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Chapter

Sleep and Resilience during the COVID-19 Pandemic

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Abstract

Since early 2020, the COVID-19 pandemic has had a profound effect on the mental health and wellbeing of much of the population. Rates of depression, anxiety, loneliness, suicidal ideation, and other mental health concerns increased during the first year of the pandemic, with heightened fears of the virus, social isolation, and economic instability. Psychological resilience remains a key factor in sustaining healthy emotional functioning during the crisis and facilitating rapid recovery as we move forward to build a better post-pandemic world. Our research, and that of others, suggests that healthy sleep is one of the most powerful aspects of psychological resilience. This chapter will summarize the current literature on psychological resilience, particularly as it relates to the pandemic, and describe the important role of sleep as a key component of resilience capacity. We will discuss novel empirical data linking sleep and resilience during the pandemic. We will conclude with concrete, empirically based suggestions for modulating sleep to sustain psychological resilience during the present crisis and those that may emerge in the future.

Keywords: sleep, insomnia, resilience, mental health, COVID-19

1. Introduction

Resilience is a key factor for protecting and sustaining healthy psychological functioning after exposure to stress and trauma. The first year of the pandemic has resulted in significant increases in a number of mental health problems, including increased anxiety, depression, suicidal ideation, and alcohol abuse, among others [1]. Despite the general increases in mental health problems during the pandemic, there has also been considerable variability in the magnitude of these effects, suggesting that many people have demonstrated remarkable resilience in the face of uncertainty and adversity. It is critical that we identify the factors that have contributed to these positive outcomes. Furthermore, as the recovery continues, we need to identify methods for bolstering resilience and protecting individuals against future adversities. Previous research has shown that sleep is a vital component of resilience and is significantly related to mental health outcomes. However, sleep was one of the major health outcomes that was negatively impacted during the pandemic, potentially hampering resilience in many people. In this chapter, we will discuss the relationship between resilience and psychological outcomes before and during the COVID-19 pandemic, with particular focus on sleep as a key contributor to resilience and mental health outcomes. We will first review the existing literature

on these topics and then present concrete, empirically based suggestions on how to improve sleep and bolster resilience during the pandemic and other similar crises.

2. A brief overview on resilience

Resilience can be defined as one's ability to successfully and positively adapt to, and overcome, adversity [2]. This definition can be extended to mental health outcomes when an individual is faced with a traumatizing situation or other potentially life changing adversity [2, 3]. Furthermore, while resilience may include many stable traits and capacities within an individual, most view the expression of resilience as a dynamic process with a trajectory that can change throughout a person's life [2, 4]. Personal resilience can ebb and flow throughout the course of our lives depending on various personal biological, environmental, or systemic factors [3]. Thus, resilience is an evolving interaction among our character traits, biological propensities, and the environment that allows us to positively adapt and bounce back from adversity.

Importantly, resilience is not generally conceptualized as simply the absence of mental disorders, as posttraumatic stress reactions and other adverse stress-related outcomes can still occur concurrently with resilience-related growth [4]. Instead, resilience refers to one's personal ability to overcome adversity and mitigate the effects of stress on the development or worsening of mental disorders [5, 6]. Likewise, resilience can also be a mechanism for accelerating recovery from adversity-related mental health problems such as posttraumatic stress disorder (PTSD) [5, 7]. While mental health research has typically focused on the risk factors for psychiatric disturbances, recent work has incorporated resilience into models of mental health to study factors that facilitate positive mental health outcomes following perceived adversity [5]. It is critical that we examine the role of resilience during the COVID-19 pandemic, which has had a significant impact on life functioning and well-being for millions of people worldwide.

3. Mental health and resilience during COVID-19

The COVID-19 pandemic has resulted in a significant decline in mental health across the globe and it is clear that this has become a co-occurring public health crisis [8]. The combined impact of COVID-19 on major life domains such as social life, occupational status, and financial security has proven to be a significant source of adversity. While many individuals found these adversities nearly insurmountable, others seemed to find ways to cope effectively in the moment, and still others may have been initially overwhelmed but were able to "bounce back" and extract the positives from an otherwise bleak situation. This bounce back capacity can act as a buffer against the onset or worsening of psychological distress and mental disorders [2]. In the context of the first year of the pandemic, researchers found resilience to be inversely related to depression [9, 10]. and anxiety [9–12]. Individuals with higher measured resilience at the beginning of pandemic experienced markedly lower levels of psychological distress compared to those with average or below average resilience, who experienced increased distress over the course of the pandemic [13]. These findings exemplify how resilience can sustain psychological health during persistent exposure to stress, and even more importantly, why it is critical to foster resilience over these prolonged periods of adversity.

But how do individuals remain resilient during prolonged stressful experiences like the COVID-19 pandemic? The use of resilience-based strategies to cope with

stress, such as employing a positive appraisal style (i.e., trying to see the positive aspects of a threatening situation and telling oneself there are worse things in life) [14, 15] or using adaptive coping skills (e.g., active coping, planning ahead, positive reframing) [6, 16, 17] have been found to reduce pandemic-related stress and protect against poor mental and physical health outcomes related to stress. Importantly, one of the most consistent factors related to resilience and mental health is perceived social support. Unfortunately, the primary mitigation strategy during the first year of the COVID-19 pandemic involved a combination of social isolation (e.g., lockdowns; quarantines; stay-at-home orders), social distancing, and face coverings, which may have all contributed to a reduction in perceived social support for many individuals. These factors led to early feelings of loneliness, increased depression, anxiety, and suicidal ideation [1, 12, 18, 19]. As the pandemic response moves into the next phases, it will be important to find healthy ways to facilitate adequate social support and human contact while safely addressing infection spread.

In addition to perceived social support, another key factor related to resilience that needs to be considered is sleep health. Because sleep is vital to normal emotional functioning, it provides the bedrock foundation for resiliency. As we will discuss in the following sections, sleep is a critical aspect of psychological functioning and resilience, and it has also been significantly impacted by the COVID-19 pandemic.

4. Sleep disturbances and insomnia during COVID-19

When COVID-19 first emerged, because it was a novel virus, there was a lack of existing information on critical epidemiological factors, like how the virus was spread, how to contain the virus, who was most at risk, and how infectious or how lethal the virus was, contributing to an overwhelming feeling of uncertainty for many. Additionally, many people experienced ongoing disruptions to their usual daily routines due to the various sociocultural changes enacted to mitigate the spread of the virus. Combined, these factors may have contributed to the significant negative impact of the pandemic on sleep health, with many studies reporting a sharp increase in sleep disturbances, including insomnia. The pandemic and its related stressors may have contributed to both a magnification of pre-existing sleep difficulties and also the rise of new-onset sleep problems for many [20–22].

During the first year of the pandemic, several studies reported on the prevalence of general sleep problems. In a global online cross-sectional survey of 59 countries, over a third of participants reported having more trouble falling asleep or more frequent night waking compared to before the pandemic [23]. In France, 74% of respondents endorsed having sleep problems or trouble sleeping over the previous week compared to 49% reported in 2017 [22]. In the United States, the number of adults experiencing any difficulties falling asleep and staying asleep nearly doubled from 2018 to 2020 [21].

Overall sleep quality has also been impacted by the pandemic. A global online cross-sectional survey involving 63 countries reported the prevalence of poor sleep quality to be 73% [24], while other cross-sectional reports from Italy listing the prevalence ranging from 52.4% [25] to 81% [26], with other countries also falling within that range [27–29]. Several longitudinal studies were able to describe changes in overall sleep quality reported before and during the pandemic. In India, around a quarter of those surveyed reported worsening sleep quality during the early stages of lockdowns compared to pre-pandemic levels [30], while no changes in sleep quality were reported among participants in Italy [31] and Argentina [32]. Interestingly,

a longitudinal study of adults in the U.S. surveyed before and after quarantine implementation found that while 29% of participants experienced a decrease in sleep quality, 47% actually reported improved sleep quality during the early quarantine period of the pandemic [33]. In Ref. [33], this improvement is attributed to increases in reported sleep duration, delayed bedtimes and wake times, and fewer reported sleep disturbances. Previous research has shown that sleep quality is associated with resilience [34–39], which highlights the importance of addressing sleep quality issues in order to maintain and boost resilience during the pandemic.

Regarding clinical insomnia, the reported prevalence during the COVID-19 period has varied widely across countries worldwide as well as within individual countries themselves. Insomnia symptoms can include sleep-onset and sleep maintenance difficulties, low sleep satisfaction, impaired daily functioning due to sleep problems, and increased concern or distress related to sleep problems [40]. Insomnia prevalence during the pandemic has been reported from a low of 10–13% in India, similar to the pre-pandemic prevalence [30, 41], to a high of 56% in Morocco [42], with other countries reporting results falling between these extremes [43–45]. Studies in China reported that among those classified as having insomnia during the pandemic period, 13.6% reported developing new-onset insomnia while 12.5% reported worsened symptoms of prior insomnia [20]. Thus, while insomnia and other sleep problems have varied over time and location, in accordance with disease transmission rates and other social factors specific to the locality, it is clear that sleep has been significantly impacted during the pandemic.

4.1 Demographic factors associated with sleep problems during COVID-19

While increases in sleep problems and insomnia have been reported worldwide, these issues have not affected everyone in the same way. There appear to be certain demographic factors associated with higher prevalence of insomnia and other sleep problems during the pandemic, indicating possible areas of focus for sleep-related interventions. For example, age appears to be one important factor for heightened sleep problems, with several studies from France and China indicating that younger people (i.e., 35 years and younger) not only had the highest prevalence of sleep problems during the pandemic, but also reported greater severity of these issues [22, 46, 47], although, a study of Chinese adults found that older age (i.e., 50 years and older) was associated with increased sleep problems [48]. Because age is associated with many other pandemic-related factors (e.g., vulnerability to complications from COVID-19; impact on social interactions; job expectations; etc.), and general susceptibility to sleep problems, further work will be necessary to disentangle these complex associations. Several studies have found that women reported more sleep problems than men during the pandemic, and this trend has been observed worldwide [20, 22, 29, 43, 47–49]. Studies in China, Greece, Spain, France, and Italy found that women reported significantly worse insomnia and other sleep problems, both in terms of frequency and severity, compared to men during the pandemic [20, 22, 43, 46, 48–50]. However, these findings need to be interpreted within the context of higher prevalence of sleep problems among women in general, as well as higher rates of anxiety and depression in women, which could exacerbate sleep-related responses to pandemic stress. Other factors associated with sleep problems during the pandemic include unemployment and/or being laid off due to the pandemic, classification as an on-site “essential worker” unable to work from home, working rotating shifts or being a shift worker, and living in urban areas [23, 29, 33, 42, 43, 49]. All of these occupational factors add stresses to an already adverse situation, so such findings are not unexpected.

4.2 Pandemic-related factors affecting sleep health

The effects of the COVID-19 pandemic are far-reaching and have resulted in significant behavior changes to prevent the spread of the virus (e.g., sheltering-in place; working from home; reduced movement; reduced exposure to sunlight and social interactions; etc.). Some of these behavioral changes can negatively impact the body's sleep regulation due to changes in the homeostatic sleep drive, circadian rhythms, and the arousal system [51]. These adjustments have had a profound effect on almost every aspect of daily life including employment, working conditions, school and education. Restrictions on regular social activities like exercise, team sports, and religious services have also disrupted daily routines for many individuals. The timing of daily activities, including daily wake time, daily light exposure, and mealtimes, helps regulate the body's circadian rhythm [51–53]. Changes in the timing of these daily activities will lead to dysregulations in the circadian rhythm resulting in changes in sleep patterns [51–53]. Changes in routines and daily activities has led to a shift in the amount and timing of daily light people are exposed to, and as mentioned above, daily light exposure is a critical component of regulating the circadian system. For some individuals, the lockdown period has allowed them to spend more time outdoors, however for others the pandemic has resulted in disruptions that have reduced daily natural light exposure, which has critically affected regulatory processes related to sleep [51]. Further, some studies have reported increased exposure to electronic screens during the stay-at-home orders, and exposure to this type of light, especially before bed, has been associated with poorer sleep quality during the pandemic [25, 30, 54]. These disruptions have important consequences for daily functioning, since sleep plays a key role in overall mental and physical health.

Disrupted sleep and insomnia are associated with anxiety, depression and suicidal behaviors, and the COVID-19 pandemic has further exacerbated this association [1, 11, 20, 24, 25, 38, 41, 44, 47, 51, 55–60]. Furthermore, insomnia has been shown to mediate the relationship between pandemic-related anxiety and suicidal ideation, meaning the heightened insomnia symptoms experienced as a result of increased pandemic-related anxiety can lead to a greater likelihood of suicidal ideation [44]. The increased symptoms of anxiety and stress reported during the pandemic, have been attributed to a wide range of factors including novel worries about one's own health and the health of loved ones, the financial impact of the pandemic, changes in social life and increased loneliness, as well as significant disruptions to work and other aspects of daily routines [43]. These recent increases in general anxiety and stress as well as COVID-19 related stress have been associated with diminished sleep health, including increased sleep difficulties, disrupted circadian rhythms, poorer sleep quality, and insomnia [11, 20, 24, 25, 33, 41, 43, 44, 47, 58–63].

Sleep problems also appear to be significantly elevated among several groups directly impacted by COVID-19 including: those diagnosed with COVID-19, those who had someone close to them diagnosed with COVID-19, those who were uncertain of their COVID-19 status, or those who knew someone who died from COVID-19-related causes [22, 29, 33, 45, 47, 49, 61].

Finally, COVID-19 related loneliness may play an important role in sleep disruption as well. With the abrupt halt of all in-person social activities and subsequent decrease in social interactions in efforts to curtail the spread of the virus, feelings of loneliness have become a major factor in sleep and mental health during the pandemic. Loneliness, made worse by the lack of accessible social support, has been associated with poor sleep quality and increased insomnia symptoms since the start of the pandemic [24, 43, 45, 61, 63]. Moreover, the link between loneliness and

sleep is stronger among those with more COVID-19 related worries and those with lower resilience [63]. Furthermore, there appears to be a bidirectional relationship between loneliness and insomnia during the pandemic [43]. In Ref. [43], the authors suggest that a) loneliness may increase cognitive arousal by inducing feelings of vulnerability; and b) sleeping poorly and/or keeping an abnormal sleep-wake schedule may further disrupt social interactions and increase frustrations associated with social isolation. During the period of pandemic-related lockdowns, these higher levels of loneliness have been linked with elevated levels of depression and suicidal ideation, further emphasizing the need to address social isolation and sleep problems during the pandemic [19].

4.3 The effects of the COVID-19 pandemic on sleep health in healthcare workers

Healthcare workers in particular have faced tremendous stress during the COVID-19 pandemic due to a range of factors, such as increased workload, long working hours, high work intensity, emotional demands, and increased risk of infection. As a result, the prevalence of sleep problems, especially insomnia, have significantly increased for healthcare workers during the pandemic [64–66]. As the pandemic continued to unfold during the first year and the number of cases and deaths continued to rise, the impact on sleep among healthcare workers became undeniable [66]. The severity of sleep problems is quite variable among healthcare workers, but these trends seem to be consistent in healthcare populations worldwide. In a study conducted at a large medical center in New York City in April 2020, during a peak of inpatient COVID-19 admissions in the city, sleep disturbances were highly prevalent among healthcare workers, with nearly 75% of those surveyed reporting at least moderate insomnia symptoms and 26% reporting severe or very severe sleep problems [17]. Similarly, among physicians working in Slovenia, those working at COVID-19 entry points were more likely to experience nighttime awakening and frequent nightmares, and to sleep less than 5 hours per night in comparison to other physicians working during the same time period outside of COVID-19 hotspots [67]. Likewise, a study among doctors and nurses working with COVID-19 patients in China found that overall sleep quality was low [59]. It is clear that the pandemic has had a significant global impact on sleep, and this effect has been particularly potent among healthcare workers.

5. Long term consequences of COVID-19 related sleep disturbances and insomnia: sleep as a cornerstone of resilience

5.1 Sleep as a critical component of emotional health

The connection between sleep and emotions has been extensively investigated, particularly in the context of insomnia. Until recently, sleep problems were viewed as a symptom of mental disorders; however, recent evidence suggests that there is a bidirectional relationship between sleep and emotions, specifically, that sleep disturbance actually precede and contribute to the onset of disorders like depression [56, 68]. Indeed, insomnia symptoms can present before the onset of psychiatric illness and can persist past remission and recovery. Evidence suggests that, among non-depressed individuals, those presenting with insomnia appear to be twice as likely to go on to develop depression as those without insomnia [56].

There are multiple theories behind the relationship between sleep and emotional health, though the common denominators in these theories seem to suggest that disrupted Rapid Eye Movement (REM) sleep and daytime symptoms resulting

from poor sleep tend to be leading contributors to emotional dysregulation [69–72]. REM sleep is hypothesized to play a critical role in emotional processing through the coordinated activation of affect-related brain regions, such as the amygdala and hippocampus, during neurochemical brain states that help to strip away the emotional intensity of memories [69–72]. Through repeated nightly REM sleep sessions, formerly unpleasant or traumatic memories become less potent, helping to maintain emotional health. Individuals with insomnia, however, often report experiences of non-restorative sleep, restless REM sleep (characterized by frequent REM arousals), as well as disruptions to REM sleep, which may hinder emotion recalibration processes that occur during sleep, further contributing to chronic hyperarousal and emotion dysregulation during the day [69–72]. Thus, REM sleep is necessary for modulating normal emotional responses to daily events. When REM sleep is curtailed, emotional responses can more easily become skewed, and this can alter an individual's life outlook and impair their ability to respond to challenges in adaptive ways.

Insomnia can also have a significant adverse impact on daytime functioning, which has also been found to be closely related to the development of psychiatric problems [72]. Insufficient sleep is associated with mood disruption and increased symptoms of depression, anxiety, paranoia, and somatic complaints [73, 74]. Daytime symptoms of insomnia include fatigue, daytime sleepiness, irritability, and reduced motivation and energy, in addition to attention and memory impairments [72]. Interestingly, although both nighttime and daytime symptoms of insomnia are significantly associated with depression and anxiety symptoms, there is a stronger relationship between the experience of daytime impairments and symptoms of depression and anxiety [72].

Additionally, there is evidence to demonstrate the bidirectionality of sleep and affective state. Poor sleep quality or lack of sleep (e.g., sleep deprivation) tends to be associated with increased negative and decreased positive affect, and likewise, negatively valenced cognitions that tend to appear before sleep-onset in insomnia patients (e.g., worrying, rumination) can also contribute to difficulties with falling asleep [72]. Daytime symptoms of insomnia are also associated with greater negative emotionality and diminished positive emotionality, which may be a risk factor for mental disorders like depression [72]. Affective states have also been found to impact sleep. For example, negative affect related to loneliness has been associated with insomnia symptoms like poor sleep efficiency and more sleep disturbances [75, 76]. This has clear relevance during the pandemic, as loneliness levels have increased dramatically due to lockdowns and quarantines [77]. Other affective states related to negative emotionality like grief, hostility, and impulsivity are all related to insomnia symptomology, such as shorter sleep duration, poor sleep quality, and daytime impairment. Alternatively, positively valenced affective states like romantic love have been associated with better sleep outcomes, such as better sleep quality and increased daytime functioning [72].

The onset of emotion dysregulation and mood disorders due to sleep problems may be facilitated by the inter-relationships between resilience, emotional functioning, and sleep [36, 38, 70]. Because sleep plays such a critical role in emotional and mental health, increased pandemic-related sleep problems are likely to have contributed to the significant increase in mental health problems observed during the pandemic [70, 78]. Even acute sleep disruptions due to the pandemic have the potential to progress to more chronic insomnia and other sleep and mood disorders [21, 51, 79]. Therefore, to prevent potential long-term sleep and mental health issues and build resilience, it is vital to address pandemic-related sleep disruptions and insomnia through appropriate and timely interventions to improve sleep and in turn, improve psychological outcomes.

5.2 The bidirectional relationship between sleep and resilience

Sleep has been identified as a key aspect of psychological health, based on its connection to emotional functioning and the stress response [36, 38, 56, 71, 72]. The role of sleep on mental health outcomes is closely interconnected with resilience, wherein resilience acts as a buffer against the effects of adversity on mental health [5–7]. Similarly, low levels of resilience have been associated with several factors related to sleep, including high stress-related sleep reactivity, emotional dysregulation, and hyperarousal [36, 38, 80]. Thus, it is critical to understand that sleep also plays an important role in resilience, especially during crisis situations.

The relationship between sleep and resilience is reciprocal in nature: better sleep can bolster resilience, and greater resilience can also lead to better sleep. This relationship has been documented in a number of studies involving both children and adults [34–37, 39, 81, 82]. In a longitudinal study of a U.S. military population, poor sleep (e.g., frequent sleep disturbances, trouble falling or staying asleep) was associated with lower resilience outcomes compared to those with healthy sleep [37]. Further, resilience among U.S. military Veterans significantly moderated the relationship between poor sleep and negative psychological outcomes [39]. Veterans who reported poor sleep had worse physical and psychological health and lower resilience compared to good sleepers, yet among the poor sleepers, those who reported greater resilience experienced fewer negative physical and mental outcomes, suggesting that resilience may be a protective factor against negative health outcomes in those with poor sleep [39]. Additionally, shorter sleep length has been associated with increased vulnerability to stress, which may contribute to the effect of sleep on resiliency during stressful times [72]. However, resilience can buffer the negative impact of stress on sleep, where higher levels of resilience can protect against the sleep disturbances that arise due to increased perceived stress [35].

As described above, insomnia can disrupt sleep processes necessary for emotional processing, leading to increased risk of heightened emotional reactivity during the day [69–72]. Furthermore, daytime insomnia symptoms are also closely related to increased negative emotionality and decreased positive emotionality [72]. Emotional reactivity is also closely related to stress, and resilience can help protect against the effects of stress on emotional responses [83, 84]. Resilience has also been found to predict negative emotional responses to stressful life events, specifically, higher resilience can buffer the effects of stressful life events on the development of psychiatric symptoms [84]. Resilience can also facilitate adaptive emotional responses to stress that are often found in psychiatric disorders such as depression and PTSD through genetic and neurological factors [85].

When individuals are low in resilience, they are also more susceptible to emotion dysregulation after exposure to stressors, which also leads to greater vulnerability to psychopathology [36]. Resilience helps bolster emotion regulation abilities through the use of adaptive coping strategies to overcome stress [80]. For example, individuals high in resilience tend to use more effective emotion regulation strategies such as cognitive reappraisal to reframe stressful situations in a positive light and decrease maladaptive emotion responses [80].

Hyperarousal is another critical factor that contributes to poor mental health outcomes and is linked to both sleep and resilience. Insomnia often leads to cognitive (e.g., intrusive thoughts, dysfunctional beliefs) and physiological (e.g., central nervous system, brain regions) hyperarousal [71, 72]. Hyperarousal can have severe consequences for emotion regulation abilities, due to the fact that sustained levels of hyperarousal can deplete cognitive and physiological resources needed to effectively regulate emotions [71]. Emotion processing deficits, especially in the context of stressful situations, can in turn make insomnia symptoms worse [36, 86]. In [36],

the authors investigated the relationship between resilience, emotion dysregulation, and pre-sleep hyperarousal and found that resilience predicted hyperarousal, where lower resilience resulted in increased pre-sleep cognitive hyperarousal. Furthermore, increased emotion dysregulation, predicted by low resilience, mediated the relationship between resilience and hyperarousal [36]. This relationship was worse in individuals with insomnia compared to good sleepers [36].

Recent research into the neurobiological mechanisms behind resilience has revealed how the neuronal systems behind sleep are closely related to those responsible for resilience [87]. Resilience and sleep are linked to similar brain regions, structures, and neural circuits that are key for autonomic activation (e.g., hypothalamus-pituitary-adrenal axis, noradrenergic system, serotonergic system, dopaminergic system) and emotional processes (e.g., hippocampus, amygdala) [81, 87]. Further, sleep loss can inhibit brain functioning in areas related to resilience, particularly those associated with autonomic activation and emotional functioning [81]. However, brain plasticity also plays a critical role in both resilience and sleep [87]. Research suggests that neural plasticity is vital for the development of resilience as a result of its connection to the central nervous system (CNS) [88]. Increased plasticity may be a sign of greater resilience, given the role of neural plasticity in stress recovery [88]. Additionally, brain plasticity plays a key role in our ability to adapt to challenges and respond to stress, due to its role in learning adaptive behaviors and emotion regulation skills in response to stress [87]. However, poor sleep quality, sleep loss, and sleep disturbances during both REM and non-REM sleep can negatively affect neural plasticity, which in turn has consequences for recovery from stress exposure [81, 87]. Research regarding the synaptic homeostasis hypothesis posits that deep sleep can enhance neural plasticity, which in turn may improve resilience; alternatively, dysregulation of synaptic homeostasis is characteristic of psychiatric disorders that involve sleep disturbances, like depression [89, 90]. Plasticity, which is critical for maintaining and enhancing resilience, is also particularly susceptible to sleep health, further emphasizing the importance of sleep for preserving resilience during prolonged periods of stress.

Resilience reflects our ability to adapt to and overcome adversity, and this ability appears to be facilitated by the emotional, physiological, and neurobiological processes of sleep. Without sufficient restorative sleep, individuals appear to lack the ability to process and regulate emotions effectively and are therefore more susceptible to the vicissitudes of life and are more vulnerable to being overcome by adversity. Likewise, when resilience is low, it becomes difficult to obtain sufficient restorative sleep. Thus, these factors operate synergistically to sustain mental health.

5.3 Sleep and resilience during the pandemic

The COVID-19 pandemic has emphasized the importance of the sleep-resilience relationship, particularly for mental health-related issues. The relationship between sleep health and resilience has proven crucial for professions that were exposed to greater amounts of stress during the pandemic, such as healthcare workers. For instance, physicians who reported better sleep during the early stages of the pandemic were able to remain more resilient at work, experienced fewer self-regulatory failures and lower negative affect [67], and greater life satisfaction [91]. Clearly, obtaining sufficient restorative sleep is a vital component to maintaining the ability of healthcare workers, and others, to effectively navigate the intense emotional aspect of their work and bounce back despite adversity. There is substantial evidence to support the bidirectional relationship between sleep and resilience, and how this relationship can have important implications for mental health outcomes. While previous research on sleep and resilience has focused on populations that are

more susceptible to mental health problems due to stress (e.g., military populations, adolescents, healthcare professions), the COVID-19 pandemic has emphasized how important the sleep-resilience relationship is for the general population. It is critical that we address the connection between resilience and sleep health during prolonged periods of stress in order to prevent or curtail a mental health crisis.

6. Future directions for improving resilience, sleep, and mental health

Thus far, the discussion has focused on the impact of the COVID-19 pandemic on mental health and sleep outcomes, as well as the critical role of sleep as a core neurobiological process underlying resilience. In this next section, we present strategies and proposed interventions for addressing COVID-19 related mental health outcomes, with a specific focus on the role of sleep and resilience. It is critical that public health officials, medical professionals, community leaders, and other management positions implement empirically based interventions to address the effects of the pandemic on mental and physical health.

Intervention programs aimed toward improving resilience by enhancing sleep specifically can have a long-lasting impact on stress and health even after the pandemic subsides. These interventions can utilize technology to maintain social-distancing requirements yet still provide access to evidence-based self-help tools, education resources, and telehealth consultations to enhance resilience and sleep, and in turn, improve mental health [24, 57]. Online intervention programs are easily accessible and can be used with or without formal psychotherapy or counseling. With more and more people spending time on their phones and computers during the pandemic, online training or intervention programs can be a way to reach many people. Overall, interventions should not just focus on the reduction of negative outcomes; they should also be designed to promote positive adaptation and educate individuals on how to capitalize on the resources they already have [92].

6.1 Resilience training

An obvious method to build resilience is to develop programs that specifically train relevant skills. Resilience training has been a topic of interest in recent years and these types of programs may prove especially useful during the pandemic. Existing research has shown that resilience can be learned, a finding that is supported by evidence that it evolves dynamically rather than remaining stable over the lifetime [2, 13]. Resilience training programs can teach individuals how to effectively utilize adaptive coping strategies to combat chronic and acute stressors such as the COVID-19 pandemic. Effective interventions often emphasize the importance of keeping a daily routine, cultivating positive emotions in everyday life, and keeping in touch with social networks to maintain one's social support system [93].

Social support plays a key role in boosting and maintaining resilience through adversity. Social support is crucial for maintaining resiliency and psychological functioning during prolonged periods of stress, and there is evidence to show how the accessibility and availability of social support has played an important role in mental and physical health outcomes during the pandemic. With pandemic-induced loneliness and social isolation having direct, negative effects on mental health and sleep outcomes, it is critical to develop creative and innovative ways to increase the availability of social support for all populations. While social support from friends and family is particularly protective [94], social support can also come in the form of investing in social capital. Social support, which refers to the size and source of social networks, and social capital, which refers to social trust and

feelings of belonging in social groups, are associated with mental health and sleep outcomes [94, 95]. As social support and social capital increase, mental health and sleep outcomes also tend to improve [94, 95], although causality is difficult to demonstrate in many of these studies due to their cross-sectional design. With this in mind, finding ways to increase social support and social capital would seem to be relevant to psychological crisis prevention programs [57].

6.2 Sleep education and cognitive Behavioral therapy (CBT)

Sleep hygiene, which involves making behavioral and environmental adjustments that support good sleep, has been shown to be effective at improving sleep health during the pandemic [47, 53, 78, 96, 97]. Furthermore, cognitive behavioral therapy (CBT) techniques can be beneficial for improving both mental health and sleep health. CBT focuses on breaking maladaptive thinking patterns that can lead to mental health problems such as depression [98]. CBT combines behavioral techniques (e.g., stimulus control, relaxation) with cognitive (e.g., learning to manage worries, intrusive thoughts) and educational (e.g., coping skills) components to address depression, anxiety, and other related disorders [98]. CBT can help with both chronic and acute insomnia, and CBT for insomnia (CBT-I) has become a leading treatment for insomnia and poor sleep health [78, 98].

CBT-I includes several key features. Sleep hygiene and sleep beliefs are critical for improving sleep behaviors and overall health and CBT-I interventions typically include an element of sleep education to address maladaptive sleep behaviors and sleep beliefs as well as information regarding the importance of reducing screen time before bed, avoiding bright light at night, and being mindful of time spent in bed [78]. Additionally, sleep hygiene should address minimizing habits that can negatively affect sleep (e.g. drinking caffeine in the late-afternoon/evening, alcohol intake, exercising near bedtime) and promote habits that keep one's circadian rhythm in balance (e.g. increasing physical exercise and daytime hours spent outside) [47, 78]. The development of digital CBT has made CBT more accessible and is especially relevant for use during the pandemic [98, 99].

6.3 Physical activity and daylight exposure

Lockdowns and social distancing guidelines due to the pandemic have had a negative impact on levels of physical activity and daylight exposure [47, 100]. Reduced daylight exposure and physical activity during the pandemic have been associated with poor sleep quality and lower resilience, which in turn have adversely affected depression and anxiety symptoms [47, 62, 94, 100]. Timing of light is critical to maintain a normal daily rhythm, and it is important to incorporate daily light exposure into daily routines and aim to spend time outside exposed to bright sunlight, especially in the mornings, while also limiting light from screens in the evening [53]. Similarly, incorporating physical activity into a daily routine can act as a buffer against some of the negative effects of the pandemic and lockdowns on sleep quality and mental health [53]. Light exposure and physical activity have the effect of resetting the daily rhythm and are associated with better sleep quality and greater resilience [94, 100].

7. Conclusions

During its first year, the COVID-19 pandemic had a powerful impact on nearly every aspect of daily life, leading to significant increases in mental health problems

across the globe. Nonetheless, many individuals have weathered the pandemic without undue harm or have rebounded from major life setbacks to be stronger than before. These individuals show psychological resilience, which reflects the ability of the individual to rapidly recover from such setbacks and even grow stronger in the process. Many factors contribute to individual resiliency, including the availability of social, emotional, behavioral, material, and physiological resources. Considerable evidence suggests that one of the key physiological resources that contributes to resilience is sufficient restorative sleep. Without adequate sleep, the brain rapidly declines in its capacity to process emotions and cope effectively with change. Cognitive flexibility becomes limited during periods of insufficient sleep, and it becomes difficult to identify effective solutions to life's challenges. Unfortunately, the anxiety and stresses of the pandemic adversely impacted the sleep of a large proportion of the population, reducing the ability of many people to cope with setbacks and regulate emotional responses.

In short, psychological resilience during the pandemic was severely hampered by the chronic sleep disruptions of the past year, and this appears to have contributed to elevated rates of mental health concerns. However, sleep is a physiological process that is highly modifiable through small changes in behavior and other effective cognitive and lifestyle interventions. While sleep is not the totality of resilience, we contend that it is difficult, if not nearly impossible, to remain optimally resilient when sleep is deficient. Accordingly, we suggest that increasing the regularity, duration, and quality of sleep will help restore and sustain the physiological foundation for resilience, and we provide several practical suggestions for improving sleep. Psychological resilience will be key to the success of the recovery effort as the pandemic subsides, and such resilience is built firmly on the physiological foundation provided by sufficient restorative sleep each night.

Conflict of interest

The authors have nothing to declare.


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