**	13.20	21.50*
Time trend test(T)	76.35**	-12.33**	99.92**	3.87**	-5.18**	-1.02	-2.73**	2.69**

*$P < 0.05$; **$P < 0.01$

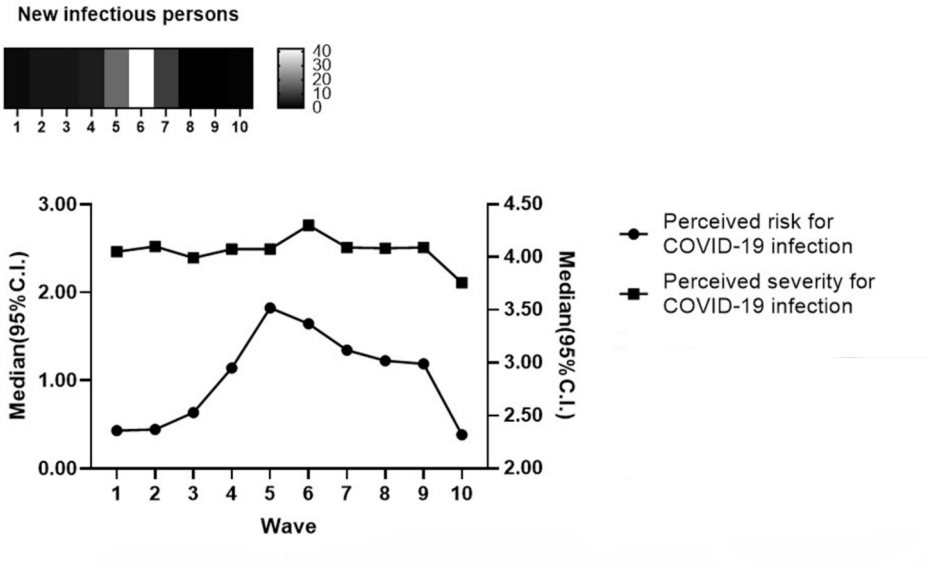

Fig. 1 Changing trends of perceived risk and severity for COVID-19 infection

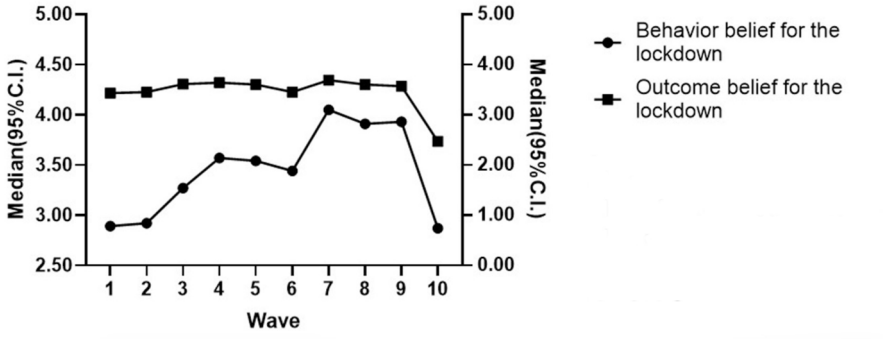

Fig. 2 Changing trends of behavior belief and outcome belief for the lockdown

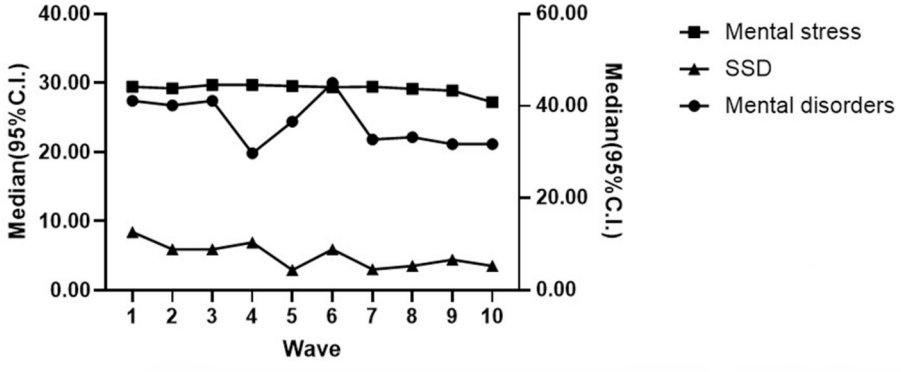

Fig. 3 Changing trends of mental stress, SSD and mental disorders

Table 3 Quarantine, the COVID-19 surge's influence on public cognition, mental response, and mental and behavioral problems

Group	β(SE)	Standard β
Perceived risk for COVID-19 infection		
Quarantine##	-0.3632(0.0507) **	-0.1553
The COVID-19 surge	0.6584(0.0617)	0.2934
Perceived severity for COVID-19 infection		
Quarantine##	0.0589(0.0419)	0.0334
The COVID-19 surge	0.2162(0.0482) **	0.1280
Behavior belief for the lockdown		
Quarantine##	-0.6164(0.482) **	-0.2858
The COVID-19 surge	0.1073(0.0458) **	0.0649
Outcome belief for lockdown		
Quarantine##	-0.0976(0.0461) *	-0.0488
The COVID-19 surge	0.0281(0.0522)	0.0155
Mental stress		
Quarantine##	0.5677(0.4123)	0.0320
The COVID-19 surge	1.0528(0.4652) *	0.0649
Short sleep duration (SSD)		
Quarantine##	0.2681(0.1103) *	0.0622
The COVID-19 surge	0.0443(0.2979)	0.00427
Mental disorders		
Quarantine##	0.3846(0.1053) **	0.0972
The COVID-19 surge	0.2611(0.1208) *	0.0720

##: Adjusted new infectious persons

*$P<0.05$; **$P<0.01$.

infected persons (T: -1.02, $p>0.05$), while a significant difference within the 10 waves was observed (χ^2: 20.00, $p<0.01$).

In Table 3, it can be seen that the COVID-19 surge was positively associated with perceived severity risk for COVID-19 infection (β: 0.2162, $p<0.01$). The quarantine, however, was negatively associated with perceived risk (β: -0.3632, $p<0.01$). The quarantine was negatively associated with both behavior belief (β: -0.6164, $p<0.01$) and outcome belief for lockdown (β: -0.0976, $p<0.05$), but the COVID-19 surge was only positively associated with behavior belief (β:0.1073, $p<0.01$). Only the quarantine was significantly associated with SSD (β: 0.2681, $p<0.05$). Both the COVID-19 surge and the quarantine were positively associated with mental disorders, standard β value was 0.0972 and 0.0720.

Discussion

Addressing a gap in the literatures, this study examined temporal trends and differences between several variables from stimulus to mental and behavioral problems, and how they were affected by the COVID-19 surge and the quarantine in China.

High levels of perceived risk and severity for COVID-19 are associated with mental and behavioral problems as well as adverse health consequences [2, 20, 23]. According to the psychometric paradigm, people judge the riskiness of a hazard based on perceived risk characteristics. Indeed, perceived risk and perceived severity have different properties, they may manifest differently in different stage of the COVID-19 epidemic. This finding underlined that perceived risk for COVID-19 infection showed a statistically significant upward trend. From distribution of the perceived risk by different observation time points, the values were lower before and during the lockdown, increased in the epidemic period, and then decreased in the sporadic infection period. Further results showed quarantine was negatively associated with perceived risk, but the COVID-19 surge was not associated with it. For the perceived severity a different result was found. The quarantine was not significantly associated with perceived severity; the COVID-19 surge was positively associated with perceived severity. This can be explained in that the quarantine may make students feel protected and thus less likely to develop a COVID-19 infection. Even though they felt at risk of contracting COVID-19, they did not perceive an infection would be that serious. This could be due to anecdotal and personal evidence that many people survived infection, or it could be a defense mechanism to control the fear of having severe consequences from a COVID-19 infection.

There were differences and change trends in the negative behavior belief for lockdown and the negative outcome belief for lockdown. For the negative behavior belief there was a statistically significant upward trend across the total observation period. This indicates both the quarantine and COVID-19 surge periods may have influence on the beliefs about lockdown. Further analysis showed quarantine was negatively associated with behavior beliefs and outcome beliefs for lockdown; the COVID-19 surge was positively associated with the behavior beliefs, but not associated with the outcome beliefs. This can be explained, as it is likely lockdown organizations and universities provided much information on the benefits of lockdown for students, and this influenced their opinions and attitudes toward the lockdown. It is also possible the quarantine made students feel relatively secure, and as a result they had less negative beliefs about the lockdown. After lockdown ended, students may have looked back and concluded that COVID-19 was no big deal, and they then had more negative behavior beliefs toward lockdown. Peoples' behavioral beliefs, along with their perceived outcome evaluations in relation to the behavior would impact the behavior [18]. In fact, the behavior beliefs and the outcome beliefs are different. This study supports this viewpoint. They should be treated differently in the handling of the lockdown for the COVID-19 epidemic.

This study found higher levels of mental stress existed in the quarantine period and the COVID-19 surge

period. Mental stress then showed a decline during the time of sporadic infections. Prior studies had found that COVID-19 infections [9, 23] and quarantine periods may induce mental stress [24, 25]. This study found that there is an association between the COVID-19 surge and mental stress, which is supported by SCM theory and prior empirical study results. However, the quarantine was not associated with mental stress, which is not consistent with other studies [5, 21]. Further study on the impact of the pandemic and quarantine on mental stress is needed.

This study hypothesized that the surge of COVID-19 and the quarantine may have affected sleep duration [30–33]. However, this study found only the quarantine period was associated with SSD. Sleep is an integral part of proper human functioning [29]. SSD is thought to be a behavioral problem that contributes to many health problems, and generally results in lower general health status and higher mortality [36, 37]. SSD problems by the quarantine must be given sufficient attention. Simultaneously, SSD also showed a significant downwards trend with the surge of COVID-19 pandemic and the ending of quarantine. This indicates a possible effect on both quarantine and the COVID-19 surge on SSD.

Mental disorders have been a concern during the COVID-19 infection and the quarantine [26–28]. This study found that there were statistically significant differences between the different observation waves, and statistically significant downwards trend across the total observation period. Not only was the COVID-19 surge significantly associated with mental disorders, but the lockdown was also associated with mental disorders. This is consistent with prior studies [26–28]. Based on these results it would appear the effect of the quarantine period was stronger than the effects of the COVID-19 surge. This information should be considered by decision makers when considering future quarantine policies.

Study limitations

There are several limitations to this study. First, our sample size seems small. Nevertheless, this is a prospective longitudinal panel study, and the variables included were repeatedly measured for each participant. That being so, the statistical power for the tests used in this study was high. We estimated the power for repeated-measures for each variable. This analysis found a statistical power of 0.8 (1-β) at given sample size, 5% significance level, and effect size which used a parameter in the model was acceptable. The statistical power for all variables achieved the accepted level ($1\text{-}\beta \geq 0.8$). This indicates that the sample size in this study was large enough to make appropriate inferences. Second, sample attrition may introduce "cluster" bias because many longitudinal studies likely over-represent some of characteristics. In this study only 14% of participants were under 22 years of age. The sample used in this study did not align with typical university student populations [39, 48]. A more sophisticated design and representative sample would be necessary to completely resolve this problem. Another important limitation is that participation was confined to university students. University students were selected because they have good completion rates for following up in a panel study of this type. Because we did use students, our results cannot be generalized to the wider Chinese population. Thirdly, since this is a panel study, we can only observe a limited number of samples, and the data was obtained through the Campus BBS. Consequently, the sample's representativeness is inadequate, which may result in biases in the findings. Fourthly, in this study, we used "newly infected individuals" as a confounding variable. The determination of "newly infected individuals" was obtained through self-report potentially introducing biases. Fifth, this study did not consider the different impacts of COVID-19 variants. At the time this study was conducted, the dominant variant in China was Omicron, which is known to cause milder symptoms compared to earlier variants like Delta. So that the results might differ if the study were conducted during different phases of the pandemic. Further research should pay attention to this issue.

Conclusion

This study compares effects of COVID-19 surge and the quarantine to mental and behavioral problems. The quarantine produced more and stronger influences on the outcome variables, mental health issues and behavioral problems. The COVID-19 surge greatly disturbed people's lives and work, which lead to serious mental and behavioral problems, but the quarantine period posed even greater challenges to people's mental and behavioral issues than the COVID-19 surge. It is necessary for the government to pay close attention to the impact of quarantine during the COVID pandemic and to use quarantine with caution in future pandemics and epidemics.

Abbreviations

SCM	Stimulus, Cognition and Mental health
SSD	Short Sleep Duration
BBS	Bulletin Board System
CPSS	Chinese version of the Perceived Stress Scale
CHQ	Chinese Health Questionnaire
GHQ	General Health Questionnaire
TRA	Theory of Reasoned Action
HBM	Health Belief Model

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Author contributions

TY and SP conceptualized the study. YT analyzed the data, interpreted the results, and drafted the manuscript. SP conducted the survey and administered the project. RC validated the results, and revised and edited the manuscript. All authors read and approved the final manuscript.

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Data availability
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
The study was conducted in accordance with the Declaration of Helsinki, and was approved by the Ethics Committee at the Medical Center, Jinan University (IRB), with reference number (JNUKY-2022-047). Informed consent was obtained from all participants. All participants were informed about the goals of the study, anonymity of their participation, and the option to cancel their participation at any time.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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