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The Effects of Sleep Deprivation on Mental Health and Neurological Disorders

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THE EFFECTS OF SLEEP DEPRIVATION ON MENTAL
HEALTH AND NEUROLOGICAL DISORDERS

by

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ABSTRACT

Sleep deprivation is defined as an individual sleeping less than 6 hours per night. It is a common behavior amongst individuals who live in industrialized nations.¹ Along with industrialization, its prevalence is also expected to rise with age.² Despite this, there has been a shift in recent years with sleep deprivation increasing in the youth, likely related to the increased use of technology during the nighttime.³ Sleep deprivation and chronic sleep disruption are behaviors commonly observed amongst patients suffering from neurological and psychiatric disorders, like Alzheimer's disease, Parkinson's disease, depression, and anxiety. Many of these patients suffer from sleep disorders like insomnia, hypersomnia, and rapid eye movement sleep behavior disorder. It has long been thought that lack of sleep was caused by these disorders, yet there may be evidence to support a bidirectional relation between the two. We searched the literature to determine if there is a link between sleep disorders and sleep deprivation causing the exacerbation of these neurological and psychiatric disorders. Some studies support this hypothesis, for example, linking β -amyloid plaque buildup to lack of sleep, therefore increasing the risk of Alzheimer's disease among chronically sleep deprived individuals.⁴ In this presentation we will take a closer look into the possible reasons as to why poor sleep may negatively impact cognitive health.

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INTRODUCTION

Sleep deprivation and chronic sleep disruption are behaviors commonly observed amongst patients suffering from neurological and psychiatric disorders. Many of these patients suffer from sleep disorders like insomnia, hypersomnia, and rapid eye movement sleep behavior disorder. We theorize that there must be a root cause between neurodegenerative and psychiatric disorders that typically causes these issues to arise simultaneously. We also theorize that sleep disorders and sleep deprivation may be a prime contributor to the exacerbation of these neurological and psychiatric disorders.

This project will explore the existing literature using search engines like PubMed and entering keywords relevant to the project (like sleep deprivation, anxiety and depression, and Alzheimer's). Once all the information has been garnered, it will then be integrated and condensed in a manner that will allow us to propose a solution to the threat that sleep deprivation poses to our neurological and psychiatric health.

WHY IS SLEEP NECESSARY?

Sleep is a vital mechanism for many species on earth⁵. This loss of consciousness is accompanied by many physiological markers that indicate that the body is at rest and is undergoing any necessary repairs, development, and growth of tissues and cells^{5,6}.

There are two main stages undergone during sleep: synchronized, light, NREM sleep, and desynchronized, deep, REM sleep^{5,6}. The synchronized stage typically follows directly after an individual loses consciousness, and is maintained during the duration of the individual's sleep -- except for cyclical intervals in which REM sleep dominates for a period of 2-20 minutes⁶. Synchronized sleep is characterized by a loss in muscle tone, a slight reduction of blood pressure and heart rate, and slow, high-voltage encephalographic waves^{5,6}. The periods in which the desynchronized, REM sleep dominates, is a stark contrast to synchronized sleep. This stage is accompanied by rapid, low-voltage encephalographic waves, twitches of the limbs, trunk and head, rapid eye movement (REM), dreaming, and increased arousals^{5,6}. Cardiovascularly, there is a sharp drop in blood pressure and heart rate during REM sleep that is interspersed with acute and brief elevations in the aforementioned categories⁶. These phasic changes coincide with the cyclical bursts of motor excitation observed during REM sleep⁶.

WHAT CAUSES SLEEPINESS?

Human bodies are dominated by their circadian rhythms. This type of 'biological clock' helps regulate an individual's physiological functions to a schedule that is best suited for his environment^{7,8,9}. The physiological changes brought on by the circadian rhythm coincide with the visual cues from our surroundings, particularly light and dark (sunrise and sunset). In order for the circadian rhythm to synchronize itself according to its environment, it must first receive and process the visual cues that denote a change in the surroundings^{7,8,9}.

The Suprachiasmatic Nucleus (SCN) is the processing center that receives the visual cues leaving the optic pathway — directly from the retinohypothalamic (RHT) tract and indirectly from the geniculohypothalamic tract (GHT) — and processes them accordingly, resulting in the creation of a circadian rhythm that is tailored to an individual’s specific environment. The SCN is situated in the anterior hypothalamus directly above the optic chiasm^{7,8}.

Once the circadian rhythm has been established, the SCN sends efferent signals to commence the production of gamma aminobutyric acid (GABA) once the “internal clock” begins to approach nighttime^{7,8}. Once secreted, this neurotransmitter begins the descent into sleep by inhibiting axonal depolarization, therefore reducing overall arousal. As the individual’s arousal is diminishing, the SCN also sends signals to the pineal gland, indicating that it is time to go to sleep⁷. As the pineal gland receives this information, it begins producing melatonin, a hormone that induces drowsiness and eventually helps the individual remain asleep^{7,8,9}.

WHAT IS SLEEP DEPRIVATION?

Sleep deprivation is an issue that most of us will experience at some point in our lives¹. Sleep deprivation can be broken down into three main types: total sleep deprivation, chronic sleep restriction, and sleep fragmentation¹⁰. Total, also known as acute sleep deprivation occurs when an individual refrains from sleeping entirely.¹¹ Chronic sleep restriction occurs when an individual repeatedly does not meet the recommended 7-9 hours of continuous sleep for adults over a prolonged period of time^{11,12}. Sleep fragmentation, or sleep disruption, occurs when an individual’s sleep is interrupted, regardless of whether the individual collectively meets the

recommended amount; and tends to affect individuals suffering from sleep disorders like insomnia and sleep apnoea^{13,14,15}.

Although the three different types result in similar symptoms, the effects usually vary in severity depending on the extent of the deprivation instead of the type of disturbance¹³. The impact of sleep deprivation could also vary on an individual basis, considering the widely accepted belief that every individual has a unique sleep need that depends on factors that are out of the individual's control, like genetics¹³.

Unfortunately, as life's obligations become more demanding and a 24/7 hour schedule is adopted more and more worldwide, sleep deprivation seems to increase simultaneously with both age and industrialization¹.

WHAT ARE THE EFFECTS OF SLEEP DEPRIVATION AND WHY DO THEY OCCUR?

One of the widely known side effects of sleep deprivation is drowsiness. The more sleep deprived an individual becomes, the drowsier he will become as his body is demanding to be given what is necessary. Much like the direct relationship between hunger and not eating, as the body is continuously denied the vital time the rest, repair, and growth that sleep provides, the SCN continues to signal that it is time to sleep, in an effort to convince the body to succumb to sleep^{7,16}.

As drowsiness increases due to the elevated levels of GABA and melatonin being secreted, cognition, attention, and motor ability are impaired as a result. An individual's ability to focus on such tasks is heavily affected by the constant drowsiness that serves as a reminder that the body needs to sleep^{16,17}. This impairment can pose serious threats to an individual's safety, particularly when they affect tasks that require constant vigilance and attention, like driving.

In contrast, sleep deprivation not only poses the aforementioned short-term effects, but it can also alter an individual's physiology in the long run. Chronic sleep deprivation has been linked to altered endocrine function that cause changes in metabolic processes that may result in weight gain, obesity, and its related illnesses^{18,19}. Loss of sleep results in an increased secretion of ghrelin, which is a hormone that increases appetite, and a reduction of leptin, which is a hormone that signals satiety²⁰. Over time, the combination of these two endocrine changes makes the prospect of weight gain very likely. Another endocrine change that may contribute to the threat of the previously discussed hormonal changes is the observed decrease in glucose metabolism in sleep deprived individuals^{21,22,23}. This decrease may lead to the eventual development of insulin resistance, which can further complicate health through the development of type 2 diabetes, and the increase of adipocytes in the body. High levels of insulin and cortisol and low levels of human growth hormone and testosterone caused by sleep deprivation also work in tandem to increase adipose tissue in the body^{21,22,23}.

Another potential long-term effect of constant sleep deprivation is increased cardiovascular morbidity. Since the characteristic drop in blood pressure during sleep is absent during sleep deprivation, over time, an individual's blood pressure may become consistently higher during the

day, an issue that may propagate further cardiovascular ailments¹⁶. This increase in blood pressure and heart rate is likely due to an observed increase in sympathetic outflow and an increase in the amount of certain hormones -- like cortisol and norepinephrine -- amongst sleep deprived individuals¹⁶. The increased risk of obesity and weight-related issues previously discussed may also be a factor that further compromises a sleep-deprived individual's cardiovascular system.

There is a close relationship between the immune system and sleep. During infection, the production of inflammatory cytokines like interleukin-1 (IL-1) and tumor necrosis factor (TNF) contribute to the regulation of sleep in the body by increasing drowsiness, while the anti-inflammatory cytokines help inhibit sleep. IL-1, for example, helps regulate synchronized, NREM sleep²⁴. Altered secretion of IL-1 leads to fragmentation of synchronized sleep and a decrease in the presence of desynchronized sleep²⁴. It is thought that this alteration may be a way for the immune system to encourage fever during infection, which could be a vital tool in staving off the pathogen²⁴. Chronic sleep deprivation is linked to decreased immunological efficiency due to a decrease in anti-inflammatory cytokine production, certain peripheral leukocyte amount (particularly NK cells), and their efficiency, as well as an increased risk of inflammatory disease due to the increased amount of proinflammatory cytokines in circulation²⁵. Therefore, poor sleep patterns may lead to a compromised immune system, which in turn increases the threat of infection and its magnitude amongst sleep deprived individuals²⁵.

There seems to also be a strong association between lack of adequate sleep and an increase of inflammatory mediators in the body. Some of the previously discussed factors contribute to the

increase of such substances. The altered metabolic rate resulting in an increase of adipocytes plays a large role in this issue since adipocytes are known to produce the inflammatory cytokine interleukin-6 (IL-6)²³. An elevated presence of IL-6 is a predictor of potential cardiovascular disease, which may worsen the risk of said issue already posed by other factors of sleep deprivation. Excessive inflammation may also be influenced by the immunological changes induced by sleep deprivation. Although some peripheral leukocytes have been shown to decrease during the absence of sleep, others -- like monocytes, neutrophils, and phagocytic cells -- actually increase in amount²³. The increased presence of these particular leukocytes in peripheral circulation may also contribute to excessive inflammation because these cells also participate in the production of inflammatory cytokines and chemokines -- like the previously discussed IL-6²³.

There are many more ways in which the body responds to a lack of sleep, since the mechanism is such an integral contributor to overall health and proper physiological function. The focus of this paper is to look closer at the relation between sleep deprivation and psychiatric and neurological disorders. This paper will try to draw attention to the increased threat posed to the aforementioned areas caused by a lack of proper sleep, understand why they occur, and possibly theorize ways with which we can protect our mental health and cognitive function from this issue by exploring and integrating the scientific literature out there.

SLEEP DEPRIVATION AND NEUROLOGICAL DISORDERS

Sleep disturbances and lack of proper sleep has been widely observed amongst patients suffering from neurological diseases. Amongst the main disturbances documented are circadian sleep-wake rhythm disturbances, excessive nocturnal motor activity, rapid eye movement (REM) sleep behavior disorder (RBD), insomnia, and hypersomnia²⁶. RBD is characterized by absence of muscle atonia and intense motor activity related to the individual's dream state (oneirism) during REM sleep. Insomnia is characterized by a difficulty to initiate or remain asleep^{26,27}. Hypersomnia usually consists of excessive daytime sleepiness (EDS) and irresistible sleep attacks²⁶.

Although some of these disturbances may be linked to medication side effects, it is a possibility that the same neurological lesions that result in these neurological disorders are also resulting in the observed sleep disturbances²⁸. Despite the belief that sleep disorders and neuropathies may arise from the same mechanistic origin, there are other theories that believe that these neuropathies may arise as a cause of the sleep disturbances to begin with²⁸. Disregarding whether the sleep disturbances or neuropathy came first, these two issues seem to create a positive feedback loop⁴. As one issue worsens, it encourages the worsening of the other issue, which in turn worsens the original issue, therefore exacerbating both disorders simultaneously.

PARKINSON'S DISEASE

Parkinson's disease (PD) is the most common neurodegenerative movement disorder, with an estimated 500,000 patients in the US alone^{4,29}. PD is characterized by bradykinesia, resting tremor, postural instability, and cogwheel rigidity. It is thought to be a result of degeneration in the zona compacta of the substantia nigra and the depletion of dopaminergic neurons in this area, as well as the presence of Lewy Bodies in surviving neurons^{28,29}.

Patients with PD may experience various sleep disorders, typically including RBD, EDS, and insomnia^{28,30}. About 74-98 percent of patients suffering from PD indicate sleep disorders as the culprits of a decreased quality of life^{4,30}. The insomnia may arise from various factors, ranging from medication and excessive nocturia to the persistence of parkinsonian tremors during sleep (especially during NREM sleep)⁴. This difficulty with initiating and maintaining sleep may be the factor that leads to EDS amongst PD patients. Although it is not yet known why PD is typically accompanied by RBD, a correlation between the two has been widely documented. Various studies have come to the conclusion that RBD can be a manifestation of Parkinsonism that occurs many years before PD diagnosis²⁸.

ALZHEIMER'S DISEASE

Alzheimer's disease (AD) is thought to arise from the following: β -amyloid neuritic plaques, neurofibrillary tau protein tangles, amyloid angiopathy, and dystrophic cortical neuritis³¹. Disturbed sleep is observed in the early development of AD and is closely associated with the

disease as it progresses; with a positive correlation between sleep disorder severity and cognitive disfunction^{32,33}.

Sleep disruption in AD usually consists of disruption of circadian sleep-wake patterns, increase nighttime wakefulness, a reduction of REM sleep, and an increase in REM sleep latency, all of which worsen as the disease progresses²⁸. As these disruptions worsen, so does EDS and daytime somnolence. Despite engaging in daytime napping, this does not compensate for the lack of REM sleep, since the napping typically only consists of early stages of NREM sleep²⁸.

Some studies suggest that lack of proper sleep directly increases the level of β -amyloid plaques in the brain, and results in its chronic accumulation; while engaging in proper sleep results in opposite effects⁴. There also seems to be a relation between the amount of β -amyloid plaques present and sleep quality. Individuals with elevated levels of β -amyloid plaques tend to experience poor sleep and an increase in sleep disorder prevalence, an issue that can further increase the accumulation of β -amyloid⁴.

Another study has found that chronic sleep deprivation leads to an acute increase in tau protein accumulation in both mice and humans³⁴. Tau protein is thought to be responsible for the cortical atrophy and subsequent cognitive impairment in AD.

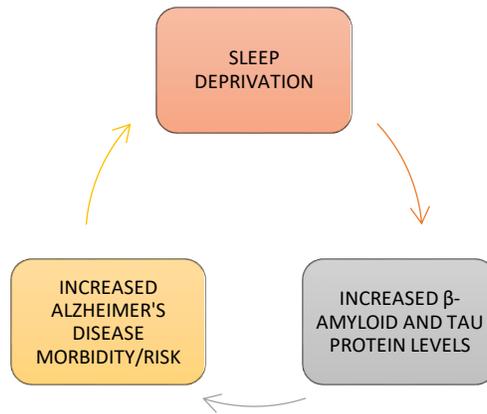


Figure 1: Displays the positive feedback loop formed between sleep deprivation and Alzheimer’s diseases.

DEMENTIA

Although there is no clear mechanism for sleep’s role in memory, there is a consensus that sleep plays a major role in memory consolidation³⁷. This role is further subdivided by the stages of sleep, NREM sleep aids in the consolidation of motor skills, while REM sleep aids in the consolidation of perceptual skills³⁷. Despite this consensus, the effect that sleep disorders have on an individual’s memory is an area of research that remains relatively untouched³⁷. The importance of proper sleep in effective memory consolidation raises the question: how is the memory of those with poor sleep affected, and can the effects of chronic sleep disruption brought on by these disorders encourage the onset of dementia at a later age?

Some studies have found that the patients with primary insomnia experiences a decrease in verbal and visual declarative information, those with narcolepsy experienced impaired visual procedural skills, and patients with obstructive sleep apnoea experienced impaired verbal declarative information³⁷. Although there is no research directly linking said disorders with the

exacerbation of dementia, sleep disorders are commonly observed amongst those suffering from dementia. As previously mentioned, both Parkinson's disease and Alzheimer's disease have been associated with certain sleep disorders like RBD and EDS, vascular dementia (VaD), dementia with Lewy bodies (DLB), and frontotemporal dementia (FTD) all also coincide with a prevalence of sleep disorders³⁸.

DLB is characterized by the presence of Lewy bodies in the brainstem nuclei (like PD), as well as the cerebral cortex and subcortical white matter³⁸. Lewy bodies are formed by the aggregation of α -synuclein, which makes DLB an alpha synucleinopathy. DLB is the second, most prevalent form of dementia (AD is the first), encompassing 25% of all cases³⁸. Similar to PD, 90% of individuals with DLB have some sort of sleep disturbance³⁸. These are mostly sleep movement disorders, EDS, and RBD. Also similarly to PD, RBD can be a marker for DLB many years before its onset. RBD is highly associated with cognitive decline in patients with PD and DLB, and as many as 50% of RBD patients have some sort of cognitive impairment³⁸. This relationship between RBD and cognition serves to suggest that proper sleep plays a role in healthy cognitive function, and its disruption can potentially lead to cognitive decline.

FTD encompasses a variety of diseases that are characterized by the atrophy of the frontal and/or temporal lobes of the cerebral cortex. Although there is not extensive research regarding sleep disorders and FTD, increased nocturnal activity, decreased morning activity, and EDS have been documented amongst FTD patients³⁸.

VaD is a type of vascular cognitive disorder that is characterized by the loss of cognitive function due to injury caused by cerebrovascular disease (thrombosis, ischemia, embolism)³⁸. Although VaD is directly caused by cerebrovascular disease, poor sleep patterns can exacerbate the conditions that lead to cerebrovascular disease, like hypertension, obesity, and cardiovascular disease (**Figure 2**)^{38,39}. Therefore, sleep disorders can be potential predictors of VaD, and taking preventative measures regarding sleep disorders could help reduce the risk of VaD by lowering the risk for cerebrovascular disease.

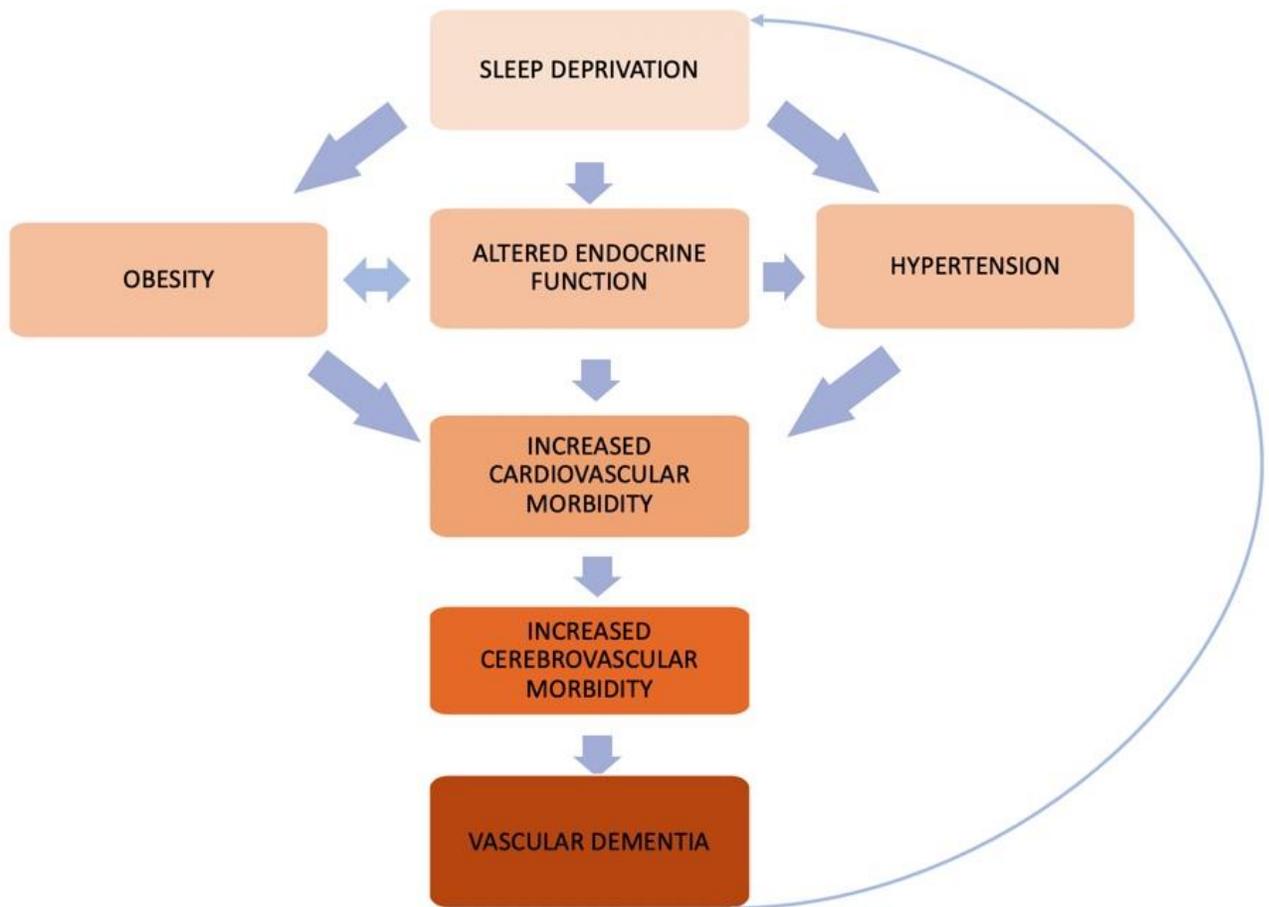


Figure 2: Displays the complex network through which sleep deprivation could lead to an increased risk for vascular dementia.

PROGRESSIVE SUPRANUCLEAR PALSY

Progressive supranuclear palsy (PSP) is a neurodegenerative disease characterized by supranuclear extraocular movement abnormality (especially early downward gaze impairment), dystonia, pseudobulbar palsy, gait disturbances and akinetic rigidity²⁸. PSP pathology typically consists of gliosis and neuronal loss with neurofibrillary tangles present in subcortical nuclei, and a relatively unharmed cerebral cortex.

Sleep disturbances have been observed to be present in almost all cases of PSP, and typically consist of severe insomnia (more so than that observed in PD and AD) with a lack of the ability to initiate sleep as well as maintain it^{28,35}. The severity of the insomnia is believed to increase with the severity of the motor impairment in those suffering from PSP^{28,35}.

EPILEPSY

Although the term “epilepsy” encompasses a wide variety of conditions, they are all generally characterized by the periodic onset of epileptic seizures. Epileptic seizures can be defined clinically as abnormal neuronal hyperactivity within the grey matter of the cerebral cortex⁴⁰. There are approximately 50 million people affected by epileptic seizures worldwide⁴¹.

Interestingly, it has been well documented that there is a higher risk for the manifestation of an epileptic episode during sleep, or directly after waking in comparison to other times of the day⁴².

Therefore, during the attempted diagnosis of suspected epilepsy within a patient via electroencephalography (EEG), sleep deprivation has been successfully employed in the provocation of seizures when they have failed to manifest during normal wakefulness⁴². Epilepsy and sleep disorders are so entwined, that their comorbidity has often led to epilepsy being misdiagnosed as sleep disorders⁴². The idea of this comorbidity is also supported by studies that show that effective control of epileptic seizures correlates with a decrease in the prevalence of sleep disorders associated with chronic epilepsy⁴³.

Individuals diagnosed with epilepsy are also frequently diagnosed with obstructive sleep apnoea⁴⁴. Obstructive sleep apnoea (OSA) is characterized by a cessation of air flow for more than 10 seconds during sleep, which occurs five or more times per hour⁴⁵. This condition is more commonly observed during REM sleep, which is attributed to the upper airway muscle hypotonia that occurs during this stage of sleep⁴⁵. Some studies show that continuous positive airway treatment of OSA lead to diminished epileptic episodes and improved cognitive abilities⁴¹. These results serve to suggest that poor sleep quality experienced with OSA helps exacerbate epilepsy and cognitive impairment (**Figure 3**). Also, other studies have shown that 12% of elderly epilepsy patients have been found to suffer from RBD⁴¹.

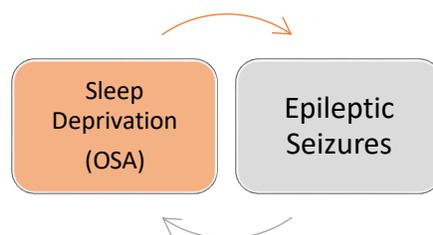


Figure 3: Displays the relationship between sleep deprivation, like Obstructive Sleep Apnoea, and epilepsy. As the deprivation worsens, so do the seizures, and vice versa.

SLEEP DEPRIVATION AND PSYCHIATRIC DISORDERS

Similar to the observed correlation between sleep deprivation and neurological disorders, there also appears to be a relationship between sleep disorders and the increase risk of psychiatric disorders. One study showed that 40% of patients with insomnia and 46.5% of patients with hypersomnia met the criteria for mental illness⁴⁶. Although there appears to be conflicting evidence regarding depression, the works referenced below show that as an individual's sleep quality declines, he is more likely to develop certain mental health disorders like anxiety, schizophrenia, and paranoia.

ANXIETY AND DEPRESSION

Anxiety and depression are mental health disorders that although different, typically accompany one another. Anxiety is usually characterized by heightened fear and stress towards a particular stimulus or stimuli that interfere with an individual's normal daily function. The anxious response to the stimulus may range from mild to very severe, and from (outwardly perceived) irrational to a rational fear instilled by previous trauma⁴⁷. Depression typically consists of a negative mood state, feelings of lethargy, and loss of interest. Similar to anxiety, depressive episodes may range from mild to major, and may result in changes in daily behavior like loss of appetite and self-esteem.

There appears to be a correlation between individuals suffering from major anxiety and depressive disorders and an increase in sleep disruption, sleep latency, trouble remaining asleep, and increased time awake^{48,49}. Many studies show a correlation between increased sleep deprivation and increased negative mood states and perceived feelings of anxiety^{50,51}. When sleep deprived, adolescents perceived their main worries to be more threatening, relative to when rested⁵⁰. In one study, most psychologically and physically healthy subjects reported increased perceived feelings of anxiety, depression, general distress and a negative mood state following acute sleep deprivation⁵². Alarming, a meta-analysis on sleep disturbances and suicidal thoughts and behaviors found a significant association between sleep disturbance and increased relative risk for suicidal ideation, suicide attempt, and suicide⁵³. Another factor that could link sleep deprivation to an increased risk for depression is the fact that low testosterone has been hypothesized to cause depression among men, and as mentioned previously, sleep deprivation may lead to decreased levels of testosterone.

Interestingly, sleep deprivation, and sleep-wake cycle disturbance has been a common treatment for depressed mood for the last 30 years and has a recorded 60% effectiveness in most subgroups of affective disorders^{54,55}. Although the reason as to why sleep deprivation improves depressive mood has not reached a consensus, a possible theory as to why it is effective states that the sleepiness induced purposefully though sleepiness may help counter the states of hyperarousal commonly observed during depressive episodes⁵⁵.

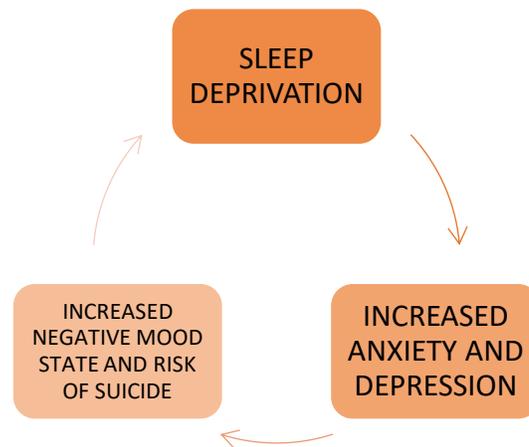


Figure 4: Displays the positive feedback loop observed between sleep deprivation and anxiety and depression.

BIPOLAR DISORDER

Bipolar disorder is a mood disorder that is characterized by the fluctuation of manic and depressive episodes. The episodes can range in severity, from mild depression and hypomania, to severe depression and mania that can be accompanied by psychotic episodes⁵⁶. Mania is described as hyperactive, extremely optimistic mood that can result in impaired judgments⁵⁶. Hypomania is described as mild manic episodes that pose no danger to the patient or others and generally lack any form of psychosis. There are two main types of bipolar disorder: bipolar I disorder and bipolar II disorder. Bipolar I disorder is characterized by severe episodes of mania and depression that severely threaten the patient’s safety and quality of life, whilst bipolar II disorder is characterized by minor depressive episodes and hypomania⁵⁶. Despite the differences between the two different types, they both exhibit some sort of sleep disturbances.

During manic episodes, the majority of patients exhibit a decreased need for sleep, whilst during depressive episodes, hypersomnia and insomnia were observed to varying degrees⁵⁷. Although

sleep disruptions are also observed in between episodes, there is an increase in sleep disruption directly preceding and during the manic-depressive episodes⁵⁷. One study showed that manic episode proceeded the day after a night of decreased sleep, while a shift towards a depressive episode was observed the day following a period of increased sleep duration⁵⁷. There is evidence to suggest that sleep deprivation may be an effective mode of inducing manic and hypomanic episodes in bipolar disorder patients⁵⁷. This evidence serves to suggest that sleep disruption may have a direct role in exacerbating the severity and onset of manic-depressive episodes of bipolar disorder.

SCHIZOPHRENIA

Schizophrenia is a type of severe psychotic disorder that is characterized by cognitive impairment, delusions, hallucinations, and thought disorder. Although there is no wide consensus in regard to the etiology of schizophrenia to date, the disease is thought to be caused by some sort of hereditary, genetic disorder⁵⁸. This is likely due to the fact that schizophrenia is a heterogeneous disorder and cannot likely be attributed to one, sole reason, but rather to a combination of multiple factors. Some hypotheses theorize that schizophrenia may stem from over secretion of dopamine and hyperstimulation of dopamine 2 receptors, while others theorize that schizophrenia is caused by N-methyl-D-receptor hypofunction due to diminished glutamine and gamma-aminobutyric acid (GABA)^{59,60}.

Sleep disturbances are a common occurrence amongst those suffering from schizophrenia and are experienced by 80% of patients⁶¹. One study demonstrated that poor sleep resulted in lower

glutamate levels and increased psychotic symptoms in schizophrenic patients⁶¹. Therefore, this study supports the idea that poor sleep may play a role in the exacerbation of the psychopathology of schizophrenia, as well as reinforce the hypothesis that decreased glutamate levels may be a cause of schizophrenia, since the diminished glutamate levels caused by poor sleep resulted in increased psychosis amongst patients. Schizophrenia is also affected by bouts of depression and suicide attempts, and paranoid thoughts. As mentioned before, sleep disruption can have a negative impact on mental health and increase the likelihood of suicide attempt which can worsen the mental state of schizophrenic patients. Also, there are studies that show a comorbidity between insomnia and paranoia⁶². As the subjects became more sleep deprived due to insomnia, their paranoia grew, which then increased their likelihood of having insomnia. Also, subjects experienced an increase in cognitive disorganization and hallucinations along with insomnia⁶². These studies also serve to show that poor sleep can have a negative impact on schizophrenic patients, as seen below in **Figure 5**.

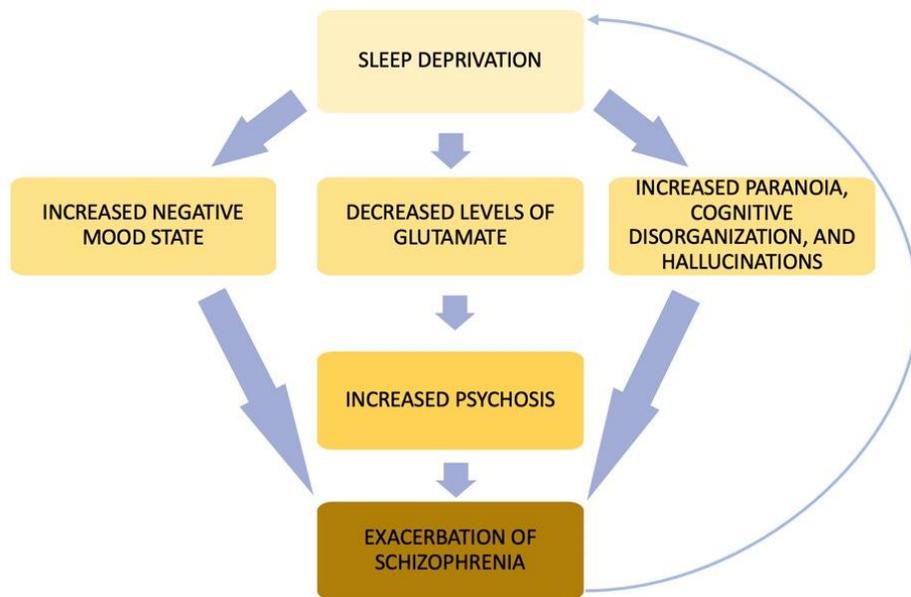


Figure 5: Displays the paths through which sleep deprivation can lead to the exacerbation of schizophrenia.

POST-TRAUMATIC STRESS DISORDER

Post-traumatic stress disorder (PTSD) has high rates of comorbidity with other psychiatric disorders⁶³. Amongst these are panic disorder, major depressive disorder, and anxiety. PTSD symptoms consist of intense feelings fear, terror, helplessness following a traumatic event in the patient's life⁶⁴. Many studies show that there is a prevalence of sleep disorders among PTSD patients, with one analysis stating the 70% of subjects with PTSD experienced poor sleep quality, while another states that 44% of Vietnam War combat veterans experienced a difficulty initiating and maintaining sleep⁶³. PTSD patients hold higher rates of insomnia, nightmares, and startle responses, even when the psychiatric comorbidities are confounded for. The relation between PTSD and sleep disorders, along with the similar relation that PTSD's comorbidities have with sleep disorders paint a worrying picture a positive feedback loop, where both states aid in the worsening of the other (**Figure 6**).

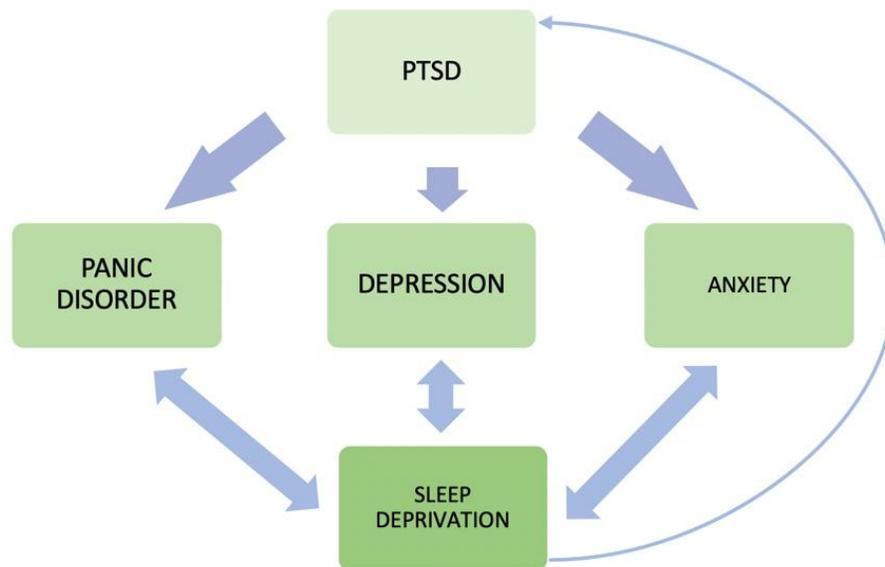


Figure 6: Displays the path through which PTSD and its comorbidity with panic disorder, depression, and anxiety can worsen sleep deprivation and vice versa.

DISCUSSION

Sleep deprivation poses a clear threat to public health, and unfortunately is an issue that seems to be growing in magnitude as the world becomes more industrialized⁵. Although lack of proper sleep affects almost all aspects of human physiology, the effects it has on neurodegenerative and psychiatric diseases may be one of the most worrisome.

As life expectancy increases worldwide, so does the prevalence of neurodegenerative disorders. Diseases like Parkinson's and Alzheimer's and other types of dementia are issues that arose in the 20th century as more and more people began living past the age of 70⁶⁵. Much like the observed increased risk of neurodegenerative diseases among the elderly, sleep disruption and sleep deprivation have also been documented to increase with age. Sleep deprivation has been shown to have a direct relationship in the exacerbation of said neurodegenerative diseases. This link is so significant that certain sleep disorders, like RBD can be valuable predictors of diseases like PD and DLB many years before their manifestation. Epilepsy and PSP also show a strong relationship with sleep disorders, with the vast majority of patients also suffering from said disorders.

Along with the alarming relationship between poor sleep health and neurological diseases comes the alarm of a similar link observed in psychiatric disorders. This similarity is to be expected, considering the role that the nervous system plays in both neurological and psychiatric disorders. Many of these diseases unfortunately share comorbid relationships and exacerbate one another.

For example, many patients undergoing severe cognitive and neurological damage experience feelings of anxiety and depression. This is an unfortunate fact, especially when the role of sleep disruption is taken into account. We now know that sleep deprivation is a common symptom of neurological disorders like dementia, and we also know that poor sleep can increase negative thoughts and negatively impact mental health, which can therefore amplify the depressive and anxious thoughts that often accompany these disorders. We also have to take into account the comorbidity amongst psychiatric disorders. For example, the majority of PTSD patients also experience mood disorders like depression and panic disorder. Similar to the aforementioned analysis on the link between dementia, sleep disruption, and impaired mental health, the comorbidity observed between psychiatric disorders – which themselves have links to increased sleep disruption – clarifies an unfortunate truth that raises the gravity of this topic: The effects of sleep disorder on mental and neurological health, and neurological and mental disorders on sleep health create a positive feedback loop that only serve to worsen one another and ultimately damage the patient's overall health.

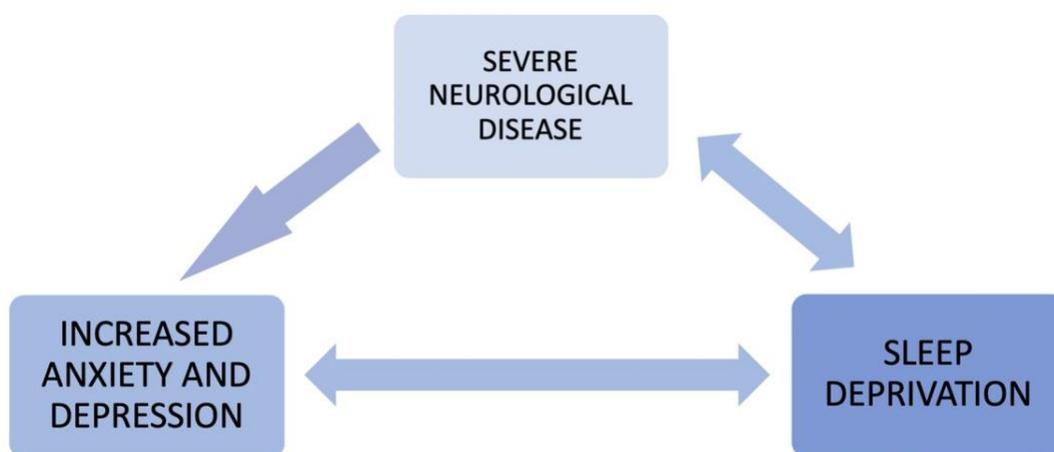


Figure 7: Displays the link through which sleep deprivation leads to the exacerbation of neurological and psychiatric disorders, and how these disorders can increase sleep deprivation, therefore creating a positive feedback loop.

The drastic change to our social structure the past decades, along with the relation between social media use and increased depression amongst younger populations is a major cause for concern⁶⁶. Humans are not prioritizing sleep in our technology-driven society, a choice that will unfortunately result in decreased global health, not confined to just neurological and psychiatric disorders. Poor sleep has been shown to negatively impact endocrine function, cardiovascular health, and immune health. Now, more than ever, we should focus on the relationship between proper sleep and these diseases in efforts to minimize their prevalence in our global health.

Practicing proper sleep hygiene should be a topic that is taught and given priority in society, much like the importance of proper nutrition and exercise. Further research should look into the actual mechanisms through which sleep deprivation exacerbates the disorders explored in this paper. Once the mechanisms are well understood, then we can possibly propose a solution to target these positive feedback loops accordingly. Ultimately, the best solution would be to apply proper sleep hygiene habits that diminish sleep disruption related effects.

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