Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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Self-help cognitive behavioral therapy application for COVID-19-related mental health problems: A longitudinal trial

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ABSTRACT

Background and aim: Recently, the availability and usefulness of mobile self-help mental health applications have increased, but few applications deal with COVID-19-related psychological problems. This study explored the intervention efficacy of a mobile application on addressing psychological problems related to COVID-19.

Methods: A longitudinal control trial involving 129 Chinese participants with depression symptoms was conducted through the mobile application "Care for Your Mental Health and Sleep during COVID-19" (CMSC) based on WeChat. Participants were divided into two groups: mobile internet cognitive behavioral therapy (MiCBT) and wait-list. The primary outcome was improvement in depression symptoms. Secondary outcomes included improvement in anxiety and insomnia. The MiCBT group received three self-help CBT intervention sessions in one week via CMSC.

Results: The MiCBT group showed significant improvement in depression and insomnia (all$P < 0.05$) compared with the wait-list group. Although both groups showed significant improvement in anxiety at the intervention's end, compared with the wait-list group, the MiCBT group had no significant advantage. Correlation analysis showed that improvement in depression and anxiety had a significant positive association with education level. Changes in insomnia were significantly negatively correlated with anxiety of COVID-19 at the baseline. CMSC was considered helpful (n=68, 81.9 %) and enjoyable (n=54, 65.9 %) in relieving depression and insomnia during the COVID-19 outbreak.

Conclusions: CMSC is verified to be effective and convenient for improving COVID-19-related depression and insomnia symptoms. A large study with sufficient evidence is required to determine its continuous effect on reducing mental health problems during the pandemic.

1. Introduction

The global Coronavirus disease 2019 (COVID-19) outbreak was reported as originating in China in December 2019. On March 11, 2020, the World Health Organization (WHO) declared COVID-19 as the first major global infectious disease epidemic since the 2003 severe acute respiratory syndrome (SARS) outbreak (Agyapong, 2020; Paules et al., 2020). A WHO survey (World Health Organization, 2020) found that the epidemic's sudden nature, the related uncertainty, and the increased psychological pressure over time led to the disruption of important mental health services in 93 % of countries. In the pandemic's early stage, Chinese people faced serious mental health challenges, such as depression, anxiety, fear, and insomnia (Liu et al., 2020; Xiang et al., 2020). A recent cross-sectional study of 1120 Chinese residents reported that 53.8 % experienced moderate to severe psychological problems, including moderate to severe symptoms of depression (16.5 %), anxiety (28.8 %), and stress (8.1 %; Wang et al., 2020). While many local healthcare workers worked to limit the negative impacts of COVID-19, they experienced several psychological problems, much like the general public. A survey of 1257 Chinese healthcare workers in fever clinics and wards showed more serious symptoms of depression, anxiety, insomnia, and distress (Lai et al., 2020). An internet survey suggested that worse psychological resilience was closely correlated with depression, anxiety, and somatization symptoms caused by COVID-19 in China (Ran et al., 2020). Some believe that psychological resilience development (through psychotherapy) could potentially mitigate the impacts of

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adverse events (Ran et al., 2020).

To prevent or limit the epidemic's spread and negative consequences, governments implemented closure and isolation measures (Dan et al., 2020). Although isolation measures were found to effectively control the spread of pneumonia, they made it difficult for patients with mental illness to seek timely, professional medical treatment as outpatients or during hospitalization. Furthermore, many people with COVID-19-related psychological problems experience deteriorating health, loneliness, and a sense of hopelessness due to routine disruption (Brooks et al., 2020). Indeed, the negative mental health outcomes resulting from a global public health emergency may not be conducive to epidemic control or development of mental health services. Consequently, it is essential to consider how to appropriately and conveniently deal with the epidemic-related psychological problems, particularly in severe circumstances.

Cognitive behavioral therapy (CBT) is recognized as a non-pharmacological treatment supported by strong evidence of efficacy in mitigating mental health problems. It emphasizes the effect of individuals' reasonable cognitive beliefs and attitudes on their feelings and behaviors to help them proactively solve life challenges (Drake, 2016). Although most clients are highly amenable to traditional CBT (conducted face-to-face by trained psychiatrists or psychotherapists) (Leykin et al., 2007; van Schaik et al., 2004), the main challenges are lack of professional therapists, high cost, stigma, and constraints regarding service location and time (Mechanic, 2007). Thus, CBT's availability and convenience are somewhat limited, especially during epidemic isolation (Kohn et al., 2004).

However, internet-based CBT (iCBT) may provide potential solutions to such challenges. It disseminates CBT through lessons or modules over the Internet (Andrews et al., 2018). A randomized controlled trial on depression treatment showed that iCBT is equally efficacious as traditional CBT. However, guided iCBT requires regular guidance from professional psychotherapists through email or phone (Wagner et al., 2014). Although therapists' participation is greatly reduced in iCBT compared with traditional CBT (Carlbring et al., 2018), clients are never completely separated from support from professional therapists. Obviously, inconvenience is not conducive to further promotion of guided iCBT. The self-help pattern is another potential avenue for clients to utilize iCBT, wherein training or adjustment is completed according to established network intervention plans, without therapist participation (Wenxuan et al., 2019). In a randomized controlled study of patients with panic disorder (Ciuca et al., 2018), the effects on self-help and guided iCBT groups were significantly better than those on the wait-list group, with no significant difference between the two intervention methods. This indicates that self-help iCBT may be better for the public's psychological intervention during the COVID-19 epidemic.

Since their emergence in 2011 (Miralles et al., 2020), digital mobile health (mHealth) applications have shown increasing potential in mental health services' development (e.g., Jiankang Bao or the health kit on WeChat; Mosa et al., 2012). These can provide relatively comprehensive medical services, such as symptom screening and assessment, health intervention, recurrence monitoring, and medical big data. Their characteristics of high efficiency, convenience, and easy promotion allow such applications to make up for the shortcomings of traditional telehealth and computer-based health systems (Krishna et al., 2009). There is, therefore, an urgent need for convenient mHealth applications that can alleviate COVID-19-related mental health problems and decrease the treatment gap in the mental health system.

This study explored the intervention efficacy of a convenient, self-help, iCBT theory-based mobile application called "Care for Your Mental Health and Sleep during COVID-19" (CMSC) for depression, anxiety, and insomnia symptoms. This application solves COVID-19-related psychological problems using WeChat.

2. Materials and methods

2.1. Study design

A longitudinal two-arm clinical trial was conducted with data collected at baseline and the end of intervention/waiting (i.e., one week from baseline allocation). Participants were assigned to the mobile iCBT (MiCBT) or wait-list group. The primary outcome was change in depression symptoms at baseline and one-week post-intervention. Secondary outcomes were changes in anxiety and insomnia after the CMSC intervention. The research period was April-June 2020. The trial was conducted entirely on the Internet through CMSC. Approval was obtained from the Clinical Research Ethics Committee of the First Medical Center of the Chinese People's Liberation Army General Hospital before the study began.

2.2. Sample size and participants

Researchers hypothesized an initial medium effect size of 0.50, similar to prior online public mental health interventions in preliminary CBT studies (Calear et al., 2009; O'Dea et al., 2020). This study followed this existing research for calculation. Each group required a minimum sample size of 77 subjects, with statistical power of 80 %, significance level of 5%, and allowing for dropout rate of 20 %. Ultimately, the MiCBT and wait-list groups had 83 and 46 participants, respectively. These individuals successfully completed the evaluation at baseline and one-week post-intervention.

Participants were at least 18 years old, were Chinese residents, had depression symptoms (9-item Patient Health Questionnaire [PHQ-9] score: 5–27), could read and understand Chinese, and had independent access to an iOS or Android mobile phone (to avoid the influence of others' assistance). No exclusion criteria existed, and participants could drop out due to personal reasons. Moreover, the allocation was non-randomized and there was no blinding in the trial.

2.3. Recruitment and consent

The subjects were recruited in two different working units through a QR code with the CMCS's address. Considering the close relationships between colleagues in the same working place, it is difficult to randomly divide participants into two groups (intervention and control) in the same unit. Therefore, this study adopted a non-randomized control method, wherein all subjects in one working unit were the MiCBT (intervention) group, and all subjects recruited in the other unit were the wait-list (control) group. Using their WeChat ID and mobile phone number, a unique safety system account was established for each participant (Fig. 1A). Participants were asked to complete the informed consent forms online.

2.4. Procedure

The research team reviewed and approved the consent forms. Through online self-help assessment, a built-in CMSC feature, all participants could immediately accept the first iCBT intervention session and do so again every three days. When participants completed three sessions, the second self-help psychological CMSC assessment was conducted online. They had to remain active for at least seven days to complete the study. The CMSC had an independent reminder notification function. Participants could also receive mental health training based on CBT theory for COVID-19-related psychological problems and obtained a detailed mental state assessment report once all psychological measurements were completed. However, they could not receive a clinical illness diagnosis, and there was no monetary compensation for participation. If the assessment suggested extreme depression, including the risk of suicide or self-harm, the MiCBT or wait-list group participants were immediately encouraged to seek additional professional help from

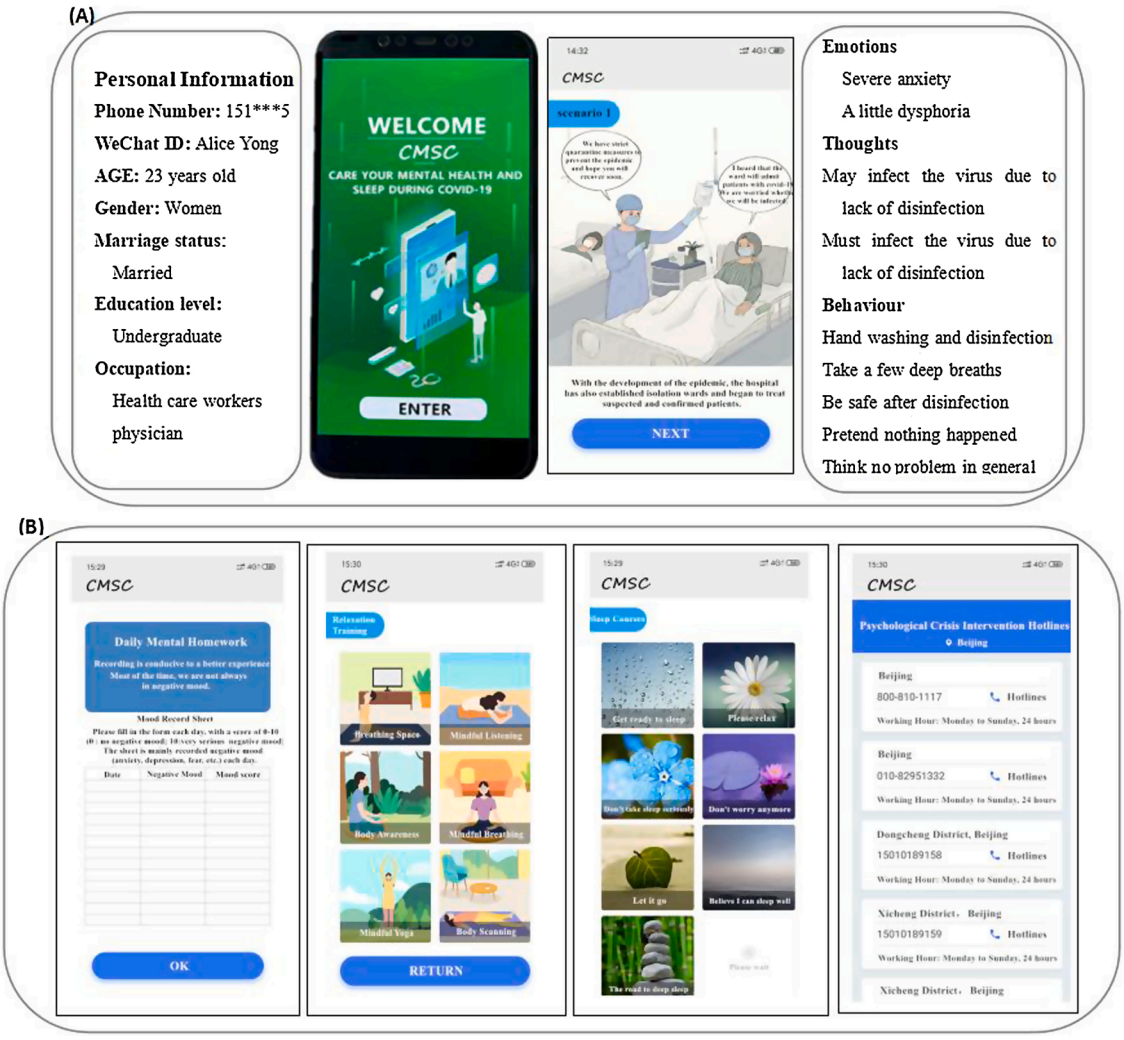

Fig. 1. (A) Therapeutic components within the CMSC application. (B) Other modules in the CMSC application. These icons were translated from the Chinese version.

a mental institution. Moreover, CMSC provided 359 national hotlines for psychological aid to provide timely and comprehensive psychological assistance and information (Fig. 1B).

2.5. Intervention

The CMSC is a self-help storytelling application based on CBT theory. It aims to help users overcome mental health problems related to COVID-19. It comprises three parts: evaluation, psychological intervention, and other. After registration, the application collects users' demographic information and evaluates their mental health status. Subsequently, users can enter the mainly CBT-based psychological intervention section, where they first watch a story comprising pictures and texts of a person encountering various COVID-19-related problems (e.g., meeting someone coughing who is suspected of being infected with COVID-19 in a supermarket). When the story finishes, subjects imagine themselves as this story's protagonist, including their thoughts, emotional reactions, and behaviors in that situation. After they select an option closest to their response in that situation, CMSC automatically plays an expert video to explain the relationships among their selected thoughts, emotions, and behaviors, and how to relieve bad moods by changing unreasonable cognition based on the CBT theory. Each intervention session had four different stories that took about 30 min to complete. Moreover, homework based on CBT theory, such as mood record sheets, was deemed as part of the psychological intervention to improve participants' everyday mood and sleep. The third section comprised three parts: courses to improve sleep quality, relaxation training, and national psychological aid hotline (Fig. 1A and B). The application was completely self-paced without psychotherapist support. Until now, CMSC could only be accessed through a specific connection and was only accessible to the study participants.

2.6. Wait-list group

The wait-list group was allowed access to the evaluation function of CMSC only when collecting their demographics and mental assessments. They could not visit the psychological intervention function and third section of CMSC during the trial. However, they could voluntarily use the application after completing the one-week post-test survey. No restrictions existed on the use of other mental health systems or applications during this time.

2.7. Measurements

2.7.1. Primary outcome: depression symptoms

The PHQ-9 (Zhang et al., 2013) assessed the depression systems' severity in the past two weeks. Participants were asked to rate the recent symptoms' frequency on a scale of 0 (never) to 3 (nearly every day) for each item. The PHQ-9 scores (total range: 0–27) were interpreted as normal (0–4), mild (5–9), and moderate and above (10–27). Higher scores indicated more severe depression. The Chinese version of the PHQ-9 showed good reliability (Cronbach's $\alpha = 0.91$; Xiaoyan et al.,

2017).

2.7.2. Secondary outcomes

2.7.2.1. Anxiety symptoms. The 7-item Generalized Anxiety Disorder (GAD-7; Xiaoyan et al., 2010) assessed the anxiety symptoms' severity in the past two weeks. Participants rated their recent symptoms' frequency on a scale of 0 (never) to 3 (nearly every day) for each item. Higher scores indicated more severe anxiety, with total scores ranging from 0 to 21.

2.7.2.2. Insomnia symptoms. The 7-item Insomnia Severity Index (ISI; Yu, 2010) assessed insomnia symptoms' severity over the past month. Participants rated the frequency of recent sleep conditions on a scale of 0 (lightest) to 4 (most severe) for each item. Higher scores indicated worse sleep, with total scores ranging from 0 to 28.

2.7.2.3. Psychological resilience. The Chinese version of the Connor Davidson Resilience Scale (CD-RISC; Wu et al., 2017) assessed personal resilience in the past month. It evaluated 25 items using a five-point scoring method ranging from 0 (never) to 4 (always). The scale includes three factors: optimism, strength, and tenacity, with higher scores indicating better psychological resilience.

2.7.2.4. Anxiety self-rating scale of COVID-19. The visual analogue scale (VAS; Abend et al., 2014) assessed participants' anxiety about COVID-19 in the past two weeks. Participants rated the degree of their recent anxiety on a scale of 0 (never) to 10 (most severe), with higher scores indicating more severe COVID-19 anxiety.

2.7.3. Other measures

2.7.3.1. Demographics. All participants self-reported their age, gender (male or female), marital status (unmarried or married), and years of education during the registration.

2.7.3.2. Application satisfaction and suggestions. Participants were asked to express their expectations and satisfaction using the VAS. The total score ranged from 0 to 10; higher scores indicated a better sense of the application. Participants were also asked whether there were obvious adverse reactions to the procedure. It was hoped that participants would provide actionable suggestions for application improvement.

2.8. Quality control

The WeChat login was set to require a verification reminder, and the mobile phone number login required a password received through a short message service. The results could only be submitted after all required items were completed. Moreover, data with an average response time of more or less than three times the standard deviation (SD) were regarded as incomplete. These measures ensured high data quality and security.

2.9. Data storage and analysis

The data were collected and stored securely via the CMSC online research platform. All data were analyzed using SPSS version 20.0 (SPSS Inc., Chicago, IL, USA). Primary analyses determined the intervention's effect on depression, anxiety, and insomnia relative to the wait-list group. Preliminary evidence of CMSC's efficacy was determined by changes in psychological scores between baseline and the end of intervention. This was based on interaction between the time and group, using repeated measure analysis with a statistically significant difference (two-tailed, $P < 0.05$). A simple effect analysis was required to acquire accurate and reliable results after discovering the time and group interaction. Effect sizes (Cohen's d for *t*-test analysis and η^2 for analysis of variance) were calculated according to different score changes pre- and post-intervention, using standard deviations of the change scores pooled. Differences in dropout rates between both conditions at the end of intervention were examined and reported. In the MiCBT group, we performed correlation analyses between the change in psychological scores and age, gender, education level, CD-RISC scores, and COVID-19 anxiety at baseline. Taking the change in psychological scores as dependent variables and age, gender, marriage, education, COVID-19 anxiety, and CD-RISC scores as independent variables, we used multiple linear stepwise regression analysis to explore potential factors influencing the improvement of depression, anxiety, and insomnia symptoms. Finally, satisfaction and suggestions for CMSC were surveyed and analyzed.

3. Results

3.1. Overview of the flow of participants

Participants were enrolled during April 30-June 30, 2020. Fig. 2 shows their flow through the study. In total, 1020 Chinese participants were included and assessed for eligibility. Of these, 706 individuals without depression symptoms (PHQ-9 score: 0–4) were excluded, resulting in enrollment of 314 participants. They were assigned to the MiCBT or wait-list group. Finally, 129 participants (83 in the MiCBT and 46 in the wait-list groups) finished the trial and were included in the analysis. A total of 111 participants (57.2 %) in the MiCBT group and 59 (61.6 %) in the wait-list group withdrew from the study reporting personal issues. There were no differences in dropout rates between the two groups at the end of intervention ($P = 0.436$).

3.2. Demographics and mental health characteristics at baseline

Table 1 outlines the baseline characteristics of 129 responding participants. Their mean age was 34.64 (SD = 9.11) years, and 30.2 % (n = 39) were unmarried. Most had an undergraduate degree, and the mean number of educational years was 15.96 (SD = 1.76). No significant differences existed between the MiCBT and wait-list groups regarding demographic characteristics, except for marriage status. Moreover, no significant differences in the PHQ-9, GAD-7, ISI, CD-RISC, and COVID-19 anxiety scores were found between the two groups at baseline (all $P > 0.05$).

3.3. Differences and effect sizes in outcomes for the MiCBT and wait-list groups

Changes in PHQ-9, GAD-7, and ISI scores from baseline to end of intervention are shown in Table 2. There was a significant time × group interaction in the PHQ-9 and ISI scores at the end of the intervention. Post-hoc within-group tests showed that depression and insomnia symptoms significantly improved in the MiCBT group ($t_1 = 4.58$, $P_1<0.001$; $t_2 = 4.81$, $P_2<0.001$) but not the wait-list group (all $P > 0.05$). Moreover, only a significant time effect was found for anxiety symptoms ($F = 8.61$, $P = 0.004$).

3.4. Correlation analysis

Pearson correlation analysis revealed that education level had a significant positive association with changes in PHQ-9 ($r = 0.24$, $P = 0.029$) and GAD-7 ($r = 0.27$, $P = 0.015$) scores. Moreover, ISI score changes were significantly negatively correlated with anxiety of COVID-19 (r= -0.15, $P = 0.012$; Table 3). CD-RISC scores were only negatively correlated with the baseline scores of PHQ-9 (r=-0.25, $P = 0.004$) and GAD-7 (r=-0.23, $P = 0.010$). Further multiple regression analyses identified that education level was associated with PHQ-9 (β=0.59, $P = 0.017$) and GAD-7 (β=0.45, $P = 0.014$) score changes. Anxiety of

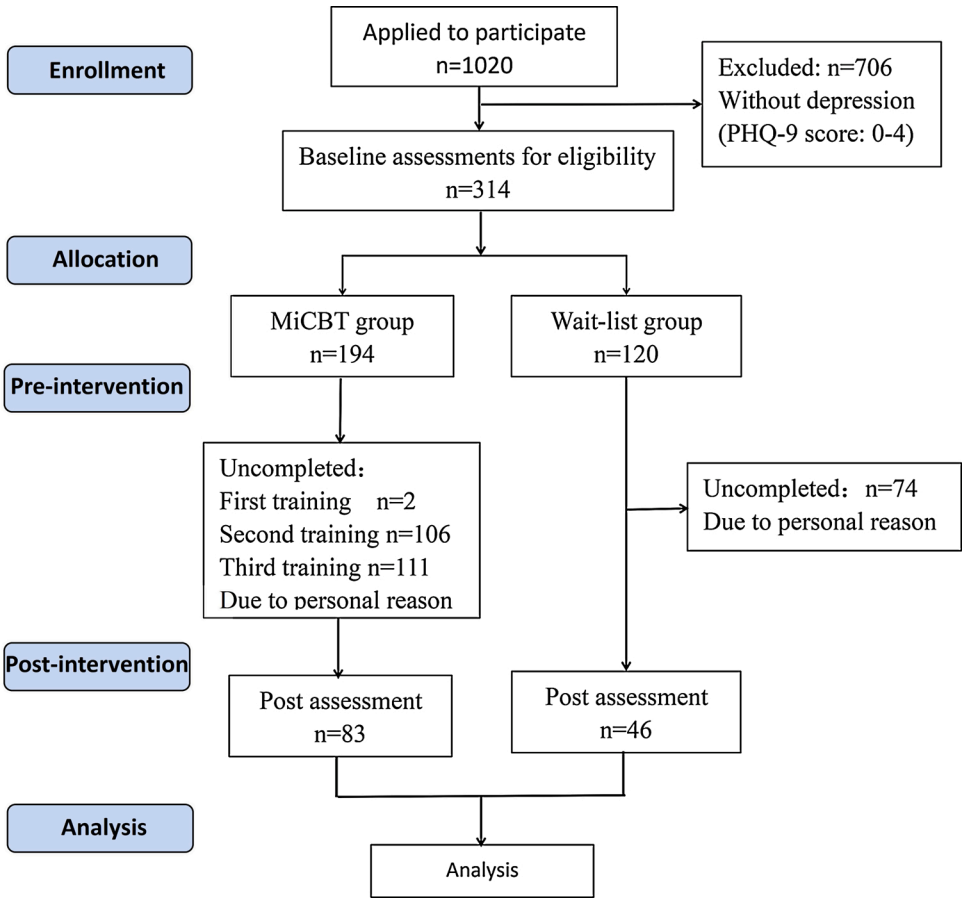

Fig. 2. Overview of the flow of participants through the trial.

Table 1
Demographic and mental health characteristics at the baseline (N = 129).

Characteristics	MiCBT group n = 83	Wait-list group n = 46	X^2/t	*P*
Age, mean (SD), y	34.92 (9.95)	34.13 (7.44)	0.47	0.641
Education, mean (SD), y	15.98 (2.19)	15.93 (0.25)	0.17	0.886
Gender, N (%)			2.87	0.090
Male	30 (36.1)	10 (21.7)		
Female	53 (63.9)	36 (78.3)		
Marriage status, N (%)			5.59	**0.018**
Unmarried	31 (37.3)	8 (17.4)		
Married*	52 (62.7)	38 (82.6)		
PHQ-9 scores, mean (SD)	8.80 (3.72)	7.65 (2.23)	2.18	0.059
GAD-7 scores, mean (SD)	5.73 (3.64)	5.35 (2.58)	0.68	0.525
ISI scores, mean (SD)	10.72 (5.16)	8.96 (5.23)	1.85	0.066
Anxiety of COVID-19 scores, mean (SD)	3.00 (2.52)	3.48 (2.29)	−1.07	0.289
CD-RISC scores, mean (SD)	56.53 (12.71)	57.89 (11.70)	−0.60	0.550

* Married category included widowed and divorced participants. Bold values indicate $P < 0.05$. Abbreviations: PHQ-9=The 9-item Patient Health Questionnaire; GAD-7=The 7-item Generalized Anxiety Disorder; ISI=The 7-item Insomnia Severity Index. CD-RISC=The Chinese version of the Connor Davidson Resilience Scale; Anxiety of COVID-19=The visual analogue scale (VAS) of anxiety self-rating of COVID-19.

COVID-19 was a risk factor for ISI score changes (β=-0.57, $P = 0.012$).

3.5. Satisfaction and suggestions

Finally, 82 participants completed the satisfaction survey and identified practical suggestions for the application's improvement post-intervention (see Table 4). More than 80 % reported that CMSC was helpful and they were eager to participate in the process again. None reported adverse events.

4. Discussion

To our knowledge, this is one of the first self-help, online, psychological intervention studies to verify the effectiveness and acceptability of a mobile self-help iCBT application for common mental health problems related to COVID-19. The main outcomes illustrated that some COVID-19-related mental health problems can be markedly improved in as short as one week for participants with depression via CMSC. This can be done using three convenient and efficient training sessions grounded in CBT theory.

Concerning outcomes, CMSC leads to significant improvements in depression and insomnia symptoms among individuals with depression relative to those in the wait-list group. CMSC likely helps them change unreasonable beliefs about COVID-19-related psychological problems (i.e., knowledge), learn how to deal with such problems correctly (i.e., attitude), acquire clues and appropriate strategies in reality (i.e., availability), and normalize the process of coping with depression and insomnia symptoms (O'Dea et al., 2020; Rajabi Majd et al., 2020). However, we found no significant within-group differences at the end of trial in the wait-list group, indicating that depression and insomnia are not obviously relieved over a relatively short period. This indicates the necessity to adopt appropriate interventions, such as CMSC, to alleviate COVID-19-related depression and insomnia. Compared with other studies exploring digital mental health tools' potential to address psychological symptoms, we found that CMSC's pre-post effect size on depression (Cohen's d = 0.51) and insomnia (Cohen's d = 0.53) are likely to be moderate. The effect size was comparably high in the software intervention experiments for mental health problems (Agyapong,

Table 2
Differences and effect sizes in outcomes between MiCBT group and wait-list group.

Variables	Group	N	Baseline	End of Intervention	Time × Group Effect		Effect size[a]		Effect size[b]	
			Mean ± SD	Mean ± SD	*F*	*P*	η^2	95 % CI	Cohen's d	95 % CI
PHQ-9	MiCBT group	83	8.80 ± 3.72	6.47 ± 4.67	4.30	**0.040**	0.03	0.00–0.11	0.51	0.27–0.73
	Wait-list group	46	7.56 ± 2.23	6.93 ± 3.96					0.21	−0.08–0.50
	Total	129	8.39 ± 3.30	6.64 ± 4.42						
GAD-7	MiCBT group	83	5.73 ± 3.64	4.51 ± 4.10	0.73	0.394	0.01	0.00–0.06	0.36	0.14–0.58
	Wait-list group	46	5.35 ± 2.58	4.67 ± 3.80					0.18	−0.11–0.47
	Total	129	5.60 ± 3.30	4.57 ± 3.98						
ISI	MiCBT group	83	10.72 ± 5.16	7.99 ± 5.11	7.10	**0.009**	0.05	0.00–0.14	0.53	0.30–0.76
	Wait-list group	46	8.96 ± 5.23	8.72 ± 5.38					0.05	−0.24–0.33
	Total	129	10.09 ± 5.23	8.25 ± 5.20						

[a] the time × group effect size with η^2 value in repeated measures analysis.
[b] the effect size with Cohen's d value before and after the intervention in each group. Abbreviations: PHQ-9=The 9-item Patient Health Questionnaire; GAD-7=The 7-item Generalized Anxiety Disorder; ISI = The 7-item Insomnia Severity Index.

Table 3
Correlation of change in psychological scores and variables at baseline.

Pearson correlation	Education level		Anxiety of COVID-19	
	r	*P* values	*r*	*P* values
Change in PHQ-9 score	0.24	**0.029**	−0.18	0.116
Change in GAD-7 score	0.27	**0.015**	−0.14	0.207
Change in ISI score	0.15	0.192	−0.28	**0.012**

The change in PHQ-9, GAD-7 and ISI scores means the baseline scores minus the post-intervention scores. Abbreviations: PHQ-9=The 9-item Patient Health Questionnaire; GAD-7=The 7-item Generalized Anxiety Disorder; ISI = The 7-item Insomnia Severity Index; Anxiety of COVID-19=The visual analogue scale (VAS) of anxiety self-rating of COVID-19.

Table 4
Satisfaction and suggestions with CMSC application (N = 82).

	Positive No.(%)	
Feeling		
I enjoyed using the application	54	65.9
I thought that the CMSC application was helpful	68	81.9
I would participate again in the future if more scenarios	80	96.3
I had no obvious adverse events after using the app	82	100
Suggestions		
More resources, more interaction to cover a wider series of scenarios	NA	NA
Increasing push notifications to remind them	NA	NA
Longer intervention time and more evaluation	NA	NA
Repairing related technical issues and making more convenient	NA	NA

2020; Burger et al., 2020; Zhang and Smith, 2020).

For anxiety symptoms, although the analysis of variance showed no significant time and group interaction for GAD-7, there was a significant time effect at the post-intervention period, indicating that the decrease in anxiety symptoms over time was significant. This may be caused by widespread trait anxiety among individuals during the COVID-19 epidemic (Stevenson et al., 2019). The main anxiety may be easily caused or affected by life and work pressure (Andersson et al., 2019; Miralles et al., 2020), as opposed to specific anxiety issues stemming from the epidemic. Remission of anxiety symptoms might be attributable to the passing of time, self-efficacy, or spontaneous remission (Whiteford et al., 2013). Therefore, we need to modify CMSC's design to target the resolution of anxiety symptoms in further research.

A recent systematic review found very few new mobile/digital tools addressing health issues during the epidemic. Only one study from March 2020 targeted the psychological issues caused by COVID-19 using a supportive text message (Text4Mood) program to address pandemic-induced psychological problems (Agyapong, 2020). Subscribers received free supportive texts about mental health education every day. Indeed, Text4Hope sent messages daily, regardless of network availability. In contrast, our CMSC uses CBT techniques in the more convenient and acceptable form of videos and pictures (Lester et al., 2019). As we assumed, this distinctly visual approach provided participants a better intuitive experience, which was easier to understand and had better curative effects than text. Additionally, other pre-2020 digital health tools, such as Moodgym, Beating the Blue, and Be Good to Yourself, were modified based on their original frameworks and thus lacked innovation closely related to COVID-19 (Lüdtke et al., 2018; Rodriguez-Pulido et al., 2020). Although a study on Moodgym (Yeung et al., 2018) found a medium effect size (Cohen's d = 0.6), similar to our results, its subjects were outpatients with significant and clinically diagnosed depression (not the general public with depression symptoms, as in our study). These factors made their study more likely to obtain expected results. All considered, the CMSC intervention may be more conducive to the general public's mental health, being a succinct, convenient, and effective tool for mental health promotion in the COVID-19 era.

The current state of rapid technology development, marked by a significant focus on evaluation of mHealth applications, ensured the study's speedy and precise execution (Nicholas et al., 2016). This research's major achievement is its successful completion in just two months, from the screening's beginning to the trial's end. Compared with the conventional iCBT duration of 4–8 weeks (Lindegaard et al., 2020; O'Dea et al., 2020; Yeung et al., 2018), we rapidly achieved significant improvement in mental health problems using three short and efficient psychological interventions in a single week. Notably, we did not include a post-intervention follow-up. However, constant changes that mark the COVID-19 epidemic necessitate fast-acting treatment leading to moderate to large effects in a short time. Such resources, like CMSC, are worth public recommendation. Accordingly, it is worthwhile to increase the duration of follow-up and expand sample sizes in further studies of this nature.

Psychological resilience is regarded as an individual's potential to help oneself deal with challenges and overcome crises (Ran et al., 2020). Resilience has been negatively correlated with mental health among internal migrant workers in the service industry (Yang et al., 2020). Moreover, some indicate that individuals with low resilience are more likely to suffer from anxiety and depression because of worse adaptability to sudden and stressful events (Poudel-Tandukar et al., 2019). As early as the SARS's peak period, researchers proposed that bolstering resilience may be the best strategy to alleviate the epidemic (Maunder et al., 2008). These results are consistent with our partial findings that individuals with the worse depression and anxiety symptoms had poorer resilience at baseline. However, we found no relationship between mental resilience and improvement in depression, anxiety, and insomnia. There may have been insufficient time in our study to observe its potential relationship with improvement of mental health. Further research should verify this association. Moreover, resilience may be an important factor for future research on mental health issues related to

emergencies, epidemics, and disasters.

We also investigated potential factors affecting the improvement of depression, anxiety, and insomnia. The results suggest that participants with more education tended to have better improvement in depression and anxiety. A follow-up study six months after CBT (Hundt et al., 2014) showed that more educated persons benefited more from CBT regarding improvements in self-reported worry, consistent with our findings. Moreover, we found that initial lower anxiety severity predicted better intervention outcomes for insomnia. The previous consistent findings suggest that anxiety symptoms to have a negative influence on sleep, which may be through maladaptive emotion regulation (Kirwan et al., 2017). Thus, we believe that education is a positive factor while worry about COVID-19 is a negative factor in predicting CMSC's intervention efficacy.

Most participants who completed the study conducted a satisfaction survey and made feasible recommendations, for example, more videos and scenarios. The high satisfaction level suggests that individual motivations might drive them to actively enjoy this research. As no financial reward existed for participation, the study's positive results likely stem from participants' interest in this intervention, rather than material or monetary compensation. A systematic review of therapist-supported iCBT for various mental health problems showed that the dropout rate in 19 studies ranged from 2% to 83 % (Melville et al., 2010). Although our dropout rate of 57%–62% was slightly high, it is acceptable in applications of self-help iCBT, considering that many participants may not have obvious psychological problems and consider it unnecessary to persist and complete the study. Additionally, lack of monetary compensation may contribute to failure of completion among participants. This indicates that appropriate promotion or compensation strategies can increase the application's attractiveness, thus benefiting more individuals (O'Dea et al., 2020)

5. Limitations

There are several limitations to consider. First, due to the urgency brought on by the epidemic, concerns about missing the ideal intervention period, and need to quickly recruit participants, we failed to conduct randomized allocation, weakening some strength of evidence-based medicine. Second, adequate evaluation was not set after each training, as the evaluation was conducted after every three training sessions. The corresponding inter-training evaluation in CMSC will be increased in the future. Third, lack of an extended follow-up period restricted the observation of the application's sustainability beyond the efficacy witnessed in the short term. We aim to expand the sample size in the future and increase the proper follow-up period to enrich the trial. As users suggested, greater scene variety and more intervention sessions may be needed to entice other interested participants to join future CMSC studies. Nonetheless, this study provides meaningful preliminary evidence to support the effectiveness and feasibility of CMSC as a non-drug intervention for individuals with COVID-19-related mental health problems.

6. Conclusion

To our knowledge, few studies have examined CMSC applications' effectiveness for improving depression and insomnia symptoms related to COVID-19. Our self-help iCBT intervention showed comparably higher rates of engagement, compliance, and tolerance among users, demonstrating that MiCBT is acceptable to help the public deal with mental health challenges. Future improvements include enhanced scene variety and extended intervention follow-up for stronger long-term effects on mental health outcomes.

Author contributions

JQS executed the analyses, interpreted the data, and wrote the first draft of the manuscript. SPT and RHJ conceived and designed the study, supervised the project, and gave important suggestions for the revision of the manuscript. HZF, DL and MZ undertook the statistical analyses. WQ, NC, YLZ provided important technical support. All authors contributed to and have approved the final manuscript.

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Data availability statement

The datasets analyzed in this article are not publicly available. Requests to access the datasets should be directed to 350800271@qq.com.

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Ethics statement

The study was approved by the Clinical Research Ethics Committee of the First Medical Center of the Chinese People's Liberation Army General Hospital. The participants provided their informed consent forms online in this study.

Declaration of Competing Interest

The authors report no declarations of interest.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.ajp.2021.102656.

References

Abend, R., Dan, O., Maoz, K., Raz, S., Bar-Haim, Y., 2014. Reliability, validity and sensitivity of a computerized visual analog scale measuring state anxiety. J. Behav. Ther. Exp. Psychiatry 45 (4), 447–453.

Agyapong, V., 2020. Coronavirus disease 2019 pandemic: health system and community response to a text message (Text4Hope) program supporting mental health in Alberta. Disaster Med. Public Health Prep. 1–2.

Andersson, G., Carlbring, P., Titov, N., Lindefors, N., 2019. Internet interventions for adults with anxiety and mood disorders: a narrative umbrella review of recent meta-analyses. Can. J. Psychiatry 64 (7), 465–470.

Andrews, G., Basu, A., Cuijpers, P., Craske, M.G., McEvoy, P., English, C.L., Newby, J.M., 2018. Computer therapy for the anxiety and depression disorders is effective, acceptable and practical health care: an updated meta-analysis. J. Anxiety Disord. 55, 70–78.

Brooks, S.K., Webster, R.K., Smith, L.E., Woodland, L., Wessely, S., Greenberg, N., Rubin, G.J., 2020. The psychological impact of quarantine and how to reduce it: rapid review of the evidence. Lancet 395 (10227), 912–920.

Burger, F., Neerincx, M.A., Brinkman, W.P., 2020. Technological state of the art of electronic mental health interventions for major depressive disorder: systematic literature review. J. Med. Internet Res. 22 (1), e12599.

Calear, A.L., Christensen, H., Mackinnon, A., Griffiths, K.M., O'Kearney, R., 2009. The YouthMood project: a cluster randomized controlled trial of an online cognitive behavioral program with adolescents. J. Consult. Clin. Psychol. 77 (6), 1021–1032.

Carlbring, P., Andersson, G., Cuijpers, P., Riper, H., Hedman-Lagerlöf, E., 2018. Internet-based vs. face-to-face cognitive behavior therapy for psychiatric and somatic disorders: an updated systematic review and meta-analysis. Cogn. Behav. Ther. 47 (1), 1–18.

Ciuca, A.M., Berger, T., Crișan, L.G., Miclea, M., 2018. Internet-based treatment for panic disorder: a three-arm randomized controlled trial comparing guided (via real-time video sessions) with unguided self-help treatment and a waitlist control. PAXPD study results. J. Anxiety Disord. 56, 43–55.
Dan, L., Yanping, R., Yuqing, L., Xin, Y., Wei, Q., Zhiren, W., et al., 2020. Psychological status of Chinese residents during COVID-19 outbreak:an online cross-sectional study(in Chinese). Chin. J. Psychiatry 53 (3), 181–189.
Drake, C.L., 2016. The promise of digital CBT-I. Sleep 39 (1), 13–14.
Hundt, N.E., Amspoker, A.B., Kraus-Schuman, C., Cully, J.A., Rhoades, H., Kunik, M.E., Stanley, M.A., 2014. Predictors of CBT outcome in older adults with GAD. J. Anxiety Disord. 28 (8), 845–850.
Kirwan, M., Pickett, S.M., Jarrett, N.L., 2017. Emotion regulation as a moderator between anxiety symptoms and insomnia symptom severity. Psychiatry Res. 254, 40–47.
Kohn, R., Saxena, S., Levav, I., Saraceno, B., 2004. The treatment gap in mental health care. Bull. World Health Organ. 82 (11), 858–866.
Krishna, S., Boren, S.A., Balas, E.A., 2009. Healthcare via cell phones: a systematic review. Telemed. J. e-health 15 (3), 231–240.
Lai, J., Ma, S., Wang, Y., Cai, Z., Hu, J., Wei, N., et al., 2020. Factors associated with mental health outcomes among health care workers exposed to coronavirus disease 2019. JAMA Network Open 3 (3) e203976.
Lester, R., Park, J.J., Bolten, L.M., Enjetti, A., Johnston, J.C., Schwartzman, K., et al., 2019. Mobile phone short message service for adherence support and care of patients with tuberculosis infection: evidence and opportunity. J. Clin. Tuberc. Other Mycobact. Dis. 16, 100108.
Leykin, Y., Derubeis, R.J., Gallop, R., Amsterdam, J.D., Shelton, R.C., Hollon, S.D., 2007. The relation of patients' treatment preferences to outcome in a randomized clinical trial. Behav. Ther. 38 (3), 209–217.
Lindegaard, T., Seaton, F., Halaj, A., Berg, M., Kashoush, F., Barchini, R., et al., 2020. Internet-based cognitive behavioural therapy for depression and anxiety among Arabic-speaking individuals in Sweden: a pilot randomized controlled trial. Cogn. Behav. Ther. 1–20.
Liu, S., Yang, L., Zhang, C., Xiang, Y.T., Liu, Z., Hu, S., Zhang, B., 2020. Online mental health services in China during the COVID-19 outbreak. Lancet Psychiatry 7 (4), e17–17e18.
Lüdtke, T., Pult, L.K., Schröder, J., Moritz, S., Bücker, L., 2018. A randomized controlled trial on a smartphone self-help application (Be Good to Yourself) to reduce depressive symptoms. Psychiatry Res. 269, 753–762.
Maunder, R.G., Leszcz, M., Savage, D., Adam, M.A., Peladeau, N., Romano, D., et al., 2008. Applying the lessons of SARS to pandemic influenza: an evidence-based approach to mitigating the stress experienced by healthcare workers. Can. J. Public Health 99 (6), 486–488.
Mechanic, D., 2007. Barriers to help-seeking, detection, and adequate treatment for anxiety and mood disorders: implications for health care policy. J. Clin. Psychiatry 68 (Suppl 2), 20–26.
Melville, K.M., Casey, L.M., Kavanagh, D.J., 2010. Dropout from Internet-based treatment for psychological disorders. Br. J. Clin. Psychol. 49 (Pt 4), 455–471.
Miralles, I., Granell, C., Díaz-Sanahuja, L., Van Woensel, W., Bretón-López, J., Mira, A., et al., 2020. Smartphone apps for the treatment of mental disorders: systematic review. JMIR mhealth uhealth 8 (4), e14897.
Mosa, A.S., Yoo, I., Sheets, L., 2012. A systematic review of healthcare applications for smartphones. BMC Med. Inform. Decis. Mak. 12, 67.
Nicholas, J., Boydell, K., Christensen, H., 2016. mHealth in psychiatry: time for methodological change. Evid. Ment. Health 19 (2), 33–34.
O'Dea, B., Han, J., Batterham, P.J., Achilles, M.R., Calear, A.L., Werner-Seidler, A., et al., 2020. A randomised controlled trial of a relationship-focussed mobile phone application for improving adolescents' mental health. J. Child Psychol. Psychiatry 61 (8), 899–913.
Paules, C.I., Marston, H.D., Fauci, A.S., 2020. Coronavirus infections-more than just the common cold. JAMA 323 (8), 707–708.
Poudel-Tandukar, K., Chandler, G.E., Jacelon, C.S., Gautam, B., Bertone-Johnson, E.R., Hollon, S.D., 2019. Resilience and anxiety or depression among resettled Bhutanese adults in the United States. Int. J. Soc. Psychiatry 65 (6), 496–506.
Rajabi Majd, N., Broström, A., Ulander, M., Lin, C.Y., Griffiths, M.D., Imani, V., et al., 2020. Efficacy of a theory-based cognitive behavioral technique app-based intervention for patients with insomnia: randomized controlled trial. J. Med. Internet Res. 22 (4) e15841.
Ran, L., Wang, W., Ai, M., Kong, Y., Chen, J., Kuang, L., 2020. Psychological resilience, depression, anxiety, and somatization symptoms in response to COVID-19: a study of the general population in China at the peak of its epidemic. Soc. Sci. Med. 262, 113261.
Rodriguez-Pulido, F., Castillo, G., Hamrioui, S., Martin, L.D., Vazquez-Beltrán, P., de la Torre-Díez, I., Franco-Martín, M.A., 2020. Treatment of depression in primary care with computerized psychological therapies: systematic reviews. J. Med. Syst. 44 (3), 67.
Stevenson, J., Mattiske, J.K., Nixon, R., 2019. The effect of a brief online self-compassion versus cognitive restructuring intervention on trait social anxiety. Behav. Res. Ther. 123, 103492.
van Schaik, D.J., Klijn, A.F., van Hout, H.P., van Marwijk, H.W., Beekman, A.T., de Haan, M., van Dyck, R., 2004. Patients' preferences in the treatment of depressive disorder in primary care. Gen. Hosp. Psychiatry 26 (3), 184–189.
Wagner, B., Horn, A.B., Maercker, A., 2014. Internet-based versus face-to-face cognitive-behavioral intervention for depression: a randomized controlled non-inferiority trial. J. Affect. Disord. 152-154, 113–121.
Wang, C., Pan, R., Wan, X., Tan, Y., Xu, L., Ho, C.S., Ho, R.C., 2020. Immediate psychological responses and associated factors during the initial stage of the 2019 coronavirus disease (COVID-19) epidemic among the general population in China. Int. J. Environ. Res. Public Health 17 (5).
Wenxuan, Z., Zhiren, W., Yongqian, W., Qi, Z., Weidong, W., Ning, F., Fude, Y., 2019. A meta-analysis of efficacy of internet-based and traditional cognitive behavioral therapy in neurotic disorders(in Chinese). Chin. Mental Health J. 033 (005), 328–333.
Whiteford, H.A., Harris, M.G., McKeon, G., Baxter, A., Pennell, C., Barendregt, J.J., Wang, J., 2013. Estimating remission from untreated major depression: a systematic review and meta-analysis. Psychol. Med. 43 (8), 1569–1585.
World Health Organization, 2020. Novel Coronavirus(2019-nCoV Situation Report -12) [EB/OL]. https://www.who.int/zh/news-room/detail/05-10-2020-covid-19-disrupting-mental-health-services-in-most-countries-who-survey.
Wu, L., Tan, Y., Liu, Y., 2017. Factor structure and psychometric evaluation of the Connor-Davidson resilience scale in a new employee population of China. BMC Psychiatry 17 (1), 49.
Xiang, Y.T., Yang, Y., Li, W., Zhang, L., Zhang, Q., Cheung, T., Ng, C.H., 2020. Timely mental health care for the 2019 novel coronavirus outbreak is urgently needed. Lancet Psychiatry 7 (3), 228–229.
Xiaoyan, H., Chunbo, L., Jie, Q., Haisong, C., Wenyuan, W., 2010. Reliability and validity of a generalized anxiety disorder scale in general hospital outpatients(in Chinese). Shanghai Arch. Psychiatry 22 (4), 200–203.
Xiaoyan, S., Yixue, L., Canqing, Y., Liming, L., 2017. Reliability and validity of depression scales of Chinese version: a systematic review(in Chinese). Chin. J. Epidemiol. 38 (1), 110–116.
Yang, X., You, L., Jin, D., Zou, X., Yang, H., Liu, T., 2020. A community-based cross-sectional study of sleep quality among internal migrant workers in the service industry. Compr. Psychiatry 97, 152154.
Yeung, A., Wang, F., Feng, F., Zhang, J., Cooper, A., Hong, L., et al., 2018. Outcomes of an online computerized cognitive behavioral treatment program for treating chinese patients with depression: a pilot study. Asian J. Psychiatr. 38, 102–107.
Yu, D.S., 2010. Insomnia severity index: psychometric properties with Chinese community-dwelling older people. J. Adv. Nurs. 66 (10), 2350–2359.
Zhang, M., Smith, H.E., 2020. Digital tools to ameliorate psychological symptoms associated with COVID-19: scoping review. J. Med. Internet Res. 22 (8), e19706.
Zhang, Y.L., Liang, W., Chen, Z.M., Zhang, H.M., Zhang, J.H., Weng, X.Q., et al., 2013. Validity and reliability of patient health questionnaire-9 and patient health questionnaire-2 to screen for depression among college students in China. Asia. Pac. 5 (4), 268–275.