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Digital Cognitive Behavioral Therapy for Insomnia Promotes Later Health Resilience During the Coronavirus Disease 19 (COVID-19) Pandemic

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PC had access to all data from the study, and also had complete freedom to direct analyses and reporting of results without influence from funders

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Abstract

Study Objectives: Stressful life events contribute to insomnia, psychosocial functioning, and illness. Though individuals with a history of insomnia may be especially vulnerable during stressful life events, risk may be mitigated by prior intervention. This study evaluated the effect of prior digital cognitive-behavioral therapy for insomnia (dCBT-I) versus sleep education on health resilience during the COVID-19 pandemic.

Methods: COVID impact, insomnia, general- and COVID-related stress, depression, and global health were assessed in April 2020 in adults with a history of insomnia who completed a randomized controlled trial of dCBT-I (*n* = 102) versus sleep education control (*n* = 106) in 2016-2017. Regression analyses were used to evaluate the effect of intervention conditions on subsequent stress and health during the pandemic.

Results: Insomnia symptoms were significantly associated with COVID-19 related disruptions, and those previously received dCBT-I reported less insomnia symptoms, less general stress and COVID-related cognitive intrusions, less depression, and better global health than those who received sleep education. Moreover, the odds for resurgent insomnia was 51% lower in the dCBT-I versus control condition. Similarly, odds of moderate to severe depression during COVID-19 was 57% lower in the dCBT-I condition.

Conclusions: Those who received dCBT-I had increased health resilience during the COVID-19 pandemic in adults with a history of insomnia and ongoing mild to moderate mental health symptoms. These data provide evidence that dCBT-I is a powerful tool to promote mental and physical health during stressors, including the COVID-19 pandemic.

Keywords: stress, COVID-19, insomnia, depression, CBT-I, engagement, prevention, primary care, digital health

Clinical Trial: Sleep to Prevent Evolving Affective Disorders; NCT02988375 (https://clinicaltrials.gov/ct2/show/NCT02988375)

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Statement of Significance

This study examines the role of insomnia treatment in promoting resilience during the COVID-19 pandemic. Results indicate people who received treatment years prior to the pandemic exhibited better insomnia and stress regulation despite similar exposure to COVID-19. The protective effects were also observed in depression and global health.

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Introduction

The 2019 coronavirus disease (COVID-19) pandemic has had health consequences that extend well-beyond symptoms of the virus. Mental health problems, including symptoms of insomnia, posttraumatic stress, and depression are already being observed in the context of COVID-19[1–5] and have been documented during previous epidemics (e.g., SARS, MERS).[6] As a consequence, COVID-related disability and mortality will include impairment from mental illness, which is already a leading contributor to global disease burden.[7] Public health interventions that aim to reduce COVID-related disease burden should include interventions to promote mental resilience.[8–11]

Insomnia is a common and debilitating consequence of pandemic-related stress and schedule disruption,[3,9] and thus is of particular relevance during the COVID-19 pandemic. Although sleep disruption can be a symptom of mental disorders, insomnia is increasingly considered a distinct and comorbid disorder that warrants sleep-focused intervention.[12–14] In addition to the suffering associated with sleeplessness, insomnia triggers and/or exacerbates other mental health problems,[15–18] adds to distress and impairment when comorbid with mental illness,[19–24] and frequently persists after other symptoms of mental illness have remitted.[25–29] This may be because insomnia further sensitizes the stress system,[30] leading to increased perceptions of life events as more stressful[31] and reduced resilience and recovery from stress.[32]

Although the evidence clearly supports managing and treating insomnia, it is also important to examine how resilience can be promoted to prevent insomnia in response to new stressors. This aligns with the growing call for a focus on prevention to increase impact for public health.[33,34] Insomnia is an ideal target for prevention because it is well-defined, highly modifiable, and is a robust risk factor for a range of psychiatric and medical morbidities.[18,35,36] Moreover, the treatment effects of Cognitive Behavioral Therapy for Insomnia (CBT-I) – the recommended first-line treatment for chronic insomnia [37,38] – extend beyond insomnia to reduce the incidence, severity, persistence, and recurrence of non-sleep mental and physical health problems. For example, CBT-I has been shown to reduce non-sleep symptoms of depression and anxiety,[39,40] non-sleep focused rumination,[41] chronic pain,[42] as well as global health and quality of life.[43] Together, these results suggest that the effects of insomnia treatment may strengthen health across multiple domains to promote resilience against future stressors. Indeed, we have shown that CBT-I reduced the one-year incidence of depression by 50%, even when delivered digitally (dCBT-I) for increased accessibility.[44]

The overarching aim of the present study was to examine resilience in the sleep and stress systems during the COVID-19 pandemic. As individuals with a history of insomnia disorder are at higher risk of experiencing stress and insomnia symptoms during the COVID-19 pandemic, we were interested in evaluating if those who had previously received insomnia treatment experienced more resilience. To accomplish this aim, we invited participants from a 2016-2017 dCBT-I intervention trial to complete measures of COVID impact, symptoms of insomnia, general- and COVID-related stress, and depression and physical health. Participants in this trial predominantly resided in the Detroit metropolitan area, which was disproportionately impacted by the COVID-19 pandemic. Our central hypothesis was that individuals who previously received dCBT-I would show more health resilience during the COVID-19 pandemic compared to individuals who received sleep education. Our first specific hypothesis was that insomnia symptoms during the pandemic would be less severe in those who previously received dCBT-I compared to those in the sleep education control condition. Our

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second specific hypothesis was that those who previously received dCBT-I would report less stress during the pandemic compared to participants in the control condition. Our third hypothesis was that participants who previously received dCBT-I would have lower depressive symptoms and better global health compared to the control group.

Methods

Participants for this study were recruited from a previous randomized controlled trial (NCT02988375) testing the efficacy of self-guided dCBT-I compared to a sleep education control in treating insomnia[71] and preventing incident depression.[44] Participants in the SPREAD trial were enrolled between 2016 and 2017, with a final sample of 358 in the dCBT-I condition and 300 in the control condition. Those in the dCBT-I condition completed 6 sessions of self-guided dCBT-I, which were directed by an animated "virtual therapist" who reviews and guides progress with the participant. Individuals randomized to the online sleep education condition received six weekly e-mails based on the NIH guide to healthy sleep (National Institutes of Health, 2011). Eligibility for the SPREAD trial was assessed via an online screener. This approach has been validated against clinician-administered diagnostic interviews.[72,73] Eligible participants met criteria for insomnia disorder based on the DSM-5: insomnia symptoms present on 3 or more days per week, with significant distress or impairment, and of at least 3 months duration. Participants were excluded from the SPREAD trial if they reported a diagnosis of any untreated sleep disorders other than insomnia (e.g., obstructive sleep apnea, restless legs, narcolepsy, etc.), and bipolar or seizure disorders. Because the SPREAD trial included a depression prevention aim, individuals with high depression chronicity (self-reported daily or near daily depressed mood and anhedonia) were excluded (see Cheng et al., 2018[71] for addition details).

All 658 participants in the SPREAD trial were eligible for this follow-up study. The recruitment plan targeted enrollment at 200 participants, which would achieve sufficient power (0.8) to detect a moderate effect size for each hypothesis test. Email invitations were sent during the last week of April 2020, five weeks into the Michigan state-wide stay-at-home order, with approximately 40,000 cases and 3800 deaths across the state. Enrollment was closed in the first week of May when the targeted sample size was achieved. The final sample included 208 participants (dCBT-I: *n* = 102; control: *n* = 106).

Measures of interest

Once enrolled, participants completed an online survey that assessed for COVID impact, insomnia, stress, and health during the COVID-19 pandemic.

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Impact of the COVID-19 pandemic. Direct impact from the COVID-19 was measured using the same framework as the Life Events Checklist.[74] Three prompts were included: 1) Exposure to the coronavirus, 2) Life-threatening illness or injury related to the coronavirus, 3) Severe human suffering related to the coronavirus. Participants were asked if those items happened to them in six different ways: 1) it happened to them, 2) they witnessed it happening to someone else, 3) they learned about it happening to a close friend or family member, 4) they were exposed to it as part of their job, or if 5) they are unsure or 6) it does not apply to them. Direct impact from the novel coronavirus was operationalized as any endorsement of responses 1 through 4 on at least one of the three items described.

The impact of the COVID-19 pandemic on daily life was measured using the Coronavirus Impact Scale (CIS). The CIS was made available through a collection of COVID-19 Research Tools assembled by the Office of Behavioral and Social Sciences Research at the National Institutes of Health.[75] The CIS rates the degree of change across multiple domains of daily life on a four-point Likert scale (0 = No change, 1 = Mild, 2 = Moderate, 3 = Severe) across 11 items. Domains assessed included routines; income/employment; access to food, medical care, and mental treatment; access to social support; pandemic related stress; familial stress and discord; and diagnoses of coronavirus. One open-ended item allowed free text responses to capture other ways in which daily life may have been impacted by the COVID-19 pandemic. Given the recency of the pandemic, there is no psychometric data available for the CIS.

Insomnia

. Symptoms of insomnia were assessed using the 7-item Insomnia Severity Index (ISI),[76] with higher scores indicating increased insomnia severity (range 0 – 28). A score of 15 or greater on the ISI was used as a threshold for moderate to severe insomnia. Because the ISI is not designed to assess insomnia in response to a specific event, another question was included to assess the impact of the COVID-19 pandemic on sleep using a 5-point Likert scale. The prompt was, "*How much impact did the COVID-19 pandemic have on your sleep?*", and responses ranged from Not at all (0) to Very much (4). Results from this item was examined independently and was not incorporated into the ISI.

Stress. Both general stress and stress specific to the COVID-19 pandemic were assessed. General stress was measured using a validated single-item instrument.[77,78] The prompt for this instrument was "*Stress means a situation in which a person feels tense, restless, nervous or anxious or is unable to sleep at night because his/her mind is troubled all the time. Do you feel this kind of stress these days?"* Response on this instrument was on a 5-point Likert scale ranging from never (0) to always (4).

Stress and trauma specific to the COVID-19 pandemic was assessed using the 22-item Impact of Events Scale[79] ($IES_{COVID-19}$). The IES measures the amount of distress associated with a specific event. Though the IES allows individuals to specify the event in question, we predetermined "the COVID-19 pandemic" in the instructions as we were interested in measuring stress specifically associated with the COVID-19 pandemic. The total score on the IES ranges from 0 to 88, with a score of 24 indicating clinically significant impairment. The IES score comprises three component scores: cognitive intrusion, avoidance, and hyperarousal. Both cognitive intrusion and avoidance describe psychological experiences of stress prior to assimilation of the trauma, the cognitive intrusion

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reflecting repeated thoughts about the trauma, and avoidance reflecting effortful avoidance of reminders of the trauma. The third component describes physiological hyperarousal as a cluster of PTSD symptoms.

Health Outcomes. In addition to insomnia symptoms, we also assessed for other health outcomes including depression and global health. Depression was assessed using the 16-item self-report Quick Inventory of Depressive Symptomatology (QIDS-SR_{16}),[81] a reliable and validated instrument for measuring depression symptoms commonly used in clinical trials. Scores on the QIDS-SR_{16} range from 0 to 27, and a score greater than 10 reflects moderately severe symptoms. Global health was assessed via the Global-10 from the NIH Patient-Reported Outcomes Measurement Information System (PROMIS).[82] The Global-10 assesses general domains of health and functioning including overall physical health, mental health, and overall perceived quality of life. The Global-10 has two components: Global Physical Health (GPH), and Global Mental Health (GMH). Both components are normed on a T-score distribution, with the population mean at 50 and a standard deviation of 10 points. Higher scores on the Global-10 and its components indicate better health.

Analytical Approach

The hypotheses were tested with ordinary least squares regression models with Condition (dCBT-I, sleep education control [reference group]) as the independent variable. All analyses controlled for pre-treatment insomnia severity as a measure of insomnia risk. The first hypothesis was tested using standardized scores from the ISI as the dependent variable. Because the dCBT-I condition reported less insomnia after treatment compared to those in the control condition, a sensitivity analysis was conducted in a subsample of individuals who reported symptom resolution (ISI < 8) at one-year follow-up. This analysis enabled more robust inference regarding symptom resurgence during the COVID-19 pandemic. To distinguish symptom resurgence from normative variations in sleep (especially given the context of a global pandemic), symptom resurgence was operationalized as moderate to severe symptoms (ISI ≥ 15) in those who previously reported symptom resolution. The second hypothesis was tested using standardized general stress and $IES_{COVID\text{-}19}$ total and component scores as the dependent variables via regressions models. The third hypothesis was tested using standardized scores on the QIDS-16_{SR} and the Global-10 component t-scores as the dependent variables in regression models. To examine the robustness of results, effect sizes were also contrasted between those who were and were not directly impact by the coronavirus.

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Given that research conducted during a global pandemic may be vulnerable to selection bias,[83,84] we utilized sampling weights for all analyses to mitigate differences in the probability of selection into the study relative to the original population of SPREAD trial participants. Sampling weights equal to the reciprocal of the selection probability in each condition were utilized to balance the probability of selection based on insomnia severity following treatment in the SPREAD trial. Insomnia severity categories were non-clinically significant (ISI ≤ 7), subthreshold (ISI > 7 and ≤ 14), and clinically significant (ISI ≥ 15). The final weighted mean (9.8 ± 5.7 SD) did not differ significantly from the population mean (10.4 ± 5.8 SD), suggesting that selection bias was likely minimal.

Results

The final sample included 208 (dCBT-I: *n* = 102; control: *n* = 106; see Table 1 for a summary of sample characteristics by group). During the COVID-19 pandemic, 67.3% of the sample reported direct impact from the coronavirus, and 26.4% reported living alone during the shelter-in-place orders. On average, the sample reported mild disruptions across the domains assessed on the CIS (*M* = 1.1 ± 0.03 *SE*). The three domains most impacted by COVID-19 included daily routines (*M* = 2.2 ± 0.06 *SE*), stress (*M* = 1.7 ± 0.06 *SE*), and social support (*M* = 1.6 ± 0.06 *SE*). The control and dCBT-I condition reported similar levels of disruption due to COVID-19. However, despite similar levels of disruption due to COVID-19, those who previously received the sleep education control reported that the pandemic had a larger impact on their sleep (*M* = 2.0 ± 0.12 *SE*) compared to those who received dCBT-I (*M* = 1.5 ± 0.11 *SE*), *p* = .009.

[Table 1]

Insomnia during COVID-19

The average ISI score was 12.1 ± 0.48 SE (see Figure 1 for ISI by group), with 34.1% reporting moderate to severe insomnia symptoms (ISI ≥ 15). Adjusting for baseline insomnia symptoms, ISI scores during the pandemic were significantly associated with the impact of the coronavirus assessed by CIS scores, B = 0.52 ± 0.05 SE, *p* < .001 (see Figure 1). Similarly, those who reported that the pandemic had a larger impact on their sleep also exhibited more severe ISI scores, B = 0.83 ± 0.05 SE, *p* < .001. Together, these data indicate a robust association between insomnia symptoms and the COVID-19 pandemic.

Consistent with our hypothesis, results also revealed that those who previously received dCBT-I exhibited less severe insomnia symptoms during the pandemic, b = -2.9 ± 0.8 SE, *p* = .001 (B = -0.41), indicating that ISI scores were approximately 3 points lower in the dCBT-I group compared to the control group during the pandemic. The effect size of dCBT-I on insomnia symptoms during COVID-19 were comparable between individuals directly impacted by the coronavirus (B = -0.43) compared to those who were not directly impacted (B = -0.37). Sensitivity analysis also revealed that odds of resurgent moderate to severe insomnia during COVID-19 in those who previously reported symptom resolution (ISI < 8 at one-year follow-up) was 51% lower in those who received dCBT-I relative to control, OR = 0.49, 95% CI [0.25, 0.96], *p* < .001.

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[Figure 1]

Stress during COVID-19

The sample reported a mean general stress score of 2.3 ± 0.07 SE (see Figure 2 for means by condition). Consistent with our hypothesis, those who previously received dCBT-I also demonstrated a trend of less overall stress levels during the COVID-19 pandemic compared to the control condition, b = -0.2 ± 0.1 SE, p = .055 sample (B = -0.25), despite similar exposure to disruptions due to COVID-19. The buffer effect of dCBT-I on stress was larger for those reporting direct impact by the coronavirus (B = -0.36) compared to those who were not directly impacted (B = -0.09).

In terms of COVID-19 specific stress, the sample reported a mean $IES_{COVID\text{-}19}$ score of 26.5 ± 1.0 SE (see Figure 2 for component scores by condition). Those who previously received dCBT-I reported lower total $IES_{COVID\text{-}19}$ scores compared to the control condition, b = -4.1 ± 1.9 SE, p = .03. Analyses of the $IES_{COVID\text{-}19}$ component scores revealed a significant effect for cognitive intrusion, b = -0.3 ± 0.1 SE, p = .03 (B = -0.30), a marginal effect for hyperarousal, b = -0.2 ± 0.1 SE, p = .08 (B = -0.23), but no significant effect for avoidance (p = .23). The buffer effect of dCBT-I against cognitive intrusion was comparable for those who were directly impacted by the coronavirus (B = -0.31) than those who were not directly impacted (B = -0.26).

[Figure 2]

Health during COVID-19

Depression. The sample reported a mean $QIDS\text{-}SR_{16}$ score of 10.6 ± 0.3 SE (see Figure 3 for means by condition). Those who previously received dCBT-I also showed lower depressive symptoms, b = -1.3 ± 0.5 SE, p = .01[1]. Importantly, the odds of moderate to severe depressive symptoms during COVID-19 was 57% lower in those who had received dCBT-I compared to those who received sleep education, OR = 0.43, 95% CI [0.30, 0.61], p < .001.

Global Health. The sample's average Global Physical Health (GPH) and Global Mental Health (GMH) t-scores were 45.7 ± 0.5 SE and 43.4± 0.6 SE, respectively (see Figure 3 for means by condition). Results from the multivariate regression indicated that who previously received dCBT-I reported better global health, $F(2,204) = 3.77$, p = .02.

Consistent with the other results, those who previously received dCBT-I exhibited better Global Physical Health, b = 2.76 ± 1.01 SE, p = .006. As the subscales are normed on a T-score distribution (M = 50, SD = 10), this indicates that while both groups show GPH scores within a SD of the population mean, the deviation from population mean in the control group (5.9 points) was approximately two-fold higher that of the dCBT-I group (3.1 points), indicating better global physical health in the dCBT-I group relative to the control group. In contrast, group differences on the GMH

[1] Results were not substantively different when sleep items were removed from the $QIDS\text{-}SR_{16}$.

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component did not achieve statistical significance, b = 1.46 ± 1.10 SE, p = .18 (effect size corresponds to a Cohen's d of 0.15).

Given that the sample was powered to detect moderate effect sizes, additional analyses were conducted to examine the odds of low GPH and GMH scores, defined as scores half a standard deviation lower than the population norm (t-score ≤ 45, corresponding to a Cohen's d of 0.5). These variables were then used in a logistic regression with Condition as the predictor of interest. Results indicated that the odds of reporting low GPH and GMH was 58% and 42% lower in the dCBT-I group relative to the control group, respectively (see Figure 3), GPH: OR = 0.42, 95% CI [0.29, 0.62], p = .002; GMH: OR = 0.58, 95% CI [0.42, 0.82], p < .001.

[Figure 3]

Discussion

The results of this study support the overall hypothesis that dCBT-I treatment increases health resilience during the COVID-19 pandemic. Consistent with other early reports of COVID-related health outcomes,[3,5] COVID-related disruptions in daily life were associated with insomnia symptoms. At the time of data collection, southeast Michigan was a significant hotspot of COVID-19 cases (approximately 40,000 cases and 3800 deaths) and it is therefore not surprising that most of the participants in this sample reported that the COVID-19 pandemic had a direct impact on their lives. On average, the sample also reported insomnia symptoms, moderate overall stress, clinically significant COVID-related stress, moderate depressive symptoms, and moderate overall health.

Considered together, these results provide evidence that dCBT-I promotes health resilience in an adult population with a history of insomnia and ongoing mild to moderate psychiatric symptoms. Results showed that, relative to a sleep education intervention, adults who completed dCBT-I in 2016-2017 had lower symptoms of insomnia, lower general stress and COVID-related cognitive intrusions (intrusive thoughts, feelings, and imagery; nightmares; dissociative-like re-experiencing), lower depressive symptom severity, and better global health. Moreover, these data suggest that dCBT-I helped build resilience during the COVID-19 pandemic. Relative to sleep education, dCBT-I prevented a resurgence of clinically significant insomnia during the pandemic by 50%. Additionally, the odds of moderate to severe depression in those who received dCBT-I was almost 60% lower than the sleep education group. These health outcomes were observed in April 2020 of the COVID-19 pandemic, 3-4 years after treatment completion, suggesting that dCBT-I offers long-lasting protection across multiple health domains and in the context of a global health threat. In light of the pressing mental health needs associated with the COVID-19 pandemic, the significance of these results is difficult to overstate. They add to a growing literature suggesting that behavioral insomnia treatment improves health, [39,59,66,68–70] and provide the first prospective evidence that dCBT-I increases health resilience during later stressors — in this case the COVID-19 pandemic.

This study was not designed to examine mechanisms of insomnia treatment; however, there are a number of potential mechanisms by which dCBT-I may promote health resilience. Hyperarousal models posit that insomnia may be related to disruptions in biological (autonomic and central nervous system functioning[85–88]) and cognitive systems (cognitive arousal, worry and rumination,

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and emotional distress[58,89–91]) that support energy mobilization.[92–96] CBT-I can mitigate these underlying mechanisms, [41,59,97,98] especially as the components of CBT-I (e.g., cognitive restructuring, relaxation, sleep hygiene) are designed to target the arousal system as a barrier to sleepiness around the sleep period. Indeed, our results suggest that those who previously completed dCBT-I experienced less stress, and cognitive intrusion and hyperarousal on the $IES_{COVID-19}$. Additionally, research should also further examine different mechanisms by which insomnia contributes to adverse outcomes relevant to the COVID-19 pandemic, such as stress and trauma-related symptoms (e.g., vigilance to threat) versus depressive symptoms (e.g., hedonic processing). Different types of insomnia (e.g., short sleep and non-restorative phenotypes) may also differentially impact biological and cognitive-emotional systems. For example, whereas medial prefrontal cortex functioning has been implicated in the relationship between non-restorative sleep and later depressive symptoms, it does not have a significant role in the relationship between nocturnal insomnia symptoms and later depressive symptoms.[99] Understanding the mechanisms by which insomnia contributes to different types of mental health problems (multifinality), or how different types of insomnia contribute to the same mental health problem (equifinality) may facilitate personalized and mechanistically-specific treatment approaches.

It is now evident that the COVID-19 pandemic will likely be a long-term stressor for many, particularly as the temporary support systems begin to subside (e.g., federal stimulus payments, enhanced unemployment), and as additional waves recur. This has potential to perpetuate a compounding cascade of negative consequences for mental and physical health, particularly as chronic stress increases allostatic load and erodes biological and emotional-cognitive systems .[100] As such, it is also important to consider the role of insomnia treatment during the COVID-19 pandemic, particularly as untreated insomnia is both common and debilitating. Epidemiological data prior to the pandemic indicates that approximately 9% of adults within the United States report daily or near daily insomnia symptoms,[101] and this number may have increased due to COVID-19. Additionally, the economic burden of insomnia is significant,[102–106] and is worsened by its medical comorbidities.[107,108] Together, these data suggest that the prevalence and costs of insomnia are likely to increase as the COVID-19 pandemic continues.[3,9] dCBT-I offers an accessible (self-paced, geographically unrestricted, low cost), acceptable, and efficacious intervention for insomnia and mental health.[39,109] Our data suggest that we could capitalize on the promise of dCBT-I to promote mental and physical health during the COVID-19 pandemic.

This study has both strengths and limitations that impact the significance of these results. Strengths of this study include the assessment of long-term effects of dCBT-I during a natural and chronic stressor that will have a myriad of major implications for public health. Most of the sample reported direct impact from the coronavirus, providing face validity to our claim that dCBT-I improves health resilience. The study sample (n = 208) allowed for adequate power to detect moderate effects of dCBT-I on health outcomes. Furthermore, the study included sleep education as an active comparison condition to control for non-specific effects of intervention effort and attention on health outcomes. The sample was also heterogeneous with regard to race/ethnicity and socioeconomic status, providing greater confidence in the generalizability of the results.

Limitations of this study include potential selection bias considering the context of a global pandemic; however, the analyses utilized sampling weights to mitigate this limitation. Additionally, the measure of general stress included sleep disturbance as part of the phenomenology of stress

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response. The sample size, although large enough to detect moderately large effects of interest, was not sufficient to detect potential moderators of dCBT-I outcomes (e.g., COVID-exposure, COVID-related stress, race, socioeconomic status) in primary hypothesis tests. We also did not design the study to examine mechanisms by which dCBT-I may differentially predict individual health outcomes (i.e., insomnia symptoms, COVID-related intrusions, depressive symptoms, global physical health). Finally, data collected in April 2020 may not represent the effects of dCBT-I later in the course of the COVID-19 pandemic. Additional follow-up assessments could help establish the persistence of benefit from dCBT-I and the relationship between mental health symptoms and COVID-19 chronicity and impact over time.

Conclusion

This study examined the role of prior treatment of insomnia with digital CBT-I (dCBT-I) on health resilience during the COVID-19 pandemic. Results demonstrated that those who received dCBT-I reported less insomnia, stress, depression, and better global physical health compared to those who received a sleep education control. Indeed, the risk of clinically significant insomnia and depression during the pandemic was reduced approximately by half in the dCBT-I group relative to the control group. Future research should examine the mechanisms by which insomnia treatment may enhance resilience, and the role of dCBT-I in mitigating the adverse health consequences of the COVID-19 pandemic.

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Author Contributions

Concept and Design: Cheng, Casement, Drake

Acquisition, Analysis, or Interpretation of data: Cuamatzi Castelan, Cheng, Casement

Drafting of manuscript: Cheng, Casement

Critical revision of the manuscript for important intellectual content: Kalmbach, Drake

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Tables and Figure Captions

Figure 1. Insomnia symptom severity during the COVID-19 pandemic. Panel A: Bubble chart of the weighted association between insomnia symptoms and disruptions to daily life due to COVID-19 (r = 0.60). Larger points indicate stronger weighting. Panel B: Estimated marginal means for insomnia severity by group. Error bars represent one standard error. $^{***}p \leq .001$, $^{**}p \leq .01$, $^{*}p \leq .05$, $^{\dagger}p < .10$

Figure 2. Estimated marginal means for stress by group. Panel A: General stress; Panel B: COVID-19 specific stress as measured on the Impact of Events Scale specific to COVID-19. Error bars represent one standard error. $^{***}p \leq .001$, $^{**}p \leq .01$, $^{*}p \leq .05$, $^{\dagger}p < .10$

Figure 3. Odds ratios of clinical outcomes in the dCBT-I relative to the control group. Resurgent Ins = resurgence of moderate to severe insomnia during COVID-19 in individuals who showed symptom resolution following the SPREAD trial; Mod-Sev Dep = moderate to severe depression on the Quick Inventory of Depressive Symptomatology ($QIDS\text{-}SR_{16}$); Low GPH = Global Physical Health scores below half a standard deviation of the population norm; Low GMH = Global Mental Health scores below half a standard deviation of the population norm. Error bars represent the 95% confidence intervals.

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Table 1. Baseline sample characteristics by group. dCBT-I = digital Cognitive Behavioral Therapy for Insomnia; CIS = Coronavirus Impact Scale. No group differences were detected at $p < .05$.

	Control (*n*=106)	**dCBT-I** (*n*=102)
Age (M ± SD)	44.7 ± 14.2	44.6 ± 14.1
Sex (Female)	84.0%	72.5%
Race		
White	68.8%	73.5%
Black	27.4%	18.6%
Other	3.8%	7.8%
2019 Household Income		
Very low (<15k)	9.4%	5.0%
Low (<35k)	23.6%	19.6%
Middle (<75k)	34.0%	43.1%
High (≥75k)	33.0%	32.4%
Married/Partnered	48.1%	59.8%
Living alone	28.3%	24.5%
Pre-treatment ISI (M ± SD)	17.0 ± 4.12	18.0 ± 3.8
COVID-19 direct impact	67.0%	67.6%
CIS (M ± SD)	12.1 ± 5.3	11.4 ± 4.3

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Figure 1

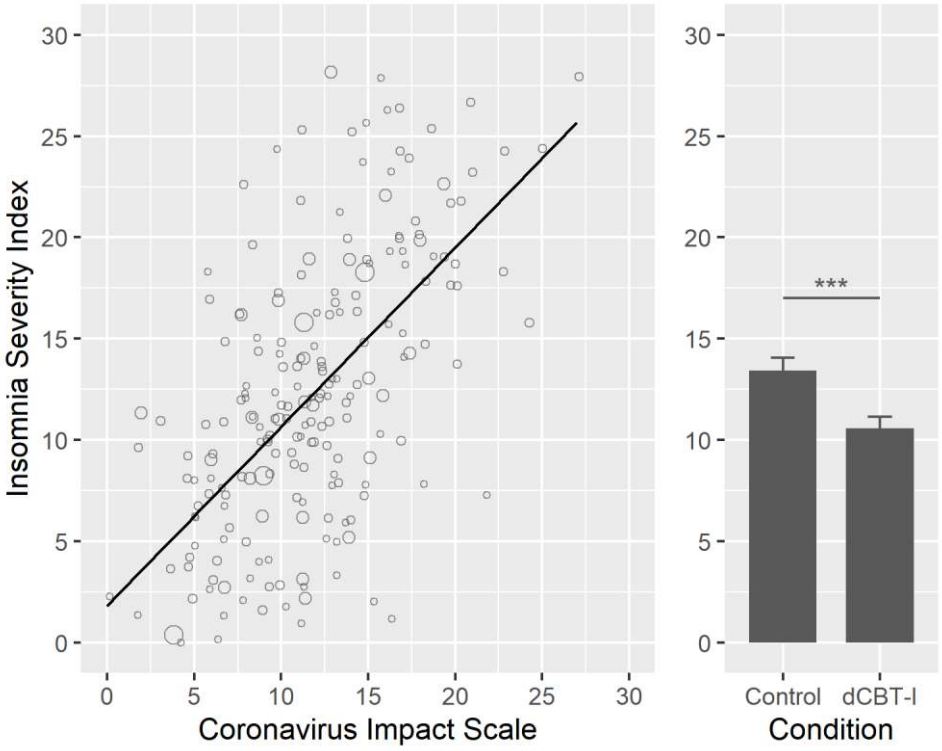

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Figure 2

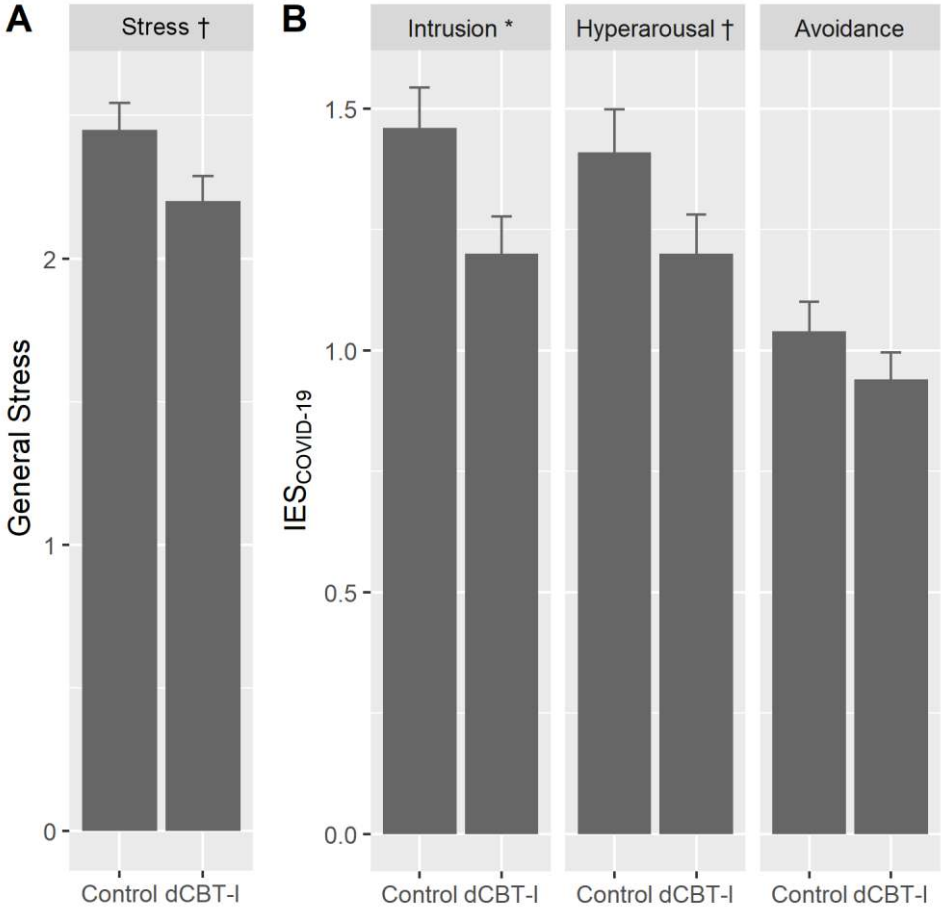

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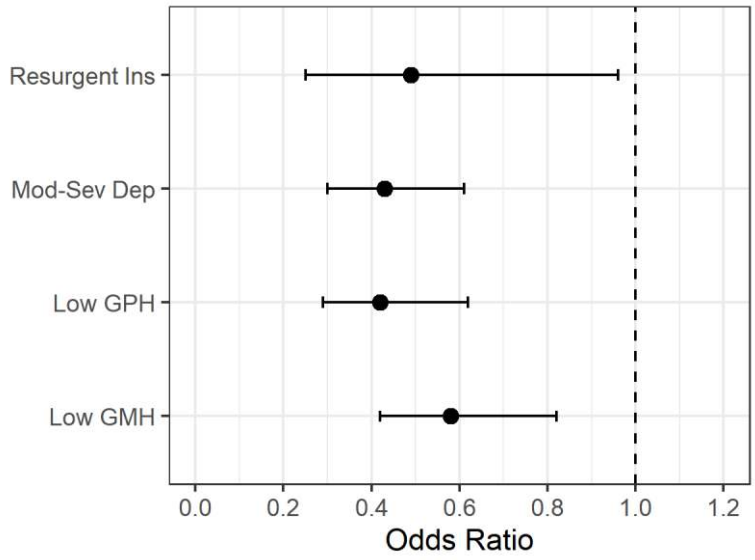
Figure 3



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