Balancing Sleep, Work and Well-being during Lockdown: Exploring the Relationships between Working Women's Mood and Sleep Status during New Zealand's COVID-19 Lockdown

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Abstract

Background: Sleep is important for good physical and mental health and the pandemic lockdown created a unique situation that impacted psychological and social drivers for sleeping well. The purpose of this study was to examine how the COVID-19 lockdown affected sleep, mood and loneliness in working women in New Zealand (NZ). The main hypothesis was that indicators of poorer mood and increased loneliness during the confinement would predict poorer subjective sleep quality.

Methods: A sample of 498 female workers, aged 21-83 (N = 498) completed questionnaires pertaining to demographic data, and including the Pittsburgh Sleep Index Questionnaire (PSQI), Hospital Anxiety and Depression Scales (HADS) and de Jong Gierveld Loneliness scale - 6 item (GLS-6) during the first lockdown in NZ, April 2020. The hypothesis was tested in two steps: a confirmatory factor analysis was used to test how the key measures performed in this unique COVID-19 lockdown situation and on this population. Secondly, a full structural model was run to test the predictive relationship between mood and loneliness on subjective sleep quality.

Results: Using standardised cut offs within the scales, 54.8% of the NZ working women were identified as 'poor sleepers', 42.4% were borderline or at risk for anxiety and 31% for depression. Furthermore, 47.3% reported overall loneliness with 52.7% reporting being socially lonely and 89.3% emotionally lonely. Anxiety and depression were significantly predictive (p< 0.001) of subjective sleep quality (b = .49 and .39 respectively), however social and emotional loneliness were not. The fit of the predictive model provided a good overall fit given its complexity however, CFA results indicated the key measures did not perform well in a pandemic context compared to previous research in a non-pandemic context.

Conclusion: Pandemic-related lockdown restrictions contributed to poor mood, subjective sleep quality, and elevated loneliness in NZ working women. It found that mood was predictive of poor sleep quality but loneliness was not. This is a unique insight into psycho-social impacts on sleep and well-being in NZ working women during a rigorous COVID-19 lockdown whilst the infection rates remained low. These findings may help promote practices that support well-being and subsequent sleep health for working women, both in day-to-day life as well in general crises situation.

Keywords: COVID-19 lockdown, sleep, mood, anxiety, depression, loneliness, woman, worker, Zealand, SEM analysis, confirmatory factor analysis

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List of Abbreviations

CFA	Confirmatory Factor Analysis
CFI	Comparative Fit Index
GLS-6	de Jong Gierveld Loneliness Scale 6-item
HADS	Hospital Anxiety and Depression Scale
NREM	Non-Rapid Eye Movement
NZ	New Zealand
PSG	Polysomnography
PSQI	Pittsburgh Sleep Quality Index
REM	Rapid Eye Movement
RMSEA	Root Mean Square Error of Approximation,
SEM	Structural Equation Model
TLI	Tucker Lewis Index

Introduction

On March 11, 2020 the World Health Organisation characterised COVID-19 as a pandemic (World Health Organisation, 2020). The restrictions that followed abruptly changed daily life for people worldwide. Mandatory lockdowns and social distancing measures were adopted by public health authorities as an epidemiological containment strategy. Existing literature suggests that the stress associated with the COVID-19 lockdowns significantly affected sleep quality, mood and loneliness on a global scale (Jahrami et al., 2022; Pai & Vella, 2021; Rezaei & Grandner, 2021; Wu et al., 2021). Research indicates that the lockdowns and the subsequent disruptions to social and personal routines had differential impacts on gender and work status (Farré et al., 2022). Women were more likely to have taken on the task of home-schooling and full-time care for children who would otherwise have been in school and those not able to work from home had workplace COVID-regulations to navigate through. Geographical location and areas with higher population density were less able to prevent the transmission of COVID-19 through mitigation practices, and therefore leading to higher infection rates. This was linked to a higher prevalence of mood and sleep-related problems and may reflect the stress associated with becoming infected (Casagrande et al., 2020; Jahrami et al., 2022). New Zealand (NZ) enforced some of the most rigorous lockdown restrictions despite the disease outbreak remaining low. This made it a unique case-study to examine the psycho-social impact of the COVID-19 lockdown, since there was little risk of infection for the majority of the population.

This study examined the impact of COVID-19 lockdowns on sleep, mood and loneliness on working women in NZ and the relationship between these variables. The aims were; to provide insight into how social and physical restrictions impacted sleep and well-being in working females in NZ; to assess whether mood and loneliness predicted subjective sleep quality; to assess how the performance of the well-used scales of sleep quality, mood and

loneliness performed in a pandemic context. The study contributes to the growing body of research informing the type and timing of health-related needs and interventions beyond a pandemic context to increase the sleep and mental health status of NZ women.

The present study used a latent dataset from the 'Sleep and Well-being during COVID-19 Pandemic Restrictions Survey', which was conducted during the first nationwide lockdown in April and May, 2020 (Gibson et al., 2020). In order to examine the main research question, the thesis is organised into four main chapters: Literature review, methods, results and discussion. The literature review comprises of four subsections: Firstly, the literature review will focus on what sleep is, how it is defined, and measured. This will provide a contextual framework to help understand how a unique situation like the pandemic may have impacted various sleep parameters. Secondly, it will investigate the psychological and social factors associated with sleep and introduce the Social-Ecological Model of Sleep Health (Grandner, 2019). Thirdly, it will look at the COVID-19 pandemic context and critically evaluate how sleep, mood and loneliness were impacted during the pandemic and subsequent lockdowns across the world. The final section will summarise the aims of the study with a description of the research question, hypothesis, outline how the research question will be answered and what determines whether the prediction is supported.

Literature Review

Literature Search Strategy

All articles, specifically around the COVID-19 literature, available online on 26-04-2022 were reviewed using the following search strategy: Covid* OR coronavirus OR sars-cov-2 AND "lock down" OR lockdown OR isolat* OR quarantine*AND mood* OR anxiet* OR depress* AND sleep* AND loneliness*. The results were from MEDLINE, PsycINFO, CINAHL, Scopus and Web of Science. The base search had 1457 results, which were reduced to 964 with duplicates removed. Date range was 2020 to 2022. This was then qualified with a range of other keywords: loneliness, women, work, employee, structural equation modeling (SEM), confirmatory factor analysis (CFA), PSQI, Zealand. 224 articles were chosen for this study because of their relevance, robust methods and the quality of the research.

The Conceptualisation of Sleep and Sleep Health

Sleep is a fascinating and complex phenomenon that is a foundation for overall physical and mental health. Sleep supports every single system in the body including metabolic, immune, cognitive function and emotional regulation. In order to examine the relationship between sleep, mood and loneliness during the COVID-19 pandemic and associated lockdown, it is important to understand what sleep is, how it is conceptualised, defined and measured.

Definitions of Sleep and Sleep Health

The definition and conceptualisation of sleep is dependent upon the context from which it is viewed. For example, the medical definition emphasises physiological and

neurobehavioral aspects of sleep stating: "Sleep is a recurring, reversible neurobehavioral stage of relative perceptual disengagement from and unresponsiveness to the environment. Sleep is typically accompanied (but not necessarily) by postural recumbence, behavioural quiescence, and closed eyes" (Carskadon & Dement, 2011, p. 16). The medical model often has a focus on sleep deficiency such as sleep disorders, sleep dysfunction and treatment. This is opposed to sleep health, which is conceptualised as a positive frame of reference of functioning and adaptation. Buysse (2014) defined sleep health as "a multidimensional pattern of sleep-wakefulness, adapted to individual, social, and environmental demands, that promotes physical and mental well-being. Good sleep health is characterised by subjective satisfaction, appropriate timing, adequate duration, high efficiency, and sustained alertness during waking hours" (p. 12). It emphasises sleep health as the dynamic interaction between involuntary biological processes and voluntary behavioural decisions. This highlights both the complexity of sleep and the difficulties faced in addressing different aspects of sleep-related health.

Sleep Conceptualised as a Physiological Process

The physical state of sleep can be characterised as a circadian state with a period of reduced activity, partial or full suspension of consciousness, a decreased responsiveness to external stimuli and relative muscle inhibition (Fuller et al., 2006). However, neurophysiologically, sleep has been found to be a dynamic state of brain activity that regulates sleep quality and quantity and permits development, growth and maintenance on a whole-body level (Carskadon & Dement, 2011). Brain activity during sleep can be visualised using polysomnography (PSG). PSG is an objective measure of sleep which measures brainwaves (electroencephalography) and other physiological parameters such as eye movement (electrooculogram), respiration, heartrate, blood oxygen levels and muscle activity

(electromyography). It enables differentiation and identification of the stages and characteristic features of sleep, termed sleep architecture.

Using PSG, studies have shown sleep is an active process that can be divided into five stages and two distinct states, rapid eye movement (REM) and non-rapid eye movement (NREM) sleep, that cycle throughout the night in 90-minute blocks (Carskadon & Dement, 2011). NREM encompasses four stages of sleep (1- 4) which vary in the amplitude and frequency of brainwave activity, and determines the depth of sleep and threshold of arousal. Stages 1 and 2 are lighter stages of sleep that occur early in the night and have low amplitude and higher frequency brainwaves. Stages 3 and 4 are deeper stages of sleep consisting of low frequency and higher amplitude of delta waves. The salient features of REM sleep include the rapid eye movement that is usually associated with dreaming, and the skeletal muscle inhibition that prevents the body from 'acting out' dreams. REM sleep is considered important for memory consolidation and emotional regulation processes (Desseilles et al., 2011).

The ratio of NREM to REM sleep changes within each cycle. The majority of NREM stages 3 and 4 sleep is attained in the early part of the night whereas REM sleep predominates in the latter hours of sleep. Using a PSG shows that the frequency of the brain waves has a different composition in the different stages. NREM 3 and 4 are the deepest sleep stages where NREM 3 is characterised by delta oscillations and low frequency (0.5- 4 HZ), termed slow-wave sleep (Walker & van der Helm, 2009). These brain waves are generated by high-voltage synchronisation of cortical brain activity which is essential for glymphatic clearance of metabolites. Through the different stages of sleep, the brain undergoes significant alterations in neurochemistry and neural processes that supports various brain and bodily functions (Saper et al., 2001). Studies show that slow-wave sleep appears to have a

significant role in learning, memory, energy conservation, hormone release, immunity and clearance of metabolites (Léger et al., 2018).

The Two-Process Model of Sleep-Wake Regulation

To help conceptualise the regulation of sleep / wake timing, initiation and the maintenance of sleep, Borbély and Achermann (1999) proposed a two-process model. It posits that sleep is driven by two mechanisms; the homeostatic sleep drive (Process S) and the circadian wake drive (Process C). Normal sleep and wakening are regulated through the interaction of these two processes, creating a consistent rhythm that determines when and how much people sleep (Czeisler & Buxton, 2017). Most adults require seven to nine hours sleep per night to function optimally however, this varies with age and genotype.

Process S represents the biological need for sleep. It is lowest in the morning after awakening and increases during the day (Borbély et al., 2016). Sleep onset latency indicates the degrees of sleep debt, where the shorter the sleep onset latency, the greater the debt and larger sleep pressure. Furthermore, the amount and depth of slow-wave sleep is considered another physiological marker of greater sleep pressure. The less slow-wave sleep attained the greater the drive to sleep the following day. Physiologically, sleep drive is linked to the accumulation of the neurotransmitter adenosine which increases during the hours of wakefulness and is associated with the duration and depth of SWS (Basheer et al., 2004). For example, adenosine is a key inhibitory neurotransmitter that is linked to enabling sleep onset and suppressing arousal. Sleep drive is an automatic process, however certain behaviours can promote or inhibit it. Caffeine is an adenosine receptor antagonist which reduces the ability of adenosine to bind its receptor. Subsequently, it reduces the sleep pressure and depth of slow-wave sleep impacting on the sleep drive (Urry & Landolt, 2015). A larger intake and if consumed later in the day will have a greater impact on the reduction of the sleep drive. This

highlights the importance of allowing enough time to rebuild a sufficient sleep drive after consumption of caffeine. Conversely, physical activity promotes sleep drive due to the increased need for physical restoration. Research shows that exercise increases slow-wave sleep (i.e., deeper sleep) and enables faster sleep onset latency compared to sleep without prior exercise (Driver & Taylor, 2000).

The other main driver of the sleep /wake cycle is the circadian rhythm, Process C, which regulates most physiological, biochemical and neurobehavioral processes in the body. This includes blood pressure, temperature, appetite and sleep-wake timing (Fuller et al., 2006). The circadian rhythm is an internal biological clock that operates at a molecular-level throughout the body's tissues and cells and repeats in approximately 24-hour cycles. It is primarily driven by the day/night cycle along with other environmental cues and behaviours, termed zeitgebers. Two of the key biological markers of Process C are the core body temperature and melatonin production. Core temperature is lowest at night, and increases during the day whilst melatonin rises in early evening with decreasing daylight.

In humans, the circadian clock is located in the suprachiasmatic nuclei in the hypothalamus and appears to consist of two groups of neurons; those that have an internal 'pacemaker' that generate core circadian signals which are sent to the rest of the body and others that are influenced by external environmental stimuli which can reset the rhythms (Fuller et al., 2006). As the suprachiasmatic nuclei is a unique neural pathway directly from the retina, it synchronises the body's cellular clocks with the diurnal light schedule set by the earth's rotation. This process is called 'entrainment'. Jetlag is a unique example of misalignment between the internal clock and the new destination's light cues. Daylight is the principal external cue used by the suprachiasmatic nuclei to regulate circadian rhythms and has significant impact on sleep onset latency, sleep maintenance and sleep quality (Golombek & Rosenstein, 2010). However, studies have shown that other time cues such exercise, food

intake and social interactions also have a significant impact on circadian sleep-wake regulation (Lewis et al., 2018; Mistlberger & Skene, 2004; Quante et al., 2019). For example, randomised controlled trials show exercise, particularly in the morning, has a positive effect on sleep quality, duration, efficiency and sleep onset latency (Banno et al., 2018; Hartescu et al., 2015).

As seen in the sleep drive, the circadian sleep-wake rhythm is an automatic process but certain behaviours can promote or inhibit it. If one is attempting to sleep at times that are not compatible to the individual's circadian clock, there is a misalignment between the internal biological clock and the earth or social 'clock'. This conflict between an individual's natural sleep time and the social demand of their schedule is termed 'social jetlag' and associated with adverse endocrine, behavioural and cardiovascular risk profiles (Rutters et al., 2014). The inclination for sleeping at certain times within a 24-hour period is referred to as chronotype and is closely linked to individual's circadian rhythms (Roenneberg et al., 2007). The two chronotypes are described as a 'morningness' chronotype; a preference for earlier bedtime and wake-up, and the 'eveningness' chronotype; a natural inclination towards later bedtimes and difficulty waking in the morning. Chronotype has strong a genetic component where a longer allele of the Per3 circadian clock gene is significantly correlated to morningness and a shorter allele with eveningness (Archer et al., 2003). Sleep timing and preferences are also driven by social factors like work schedules and preferences. The social-ecological aspects of sleep will be discussed later in this chapter.

In summary, the sleep drive (Process S) and the circadian rhythm (Process C) are individual physiological processes that regulate sleep-wake timing and their interaction affects the onset, duration and quality of sleep. The propensity for sleep is therefore governed by the balance between the degree of sleep pressure and regulation of the circadian clock governed by time cues. Strong sleep drive coupled with appropriate time cues, such as

reduced light and activity, promotes the initiation and maintenance of sleep. Conversely, a weak sleep drive and misaligned time cues, such as artificial light and increased activity, may disrupt the process of sleep initiation. The two-process model provides a physiological explanation for these two involuntary biological drives however, it also highlights the dynamic interaction with voluntary behavioural decisions as determinants of good sleep health. To summarise, while the biological processes rely on the regulation of a number of factors, these factors are in turn informed by the routines of society. The social processes and how these factors were jeopardised due to pandemic lockdown restrictions, will be discussed later in this chapter.

Theories of the Function of Sleep

There are multiple theories about the function of sleep however, a unified theory remains elusive. From an evolutionary perspective, sleep appears contrary by reducing the responsiveness to potential danger and threatening survival. While asleep, it reduces the ability to gather food, reproduce, socialise and nurture off-spring and therefore indicating there must be significant benefits to sleep that outweigh the drawbacks. As all animals sleep, there is a strong argument that sleep has an adaptive role to increase the overall fitness of the animal. For example, Siegel (2009) argued this is achieved by suppressing activity during times with maximal predator risk and by permitting activity at times with optimal food and prey availability and minimal predator risk. Thus, the function of sleep is proposed to be energy conservation as well as reduction of risk of predation and injury. However, these benefits could in theory also be derived solely from inactivity as opposed to sleep.

The information processing theories propose that information learned during the day is organised and secured during sleep, where memory consolidation is particularly strong. This is supported by studies that show that NREM and REM sleep are required for neuroplasticity

and forming new neural connections for memory consolidation (Kreutzmann et al., 2015; Mednick et al., 2003; Rasch & Born, 2013). The functional impact of sleep on neurocognitive processes also includes emotional information processing. The emotional-processing theories suggest that REM sleep provides a unique biological milieu for modulation and alteration of recent emotional conflict, which reduces negative mood the following day. For example, Walker and van der Helm (2009) proposed a model of how REM sleep modulates affective neural systems and the (re)processing of new emotional experiences. It suggested that the autonomic charge, which is acquired at the time of learning (i.e., the emotion), is recalibrated in the limbic and associated autonomic networks. This allows humans to navigate social and psychological challenges and negate a long-term state of anxiety (Walker and van der Helm, 2009).

Glymphatic clearance of neurotoxins is one of the stronger theories on why we sleep. Like the lymphatic systems play a central role in fluid clearance, immune response and removal of excess waste for degradation in the liver, the brain uses cerebrospinal fluid and interstitial fluid exchange to clear neurotoxins (Anzai & Minoshima, 2021). This fluid exchange is called the glymphatic system and in addition to removing neurotoxins like amyloid-beta and tau proteins, it is also responsible for distributing nutrients such as glucose, amino acids, lipids and neuromodulators (Anzai & Minoshima, 2021). Tau and β-amyloid are toxic proteins that aggregate and form plaques and neurofibrillary tangles in the brain which are heavily associated with Alzheimer's disease (Rasmussen et al., 2018). Research shows that sleep is responsible for the majority of this vital brain-cleaning process (Reddy & van der Werf, 2020). This is opposed to during wakefulness, where the glymphatic system remains mainly disengaged. For example, studies show that the during slow wave sleep, the glymphatic system clears up to 40 percent of the β-amyloid accumulation and 36 hours of sleep deprivation increased β-amyloid levels by 30 percent (Lucey et al., 2018; Xie et al.,

2013). The biological requirement for sleep may therefore reflect a vital need to support the capacity for clearance of neurotoxins and optimal cognitive functioning. This is supported by research that shows that lack of sleep negatively affects cognitive function and productivity (Lucey et al., 2018).

Although there is no unified theory about a single function and the reason for sleep, it is well known that prolonged sleep disturbances have been linked to adverse outcomes in physical and mental health. Studies have found that insufficient or poor sleep plays a causal role in leading causes of death, e.g., stroke, heart disease, accidents and is strongly associated with other negative health outcomes such as anxiety, depression, cognitive deficits and obesity (Itani et al., 2017; Taylor et al., 2003). This highlights that sleep is a multifaceted and complex phenomenon with multiple functions to maintain and enhance our brains and bodies.

How Sleep is Measured

As sleep involves a range of biological, behavioural and psychological elements, it cannot be captured in one single measurement. As discussed earlier, PSG is an objective measure of sleep which measures brainwaves and other physiological parameters. It is considered the 'gold standard' objective measure of physiological changes associated with sleep onset and progression through each stage of the sleep architecture (Rundo & Downey, 2019). PSG usually takes place in a sleep laboratory and the information can help assess sleep patterns and identify sleep disturbances. It can be used to help identify sleep disorders and to study objective sleep in relation to the patient's subjective experience.

Another aspect of sleep is measured as sleep continuity (i.e., the timeline of how a person sleeps) which can be captured by both subjective and objective measures. Among these sleep continuity parameters are the time it takes to fall asleep (i.e., sleep onset latency), wake after sleep onset, the total sleep time and sleep efficiency. Sleep efficiency is the

percentage of time asleep relative to the allocated time for sleep (Tubbs et al., 2019) or total sleep time divided by time in bed. Sleep continuity can be measured by self-report questionnaires, sleep diaries or by using an accelerometer monitor. This information can document how a well a person sleeps or indicate the presence of sleep-related disorders such as insomnia.

The benefit of the subjective measures of sleep (i.e., self-report questionnaires and sleep diaries) is that they capture both behaviours of underlying physiological and psychological information (i.e., subjective experience of sleep) as opposed to PSG. Standardised sleep questionnaires and sleep diaries can be used in large population research and in clinical settings to help identify problem sleepers or screen for specific sleep disorders. The retrospective self-report questionnaires are subject to recall bias, cognitive errors and a reduction in temporal precision, since the respondents are asked to average their sleep in the last month or year. However, they give the researcher or clinician a quick and inexpensive way to gain an overall understanding of a patient's sleep history, their subjective experience of sleep, how it impacts their daytime functioning, and whether there is a need for further investigation of potential sleep disturbances. Examples of common validated sleep questionnaires to assess sleep problems are the Insomnia Severity Index (Bastien et al., 2001), the Epworth Sleepiness Scale (Johns, 1991) and the Pittsburgh Sleep Quality Index (Buysse et al., 1989).

To overcome some of the limitations with retrospective self-report sleep questionnaires, ecological momentary assessment can be used. It involves repeated sampling of the participants behaviours and experiences in real-time in their natural environment (Shiffman et al., 2008). This type of assessment may examine the day-to-day sleep behaviours, mood and daytime functioning by collecting periodic reports at random time sampling and in a non-invasive manner. Ecological momentary assessment, using smart phones and applications to

send alarm notifications, has increased rapidly with technological advances and widespread use across all ages. The limitations of this type of assessment, using smartphone-based applications, is adherence to the research protocol such as completion or a delay of answering after the prompt or alarm notification (Yang et al., 2018). Despite these inherent challenges, it is well suited to track behaviours over time and across context while minimising recall bias and maximising ecological validity.

The objective measurements of sleep continuity can use an accelerometer which detect and measure bodily motion and sleep-wake patterns over time. The data is collected via activity monitoring devices with an accelerometer and can be used as part of sleep-wake cycle and circadian rhythm evaluation. The data is then measured against an activity threshold and an algorithm then classifies it as either 'rest' or 'sleep'. These algorithms vary in accuracy and it is therefore important to use measures and devices that have been validated in many populations and against PSG metrics. Recent times have seen the uptake of consumer smart devices (i.e., Fitbit or Apple watch) which incorporate similar technology allowing individuals to assess their own sleep and activity. The data generated from the use of these devices is now being used in large scale research projects to gain insight to global sleep/ wake and activity behaviours (Rezaei & Grandner, 2021).

Insufficient Sleep, Poor Sleep Quality and Insomnia

The term 'insufficient sleep' is often used interchangeably with 'poor sleep' and 'insomnia' despite being distinct concepts. Grandner (2019) refers to 'insufficient sleep' as "too brief a sleep duration to meet physiological needs" (p. 12). The recommended hours of sleep vary dependent on age and genotype. For healthy adults, the recommended sleep duration is seven to nine hours per night. Habitually sleeping for six hours or less is

recognised as insufficient sleep by the American National Sleep Health Foundation (Hirshkowitz et al., 2015).

Population studies of estimated prevalence of insufficient sleep duration for adults vary. This may reflect a disagreement among researchers and clinicians of what defines insufficient sleep. Liu et al. (2016) estimated that the age-adjusted prevalence of insufficient sleep (≤ 6 hours) was 35.1% in the United States. Another study found that 32% of Canadians in a nationally representative survey reported short sleep (<7 hours) (Chaput et al., 2017). Similarly, here in NZ Lee and Sibley (2019) found that 37% of NZ adults were short sleepers (<7 hours) with Māori and Pasifika reporting the highest rate of short sleep, 46.4% - 48% and 49.6% - 53.9% respectively. Although the global prevalence estimates were similar, the different cut-off scores highlight the disagreements of what defines insufficient sleep.

Researchers often operationalise poor sleep or insomnia-related problems as difficulty falling asleep, staying asleep, short sleep duration, early awakening, daytime sleepiness or subjective reports of 'poor sleep quality'. As identified above, disrupted sleep can prevent sufficient slow-wave sleep which sub-consequently can reduce sleep quality, increase sleep drive (e.g., impacting daytime sleepiness, fatigue), feelings of well-being (e.g., mood disturbances), and poor attention and memory impairment. Poor sleep is associated with sleep disorders such as insomnia however, they are not synonymous. Clinical insomnia is a subjective report of difficulty initiating and maintaining sleep despite adequate sleep opportunity. It is associated with significant distress and reduction of daytime functioning (Schutte-Rodin et al., 2008). According to the Diagnostic and Statistical Manual of Mental Disorders - fifth edition, a clinical diagnosis of insomnia is based on core criteria; difficulty falling and staying asleep; associated distress and perceived negative impact on mood and daytime function, which are clinically significant; poor sleep at least three nights a week with a minimum duration of three months (American Psychiatric Association, 2022).

The prevalence of insomnia is problematic to identify given the difference between the clinical definition of insomnia and the definition used by researchers, as well as the different and changing perceptions of the individual what constitutes 'satisfactory sleep'. An epidemiological study shows the prevalence estimates for clinically significant insomnia disorder was approximately 10% of the general adult population globally (Ohayon, 2002). The prevalence of general complaints of insomnia-related symptoms range between 9-27% for young and middle-aged adults and increases with age to 30-60% in older adults (Ohayon, 2002; Paine et al., 2005). This highlights the difference in prevalence between clinical insomnia and insomnia-related problems or poor sleep. Furthermore, the prevalence is greater in people with comorbid medical and psychiatric conditions such as major depressive disorder or chronic pain (Ohayon, 2002). A meta-analysis of epidemiological studies by Zhang and Wing (2006) conducted research into sex-differences of general insomnia. It showed that insomnia was 1.41 times more likely in women than in men. This meta-analysis included studies using self-report questionnaires as well as semi-structured or structured diagnostic interviews. Lastly, a NZ study found that 27% of adults aged 20-59 self-reported insomnia symptoms with a significant disparity between Māori (33.0%) and non-Māori (26.4%) populations (Paine et al., 2005).

Psycho-Social Processes of Sleep

As discussed above, the physiological conceptualisation of sleep involves both involuntary biological processes and voluntary behavioural choices that reflect social and ecological surroundings. The following section will provide an overview of a social-ecological model of sleep health and examine some of the psycho-social determinants and consequences of sleep. It is outside the scope of this thesis to examine all the psycho-social drivers of sleep and this section will only focus on those relevant for this study.

The Social-Ecological Model of Sleep Health

The Social-Ecological Model of Sleep Health (Grandner, 2019) is a conceptual framework that presents the 'downstream' effects of poor sleep, as well as 'upstream' determinants of sleep health. The model describes how the individual is embedded within social and societal systems where physiological, psychological and social processes interact. The model proposes that sleep is determined by individual-level factors which are embedded in social-level factors and that are entrenched in broader societal structures. Some of the individual- level factors that are associated with sleep include biology (i.e., genetics, chronotype), psychology (i.e., anxiety/ depression), beliefs and attitudes about sleep, behaviours (i.e., exercise, caffeine intake) and choices (i.e., allowing enough time for sleep). These are embedded in social-level factors which exists outside but include the individual. Social-level factors may include home and family, work, school, the neighbourhood you live in, race/ ethnicity, social networks, religion, culture and socio-economic status. The home is particularly pertinent as it encompasses the physical sleeping environment and social and family dynamics which impact on meal timing and pre-bedtime habits. Social-level factors are embedded in a societal context which can have direct or indirect effects on sleep. Societal level factors may include public policy, technology and progress (i.e., access to the internet), economics, the natural environment, globalisation, geography and racism/ discrimination. For example, daylight savings (a social construct) has a direct effect on sleep as it changes our daily exposure to natural light which directly influences the circadian rhythm and sleep-wake cycles. The model recognises that sleep is primarily determined by individual-level factors, such as genotype, but that these are influenced by both social and societal contexts (Grandner, 2019). The following sections will investigate the evidence in support of this model. It is outside the scope of this thesis to look at every factor affecting sleep health and therefore only the most relevant factors are reviewed below.

Beliefs, Attitudes and Personality's Effect on Sleep Health

Some of the main factors affecting sleep health of the individual are the attitudes and beliefs the individual holds in regards to sleep. These then drive certain behaviours that impact upon sleep health. For example, people with insomnia will often try to 'not think' (i.e., 'count sheep') as a strategy to decrease sleep onset latency, or engage in safety behaviours such as avoiding social activities in the evening and/ or early morning obligations to increase sleep opportunity. Attitudes towards sleep are formed by the degree of favourable or unfavourable evaluation of experience, need and outcome of sleep which, are informed by cognitive, affective and behavioural processes (Peach et al., 2018).

Sleep-related beliefs that have unfavourable evaluations could be catastrophising the consequences of insufficient sleep or having unrealistic expectations about sleep (i.e., immediate sleep onset latency with no awakenings at night). These are termed 'maladaptive sleep interpreting thoughts' (Lundh & Broman, 2000) and may cause daytime distress, night-time rumination and lead to increased sleep effort. However, this effort to control sleep ('sleep effort') has been shown to prolong sleep onset latency, contribute to hyperarousal and interfere with sleep (Kalmbach et al., 2018). In contrast, sleep-related attitudes that have more favourable evaluations such as beliefs in the importance and necessity of sleep, will act as drivers for better sleep behaviours, often referred to as 'sleep hygiene'. For example, allowing enough time for sleep in one's schedule, choosing to exercise regularly, exposure to bright light in the morning and avoidance of screens prior to bedtime, and the timing and amount of caffeine and alcohol intake. This is supported by research that shows that attitudes towards sleep are predictive of sleep hygiene, duration and sleep quality (Ruggiero et al., 2019). Therefore, changing an individual's beliefs and attitudes towards sleep forms a large component of cognitive behavioural treatment for insomnia. This is considered the 'gold standard' for treatment of insomnia (Manber & Carney, 2015).

Personality traits have also been linked to sleep health. For example, high levels of neuroticism, anxiogenic tendencies, internalisation, and perfectionism are associated with insomnia (van de Laar et al., 2010). Hintsanen et al. (2014) found that individuals with higher conscientiousness, extraversion and agreeableness experienced better sleep health in Australian and Finnish samples. However, more longitudinal studies are needed to determine the direction of these relationships. For example, does poor sleep causes higher levels of neuroticism or vice versa? Furthermore, personality traits have been linked to mental well-being which in turn is linked to sleep health (Lee & Sibley, 2019). This highlights the complexity of the individual-level factors that impact upon sleep health.

Sleep and Mood

The relationship between poor sleep and mental health problems is well established. Longitudinal studies have found that sleep difficulties are very common among patients with clinical anxiety and depression and equally, high levels of anxiety and depression symptoms have been found in patients with insomnia (Baglioni et al., 2011; Johnson et al., 2006; Taylor et al., 2005). For example, Taylor et al. (2005) found that people with insomnia were 9.82 times more at risk of having clinical depression and 17.35 times more likely to have clinical anxiety compared to people without insomnia. This supports a strong etiological relationship between sleep and mood. The following section will examine the evidence of a predictive relationship and direction between sleep and mood.

Jansson-Fröjmark and Lindblom (2008) proposed three different possibilities to understand the complex relationships between sleep and mood 1) insomnia-related symptoms are an epiphenomenon to anxiety and depression and as such a bi-product of mood problems, 2) anxiety and depression act as risk factors for future insomnia or sleep disturbances and there is a temporal precedence between these variables, and 3) anxiety, depression and

insomnia are bidirectionally related which, can be determined by the order of various precipitating and maintaining factors. In the past, it was suggested that sleep difficulties were secondary symptoms of various anxiety and major depressive disorders. However, it was observed that when the primary symptoms were treated the insomnia often persisted (Fang et al., 2019; Manber et al., 2008). Today it is widely accepted that anxiety, depression and insomnia are different diagnostic entities that can co-exist and exacerbate one another (Manber & Carney, 2015).

Longitudinal studies have explored the direction of the cause-effect associations between anxiety and insomnia found that anxiety disorders preceded insomnia in 73% of the cases (Johnson et al., 2006). People with anxiety had 3.35 times more risk of developing insomnia (Jansson & Linton, 2006). However, the research on the relationship and directionality between depression and insomnia related-symptoms are mixed. Jansson and Linton (2006) found that people with depression had 1.96 times more risk of developing insomnia one year on but other research suggests that insomnia preceded clinical depression between 40 - 69 % of the time (Johnson et al., 2006; Ohayon & Roth, 2003). The latter is supported by meta-analysis which showed an odds ratio of 2.60 [CI: 1.98-3.42] for insomnia predicting depression (Baglioni et al., 2011). Most of the studies used retrospective self-report data which have limitations of recall bias and cognitive errors. To overcome some of these limitations, an ecological momentary assessment study by Triantafillou et al. (2019) examined the causal day-to-day interaction between sleep and mood in participants with anxiety and depression symptoms and a control group. They collected daily reports for six consecutive weeks and found a significant relationship between daily sleep quality and mood which, supported previous longitudinal findings. The effect of sleep quality on mood was significantly larger than the reverse however, the relationships varied across participants with different levels of anxiety and depression symptoms. Thus, the second possibility, proposed

by Jansson-Fröjmark and Lindblom (2008) of anxiety and depression preceding sleep disturbances was inconclusive and warrants further examination.

Jansson-Fröjmark and Lindblom (2008) proposed a third possibility that anxiety, depression and insomnia-related problems are bidirectional, where anxiety and depression influence insomnia and insomnia-related symptoms influence mood. This is supported by numerous studies (Alvaro et al., 2013; Jansson-Fröjmark & Lindblom, 2008) which suggested that each contribute to the development of and as a consequence of the other.

In summary, the etiological relationship between mood and sleep disturbances is complex and the research findings of the directionality were conflicting and further research is needed to test it.

The Gender Sleep Gap

Sex differences in sleep-related disturbances are widely recognised across the sleep literature. As discussed earlier, approximately 10% of people experience clinical insomnia with women being particularly affected (Ohayon, 2002). A recent meta-analysis by Zeng et al. (2020) pooled data from 13 observational studies (*N*= 326,908) and found that the odds of having clinical insomnia were approximately 60% greater for women than for men. Subjective studies show that woman report greater difficulty falling asleep, have more night awakenings, longer periods of being awake and poorer sleep quality compared to men (Zhang & Wing, 2006). However, objective studies show that the differences in men and women's sleep architecture and sleep physiology may not explain the difference in sleep problems (Bixler et al., 2009). Using polysomnography, studies found that women have shorter sleep onset latency, more slow-wave sleep, better sleep efficiency and greater sleep duration than men (Bixler et al., 2009; Ohayon et al., 2004). This indicates that objectively women do not sleep worse than men, contrary to the findings from subjective studies.

Biological drivers and neuroendocrine changes associated with reproductive functioning appear to play a large role in sleep-disruptions experienced by women compared to men across the lifespan (Nowakowski et al., 2013; Suh et al., 2018). Few sex-related differences have been reported in childhood sleep-related problems (Meers et al., 2019). However, from puberty, with the onset of menses and hormonal profile change e.g., estrogen, progesterone, luteinizing hormone and follicle-stimulating hormone, the likelihood of reporting insomnia increases by 2.75 in females compare to males (Suh et al., 2018). In a study by Nowakowski et al. (2013) they found this pattern persisted throughout adulthood with a third of women reporting sleep difficulties and decreased sleep quality at the end of their menstrual cycle. Furthermore, they reported that during perimenopause and menopause, estrogen levels decreased and luteinizing hormone, follicle-stimulating hormone increased significantly. This was linked to hot flushes and night sweats causing sleep-disturbances. The hormone fluctuation and physical discomfort during pregnancy and post-partum as well as breastfeeding and infant care were also strongly related to sleep difficulties. In the older population, sleep quality generally decreased for both men and women. Interestingly, in a study by Mander et al. (2017) they found that older men have a greater reduction in slow-wave sleep and reduced sleep rebound effects in objectively measured sleep disturbances. Yet, in subjective studies, older women self-reported poorer sleep quality and longer sleep onset latency compared to men (Ohayon et al., 2004; Zhang & Wing, 2006). The discrepancy between the objective and subjective measured sleep disturbances across the life span indicates that women may have increased sensitivity to sleep disruption. This may be due to the differential impact and disruption that female reproductive hormones have compared to males' hormonal profiles. More research is needed to understand these gender disparities including physiological as well as sociological differences.

The psychosocial factors associated with gender disparities in sleep and the reasons for the higher prevalence of insomnia-related symptoms in women have been examined in the literature. Research has found that women are more vulnerable to certain pathologies that show high co-morbidity with insomnia and sleep disruption (Altemus et al., 2014; Johannes et al., 2010). As discussed earlier, a highly co-morbid relationship exists between psychiatric disorders and insomnia. A study by Altemus et al. (2014) found that women have twice the lifetime rates of being diagnosed with anxiety and depression disorders, which may help explain their higher prevalence of sleep-related disturbances. Research shows that pain and somatic symptoms are also more commonly reported among female populations (34% in females versus 26% in males) (Johannes et al., 2010) which, are highly associated with sleep-related disturbances (Smith et al., 2000). Therefore, sleep-related comorbidities that affect women disproportionally over men may be driving disparities in subjective sleep quality between the sexes.

The interactive relationship between sleep and stress is another psychosocial factor that appears to contribute to the sleep gender gap. Traditional gender roles have, in the past, constrained women to the primary caregiver role and home-keeping duties. Whilst this expectation has changed and women have been able to step into the workforce, the majority have continued to maintain their traditional roles on top of part or full-time work. Men, on the other hand, have for the most part continued to maintain the status quo as primary income earner (Kelmendi & Jemini-Gashi, 2022). This has led to differential increases in stress for women, and has been associated with poorer physical health and higher rates of depression and anxiety (Del Río Lozano et al., 2017). Other gender-specific factors that make women more vulnerable to stress worldwide are unequal access to resources, employment, education, lower socio-economic status, and increased risk of domestic and sexual violence (European Commission Directorate-General for Justice and Consumers, 2021).

Research suggests that women could be more psychologically sensitive or reactive to stress than men, when experiencing a similar stress exposure (Caballo & Cardeña, 1997) which could be another driver of the gender sleep gap. Yet, the opposite was found in a study by Kendler et al. (2001) where gender differences did not explain the sensitivities to stressful life events and the prevalence of a condition (i.e., depression). Another possibility for the gender sleep disparity could be that men do not readily report anxiety and insomnia-related symptoms in surveys as it is not 'macho' and aligned with their masculine identity (Meadows et al., 2008; Warren & Campbell, 2021). An in-depth analysis of the latter psycho-social factor is beyond the scope of this thesis.

Sleep and Loneliness

A growing area of research is linking loneliness with sleep health. Loneliness is a common experience worldwide and is a growing public health concern not just for elderly but for younger people, especially in Western and high-income countries. The Government of the United Kingdom declared a 'loneliness epidemic' and in 2018 established a Minister of Loneliness role to address this crisis (Jeste et al., 2020). The prevalence of loneliness varies depending on research methodology and cut-off scores used however, studies found that one in four Australian adults were lonely (Pai & Vella, 2021). The 2018 NZ General Social Survey found that 16.6% of New Zealanders aged 15 years or older felt lonely at least some of the time (Stats NZ, 2022b). Furthermore, it found that more women reported feeling lonely (19%), compared to men (14%).

Loneliness is defined as "a discrepancy between one's desired and achieved levels of social relations" (Perlman & Peplau, 1981, p. 32). Loneliness is subjective feeling that is distressing, especially when it is outside of the individual's control. Social isolation and loneliness are interrelated but different concepts. For example, one can have a rich social life

but still feel lonely (perceived social isolation) or objectively live a solitary life but not feel lonely. Weiss (1974) distinguished between two components of loneliness; emotional and social loneliness. Emotional loneliness is characterised by the lack of intimate relationships such as a partner or best friend. Social loneliness is related to the absence of a wider social network (i.e., friends, siblings, colleagues, neighbours). Loneliness is linked to adverse health outcomes such as cardiovascular disease, poor mental health, increased risk of cognitive impairment and dementia, diminished sleep quality, and increased morbidity and mortality (Hawkley & Cacioppo, 2010; Leigh-Hunt et al., 2017).

There is mounting evidence linking loneliness and sleep quality however, the relationship and directionality remains obscure. For example, meta-analyses showed that loneliness was associated with impaired sleep quality, insomnia symptoms and sleep dissatisfaction, however not with sleep duration (Cacioppo et al., 2002; Griffin et al., 2020). Whilst older age is often linked with greater levels of loneliness (Shor et al., 2013), the above studies showed that gender and age were not moderators between loneliness and sleep quality. On the contrary, Holt-Lunstad et al. (2015) found the associations between loneliness, social isolation, living alone and mortality were larger in younger participants. Griffin et al. (2020) found no difference according to age and suggested that this could be because older people have enhanced resilience and learnt better coping strategies.

Scholars suggest that loneliness promotes an alert-state and feelings of being under threat which can induce nocturnal micro-waking that causes sleep fragmentation and a reduction in sleep quality (Kurina et al., 2011). This supports Hawkley and Cacioppo (2010)'s model of loneliness which proposed that perceived social isolation is equivalent to feeling unsafe and triggers hypervigilance. Human beings are a social species who rely on a safe and social environments to survive and thrive. Heightened feelings of vulnerability are accompanied by stress, anxiety and poor sleep. This is in contrast to Ben Simon and Walker (2018)'s study

which suggested that lack of sleep leads individuals to enforce greater social separation from one another. They argued that lack of sleep interferes with brain regions responsible for interpreting the intent of approach and prosocial signals by another human. On the flipside, the other human will judge the sleep-deprived individual as being lonelier, making them less desirable to collaborate and socially engage with, since it makes the other member of society feel lonelier in return. In summary, the relationship between loneliness and sleep remains inconclusive and further research is needed to examine the directionality.

The Impact of Social and Societal-Level Factors on Sleep Health

The individual-level factors summarised above are, according to Grandner (2019), the primary determinants of sleep health. However, such factors are influenced by the social and societal-level contexts. The following section will provide an overview of some of the social and societal-level factors as a foundation for an in-depth investigation into a pandemic context later.

Research supports the impact social factors have on the sleep health of the individual (Jehan et al., 2017; Paine & Gander, 2016). These include the home, work and schooling environments that subsume schedules, commuting, social networks, socio-economic status and ethnicity (Grandner, 2019). For example, work status and type of work can have a significant impact on the individual, and their sleep and wake routines (Jehan et al., 2017). Shift work (i.e., working outside the hours of 8am to 5pm) and rotational shifts often cause misalignment or disruption with circadian rhythm and compromise sleep and overall health. Shift workers represent between 15%-25% of the global workforce (Almeida & Malheiro, 2016; Fransen et al., 2006) and is common in professions involving essential services. Research shows that shift workers have a higher prevalence of insomnia and mental health problems compared to non-shift workers (Jehan et al., 2017). Unemployment has also been

associated with short sleep duration both during weekdays and weekends in NZ (Paine & Gander, 2016).

Societal-level factors represent the overarching influences that impact the social contexts and affect the individual. These factors may include globalisation, economics, technological progress, 'the 24/7 society', race and discrimination, the natural environment, climate change, geography and risk of disease (Grandner, 2019). For example, the accelerated pace of the capitalist society, a societal-level factor that influences the individual as well as the family as a whole (Hsu, 2014). The social acceleration, and the increasing pace at which people live impacts all aspects of social life such as intimate and family relationships, work life and affects how people sleep. Hsu (2014) argued that in the contemporary Western world, the social acceleration results in the individual devoting less time to sleep to increase the time being awake. The prevalence of sleep deprivation is therefore a result of a cultural shift, and in a capitalist society, a viable way to increase productivity.

Other examples of societal level influences are environmental disasters, global pandemics, war or terrorist attacks are societal forces which, historically, have led to rapid changes to society, daily life and schedules (Bailey, 2006; Matsumoto et al., 2015). These societal-level factors dramatically increased levels of stress, impacting on mental health and sleep. Research has shown that sleep disturbances along with anxiety, depression and post-traumatic stress disorder are the most frequent problems for victims of such events (Lavie, 2001; Matsumoto et al., 2015). North et al. (1999) found that 70% of the survivors of the Oklahoma City bombing reported symptoms of insomnia and 50% reported nightmares in the six months following the tragedy. Research on the '9/11, 2001' terrorist attacks found that 33% of a nationwide United States sample had difficulties falling or staying asleep, with females having higher levels of sleep disruption (Bailey, 2006). Large-scale disasters can also cause social isolation in affected communities following such events. Matsumoto et al.

(2015) found that lack of social and emotional support following the Great East Japan earthquake and tsunami had a stronger association with persistent sleep problems compared to other disaster consequences.

Sleep, Mood and Loneliness During COVID-19 Pandemic

The Pandemic Context

The novel coronavirus 2019 abruptly changed daily life for most people worldwide. It was first reported in Wuhan, China in December, 2019 and on March 11, 2020 the World Health Organisation declared COVID-19 a global pandemic (World Health Organisation, 2020). Mandatory lockdowns and social distancing measures were adopted as an epidemiolocal containment strategy by public health authorities globally. However, the extent and timeliness of the containment and other public health measures differed widely across countries. Efforts included state of emergency and mandatory self-isolation orders, closing international borders, social distancing, restricting domestic travel, and compulsory mask-wearing in public places. Changes to daily life included home-schooling and working remotely for many people except essential workers. By early July, 2020 the number of global COVID-19 infections were over 10 million and more than 500,000 deaths had been recorded (John Hopkins University, 2022).

The New Zealand's Ministry of Health confirmed its first COVID-19 case on the 28th February, 2020 (Ministry of Health, 2020b). On March 21st a country-wide alert level system was introduced that defined the precautions and restrictions to be taken and followed by the NZ public. On March 23rd the NZ government announced its first mandatory 'level 4' nationwide lockdown to be observed with 48 hours' notice (Ardern, 2020). The lockdown was implemented early in the pandemic when NZ's infection and mortality rates were low. It was considered one of the strictest in the world (Mathieu et al., 2020) and designed to

eliminate COVID-19 from the country, as opposed to a suppression strategy adopted by most other countries. The level 4 lockdown involved strict travel bans with the closure of international borders, mandatory quarantine for returning New Zealanders and the closure of schools, non-essential businesses, workplaces and social gatherings. People were restricted to their house-hold 'bubbles' with the exception of essential workers, and could only leave home for grocery shopping, fuel and medical supplies, treatment and personal safety (Bloomfield, 2020). The NZ government allowed exercise within the local neighbourhood and emphasised the importance of physically activity for health and well-being. This hard and fast COVID-19 elimination strategy successfully contained the virus, ending lockdown on 11th of May, 2020 with a total of 1466 cases and 22 deaths recorded (0.00043% of the population) (John Hopkins University, 2022). Comparatively, Italy, one of the early centres of the pandemic recorded 221,216 cases and 30,911 deaths during the same period (0.052% of the population) (John Hopkins University, 2022).

Social- Ecological Framework of Sleep Health in a Pandemic Context

Increasing evidence suggests that the changes and impacts associated with the COVID-19 lockdowns significantly affected sleep, mood and loneliness on a global scale (Rezaei & Grandner, 2021; Santini & Koyanagi, 2021; Wu et al., 2021). An adapted version of Grandner's Social-Ecological Model of Sleep Health (2019) was formed based on the literature review in order to summarise the factors identified as the most relevant for sleep and well-being during the pandemic.

Figure 1 *Adapted Social-Ecological Model of Sleep Health in a Pandemic Context*[1]

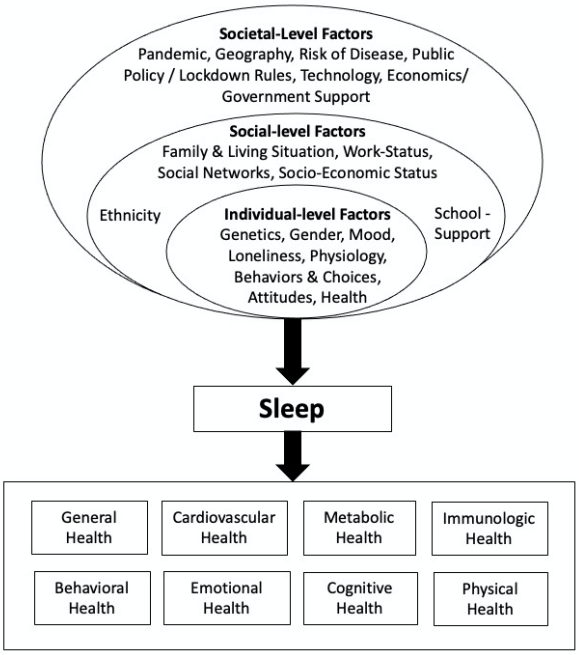


Figure 1 shows how societal-level determinants, such as geography, risk of disease and public policy oversee the social-level factors which in turn impact upon the individual and their subsequent quality of sleep. For example, lockdown measures used to mitigate the spread of COVID-19 severely restricted activities outside the household. This had an impact on the social-level factors, such as daily work and school routines, social engagements and home dynamics which act as important time cues for circadian rhythm entrainment and sleep initiation and maintenance. The closures of non-essential work places, schools and day-cares meant many had to devote more time to childcare and home-schooling whilst also fulfilling work obligations from home. This may have differentially impacted more upon women than men, given women were more likely to be the primary carer of children pre-pandemic (Zamarro & Prados, 2021). Furthermore, the potential worries of job-loss or financial hardship, the experience of isolation or lack of social contact may have had a negative impact

[1] Permission was granted by Dr Michael Grandner to use this adapted version of the Socio-Ecological Model of Sleep Health (original model available in Grandner, M., 2019, p.50)

on individual level-factors such as mental health, increasing feelings of disconnection and poor sleep. The confinement meant changes to normal routines and the home became a work and school environment, with many using the bedroom as an office. These changes likely impacted the physical sleeping environment as well as social and family dynamics, which in turn may have impacted well-being and sleep outcomes. The following sections will explore the evidence for this adapted social-ecological framework of sleep health.

Change in Sleep During the Pandemic

Global sleep data collated using both objective and subjective measures showed that sleep patterns and behaviours changed for both men and women during the COVID-19 pandemic however, there were also unique differences by gender (Alimoradi et al., 2022; Jahrami et al., 2022). Changes were observed in sleep duration, quality, and timing. A large Fitbit™ data study (*N*= 163,524) showed an increase in mean sleep duration, decreased bedtime variability and a shift to later sleep timing for all age groups compared to similar timeframes two years prior the pandemic (Rezaei & Grandner, 2021). Fitbit™ used a type of accelerometery to ascertain sleep status from movement and rest data. Although Fitbit™ is not a validated objective measure of sleep (Haghayegh et al., 2019), the large sample provided a valuable insight into a general pattern of sleep changes. A shift to later sleep timing during the lockdown was supported by other research using self-report measures (Blume et al., 2020; Cellini et al., 2020; Leone et al., 2020). These changes may reflect an increased ability to better align with the body's natural circadian rhythm, free from the constraints of work obligations, commuting and socialising, which often dictate the opportunity for and timing of sleep. A research survey found that those who preferred to sleep later seemed to have sleep-related benefits from lockdown, possibly related to the reduced discrepancy between social and biological sleep timing compared to pre-lockdown

(Blume et al., 2020). This could be related to reduced social and work pressure during the lockdown. Whilst much of the evidence suggests that sleep duration increased during the pandemic (Blume et al., 2020; Leone et al., 2020), some research found that while participants increased their time spent in bed, time spent asleep did not significantly change (Cellini et al., 2020; Gibson et al., 2022).

Whilst sleep duration and the biological alignment of sleep timing improved for some people during the lockdowns, evidence also shows that for others, subjective sleep quality decreased compared to pre-pandemic. Large systematic reviews and meta-analyses of global prevalence of sleep disturbances were conducted during the pandemic. A large meta-analysis by Jahrami et al. (2021) found an estimated global prevalence of sleep disturbances of 36% early in the COVID-19 pandemic. They examined sleep problems in three main populations, and found that while the greatest disruptions were reported within those who contracted the COVID-19 virus (75%), around a third of health care workers and the general population also reported sleep problems during the pandemic (36% and 32% respectively). Similarily, a more recent meta-analysis found an estimated global prevalence of sleep problems in the general population of 37% during the pandemic (Jahrami et al., 2022). Jahrami et al. (2022) also examined lockdown versus no lockdown periods during the pandemic, where sleep disturbances were higher during the 2021 lockdown periods (47%), compared to the non-lockdown periods (36%). They also found a large variation in prevalence of sleep problem between countries ranging from 30% in China to 60% in Spain. Jahrami et al. (2022) suggested the virus transmission rate, lockdown measures and different methods / questions used across the studies contributed to the variation of sleep disturbances. Unsurprisingly, health care workers, active COVID-19 patients and people living in densely populated areas or geographical locations severely impacted by the virus were identified as more susceptible to sleep problems (Casagrande et al., 2020; Jahrami et al., 2021; Pappa et al., 2020). For

example, research conducted in Italy found that the prevalence of sleep disturbances climbed from 30% pre-pandemic to 57% during the pandemic, with those living in Northern Italy, the pandemic epicentre, were more impacted than the less affected South (Casagrande et al., 2020). Furthermore, research reporting a 20% increase in use of the sleeping medication across 49 countries supports the notion that there was evidence of increased sleep problems as a result of the pandemic (Mandelkorn et al., 2021).

A large body of research has investigated whether difference in sex mediated the prevalence of decreased subjective sleep quality during the pandemic (Alimoradi et al., 2022; Jahrami et al., 2022). Results published to date have been mixed, potentially reflecting the varying contexts as well as forms of data collection and analysis conducted. A meta-regression of Jahrami et al. (2022)'s study showed that sex and age did not mediate prevalence of sleep problems during COVID-19 pandemic. However, this is in contrast to Alimoradi et al. (2022)'s systematic review and meta-analysis that revealed a pooled estimate of sleep problems of 31% in men and 41% in women. However, after statistically correcting for publication bias using the fill-and-trim method, the estimates of sleep problems were 27% in men and 24% in woman. The difference in prevalence between the pooled estimates and the corrected estimates, especially examining female sleep disturbances, may be explained in the quality of the studies included in the meta-analysis. Of the 54 studies included in Alimoradi et al. (2022)'s meta-analysis, 30% were deemed 'low quality' and all but two were cross-sectional. The longitudinal studies revealed a greater prevalence of sleep problems compared to cross-sectional studies in both men (48% versus 31%) and women (55% versus 41%). This indicates that the actual prevalence of sleep disturbances may be higher in women than men, however further research using only high-quality studies is needed.

Whilst the majority of the literature on sleep during COVID-19 has been focused on sleep problems, there has been little attention on improved or unchanged sleep health during

the pandemic. Some evidence suggested subjective sleep quality was predominantly unchanged by the lockdown (Leone et al., 2020) whilst other research found some participants had good or improved sleep during the lockdown (Gibson et al., 2022; Trakada et al., 2020). In a NZ study, approximately 22% of the participants reported better sleep, 33% reported no change and 45% reported worse sleep during the lockdown (Gibson et al., 2022). Similarly, Trakada et al. (2020) found that almost half the participants (47%) characterised their sleep as 'good' during the stay-at-home-orders. The authors suggested that the sleep 'gain' may be attributed to less activities and more control over life and work schedules. However, these studies did not specifically investigate the gender breakdown of those reporting their sleep as being good or better.

Other contextual factors shown to negatively impact subjective sleep quality during lockdown was younger age (Cellini et al., 2020), adverse effects on livelihood (Mandelkorn et al., 2021), socioeconomic status and caring responsibilities (Robillard et al., 2021). These factors were independent predictors for new onset of sleep disturbances during the pandemic. Whilst these are important factors, it was outside the scope of the present thesis to investigate them. Therefore, the following sections will continue to focus on gender, mood and loneliness.

Gender Inequality During the Pandemic

There is mounting evidence that globally the COVID-19 pandemic impacted women differently compared to men. For example, women accounted for approximately 80% of the health and social care workers at the time of the pandemic and therefore, had a greater exposure to the virus (Zhou et al., 2020). A meta-analysis showed increased levels of domestic violence (overall medium effect size 0.66) during the stay-at-home-orders, that affected mainly women and children (Piquero et al., 2021). Women were also

disproportionally impacted by unemployment due to the higher concentration of women working in heavily affected industries such as hospitality and service jobs, and partly due to increased childcare responsibilities which prevented many women from working (Alon et al., 2020a, 2020b; Dang & Viet Nguyen, 2021).

Research into gender division of household labour during the lockdown showed mixed results. Some found that mothers predominantly provided childcare with only a minority sharing the care work equally with their spouse/ partner (Zamarro & Prados, 2021; Zhou et al., 2020). Farré et al. (2022) found that men did increase their participation in home-schooling, housework and childcare but only slightly and that women took the majority of extra duties. In contrast, other research suggested that gender inequality at home did not increase during the pandemic in Australia (Craig & Churchill, 2021) or the US (Carlson et al., 2022). This may seem surprising however, in Australia the gender differences were already unequal and the pandemic appeared to continue this pattern. Craig and Churchill (2021) found that Australian mothers, pre-pandemic, were more dissatisfied with their work-life balance and their spouse / partner's workload share compared with Australian fathers. However, as both parents' workload became higher during lockdown e.g., 'juggling' paid work and unpaid domestic chores and childcare, more fathers reported higher levels of subjective stress, unfairness and dissatisfaction, which women may have long felt. The equal or narrowing gender differences may therefore reflect the increased stress for fathers managing the paid and unpaid workload. In NZ, Census data from 2018 showed that women also performed more unpaid work than men pre-lockdown, including childcare and looking after ill or disabled people in their household (Stats NZ, 2018). Yet, as minimal research has been done into the division of housework and childcare during the NZ lockdowns, it is not known if this may have increased during the pandemic.

Much of the attention on gender disparities during COVID-19 lockdowns has been centered around time spent on physical housework, childcare and educational roles. However, research has also found differences in cognitive and mental workloads experienced by each gender. Czymara et al. (2020) found that women were more worried about childcare and social contact during lockdown, while men were more concerned about paid work and the economy. The authors argued that the difference in focus is important because it reflects the social situation of both genders, where the division of paid and unpaid work follow the traditional breadwinner model. Whilst gender inequality is not a new concept, the COVID-19 pandemic may have exacerbated these existing disparities and increased the overall stress for working women. This was particularly so for working mothers, where evidence indicated decreased psychological well-being, increased negative emotion as well as limited career development and progression (Augustus, 2021; Zamarro & Prados, 2021).

Mental Health During the Pandemic

Prior to the pandemic, depressive and anxiety disorders were leading causes of the global health-related burden. In a global study, the World Health Organisation identified depression as the largest contributor to disability across all diseases, with anxiety the sixth leading contributor (World Health Organization, 2017). A large body of evidence suggests that well-being and mental health in the general public declined as a result of the pandemic and stay-at-home-orders (Fisher et al., 2021; Gasteiger et al., 2021; Gibson et al., 2022; Wu et al., 2021). According to a meta-analysis by Mahmud et al. (2022), the prevalence of self-reported anxiety was 30% and depression 28% in the general population during the early part of the pandemic. A large systematic review by Santomauro et al. (2021) examined the global prevalence of depression and anxiety disorders in 204 countries during the pandemic. They only included studies with pre-pandemic baseline data and meta-regression was used to

estimate the change between pre-pandemic and mid-pandemic prevalence. They found that daily COVID-19 infection rates and the reduction in human mobility were associated with an increased prevalence for both depression and anxiety disorders. Like with sleep disturbances, the greatest increases in prevalence rates were in areas with the highest infection rates and strictest lockdowns. Furthermore, they estimated that the pandemic contributed to an additional 53.3 million cases of depression (an increase of 28%) and additional 76.2 million cases of anxiety disorders globally (an increase of 26%). The study also found that risk factors for psychological distress included being female, and that younger age groups were more affected than older age groups. Females had a 30% increase in depression (24% in males), and an increase of 28% in anxiety (22% in males) which supports the notion that women were more affected by the societal and social consequences of the pandemic. Further research shows that the unemployed, those with chronic illness, essential workers (especially health and care staff), and people from black, Asian and minority ethnic groups were more likely to be affected (Proto & Quintana-Domeque, 2021; Salazar de Pablo et al., 2020; Xiong et al., 2020).

Studies from NZ indicated that anxiety and depression rates significantly exceeded population norms during the lockdown (Every-palmer et al., 2020; Gasteiger et al., 2021). For example, Gasteiger et al. (2021) found that 64% of their participants reported symptoms of depression and 53% of symptoms of anxiety. They also found that being female and in the 18 to 24 age groups conferred greater risk compared to other genders or age groups. However, this cross-sectional study compared their findings to global population norms rather than pre-pandemic NZ statistics, making it difficult to estimate how much the pandemic exacerbated these problems in NZ. A study by Every-Palmer et al. (2020) used identical measures to the NZ Health Survey 2018 (one of NZ's most consistent measures of health and well-being running annually since 2011) to better compare their during-pandemic

findings with a pre-pandemic baseline. They found that one-third of participants reported moderate to high levels of psychological distress during the first lockdown compared the NZ 2018 Health Survey baseline of 8%. Similar to international studies, Every-Palmer et al. (2020) found that younger New Zealanders (18- 24 year olds) experienced higher levels of distress (47%) compared to older adults, aged 65 years and over (10% of participants respectively). The pre-pandemic NZ 2018 Health Survey found that women were 1.8 times more likely to experience psychological distress during the last four weeks (Ministry of Health, 2020a) yet, it appeared that during lockdown this gender gap was reduced. For example, Every-Palmer et al. (2020) assessed specifically for anxiety, and found that approximately 15% of both men and women scored moderate to highly on a general anxiety measure. These results differed from Gasteiger et al. (2021) and were in contrast with international studies reported above (Santomauro et al., 2021), where women had a disproportionally higher prevalence of anxiety during lockdown. Every-Palmer et al. (2020) argued the reason for the equal prevalence of psychological distress in NZ during lockdown was because economic anxiety (i.e., worry about job loss) may have affected men and women in a similar way. Globally, females may also have experienced greater levels of psychological distress due to differential expression of health-related anxieties, driven by higher infection rates. This makes NZ an interesting and unique case study for examining how women were impacted by lockdown restrictions when during the initial lockdown there was reduced threat of COVID-19 infection compared to elsewhere.

The length and severity of lockdowns have been hypothesised as driving factors for poorer mental health outcomes during COVID-19 lockdowns (Santomauro et al., 2021). However, a recent nine-country study found that countries with stricter and longer lockdown requirements had less mental-illness related internet searches (de la Rosa et al., 2022). De la Rosa et al. (2022) used Google Trends, a tool that can analyse internet search data to provide

insight into population behaviours and health-related experiences (Nuti et al., 2014). De la Rosa et al. (2022) found that countries with stricter and longer lockdowns were associated with significantly lower Google searches that included key words such as anxiety, depression, mental health and suicide. The authors argued this could be due to benefits of spending more time in the safety and comfort of one's home, and reducing the risk of contracting the virus. However, one of the main limitations was that Google Trends does not provide reasons as to why people search for these terms – i.e., whether they are experiencing mental health symptoms or for other reasons. The insight and the contradictory findings highlighted the importance of further research into the mental health during stricter and longer lockdowns.

In summary, research suggested that anxiety and depression rates worldwide significantly exceeded population norms during the pandemic and impacted women disproportionally. NZ specific research also showed an overall increase in psychological distress during the lockdown period. However, findings were mixed as to whether this increase affected women disproportionally, as it did globally.

Loneliness During the Pandemic

A possible explanation for the increased psychological distress could be due to the social isolation and lockdown measures which has been linked to increased loneliness. Social isolation is the objective lack of interaction with other people and can cause negative feelings, such as loneliness. As discussed earlier, social isolation and loneliness are interrelated but different concepts. Loneliness is defined as a subjective feeling of perceived social isolation (de Jong Gierveld & van Tilburg, 2010). Research suggests that the COVID-19 pandemic and the associated lockdowns had a significant impact on loneliness with prevalence findings varying from 10% to 82% (Furutani et al., 2022; O'Sullivan et al., 2021;

Pai & Vella, 2021; Tesen et al., 2022). A US study by Killgore et al. (2020) assessed the impact of stay-at-home orders on loneliness and found that 62% of the participants felt 'socially isolated most of the time' and 43% reported higher levels of loneliness compared to pre-pandemic baseline. Participants who reported greater loneliness also had higher levels of depression and suicide ideation which suggested a strong association between loneliness and mood. Similarly, Santini and Koyanagi (2021) explored the association between loneliness, depressed mood and anxiety symptoms in a large European sample during the COVID-19 pandemic. Their analysis showed that participants who felt lonely (29% respectively) typically had depressed mood, anxiety symptoms and sleep-related problems that were experienced independently of having lost a close friend or relative to the virus.

In line with previous research following large-scale disasters (Matsumoto et al., 2015), loneliness was identified as a major risk for insomnia-related problems during the COVID-19 pandemic. A study by Voitsidis et al. (2020) found that pandemic-related loneliness and mood led to insomnia which were more pronounced in women and people living in urban areas in Greece. A large-scale study of Japanese workers reported a significant association between loneliness and sleep-related problems as a result of the governmental COVID-19 restrictions (Tesen et al., 2022). This study found that, during this time, having an interpersonal connection with family and friends may have had a moderating effect on sleep-related problems. Similar findings were reported in a NZ-based study where Gibson et al. (2022) found that feelings of loneliness were more prevalent in those people who reported worse sleep compared to those who reported better or unchanged sleep.

Loneliness is often considered a greater problem in older adults however, during the pandemic, research suggested that was not necessarily the case. A multi-country study by O'Sullivan et al. (2021) found that older people were significantly less prone to loneliness, especially in those aged 70 years or older. This may be due to lowering of social needs and

expectations as one age, or that they are more resilient than a younger cohort. Furthermore, O'Sullivan et al. (2021)'s study found that younger age, poorer physical and mental health, financial insecurity, lower education level, and lower perceived community support were all independently associated with a risk of loneliness during the pandemic.

A significant amount of literature discusses the link between loneliness and sleep, and loneliness and mood prior and during the pandemic however, few have investigated the predictive relationships between these factors in a pandemic context. For example, Santini and Koyanagi (2021) found that worsened loneliness was significantly associated with strong risk for depression [OR= 10.11], anxiety symptoms [OR=7.78] and sleep problems [OR= 6.26]. Similarly, in a NZ-based study, participants who reported greater levels of loneliness, anxiety and depression also reported worse sleep compared to those reporting better or unchanged sleep (Gibson et al., 2022). A study of Japanese workers examined the predictive relationships between emotional and social loneliness, mood and subjective sleep quality during the early part of the pandemic (Furutani et al., 2022). Among these workers, 36% reported poor sleep quality, 82% social loneliness (i.e., lack of wider social relationships) and 38% emotional loneliness (i.e., lack of intimate relationships), 49% reported depressive mood and 26% reported anxiety during the self-restraint period. When examining the relationships between loneliness, mood and sleep quality, Furutani et al. (2022) found that emotional loneliness but not social loneliness had a direct negative effect on sleep quality. The Japanese corporate culture value face-to-face communication and the authors proposed that the lack of social networking during the pandemic may have contributed to higher levels of social loneliness for Japanese workers. Furutani et al. (2022) also found that the relationship between social loneliness and sleep quality was mediated by both anxiety and depression. This suggested that the lack of social connection and networking may have affected anxiety and depressive symptoms, which in turn affected sleep quality. A major limitation of this

study was the use of GLS Loneliness cut-off scores ≥ 2, rather than ≥ 1 as suggested by de Jong Gierveld and van Tilburg (2010). As such, social and emotional loneliness may be higher than reported here.

Loneliness was considered a prevalent public health risk long before the COVID-19 pandemic (Jeste et al., 2020). Yet many studies investigating rates of loneliness during the pandemic failed to provide pre-pandemic comparisons. For example, Pai and Vella (2021) conducted a rapid systematic review of 24 studies across 13 countries and found that overall loneliness and mental health distress were significant during lockdown. Of the 24 studies reviewed, only three of the research papers examined levels of loneliness pre- and during-pandemic. This makes it difficult to quantitatively compare the impact of COVID-19 lockdowns on loneliness. Despite this, it is apparent that loneliness had a significant impact on mental health and subjective sleep quality during the pandemic. However, more research is required to investigate the predictive relationship between these factors.

Sleep, Mood and Loneliness Through the Lens of the 3 P Model of Insomnia

As discussed earlier, the associations between sleep, mental health and loneliness are well documented and some evidence suggests that mood and loneliness were both predictive of subjective sleep quality (Furutani et al., 2022; Jansson & Linton, 2006; Johnson et al., 2006). The 3 P Model of Insomnia provides a theoretical framework to describe the potential mechanisms for this, particularly as it relates to the pandemic (Cox & Olatunji, 2021). The 3 P's stand for 'pre-disposing', 'precipitating' and 'perpetuating' factors that lead to the onset of insomnia-related problems that could become chronic over time (Spielman et al., 1987). It suggests the presence of pre-disposing factors contributes to an increased risk of insomnia-related symptoms via the interaction with precipitating and perpetuating factors. The 3 P

Model is an extension of the diathesis-stress model where pre-disposing factors represents diatheses and precipitating factors represent stressful life events.

The classification of COVID-19 as a pandemic, along with increasing infection rates and hospitalisations, was for many a strong precipitating factor for sleep distress. This, combined with lockdown restrictions, meant that many experienced increasing levels of stress through big changes to routines, home environments and extra responsibilities such as childcare and home-schooling, along with social isolation. The perpetuating factors contributed to the increase in insomnia-related symptoms through the pandemic however, certain populations were more susceptible due to predisposing factors. These included gender, geographic location, occupation, pre-existing psychological and medical conditions. For example, females are predisposed to greater levels of anxiety (Zhang & Wing, 2006) therefore, a stressful (precipitating) event, is more likely to trigger insomnia-related symptoms in this population. During the pandemic, women were also more likely to take on the extra duties of housework, childcare and home-schooling despite being in a two-income working family (Alon et al., 2020a; Zhou et al., 2020). This therefore disproportionally increased the influence of precipitating factors experienced by women through the pandemic and could explain the differences in the subjective sleep quality between genders, as discussed above.

Research has indicated that geographical location and population density were unique predisposing factors that mediated the degree to which the COVID-19 pandemic acted as a precipitating event (Casagrande et al., 2020; Jahrami et al., 2022). Areas that were more densely populated were less able to prevent the transmission of COVID-19 through mitigation practices therefore leading to higher infection rates. This was linked to a higher prevalence of sleep-related problems (Casagrande et al., 2020; Jahrami et al., 2022). Evening chronotype is typically a predisposing factor for sleep-related problems due to the mismatch between biological sleep preferences and societal expectations. However, during the

pandemic it may have been protective against sleep disturbances. This could be due to working from home, flexible schedules and less social demand which may have enabled sleep according to circadian preference facilitating longer sleep duration and improved sleep quality (Gibson et al., 2022; Trakada et al., 2020).

Acute insomnia is a normal reaction to stressful life events and will typically resolve without an intervention if the source of stress is dealt with in a timely manner (Manber & Carney, 2015). However, the 3 P Model suggests that perpetuating factors or behaviours developed in response to the initial stressor, can lead to the maintenance and/ or exacerbation of insomnia-related symptoms. It articulates how perpetuating factors or behaviours can maintain or exacerbate insomnia-related problems during the pandemic. A systematic review and meta-analysis by Jahrami et al. (2022) found that the prevalence of sleep disturbances in 2021 was higher than in 2020, suggesting that the on-going nature of the pandemic may have prompted the initiation of perpetuating factors that lead to increased levels of sleep disruption. Pandemic-specific perpetuating factors include napping, excessive time in bed or engaging in non-sleep behaviours in bed such as working or using handheld devices. These types of behaviours reduce the homeostatic drive to sleep, increase arousal and weaken the associative cue between bed and sleep (Perlis et al., 2010). The disruption of regular routines due to social distancing and isolation may have decreased contact with circadian entrainment cues and appropriately timed 'zeitgebers' (i.e., light, exercise, meals, social interaction). Many countries banned unnecessary outdoor activity which resulted in decreased physical activity, increased sedentary behaviours and less time spent outdoors (Martínez-de-Quel et al., 2021; Werneck et al., 2020). Together, the interaction between the potential predisposing, precipitating and perpetuating factors of the COVID-19 pandemic appear to have influenced sleep health during the lockdowns.

Literature Review Summary

In summary, the divergent findings suggested COVID-19 had a mixed impact on sleep health for both men and women. The increase in sleep duration and the decrease of social jetlag during lockdown appeared to be benefits of decreased schedule demands. However, reduced sleep quality appeared to be strongly influenced by pandemic-related stresses including lockdowns which was in line with previous reports of natural disasters or trauma. More research is required to examine how lockdowns affected loneliness, mood and sleep quality, particularly focusing on the directional relationship between these variables and the differential impact it may have had on women. NZ enforced some of the strictest lockdown restrictions whilst the disease outbreak remained low. This may have minimised the effects of disease-related anxieties, experienced more strongly by women and presented a unique and novel opportunity to examine the psychosocial impact of the COVID-19 lockdown in this population.

Quality of COVID-19 Research

When the COVID-19 pandemic and the associated restrictions that followed abruptly changed daily life, many pre-pandemic research projects were put on hold. Many scholars then became dedicated to researching the impact of a 'one in a 100 year' pandemic to help shape health policy and interventions. There was a great demand for rapid distribution of research into this unknown disease and the subsequent impact of the public health measures. This resulted in an impressive number of published articles in a relatively short space of time which have helped shape public policy over the last two years. However, some of these studies were of mixed quality. A significant number of the COVID-19 publications were published on pre-print servers that allowed the research to be shared publicly before being peer reviewed or without editorial scrutiny. Due to the pandemic rush many of the studies

had poor study designs, small sample sizes or lacked methodological rigorousness which made it misleading and difficult to draw conclusions about the impact of the COVID-19 lockdowns. Other studies had substantial sample sizes (*N*= 50,000+) and included large numbers of countries. Yet, many of these studies used single-item measures which had not been validated, nor did they appear to consider cross-cultural differences in perception of the different constructs. For example, using single-item measures for variables such as anxiety, depression, loneliness or sleep quality can be problematic as they are underlying latent constructs and cannot be observed directly. These constructs may also have different cultural meaning, i.e., depression could mean something different in Japanese culture compared to NZ culture. This aim of the current research project was to only use well validated measures.

The present study used extant data from the 'Sleep and Well-being during COVID-19 Pandemic Restrictions Survey' (Gibson et al., 2022). The key measures used in this study are some of the most widely used and well validated assessment tools for sleep quality, mood and loneliness across ages and populations in a research setting. However, to ensure these measures are valid and reliable in special populations (i.e., NZ female workers) but also in a unique situation like the COVID-19 lockdown, structural equation modelling (SEM) was used to examine these questionnaires. Central to this quality assurance is the assessment of the questionnaires dimensionality to evaluate whether the items are correlated and representative of factors affecting the latent variables. This confirmatory factor analysis was an important step before constructing a full structural model to examine whether mood and loneliness predicted subjective sleep quality. The SEM-analyses use large sample sizes, and explicitly account for measurement errors. This provides stronger methodological rigorousness to draw conclusions from, compared to research using single-item measures of underlying latent constructs. Specific objectives for the CFA analysis can be found in Methods.

Research Question and Hypothesis

The COVID-19 pandemic presents a critical threat to health globally and the associated lockdown restrictions have had an all-encompassing influence on how we live. As seen in the research literature, the pandemic has had a significant impact sleep quality, mood, loneliness which are critical for physical and mental health. This study used a latent dataset from the 'Sleep and Well-being during COVID-19 Pandemic Restrictions Survey' (Gibson et al., 2022) conducted in April and May, 2020 during NZ's first lockdown. The original dataset had approximately 80% female participants and was part of a cross-cultural research project. This study worked with the strength of the dataset, and focused on a group of interest, namely female workers, which is usually underrepresented in research. To date, limited research has been conducted in NZ examining how the social and physical lockdown restrictions impacted sleep and well-being specifically for female workers. There is also an important gap in the broader literature examining the predictive relationships between loneliness, mood and sleep quality during the COVID-19 lockdown.

The main research question was; how did the COVID-19 lockdowns impact sleep, mood and loneliness in working women in NZ and was there a predictive relationship between mood, loneliness on subjective sleep quality? The aims were to;

- Provide insight into how social and physical restrictions impacted well-being in working females in NZ.
- Assess with structural equation modelling whether subjective sleep quality was moderated by mood and loneliness.

Based on existing research, it was hypothesised that:

- Indicators of anxiety, depression and loneliness would significantly predict self-reported sleep quality status during the COVID-19 lockdown for working women in NZ and have a positive relationship.

The measures of subjective sleep quality, mood and loneliness used in the survey were all well used and validated measures across different ages and populations. However, part of the aim with this study was also to assess, via confirmatory factor analysis, how these measures performed during a unique situation like the COVID-19 lockdown. Specific predictions on how these measures will perform can be found in Methods. The statistical methodology used in this study (SEM), takes the approach of hypothesis testing of causal processes between latent variables (i.e., anxiety, depression, loneliness and sleep quality) and structural theories of relationships between observed and latent variables (Byrne, 2010).

To answer the research question, this study will first describe the self-reported living status, sleep, mood and loneliness among working female participants taking part in a research survey during the first COVID-19 lockdown in NZ. Secondly, it will assess the factorial validity of the key measures and whether the models underlying the scales explains the observed responses in the sample. Lastly, to test the hypothesis of whether the levels of self-reported loneliness, anxiety and depression during the COVID-19 confinement were predictive of poor sleep quality, a full structural equation model was run. Specifically, did anxiety, depression and loneliness predict the PSQI latent variable 'sleep quality' in NZ working woman during the COVID-19 lockdown. To determine whether this prediction was supported, the regression estimates needed to be statistically significant ($p < 0.05$), have positive relationships between the individual predictors (anxiety, depression, social loneliness, emotional loneliness) and the outcome variable (self-reported sleep quality status), and the relationships to have a small effect (0.10).

Method

Participants and Procedure

Participants were drawn from an extant dataset, Sleep and Well-being during COVID-19 Pandemic Restrictions Survey (Gibson et al., 2022), which was collected online via Qualtrics ™. The online survey was launched on the 11th April 2020 during the first COVID-19 lockdown in NZ and covered Level 4 and 3 (Appendix A). The survey concluded after four weeks at the end of Level 3 lockdown. The self-report survey asked participants to complete an anonymous 57- item survey with a mixture of fixed-choice items and open-ended questions of their estimate pre-pandemic and during lockdown health and behaviours. They had to be able to read English, have the ability to provide informed consent, reside in NZ and be aged 18 years or older. Anyone younger was prohibited through Qualtrics settings and no remuneration was paid to the participants. The survey took a median 24.9 minutes to complete (Gibson et al., 2022). The survey was advertised in NZ via a press release, national television and radio, and through the Sleep Wake Research Centre and Massey University online channels e.g. social media and newsletters. The study was cross-sectional where participants were not randomly assigned to treatment and no blinding was involved. Of the 1,120 initial responses a total of 723 (65%) participants were included in the original dataset after cross-checking for validity of the data.

Ethical Considerations

The original study by Gibson et al. (2022) was approved by Massey University Northern Ethics Committee (NOR 20/14). Participation in the survey was voluntary and anonymous. The first item on the survey was an implied consent item, where only by clicking on the arrow could the online survey continue to the questions. To respect privacy and confidentiality, the survey was designed to avoid collecting any identifiable data. The

participants were informed that their anonymised survey responses would become available for other researchers to use within the original intentions of the study (i.e., sleep and well-being associated with the pandemic). Considerations to minimise harm, justice and deception and Te Tiriti o Waitangi had been assessed, addressed and approved. Upon signing a confidentiality agreement, the author of present study was given access to the dataset by one of the lead researchers of the original study, Dr Rosemary Gibson. To respect privacy and confidentiality, there were no identifiable data and the participants' anonymity was maintained.

The Measures

The broad 57-item survey included questions of demographics information (e.g., age, gender, ethnicity, education, living, working and family status), pre- and during pandemic sleep timing and sleep quality, mood, health status as well as social behavioural activities. This can be found in full in Appendix A. The options included tobacco products, beer, wine, liquor, tea, coffee and caffeinated soft drinks. An example was Question 49 *"Do you currently consume any of the following and if so, how much per week?*

The survey also included single-item indicators asking if sleep quality (Q48) and well-being (Q56) had got better, unchanged or got worse since the beginning of the COVID-19 lockdown restrictions. Question 55, a single-item measure of loneliness from the General Social Survey (Stats NZ, 2022a), asked how much during the past week the participants had felt lonely. The answers were converted into binary results, where 0 = *None or almost none of the time* and 1 = *Some of the time, Most of the time, All or almost all of the time*. The 57-item survey can be seen as a whole in Appendix A. This present study focused only on the demographic information as well as sleep quality, mood and loneliness during the COVID-19 lockdown.

For the present study, the main outcome variable was the Pittsburgh Sleep Quality Index (Buysse et al., 1989), a 19-item scale assessing self-reported sleep disturbances over the past month during the COVID-19 lockdown. The items from PSQI were calculated into seven component scores; sleep duration, habitual sleep efficiency, sleep latency, use of sleep medications, daytime dysfunction, sleep quality and sleep disturbances. An example was PSQI item 6 "*During the past month, how would you rate your sleep quality overall?* 0= *Very good*, 1= *Fairly good*, 2= *Fairly bad*, 3= *Very bad*. The PSQI assigns ordinal scores to quantitative information to generate component scores and a single global score. Each component was weighted equally on a 0-3 scale. Items from the PSQI was summed to a global score from 0 ('no sleep problem') to 21 ('severe sleep problem'). A global PSQI score > 5 indicate participants were 'poor sleepers' and had severe difficulties in at least two areas or moderate difficulties in more than three areas (Buysse et al., 1989). The PSQI measure had been validated in a pre-pandemic context and had good internal reliability ($\alpha = 0.83$; Buysse et al., 1989).

The Hospital Anxiety and Depression Scale (Zigmond & Snaith, 1983), a 14-item scale was used to assess mood and was treated as a predictor variable. The anxiety and depression subscales each had 7-items. Participants were asked to tick the reply that was closest to how they felt the past week. The responses were recorded on a 4-point Likert-type scale. An example is HADS anxiety subscale item 1 (A1) *"I feel tense or 'wound up'"*, 0 = *Not at all*, 1= *From time to time*, 2 = *A lot of the time*, 3 = *Most of the time*. Items were summed to subscale scores for anxiety and depression ranging from 0 to 21 where scores ≥ 8 indicated 'as borderline' or 'as heightened risk' (Zigmond & Snaith, 1983). The measure had high internal consistency and interrelatedness between the items ($\alpha = 0.82 – 0.83$) (Bjelland et al., 2002).

The de Jong Gierveld's short loneliness scale (de Jong Gierveld & van Tilburg, 2010), a 6-item version, was treated as a predictor variable. The social loneliness and emotional loneliness subscales had three positively and three negatively worded items. Participants were asked to indicate the extent to which each of the loneliness-related statements applied to their situation during the COVID-19 Lockdown. The responses were recorded on a 3-point Likert-type scale. For example item 1 (GLS-1): "*I experience a general sense of emptiness*", 1= *Yes*, 2= *More or less* 3= *No*. In the emotional loneliness subscale, answers '*Yes*' or '*More or less'* =1 to GLS items 1, 2, 3 and in the social loneliness scale, answers '*No*' or '*More or less'* = 1 to GLS items 4, 5, 6. The items were summed to a global score of loneliness (0-6) where scores ≥ 2 indicated overall loneliness. The subscales of emotional and social loneliness were summed to subscale scores (0-3) where scores ≥ 1 indicated social or emotional loneliness. The GLS-6 measure had good internal consistency (α = 0.70 - 0.76; de Jong Gierveld and van Tilburg, 2010).

Sample Size and Rationale of Current Dataset

This present study had different aims than Gibson et al. (2022), and asked a different question of the original study focusing specifically on working women in NZ. Working women were defined as participants who identified as female, and their employment status before the COVID-19 lockdown was either working full-time, part-time or self-employed or contractor. To test the hypothesis in the present study, CFA and SEM analyses were utilised (see further information below in Statistical Methodology). These methods are sensitive to sufficient sample size as it affects the precision and how replicable the results are. The goal was therefore to have enough power to detect a mis-specified model as well as detecting a target effect. Unlike statistical methods such as ANOVA and Multiple regression, a single a priori power analysis for SEM is more difficult due to the flexibility of SEM as well as the

model complexity (Wang & Rhemtulla, 2021). As a consequence, this present study followed Boomsma and Hoogland (2001)'s guideline of a minimum sample size of 200. After applying exclusion criteria, this study had 498 (*N*= 498) participants that were working women in NZ. See exclusion criteria with further details below.

Statistical Methodology

Structural equation modelling was used to examine whether there were predictive relationships between mood and loneliness on subjective sleep quality as well assess the performance of the main scales in a COVID-19 pandemic context.

Structural Equation Modelling

SEM is a statistical methodology that tests proposed causal relations by a series of regression equations while accounting for measurement error. These structures are modelled graphically to conceptualise the theory and processes under study (Byrne, 2010). A hypothesised model can be tested statistically to determine how consistent it is with the data; such that if the model displays an adequate goodness-of-fit then the model supports the plausibility of the hypothesised relationships. What distinguishes SEM from other statistical methodologies is it differentiates between observed and latent variables, and explicitly models and accounts for the effects of measurement error (Kline, 2016). Other statistical methods (i.e., ANOVA or logical regression) make rigid assumptions, such as only random measurement errors exist in the dependent variables, which can produce biased estimates of the relationships. SEM estimates the error variance parameters for both the independent and dependent variables and relies on the researcher to have a theoretical base for the models (Byrne, 2010).

SEM encompasses a group of procedures rather than a single statistical technique. Confirmatory factor analysis focuses on the extent to which the observed variables are connected to the underlying latent variable and the strength of the regression paths from the factor to the observed (measured) variables. A full latent variable model focuses on the hypothesised impact of a latent variables construct (i.e., anxiety, depression, loneliness) on another latent variables (i.e., sleep quality) modelling a causal direction. It is important to emphasise that a well-fitting model does not infer causation between hypothesised relationships or that the model is proven. The most that can be concluded is whether the model is consistent with the data and if it supports the direction of the relationship. Furthermore, it is important to consider the theoretical foundations of the constructs and not only evaluate the best-fitting model (Byrne, 2010).

To answer the main research question, this present study therefore used a two-step process to examine the relationships between the main variables: Firstly, it conducted confirmatory factor analyses on the key measures (i.e., PSQI, HADS, GLS-6) to assess how well the measurement models fitted the sample within a pandemic context, and compared different levels of factor structures to assess the best fit. Secondly, the CFA measurement models were used in a full latent variable model to estimate whether the latent constructs of mood and loneliness predicted the latent construct of subjective sleep quality. The following section provides an overview of the factor constructs underlying each of the measures to provide context for the analysis and as a theoretic rationale for testing and comparing certain models.

Review of Measurement Models

Review of PSQI Factor Structure

The PSQI is one of the most widely used and popular sleep assessment tools in both research and clinical settings. As highlighted above, Buysse et al. (1989) developed the measure by asking participants 19 questions relating to their usual sleep habits during the last month. The factor structure proposed by Buysse et al. (1989) is unidimensional (interchangeably referred to as a one-factor structure) and consists of seven components. The questionnaire was originally derived from empirical and clinical origins and therefore had limitations as it was not tested statistically with an exploratory factor analysis and CFA as recommended by Kline (2016). However, other studies with large sample sizes have supported a PSQI unidimensional model using CFA (Manzar et al., 2018).

Manzar et al. (2018) conducted a systemic review of the PSQI factor structure showing 30 distinct PSQI models have been proposed in the literature, hereof: Seven unidimensional, 17 two-factor, four three-factor, one four-factor and two second-order models. They appraised the methodologies of 45 studies investigating the PSQI factor structures and found the majority of the studies had significant methodological issues. The shortcomings included non-application of the parsimony principle, non-use of either EFA or CFA or not reporting relevant details, not employing multiple 'goodness of fit' indices from different categories and lack of generalisability due to small sample sizes. This limited how applicable the factor studies were and warranted the need for further validation. Manzar et al. (2018) proposed a set of guidelines to manage these methodological shortcomings in future studies. Jia et al. (2019) used these guidelines when they examined the PSQI structure validity in a large non-clinical sample. Jia et al. (2019) first employed an exploratory factor analysis followed by a CFA. They found the PSQI three-factor model (e.g., sleep efficiency, sleep latency and sleep

quality) provided a superior fit to the commonly used one-factor structure proposed by Buysse et al. (1989).

The present study therefore conducted a CFA testing Jia et al. (2019)'s PSQI three-factor model in comparison to a CFA of the original unidimensional model as well as a higher-order PSQI model which incorporated the three-factor model. Testing these models on the NZ female workers dataset would help determine how well the PSQI measure performed in a special population as well as in a unique pandemic context.

Review of HADS Factor Structure

Zigmond and Snaith (1983) developed the Hospital Anxiety and Depression Scale to measure psychological distress and to identify anxiety and depression among patients in nonpsychiatric hospital clinics. The HADS two-factor model consists of 14 items split across anxiety and depression subscales with a four-point ordinal response format. Bjelland et al. (2002) reviewed the validity of the HADS structure analysing 747 studies. They found that most of the research supported a two-factor model in accordance with Zigmond and Snaith (1983)'s subscales. Caseness was defined by scores ≥ 8 on both anxiety and depression (Herrmann 1997).

Dunbar et al. (2000) tested Clark and Watson (1991)'s 'tripartite theory' of anxiety and depression that suggested there are three underlying factors; negative affectivity, ahedonic depression and autonomic anxiety. Norton et al. (2013) conducted a meta-CFA on the HADS structure based on 21 studies and identified ten different factor structures. They ran meta-CFA on 28 samples (N= 21,820) and found that Dunbar et al. (2000)'s three-factor model was superior to Zigmond and Snaith (1983) two-factor structure. This present study therefore conducted CFAs on HADS testing these the two and three-factor models on the dataset and compared their model fit.

Review of GLS-6 Factor Structure

Gierveld and Tilburg (2006) developed the de Jong Gierveld Loneliness Scale to measure the overall emotional and social loneliness latent constructs. The original 11-item scale was shortened to a 6-item scale with three items in each subscale for use in large surveys. De Jong Gierveld and van Tilburg (2010) conducted CFA of the shortened GLS-6 scale in seven countries (*N*= 69,749) in the UN Generations and Gender Survey. Although the correlations between the items differed across countries and age-groups varied, the results supported the GLS-6 two-dimensional model of loneliness. This study therefore conducted CFA testing a unidimensional model and the Gierveld and Tilburg (2006)'s two-factor model on the dataset and compared the model fit.

Measurement Model Predictions

Based on the existing literature and the reviews of the main measurement models it was predicted that:

1. The confirmatory factor validity of the PSQI higher-order-model and the PSQI three-factor model would have a superior fit to the original PSQI unidimensional model.
2. The confirmatory factorial validity of the HADS three-factors model proposed by Dunbar et al. (2000) would have a superior fit compared to the HADS two-factor model proposed by Zigmond and Snaith (1983).
3. The confirmatory factor validity of the GLS-6 two factors model would have a superior fit compared to a GLS-6 unidimensional model.

To determine whether the predictions were supported, the fit indices (RMSEA, CFI and TLI) of the specified models would have to be statistically significant ($p < 0.05$) and have a superior fit to the competing models (closer to RMSEA < 0.06, CFI > 0.95, TLI > 0.95) (Byrne, 2010; Hu & Bentler, 1999). See Estimation Method and Model Fit Index section

below for justification of these criteria. The full structural equation model of the relationship between anxiety, depression, social and emotional loneliness predicting subjective sleep quality, was designed based on the model fit from these CFA analyses as well as considering the theoretical foundations of the constructs.

Data Analysis

The statistical data analysis consisted of several steps. Firstly, descriptive statistics were conducted calculating frequencies, means and standard deviations and Cronbach's alpha of the main variables in this study. Secondly, to test the assumptions of the structural equation models, the normality of the main variables was examined calculating the skewness and kurtosis which were presented in a table as well as histograms. Thirdly, CFA of the main measures was conducted to test how well the models fitted the data. Lastly, a full latent variable model was used to test the main hypothesis whether mood and loneliness predicted subjective sleep quality status. All descriptive statistics were conducted in IBM SPSS statistics version 28.0 (IBM Corporation, Released 2021) for Macintosh and the structural equation modelling were conducted in Amos version 28 (Arbuckle, 2021). The PSQI, HADS and GLS-6 were all treated as continuous variables.

Exclusion Criteria

This study only included participants who identified with being female and if their employment status before the COVID-19 pandemic was working full-time, part-time or self-employed or contracting. Participants who answered their work status was both full-time, part-time or self-employed were recoded to 'multiple roles'. All demographic and PSQI questions were mandatory. The missing data from participants who did not respond to any of the HADS and loneliness questions was estimated by Full Information Maximum Likelihood

based on all the observed data. This Full Information Maximum Likelihood estimation method assumed the missing values to be at least Missing at Random (Cham et al., 2017). The Full Information Maximum Likelihood approach has been shown to produce unbiased standard errors and parameter estimates compared to other estimation methods (Enders & Bandalos, 2001).

Internal Consistency Reliability

The internal consistency reliability was assessed by Cronbach's alpha coefficient on HADS, PSQI and GLS-6 measures. The seven component PSQI measure contained a relatively small number of items in each component. The Cronbach's alpha coefficient was therefore only calculated for the PSQI global score. The Cronbach's alpha coefficient was calculated for the HADS anxiety and depression subscales. Although the GLS-6 measure only contains three items for each social loneliness and emotional loneliness subscales, the Cronbach's alpha coefficient was calculated for them both. The purpose of assessing the Cronbach's alpha and the internal consistency was to measure the degree of interrelatedness among the items of the scales. This is not to be confused by homogeneity, which refers to unidimensionality (Cortina, 1993). Cortina (1993) argued that internal consistency is a necessary but not a sufficient condition for homogeneity. Items can therefore be moderately interrelated and multidimensional at the same time.

Assumptions of Structural Equation Models

The main assumption of SEM is multivariate normality for the continuous outcome variables which means that the individual univariate distributions of the variables should be normal (Kline, 2016). Non-normal distribution can affect Type-1 errors and power, and therefore impact the inferences that can be drawn from these statistical analyses. To assess

the normality of the main variables, the skewness and kurtosis were reported as well histograms for visual inspection. There are few clear-cut standards for interpreting absolute skewness and kurtosis values. Kline (2016) described values > 3.0 as severely skewed, and values from 8.0 - 20.0 as indicating severe kurtosis and therefore problematic. Lei and Lomax (2005) argued skewness values between 0.3 and 0.4 and kurtosis around 1.0 indicate a slight nonnormality, and skewness above 0.7 and kurtosis values above 2.3 as severe non-normality. This present study adopted the approach and indicators as recommended by Kline (2016) and included visual inspection of the histograms. Another assumption of SEM is to base the analysis on large sample sizes where the rule of thumb is a minimum of 200 to create a robust model (Barrett, 2007; Byrne, 2010). This present study met this assumption by using a dataset of 498 participants.

Estimation Method and Model Fit Indices

The estimation method for the CFA and SEM was Maximum Likelihood and as highlighted above, it assumed multivariate normality of the observed variables and required sample sizes larger than 200 (Byrne, 2010). There is an emphasis on global fit testing in SEM with many fit statistics available, a variety of recommended thresholds for 'goodness of fit' and no consensus how to best test the models (Hu & Bentler, 1999).The following 'goodness of fit' indices were used in this present study to determine the adequacy of the hypothesised models. The Comparative Fit Index (CFI; Bentler, 1990) is an incremental fit index that measures the relative improvement in fit between the hypothesised model and an independence model. CFI range from 0 to 1 where values close to 0.95 indicate a well-fitting model which was revised from 0.90 as representing a good model fit (Hu & Bentler, 1999). Like the CFI, the Tucker-Lewis Index (TLI; Tucker and Lewis, 1973) is a non-normed fit index ranging from 0 to 1 where values close to 0.95 is recommended as a representative of a well-fitting model (Hu & Bentler, 1999). The Root Mean Square Error of Approximation

(RMSEA) is an absolute fit index which estimates the "error of approximation in the population" (Byrne, 2010, p. 80). The RMSEA values express the degree of error involved in the model relative to its complexity i.e., number of degrees of freedom. Hu and Bentler (1999) suggested that a RMSEA value less than 0.06 indicate a good fit, and MacCallum et al. (1996) proposed values ranging from 0.08 - 0.10 indicating a mediocre fit and greater than 0.10 a poor fit. This present study used a RMSEA < 0.06 as indicating a good fit. To assess the precision of RMSEA estimates, a 90% confidence interval was reported where a narrow confidence interval indicated a good precision of the RMSEA.

Extreme Collinearity

Extreme collinearity can occur when it appears that the independent variables measure the same underlying construct, and the estimated correlation is so high that they appear not to be distinct (Kline, 2016). This can be problematic because the goal of regression analysis is to isolate the individual relationships between the independent and dependent variable. This can make it difficult to reliably estimate the individual regression coefficients and therefore cause problems with model fit and interpreting the results. To detect possible multicollinearity, a review of the standardised estimates output can reveal a substantial overlap between two variables if the estimated correlation is greater than 1.00 (Byrne, 2010).

This present study found indications of extreme collinearity between the factors PSQI1: Sleep Duration and PSQI2: Habitual Sleep Efficiency with an estimated correlation > 1.00 (see Appendix B for abbreviations of the measures and factors). This problem is referred to as a 'Heywood case' (Kline, 2016). This can be caused by having only two indicators per factor in a latent variable model combined with a small sample (Chen et al., 2001). To avoid serious model mis-specifications, the variance on the latent variable 'Sleep Efficiency' was therefore fixed to 1 (See Figure 2). Furthermore, a common constraint labelled 'aaa' was

placed on both indicator paths (e.g., PSQI1: Sleep Duration and PSQI2: Habitual Sleep Efficiency) to force them to be equal when unstandardised. This adjusted the indicator paths when standardised and avoided model mis-specification (Byrne, 2010).

Post Hoc Modifications of the Models

This present study did not conduct post hoc modifications to the measurement models or the full structural model as this would pose a risk of overfitting the model to that data, such that the estimates of the model would be biased (Babyak, 2004). This can be problematic as overfitted models have been shown to fail replication on different samples, which therefore creates uncertainty of the validity of research findings (Babyak, 2004; Hussey & Hughes, 2020).

Results

Descriptive Statistics

The original NZ dataset (Gibson et al., 2022) had 723 participants of which 595 were female (82.3%). After applying the exclusion criteria, a total of 498 (*N*= 498) NZ woman who were working prior the COVID-19 lockdown and with mean age of 44.6 years (*SD*= 12.6, Range= 21-83) were included in this study. Of these, 63.5% were working full-time, 24.5% part-time, 9% were self-employed / contracting and 3% had multiple work roles prior to the COVID-19 lockdown. The majority of the sample were NZ European (65.5%), had tertiary level education (79.3%) and reported their health was very good- excellent (69.9%). Almost half of the participants (47.4%) reported living alone. For a detailed description of this sample, including items outside of the scope of the present study, see Table C1 in Appendix C.

During lockdown, 54.8% of the participants were identified as 'poor sleepers' (i.e., scoring > 5 on PSQI Global). Almost half of the participants (45.5%) reported their sleep quality was worse than at the beginning of the COVID-19 restrictions and 30.6% rated their sleep as unchanged. It also found that 23.9% rated their sleep as better since the beginning of the lockdown.

Participant's HADS scores indicated that 42.4% scored within the range of anxiety and 31% of depression (i.e., scoring > 8 on the scale of HADS). Almost half of the participants (46.2%) rated that their general well-being and mood had changed for the worse since the beginning of the COVID-19 restrictions, and 16.4% reported better mood. High levels of loneliness (i.e., ≥ 2 on GLS-6 global loneliness scale) were reported by 47.3% of the participants with 52.7% reporting feeling socially lonely and 89.3% emotionally lonely (i.e., scoring ≥ 1 on GLS-6 subscales). Over half the participants (51%) rated that they felt lonely 'some of the time or more' during the past week on the single-item indicator.

The means, standard deviations and indicators of the normality of distribution (skewness and kurtosis) of the main variables involved in the study is displayed in Table 1.

Table 1 *Means, Standard Deviations, Kurtosis and Skewness of the Main Variables*

	N	%	*M*	*SD*	*Skewness*	*Kurtosis*	*Cronbach's Alpha*
PSQI Global	498	100%	6.63	3.55	0.86	0.61	0.719
HADS- Depression	490	98.3%	6.03	3.79	0.72	0.34	0.858
HADS- Anxiety	490	98.3%	7.29	4.38	0.63	-0.024	0.785
GLS-6 Emotional Loneliness	486	97.6%	1.52	0.89	0.18	-0.77	0.397
GLS-6 Social Loneliness	486	97.6%	1.15	1.253	0.48	-1.457	0.828

PSQI Global: Pittsburgh Sleep Quality Index Global Score, HADS: Hospital Anxiety and Depression Scale, GLS-6: De Jong Gierveld Loneliness Scale- 6 item, *N*= Number of Participants *M*= Mean *SD*= Standard Deviation

The skewness of the main variables ranged from 0.18 to 0.86 and kurtosis ranged from 1.46 to 0.61 (Table 1). For a detailed distribution of the main variables of this sample, see histogram plots in Figures C1 – C5, Appendix C. The range of skewness and kurtosis along with a visual inspections of the variables' distribution indicated that most were close to normal distribution. Based on Kline (2016)'s skewness and kurtosis cut-off scores, the results indicated that the shape of the distributions were normal (e.g., skewness values < 3.0, kurtosis < 8.0) for all the variables. The assumption of multivariate normality for SEM analysis was therefore met.

The Cronbach's alpha for the PSQI global ($\alpha = 0.72$) suggested good internal reliability despite being lower than Buysse et al. (1989)'s findings ($\alpha = 0.83$). The Cronbach's alpha for the HADS subscales (HADS-A mean 0.83, HADS-D mean 0.82) were similar to Bjelland et al. (2002)'s findings pre-pandemic. This suggested that HADS had a high level of internal consistency and reliability for both anxiety and depression subscales. The Cronbach's alpha for GLS-6 suggested that the internal consistency and reliability for the social loneliness was high (0.83) and the emotional loneliness was low (0.40) compared to Gierveld and Tilburg (2006) reliability finding in a pre-pandemic context.

Results of Confirmatory Factor Analyses

The CFA results of all the model fit indices are displayed in Table 2. The best fitting CFA models are presented in below sections, and the CFA models which had a poorer fit and their factor loadings can be found in Appendix D.

Table 2 *Model Fit Indices from CFA Results*

	SB(χ2)	*Df*	RMSEA (90% C.I.)	CFI	TLI
PSQI One-factor model	211.70***	14	0.17 (0.15, 0.19)	0.73	0.60
PSQI Three-factor model	79.65***	12	0.11 (0.09, 0.13)	0.91	0.84
PSQI Higher-order model	79.65***	12	0.11 (0.09, 0.13)	0.91	0.84
HADS Two-factor model	258.62***	76	0.07 (0.06, 0.08)	0.93	0.90
HADS Three-factor model	190.96***	74	0.06 (0.05, 0.07)	0.96	0.94
GLS-6 Unidimensional model	85.40***	9	0.13 (0.11, 0.16)	0.89	0.74
GLS-6 Two-factor model	34.92***	8	0.08 (0.06, 0.11)	0.96	0.89

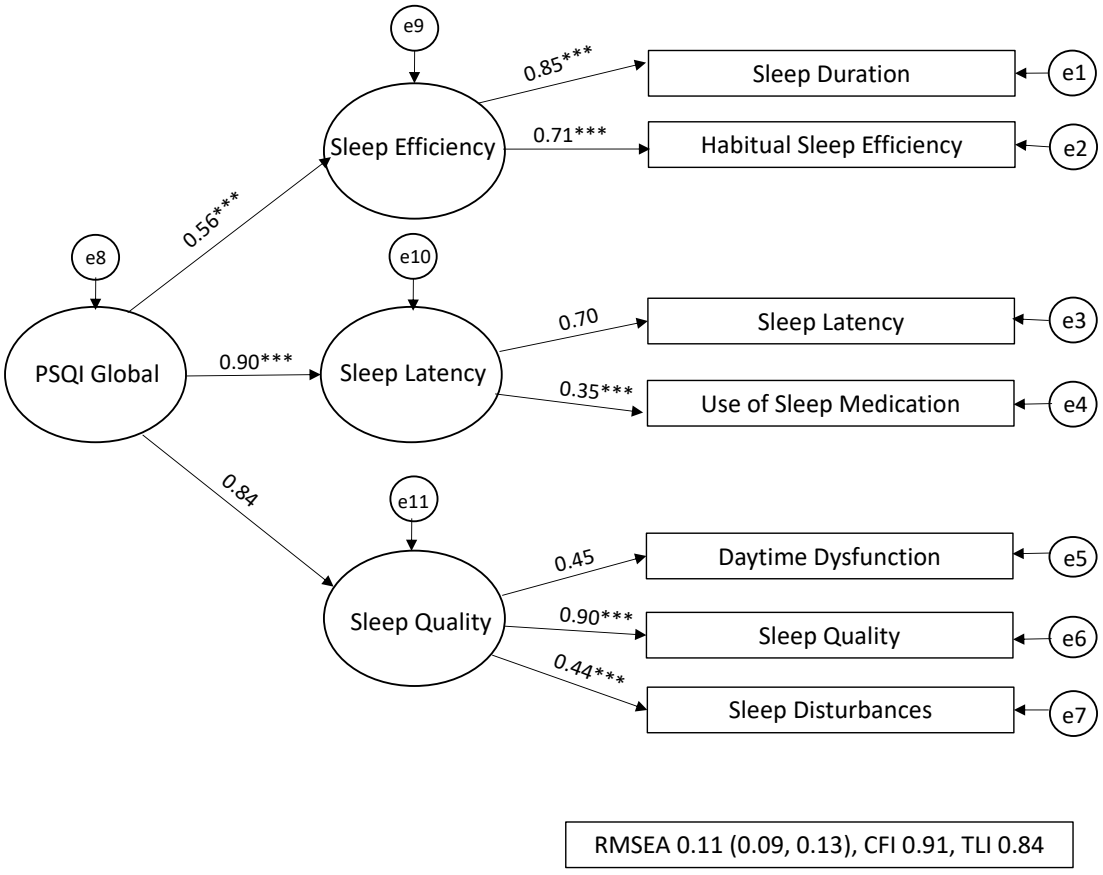
PSQI Global: Pittsburgh Sleep Quality Index, HADS: Hospital Anxiety and Depression Scale, GLS-6: De Jong Gierveld Loneliness Scale - 6 Item. SB(χ2): Chi-Square, Df: Degrees of freedom, RMSEA: Root-Mean-Square Error of Approximation, CFI: Comparative Fit Index, TLI: Tucker-Lewis Index. *p<0.05, **p<0.01, ***p<0.001

PSQI CFA

The PSQI one-factor model showed a poor fit to the data with RMSEA indices being greater than 0.10 (0.17) and both CFA and TLI well below 0.90 (0.73 and 0.60) (Figure D1, Appendix D). The standardised relationship between the single factor and the PSQI components ranged between 0.32 (PSQI4: Use of sleep medication) and 0.73 (PSQI6: Sleep quality) (Table D1, Appendix D). The hypothesised PSQI three-factor model proposed by Jia et al. (2019) was tested on the data with a CFI of 0.91 and TLI of 0.84, which showed an improved overall fit compared to the PSQI one-factor model (Figure D2, Appendix D). However, as the RMSEA fit indices were greater than 0.06 (0.11; CI: 0.09, 0.13 respectively) the threshold for an acceptable fit had been exceeded, indicating a poor fit. The relationship between the three factors and the item scores were 0.35 (PSQI4: Use of sleep medication on PSQI3: Sleep latency) and 0.90 (PSQI6: Sleep quality on PSQI global sleep quality). The correlation coefficients of the three factors ranged from 0.47 (medium correlation) to 0.76

(strong correlation). The PSQI higher-order model had identical fit indices results to the PSQI three-factor model which indicated a poor fit (Table 2). As the latter two models were identical in terms of fit indices and the PSQI higher-order model had a better theoretical fit with an overall PSQI global score, the higher-order model was therefore used in the SEM model to test the main hypothesis (see Figure 2). For a detailed description of the PSQI model fit indices, see Table D1 in Appendix D.

Figure 2 *PSQI Higher-Order Model with Standardised Path Coefficients*



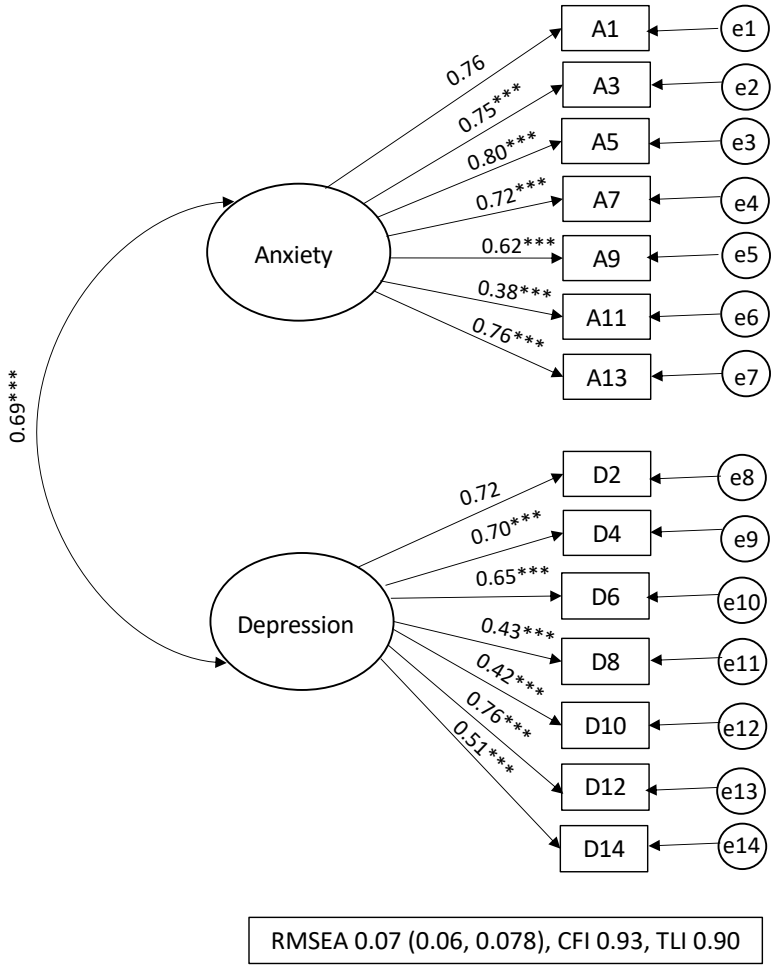
RMSEA*:* Root-mean-square error of approximation, CFI*:* Comparative Fit Index, TLI: Tucker-Lewis Index, PSQI Global: Pittsburgh Sleep Quality Index Global Score. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

HADS CFA

The HADS two-factor model by Zigmond and Snaith (1983) had a CFI of 0.93, TLI of 0.90 and RMSEA of 0.07 (Figure 3). The correlation between the two factors was 0.69,

indicating a strong association. The relationship between the HADS factors and the item scores were between 0.38 (A11: *I feel restless as I have to be on the move*) and 0.80 (A5: *Worrying thoughts go through my mind*). The HADS three-factor model proposed by Dunbar et al. (2000) had a superior fit to the HADS two-factor model; CFI of 0.95, TLI of 0.94 and RMSEA of 0.06 (Figure D3, Appendix D). This suggested the HADS three-factor model fitted the dataset well. The correlations between the three factors ranged from 0.56 - 0.88, indicating strong correlations, and the standardised loading of the items on the factors ranged from 0.38 - 0.81. However, as the theoretical constructs of the HADS two-factor model subscales (anxiety and depression) had a better fit with the intent of the study, this model was used in the structural equation model design. For a detailed description of the HADS model fit indices, see Table D2 in Appendix D.

Figure 3 *HADS Two-Factor Model with Standardised Path Coefficients*



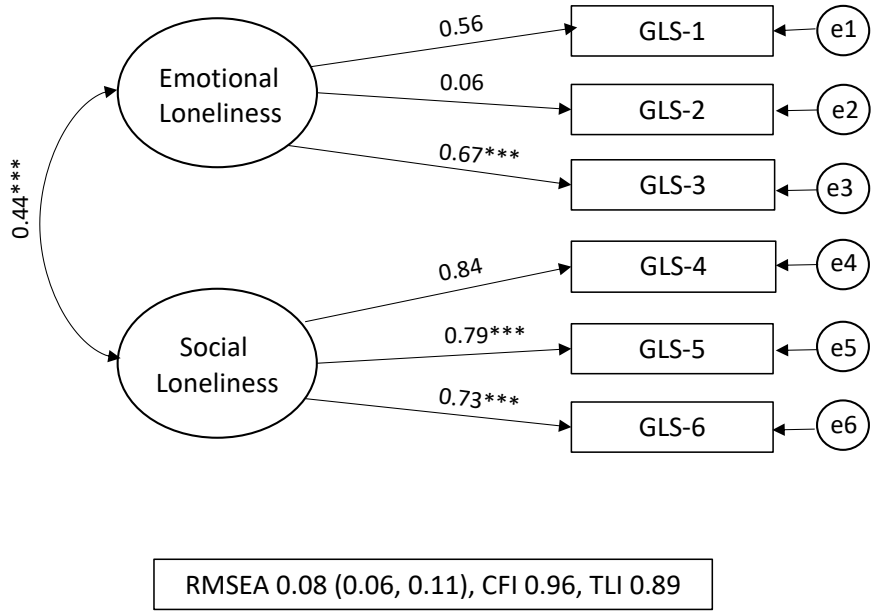
RMSEA*:* Root-mean-square error of approximation, CFI*:* Comparative Fit Index, TLI: Tucker-Lewis Index, A1: I feel tense or 'wound up', A3: I get a sort of frightened feeling as if something awful is about to happen, A5: Worrying thoughts go through my mind, A7: I can sit at ease and feel relaxed, A9: I get a sort of frightened feeling like 'butterflies' in the stomach, A11: I feel restless as I have to be on the move, A13: I get sudden feelings of panic, D2: I still enjoy the things I used to enjoy, D4: I can laugh and see the funny side of things, D6: I feel cheerful, D8: I feel as if I have slowed down, D10: I have lost interest in my appearance, D12: I look forward with enjoyment to things, D14: I can enjoy a good book or radio or TV program. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

GLS-6 Loneliness CFA

The GLS-6 two-factor model by de Jong Gierveld and van Tilburg (2010) had a CFI of 0.96, TLI of 0.89 and RMSEA of 0.08 indicating a poor fit (Figure 4). The GLS-6 unidimensional model showed an inferior fit compared to the GLS-6 two-factors model, with a CFI of 0.89, TLI of 0.74, RMSEA of 0.13 (Figure D4, Appendix D). The correlation

between the two factors was 0.44 which indicated a medium correlation. The standardised loading of the items on the GLS-6 two-factor model factors ranged from 0.06 (GLS2: *I miss having people around*) to 0.84 (GLS4: *There are plenty of people I can rely on when I have problems*). For a detailed description of the GLS-6 model fit indices, see Table D3, Appendix D.

Figure 4 *GLS-6 Two-Factor Model with Standardised Path Coefficients*



RMSEA*:* Root-mean-square error of approximation, CFI*:* Comparative Fit Index, TLI: Tucker-Lewis Index, GLS1: I experience a general sense of emptiness, GLS2: I miss having people around, GLS3: I often feel rejected, GLS4: There are plenty of people I can rely on when I have problems, GLS5: There are many people I can trust completely, GLS6: There are enough people I feel close to. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

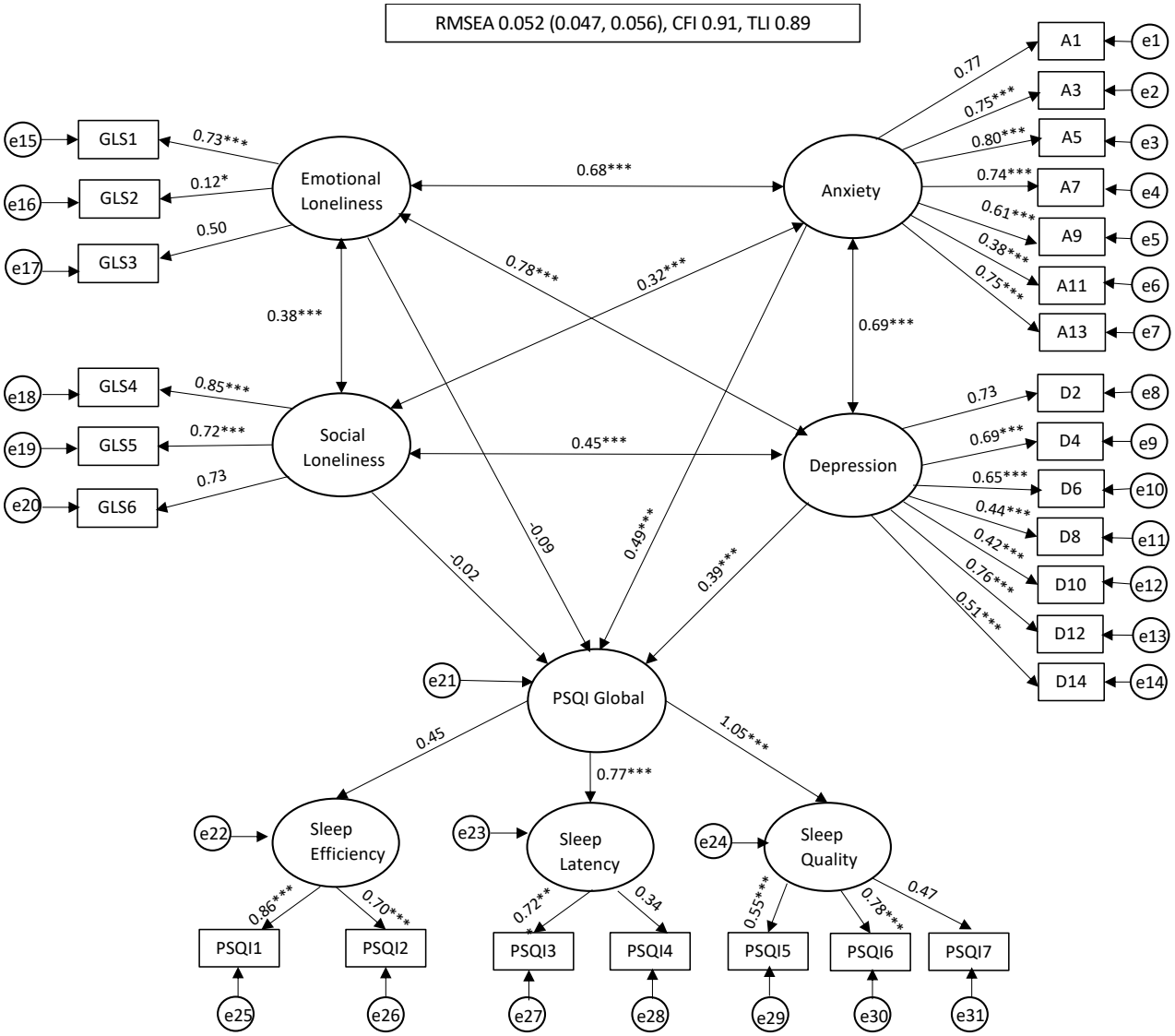
Results of Full Structural Equation Model

A structural equation model was run to test the hypothesis of this study, namely did loneliness and mood predict subjective sleep quality status for NZ female workers during the COVID-19 lockdown? The model showed there were significant positive relationships between anxiety and depression on global sleep quality, and they had medium effects;

Anxiety (*b* = .49), Depression (*b* = .39) (Figure 5). The model showed non-significant negative relationships between social and emotional loneliness on global sleep quality, and estimated small effects; Social Loneliness (*b* = -.02) and Emotional Loneliness (*b* =- .09). For a detailed description of the factor loadings for the full structural model, see Table 3. There were significant correlations between the loneliness and mood variables and the strength of the relationships ranged from 0.32 – 0.78 (Table D4, Appendix D).

The fit indices for the full structural model, CFI (0.91) and TLI (0.89), were below the acceptable cut-off scores (Table 4). The RMSEA fit index was found to be low (0.05, C.I. 90% 0.05, 0.06) which was within the recommended range, indicating a good fit to the data. The narrow confidence intervals indicated a good precision. As the RMSEA value expresses the degree of error in the model relative to its complexity, overall, this indicated that the full structural model had a good fit for a complex model of this type. The standardised factor loading of PSQI global on the latent variable Sleep Quality was 1.05, indicating an overlap between these the two variables. A common constraint of 'aaa' was placed on both indicator paths and the variance was fixed to 1, however a factor loading greater than 1 remained.

Figure 5 *Structural Equation Model of Loneliness and Mood on Sleep Quality*



RMSEA*:* Root-mean-square error of approximation, CFI*:* Comparative Fit Index, TLI: Tucker-Lewis Index, PSQI Global: Pittsburgh Sleep Quality Index Global Score, GLS1: I experience a general sense of emptiness, GLS2: I miss having people around, GLS3: I often feel rejected, GLS4: There are plenty of people I can rely on when I have problems, GLS5: There are many people I can trust completely, GLS6: There are enough people I feel close to, A1: I feel tense or 'wound up', A3: I get a sort of frightened feeling as if something awful is about to happen, A5: Worrying thoughts go through my mind, A7: I can sit at ease and feel relaxed, A9: I get a sort of frightened feeling like 'butterflies' in the stomach, A11: I feel restless as I have to be on the move, A13: I get sudden feelings of panic, D2: I still enjoy the things I used to enjoy, D4: I can laugh and see the funny side of things, D6: I feel cheerful, D8: I feel as if I have slowed down, D10: I have lost interest in my appearance, D12: I look forward with enjoyment to things, D14: I can enjoy a good book or radio or TV program, PSQI1: Sleep Duration, PSQI2: Habitual Sleep Efficiency, PSQI3: Sleep Latency, PSQI4: Use of Sleep Medication, PSQI5: Daytime Dysfunction, PSQI6: Sleep Quality, PSQI7: Sleep Disturbances. E1- e31: error. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

Table 3 Factor Loadings for the Full Structural Model

		est.
PSQI Global	<-- Depression	0.39***
PSQI Global	<-- Emotional Loneliness	-0.09
PSQI Global	<-- Social Loneliness	-0.02
PSQI Global	<-- Anxiety	0.49***
Sleep Efficiency	<--PSQI global	0.45
Sleep Latency	<--PSQI global	0.77***
Sleep Quality	<--PSQI global	1.05***
PSQI1: Sleep duration	<-- Sleep Efficiency	0.86***
PSQI2: Habitual sleep efficiency	<-- Sleep Efficiency	0.70***
PSQI3: Sleep latency	<-- Sleep Latency	0.72***
PSQI4: Use of sleep medication	<-- Sleep Latency	0.34
PSQI5: Daytime dysfunction	<-- Sleep Quality	0.55***
PSQI6: Sleep quality	<-- Sleep Quality	0.78***
PSQI7: Sleep disturbances	<-- Sleep Quality	0.47
GLS1: I experience a general sense of emptiness	<-- Emotional Loneliness	0.73***
GLS2: I miss having people around me	<-- Emotional Loneliness	0.12*
GLS3: I often feel rejected	<-- Emotional Loneliness	0.50
GLS4: There are plenty of people I can lean on when I have problems	<-- Social Loneliness	0.85***
GLS5: There are many people I can trust completely	<-- Social Loneliness	0.72***
GLS6: There are enough people I feel close to	<-- Social Loneliness	0.73
A1: I feel tense or 'wound up'	<-- Anxiety	0.77
A3: I get a sort of frightened feeling as if something awful is about to happen	<-- Anxiety	0.75***
A5: Worrying thoughts go through my mind	<-- Anxiety	0.80***
A7: I can sit at ease and feel relaxed	<-- Anxiety	0.74***
A9: I get a sort of frightened feeling like 'butterflies' in the stomach	<-- Anxiety	0.61***
A11: I feel restless as I have to be on the move	<-- Anxiety	0.38***
A13: I get sudden feelings of panic	<-- Anxiety	0.75***
D2: I still enjoy the things I used to enjoy	<-- Depression	0.73
D4: I can laugh and see the funny side of things	<-- Depression	0.69***
D6: I feel cheerful	<-- Depression	0.65***
D8: I feel as if I am slowed down	<-- Depression	0.44***
D10: I have lost interest in my appearance	<-- Depression	0.42***
D12: I look forward with enjoyments to things	<-- Depression	0.76***
D14: I can enjoy a good book or radio or TV programs	<-- Depression	0.51***

PSQI Global: Pittsburgh Sleep Quality Index Global Score, HADS: Hospital Anxiety and Depression Scale, GLS-6: De Jong Gierveld Loneliness Scale-6 item, $*p < 0.05$,$**p < 0.01$, $*** p < 0.001$

Table 4 *Model Fit Indices for the Full Structural Model*

	SB(χ2)	*df*	RMSEA (90% C.I.)	CFI	TLI
Full Structural Model	724.057***	312	0.052 (0.047, 0.056)	0.911	0.892

SB($\chi 2$): Chi-Sqaure, df: degrees of freedom, RMSEA: Root-mean-square error of approximation, CFI: Comparative fit index, TLI: Tucker-Lewis Index. $*p < 0.05$,$**p < 0.01$, $*** p < 0.001$

Discussion

This present study examined how the COVID-19 lockdown impacted mood, loneliness and subjective sleep quality of NZ working women, with specific emphasis on whether the first two variables were predictive of the third. NZ endured strict social restrictions despite the infection rates remained low therefore, the stress of becoming infected could more easily be delineated from the stress associated with the lockdown restrictions. This is in contrast to most international studies where lockdowns and high infection rates coincided. To the author's knowledge, this is also the first study to examine the predictive relationship between sleep, mood and loneliness during lockdown in NZ.

Summary of Thesis Purposes, Predictions and Attainment Criteria

The purpose of this study was two-fold: Firstly, to examine how the COVID-19 lockdown affected sleep, mood and loneliness in working women in NZ; secondly, to test the hypothesis of whether mood and loneliness during the lockdown were predictive of subjective sleep quality. To the test this hypothesis, CFA was first used to assess how the key measurement models performed on the sample and in this unique COVID-19 pandemic context. Secondly, the CFA measurement models were used in a full structural model to test if the latent constructs of mood and loneliness predicted the latent construct of sleep quality. Based on the literature review of the measurement models, it was predicted that; 1. the PSQI higher-order-model and the PSQI three-factor model would be superior to the original PSQI unidimensional model; 2. the HADS three-factor model would have a superior fit compared to the two-factor model; 3. the GLS-6 two-factor model would have a superior fit compared to a unidimensional model.

To determine whether the main hypothesis was supported, the regression estimates needed to be statistically significant ($p < 0.05$), have positive relationships between the

individual predictors (anxiety, depression, social loneliness, emotional loneliness) and the outcome variable (subjective sleep quality), and have a small effect (0.10). To determine whether the three CFA predictions were supported, the fit indices of the specified models needed to be statistically significant ($p < 0.05$) and have a superior fit to the competing models (closer to RMSEA < 0.06, CFI > 0.95, TLI > 0.95). Statistical fit as well as theoretical fit were considered.

Summary and Interpretations of Results

How was Subjective Sleep Quality Affected by the COVID-19 Lockdown?

The COVID-19 lockdown restrictions and the subsequent disruptions to social and personal routines provided challenges in personal and work life. For many, the acute stress of juggling work from home, increased domestic duties, as well as providing childcare may have compromised their sleep. This present study found that 45.5% of the NZ female workers reported that their sleep quality worsened since the beginning of the COVID-19 lockdown. This is in line with previous research following large-scale disasters (Bailey, 2006; North et al., 1999), and also comparable to other COVID-19 research examining the impact on subjective sleep quality (Alimoradi et al., 2022; Jahrami et al., 2021).

Most international research has focused on the negative impacts of COVID-19 on sleep quality. However, for some, sleep quality improved. Few studies have reported on this or discussed the potential (Trakada et al., 2020). This present study found that 23.9% of the participants had improved sleep quality since the start of the lockdown. For some, this may be attributed to less social demand and more flexible work and life schedules. This would have enabled sleep according to circadian preference facilitating longer sleep duration and improved sleep quality (Gibson et al., 2022; Trakada et al., 2020). Evening chronotype is usually a predisposing factor for sleep-related problems due to the mismatch between

biological sleep preferences and societal expectations. However, during the lockdown it may have been protective against sleep disturbances. This warrants further exploration, including assessment of chronotype and highlights the merit of further analysis into the relationship between contextual, environmental and behavioural factors as independent or mediating predictors of sleep status.

This study also found that global sleep quality scores were high (M = 6.6, *SD* = 3.5), where 58.8% of the NZ working women scored as 'poor sleepers' (scoring > 5 on PSQI). Pre-pandemic estimates of subjective sleep quality in the NZ population found that 27% of NZ adults reported current sleep-problems (Paine et al., 2005). Whilst Paine et al. (2005)' pre-pandemic prevalence study did not distinguish between genders and used a different sleep measure, it indicated that self-reported sleep quality in NZ working women dramatically decreased as a result of the lockdown. A Japanese study on male and female workers during the equivalent Japanese self-restraint period found less 'problem sleepers' (as determined by PSQI score >5.5) in comparison to pre-pandemic research in Japan (Furutani et al., 2022). It used the same questions, measures, and was conducted at the same time as the original survey (Gibson et al., 2022) of which the present study's dataset was derived from. Furutani et al. (2022) found that the Japanese workers' self-reported sleep habits remained almost regular during the self-constraint with 35.7% of the participants reporting poor sleep quality (M = 4.9 *SD* = 2.5). This is considerably lower than this current research. A possible explanation may be that the Japanese sample included fewer women and people with chronic medical conditions which may explain the relatively low sleep difficulty. This highlights the importance of gender specific breakdowns in studies like these to gain better insight into the potential risks to women's health. Further research could consider the unique factors associated with sleep status during lockdowns between cultures and exploration of qualitative data concerned 'lived experiences' of sleep changes between different countries and cultures.

Geographical areas with strict social restrictions, and high infection and death rates reported elevated rates of poor sleep (Casagrande et al., 2020; Jahrami et al., 2021). For example, North Italy was one of the epicentres of COVID-19 infections and deaths early in the pandemic and an Italian study found that 60.3% of their participants reported poor sleep quality (scoring > 5 on PSQI) during their lockdown (Casagrande et al., 2020). While this is similar to this NZ female worker sample (1.5% more in the Italian sample), Casagrande et al. (2020)'s study included both men and women. As the majority of the COVID-19 research did not report gender specific estimates of sleep problems, it is worth highlighting the meta-analysis by Zhang and Wing (2006) which found that insomnia-related problems were 1.41 times more likely in women than men. Thus, this indicated that the actual prevalence of sleep problems may also be much higher for women living in locations with greater disease outbreak.

When comparing these NZ results to international gender specific research during the lockdown, the prevalence of sleep problems was comparable. For example, Alimoradi et al. (2022)'s meta-analysis of longitudinal studies found that 55% of women (versus 48% of men) had sleep problems during lockdown which is comparable to NZ women in this present study (58.8%). The higher prevalence of 'poor sleepers' in the NZ female sample may be contributed to the focus on working women as opposed to a general female population. Although no research has been done into the division of housework and childcare during the lockdowns in NZ, Census data from 2018 showed that women performed more unpaid domestic work compared to men pre-lockdown (Stats NZ, 2018). The elevated findings could therefore indicate that the stress of having multiple roles during lockdown, with a higher proportion of the childcare and home-schooling burden while also working, may have led to poorer sleep quality.

PSQI Performance in the Pandemic Context

The PSQI is one of the most widely used assessment tools for measuring subjective sleep quality in research settings and is well validated across ages and different populations in a pre-pandemic context (Buysse et al., 1989). Yet, to ensure the measure was valid and reliable in a NZ working female population and during a unique situation like the COVID-19 lockdown, CFA was used to test the PSQI against different hypothesised models. This present study found that the PSQI higher-order model and PSQI three-factor model (Jia et al., 2019) were both statistically significant ($p < 0.001$) and had a superior fit compared to the original PSQI one-factor model (Buysse et al., 1989), supporting prediction 1. As the PSQI higher-order model and the PSQI three-factor model had identical model fit, the PSQI higher-order model was selected for the full structural model as it provided a better theoretical fit with a global score for subjective sleep quality. Despite having the best overall fit, the evidence showed that the PSQI higher-order model had a poor fit to the sample of NZ working women and in a unique pandemic context.

A possible explanation for the poor fit of the PSQI, is that the measure was constructed and tested in 'typical' or 'normal' situations and environmental conditions in order to obtain a representative sample of behaviours. The pandemic lockdown context with strict social restrictions was anything but typical. For many, the crisis caused unusual behaviours and disrupted daily patterns which may have influenced how participants interpreted the questions and why the PSQI measure performed poorly in all the different factor structures. Another possibility is that the poor fit may be attributed to group differences, such as the specific population (e.g., NZ female workers). This special population might be highly unusual compared to other populations that have been used to norm the PSQI. For example, the PSQI scale has been validated using American college students whom were predominantly young, white, 'well off' and including males and females (Dietch et al., 2016).

NZ female workers may have different characteristics compared to the normed group, such as a higher workload, a gap between the knowledge of sleep and its importance, or other potential mechanisms which could make their sleep patterns different.

Previous studies have highlighted the PSQI's methodological shortcomings where a large number of different factorial structures were found in diverse samples (Fabbri et al., 2021; Manzar et al., 2018). This cast doubt over how useful the global PSQI score was in detecting 'poor' and 'good' sleepers. Therefore, Manzar et al. (2018) proposed a set of guidelines to manage these short-comings which Jia et al. (2019) used to identify a superior PSQI three-factor model. This improved PSQI factorial model was tested in the present research however, the results showed an inadequate model fit. This cast doubt over the reliability of the measure on a NZ female workers population. The question is whether it is merely in this special population during the pandemic, or is it all populations during other global crisis situations? Limited COVID-19 studies have actually conducted CFA and this type of quality assessment of the PSQI measure during the pandemic (Wang et al., 2022). This indicated that the PSQI factorial reliability and validity in a pandemic context has been assumed and future studies are warranted to assess these in unique crises situations such as a pandemic, and also in special populations such as NZ female workers.

How Was Mood Impacted by the Lockdown Restrictions?

This study found that 46.2% of working females in NZ reported their general well-being and mood decreased since the beginning of lockdown. Comparatively, 16.4% reported increases on this single-item measure. The HADS was used to assess the different dimensions of mood and distinguish between the latent constructs of self-reported anxiety and depression. It found that 42.4% of the participants scored within the range for anxiety and 31% for depression (scoring > 8 on HADS). Historically, research has shown that problems

with anxiety and depression are some of most frequent problems for victims of large-scale disasters (Lavie, 2001; Matsumoto et al., 2015). The findings in this study were similar to other NZ COVID-research; Every-Palmer et al. (2020) found a third of their participants reported moderate to high levels of psychological distress during the first COVID-19 lockdown. However, compared to international prevalence findings, the anxiety-related symptoms in NZ female workers appeared to be greater. A global prevalence study by Mahmud et al. (2022), also conducted early in the pandemic, found almost a third of the general population self-reported anxiety which was significantly lower compared to this sample (i.e., 12.8% difference). They also found that similar rates of self-reported depression (28%) which was on par with this study.

The elevated prevalence of self-reported anxiety in NZ female workers compared to the global prevalence (i.e., on men and women) was perhaps not surprising given women have been found to be almost twice as likely to develop an anxiety disorder during their lifespan compared to men (Remes et al., 2016). Yet, the pandemic appeared to exacerbate the gender difference in anxiety and depression disorders compared to pre-pandemic baselines. For example, according to Santomauro et al. (2021)'s systematic review, the global prevalence of anxiety disorders had a greater increase in women (28%) versus in men (22%). It also had a greater increase in major depressive disorder in females (30%) compared to males (24%). Although it can be problematic comparing the NZ female worker sample to international studies that included both genders, the findings indicated that women may have been more affected by the social and economic consequences of the pandemic compared to men.

Interestingly, when comparing the NZ sample with studies from geographical locations with higher COVID-19 infection rates, the NZ anxiety and depression prevalence were much lower. For example, almost twice as many Brazilian participants were classified as having anxiety-symptoms and also a greater rate of depression-symptoms (17.3% more) than NZ

working women (Martinez et al., 2020). The authors of the Brazilian study used the same measure (HADS) and it was conducted at a similar time to this study. The difference in the prevalence rates may indicate that the reduced COVID-19 contagion in NZ had a less negative effect on mood during the lockdown compared to geographical locations with high disease and death rates. Many New Zealanders, including city-dwellers, were in a privileged position to have access to green and blue spaces during lockdown which has been linked with enhanced mood (Pouso et al., 2021). This may not have been the case in countries with denser housing and may also have been an issue during lockdown. Access to green and blue space would be interesting to explore in future research when assessing mood and sleep in different countries.

HADS Performance in the Pandemic Context

This present study found that the HADS measure provided adequate psychometric properties in a pandemic context. The reliability coefficient was 0.86 for HADS-depression and 0.79 for HADS-anxiety which indicated that the both subscales were reliable. Testing the factorial validity of the HADS models on the sample showed that the HADS three-factor model (Dunbar et al., 2000) provided a superior fit compared to the HADS two-factor model (Zigmond & Snaith, 1983), thus prediction 2 was supported. Both HADS models were statistically significant ($p < 0.001$) and the HADS three-factor model met the threshold for an acceptable fit. The HADS three-factor model was derived from Clark and Watson (1991)'s tripartite theory of anxiety and depression with subscales labelled negative affectivity, ahedonic depression and autonomic anxiety. However, as the theoretical construct of anxiety and depression subscales were a better fit with the intent of the present study, the HADS two-factor model was used in the full structural model.

How Did the COVID-19 Lockdown Impact Loneliness?

This present study found high levels of loneliness during the lockdown with 51% of the participants reporting feeling lonely some of the time or more during the last week. This is comparable with previous research following large-scale disasters (Matsumoto et al., 2015). The single item-question of perceived loneliness used in this study was identical to the loneliness indicator in the NZ General Social Survey in 2018, a biannual survey assessing the well-being of New Zealanders. The 2018 NZ General Social Survey found that 19% of women reported feeling lonely some of the time or more in the past week (Stats NZ, 2022b). Although it can be problematic comparing pre-lockdown research to current study as the samples were different, it indicated that loneliness likely increased as a result of the COVID-19 lockdown. However, as highlighted by de Jong Gierveld and van Tilburg (2010), a direct single-item question of loneliness is not sufficient in identifying people who are lonely, nor to distinguish between the different dimensions of social and emotional loneliness. Therefore, the GLS-6 item scale was used to measure the underlying latent construct of loneliness and assess its psychometric properties in this special population and context.

The current study found 47.4% of the female participants scored within the range for overall loneliness (scoring ≥ 2 on the GLS-6) which was similar to international research findings during lockdowns (Killgore et al., 2020; Pai & Vella, 2021; Santini & Koyanagi, 2021). Of these, 52.7% of the NZ female workers reported feeling socially lonely and 89.3% emotionally lonely (scoring ≥ 1 on the GLS-6 subscales). It indicated that a substantially high number of NZ working women felt an absence of intimate relationships such as a partner or a best friend during the pandemic. This may have been exacerbated by the fact that approximately half of the women (47.4%) were living alone (see C1, Appendix C) and the NZ lockdown restrictions mandated to 'stay within the bubble', not mixing with other households.

Comparing the results from present study with a study on Japanese workers, which used the exact same questions and was conducted at the same time, showed the opposite (Furutani et al., 2022). Among the Japanese workers, 82.2% reported social loneliness and felt an absence of a wider social network (i.e., approximately 30% greater than in the NZ sample) and 'only' 37.9% reported emotional loneliness (i.e., approximately 50% less than the NZ female workers). However, a direct comparison between the results is problematic as the Japanese sample included both men and women. Furutani et al. (2022) argued that Japanese corporate culture values face-to-face communication and the lack of social networking during the pandemic may have contributed to higher levels of social loneliness for working men and women. Interestingly, the Japanese sample had a higher proportion of men who felt socially lonely compared to women. This could suggest that in crisis-situation such as the pandemic, working men felt a greater absence of a wider social network and working women felt a greater need for intimate relationships. This warrants further exploration into qualitative data concerning lived experiences of loneliness changes between different countries, cultures and gender.

GLS-6 Performance in the Pandemic Context

This present study found that the GLS-6 two-factor structure (Gierveld & Tilburg, 2006) had a superior fit compared to a GLS-6 unidimensional structure, which supported prediction 3. The fit results of the GLS-6 two-factor model were mixed, where the CFI indicated a good fit (> 0.95) but the TLI and RMSEA did not meet the threshold for an acceptable fit on the NZ sample. Furthermore, the reliability coefficient was 0.83 for social loneliness however, only 0.40 for emotional loneliness which indicated that the emotional loneliness subscale was less reliable in a pandemic context. The standardised loading of the GLS-2 item "*I miss having people around*", on the emotional loneliness factor was 0.06 and not statistically

significant. Under 'normal' circumstances this reliability, non-significance and low factor loading would be problematic. However, given the unprecedented situation of the pandemic, it was likely a realistic representation of this feeling given the strict COVID-19 lockdown in NZ. Therefore, the GLS-6 two-factor loneliness structure was still utilised in the full structural model.

Did Mood and Loneliness Predict Subjective Sleep Quality?

The present research found evidence that the indicators of anxiety and depression were individually predictive of subjective sleep quality ($p < 0.001$) and had positive relationships. This indicated that participants who scored higher on the HADS-anxiety and depression scales (e.g., had higher levels of anxiousness and depressive symptoms) also scored higher on the PSQI global scale (e.g., had poorer overall sleep quality). The anxiety and depression regression estimates ranged between 0.39 to 0.49 indicating medium effects. This study found the regression paths between social and emotional loneliness on subjective sleep quality (PSQI Global) were nonsignificant ($p > 0.05$). Therefore, there was no evidence to support a predictive relationship between these variables. Although loneliness was not predictive of sleep quality, social and emotional loneliness were significantly associated with anxiety and depression.

The regression paths between mood and loneliness on subjective sleep quality both needed to fulfil the criteria of significance ($p < 0.05$), have positive relationships and a small effect size for the hypothesis to be supported. However, as only mood did fulfil the criteria, the hypothesis was not supported. It did show that in a pandemic lockdown context, mood predicted subjective sleep quality in NZ working women whereas loneliness did not.

Previous research indicated there is a strong etiological relationship between sleep, mood and loneliness however, the evidence on directionality between them remained inconclusive

(Alvaro et al., 2013; Griffin et al., 2020; Jansson-Fröjmark & Lindblom, 2008). As highlighted in the literature review, loneliness has been associated with sleep disruption (Cacioppo et al., 2002; Griffin et al., 2020), and elevated anxiety and depressive symptoms have equally been linked to poor sleep quality (Alvaro et al., 2013; Baglioni et al., 2011; Ohayon & Roth, 2003). A question posed in the present thesis was whether mood and loneliness preceded poor sleep or vice versa? To assist in answering this question, this thesis evaluated two main theories explaining these relationships in a pandemic context, namely the Socio-Ecological Model of Sleep Health (Grandner, 2019) and the 3 P Model of Insomnia (Cox & Olatunji, 2021). The adapted Socio-Ecological Model of Sleep Health, proposed in this thesis' introduction, suggested that societal-level determinants such as the global pandemic, geographical location, public policy and risk of disease significantly impacted social-level factors such as social networks, family, work and living situations. This, in turn, impacted individual-level factors such as mood, loneliness, individual behaviours and choices for each gender which in turn affected sleep health. This model therefore suggested a temporal precedence of mood and loneliness predicting sleep health.

The 3 P Model of Insomnia (Spielman et al., 1987) has been applied for decades, nevertheless, Cox and Olatunji (2021) highlighted its importance in the current pandemic context. They proposed that predisposing factors (i.e., gender, geographic location, occupation, mental health) contributed to an elevated risk of sleep problems in interaction with precipitating factors (i.e., stress associated with the working from home, home-schooling) and perpetuating factors (i.e., social isolation, pandemic-related worry / anxiety) during the pandemic. Similarly, this theory implied a temporal precedence whereby mood and loneliness impacted sleep health rather than the reverse. This thesis therefore represents an important step in the wider literature in evaluating and testing the direction of these relationships during a pandemic context. The results from this study indicated that mood

predicted subjective sleep quality in NZ working women and therefore supports the two theories and their proposed directionality, whereas loneliness did not.

Performance of the Full Structural Model in the Pandemic Context

The findings of present study suggested that the hypothesised full structural model had a good overall fit given the complexity of the model (e.g., the number of estimated parameters in the model). When evaluating the three goodness-of-fit statistics and criteria (e.g., CFI, TLI and RMSEA), at first sight, the findings were mixed. The CFI and TLI index values are both incremental fit index statistics and derived from the comparison between the hypothesised (i.e., the full structural equation model) and an independence or baseline model. The full covariance structure model had a CFI of 0.91, which indicated that the relative improvement in fit between this hypothesised model and an independence model was lower than Hu and Bentler (1999)'s recommended threshold of 0.95. Equally, the TLI of 0.89 did not meet the recommended goodness-of-fit threshold either. This indicated the full structural model did not fit the data well and the hypothesised model did not adequately describe the sample data. On the other hand, the absolute fit index RMSEA value of 0.05 (CI: 0.05: 0.06) indicated a good model fit as it met the value range recommended by Hu and Bentler (1999) (e.g., RMSEA value < 0.06). Furthermore, the narrow confidence intervals indicated good precision. It is important to note that the RMSEA value expressed the degree of error in the model relative to its complexity, whereas the incremental fit indices like CFI and TLI were not sensitive to the number of estimated parameters in the model. According to Byrne (2010), the RMSEA fit index is one of the most informative criteria in covariance structure modelling as it takes the error of approximation in the population into account. As such, it asks how well the model fits the population covariance matrix if this would be available and therefore makes the RMSEA fit index 'weightier' than the CFI and TLI index. Therefore, as the

RMSEA value in this full structural model was low, this indicated there was a good absolute fit given the complexity of the model.

This present study found indication of extreme collinearity between the latent variable PSQI Global and the latent variable Sleep Quality with a standardised factor loading greater than 1 (1.05). This indicated an overlap between these two variables. To avoid model mis-specification, a common constraint of 'aaa' was placed on both indicator paths and the variance was fixed to 1, as recommended by Byrne (2010). However, a factor loading greater than 1 remained, which indicated the model may be mis-specified. According to Chen et al. (2001), a Heywood case can be caused by having only two indicators per factors and combined with a small sample i.e., as seen in the PSQI Higher-order model. The sample size within this present study was $N = 498$ and larger than the recommended minimum of 200 (Boomsma & Hoogland, 2001). However, according to Kline (2016) even larger sample sizes may be required when there are few indicators per factor and also in complex models with more parameters, such as the full structural equation model presented here. Future research may therefore need to utilise larger sample sizes in SEM when using the PSQI higher-order model to avoid Heywood cases.

According to Jöreskog (1999), it is possible for the true value of a standardised factor loading or regression coefficient to be greater than 1, and "a standardized coefficient of 1.04, 1.40, or even 2.80 does not necessarily imply that something is wrong" (p. 1). He argued that people often have the misconception that a correlation above 1 is impossible, however factor loadings and regression coefficients are different from correlations. He argued that if the factors are correlated (oblique), then the factor loadings are regression coefficients and not correlations. Therefore, this makes it possible for the standardised factors to be larger than one. In summary, the presence of a Heywood case in this study may therefore not be

problematic as such. Yet, following Kline (2016)'s recommendations, future studies may benefit from larger sample sizes when including a PSQI Higher-order model.

This study did not conduct post hoc modifications of the full structural model to avoid the potential problem of a Heywood case. According to Babyak (2004) it is problematic when researchers modify statistical models with the goal of making the model better fit the data at hand. There is a risk of overfitting the model to the data to such an extent that the estimates of model fit will be biased. This is problematic as overfitted models has been shown to fail replication in future samples, creating uncertainty about the validity of the findings (Babyak, 2004). Hussey and Hughes (2020) argued that researcher using SEM have a large degree of freedom and decisions related validity can be made in post hoc modifications. They argued this can lead to 'cherry-picking' validity metrics that provide the best impression of the model and metrics, which they termed 'validity (v-) hacking'. This is problematic as it can affect the validity of the research conclusion. Future studies may therefore benefit from pre-registration of their research methods to provide clarity among collaborators and prevent potential claims of 'v-hacking'.

Research Strengths

What makes this present study novel is that NZ endured strict social restrictions despite the infection rates remained low therefore, the stress of becoming infected could more easily be delineated from the stress associated with the lockdown restrictions. This is contrary to most international COVID-19 studies where lockdowns coincided with high infection and mortality rates. Furthermore, some international studies conducted their research retrospectively collecting data post-lockdown which made them vulnerable to recall bias (Wang & Cheng, 2020). Therefore, these factors made this research a unique case-study to

examine the psychosocial impact of the COVID-19 lockdown, using data collected by Gibson et al. (2022) during the initial lockdown period.

To the author's knowledge, this is also the first study to examine the predictive relationship between sleep, mood and loneliness during lockdown in NZ. Problems with sleep disturbances, low mood and increased loneliness during the COVID-19 lockdown have been widely recognised through extensive global research (Jahrami et al., 2021; Mahmud et al., 2022; Pai & Vella, 2021). Prior research examining the directional relationships between these variables have been mixed (Jansson-Fröjmark & Lindblom, 2008). This study therefore contributes to a body of pandemic-related research focusing on the predictive relationships between sleep, mood and loneliness.

This study also appears to be the first research to focus on the impact of the COVID-19 lockdown in a NZ working women population. This is important as there is mounting evidence that the pandemic impacted women more than men (Alimoradi et al., 2022; Alon et al., 2020a, 2020b). Prior to the pandemic women had a higher prevalence of anxiety, depression and sleep problems which therefore makes them more vulnerable in times of crises (Zhang & Wing, 2006). Therefore, by focusing on psychological and sleep-related responses to the lockdown and their predictive relationship, it may help inform future support and public health measures for women in day-to-day life and in crisis situations.

Another strength of this study was the use of structural equation modelling, which uses large sample sizes and explicitly account for measurement errors. CFA was used to assess the dimensionality of the measures to evaluate whether the items were valid and represented the underlying latent structures on this population and in the pandemic context. This quality assurance provided a methodological rigorousness to draw conclusions from. This is in contrast to some COVID-19 research which, due to the pandemic rush, had poor study designs, used small sample sizes, lacked methodological thoroughness and were published on

pre-print servers without editorial scrutiny. This is problematic, especially in studies which only used non-validated single-item measures, as sleep quality, anxiety, depression and loneliness are underlying latent constructs that cannot be observed directly.

Limitations and Recommendations

This present study was limited by several factors. Firstly, the study used cross-sectional observational methods with retrospective self-report data. This made it vulnerable to recall bias, which restricted the measure of change over time and limited generalisability (Wang & Cheng, 2020). It inhibited the ability to identify whether the participant's sleep and well-being during lockdown worsened compared to pre-pandemic. This was partly addressed in the original Sleep and Well-being Study (Gibson et al., 2022) by including pre-lockdown estimates for sleep status, but not for mood and loneliness. This present study therefore focused on during-lockdown measures to assess the prevalence of 'problem' sleep and mood, and their predictive relationships during lockdown.

Secondly, the original online survey (Gibson et al., 2022) was collected within a limited timeframe and aimed at recruiting a heterogeneous sample. However, the sample was a convenience sample with the majority being women and of NZ European ethnicity. This impacted the generalisability of the findings. As a result, this study worked to the strength of the dataset and examined NZ working woman to focus on how this special population was impacted by the lockdown.

The demographic of present study also provided limitations and was not representative of the NZ general population. The majority of participants identified as NZ European (72.8%), were highly educated (79.3% had a university degree), a median age of 44.5 years and their health was good or excellent (69.9%). Previous research has identified disparity with Māori and Pasifika and participants with low socio-economic status being more likely to

experience sleep disturbances and problems with mental health (Paine et al., 2005). These populations were also shown to be marginalised in regards to the COVID-19 pandemic (Steyn et al., 2020). Of the participants in present study, only 2.7% were Māori and 0.8% Pasifika which indicated a response bias. Thus, the prevalence of sleep and mood disturbances will likely be greater in the general population than in this sample. Similarity, previous COVID-19 studies indicated that younger people were more negatively affected with regards to sleep, mood and loneliness compared to older age groups (Gasteiger et al., 2021; Jahrami et al., 2022; Sampogna et al., 2021). Whilst comparison of age groups was outside the scope of this study, future research may find it interesting to investigate whether the differences in subjective sleep status and well-being was age-related and whether it played a different role in males and females.

Thirdly, the underrepresentation of Māori and men in the original survey may be related to access and recruitment as the original survey was conducted online and mainly distributed through the university and social media avenues. The latter is sensitive to AI algorithms and the individual's previous search history, such that men and minority groups were perhaps less likely to have the survey appear in their social media feed. Yet other studies has indicated that white women are generally more likely to volunteer for health-related research compared to minority groups (Webb et al., 2019). The pandemic was unprecedented which meant there was limited time prior the announcement of the lockdown to design and launch the survey to fit within the level 4 and 3 lockdown timeframe. Future research could broaden avenues of recruitment such as paper-based versions of the survey or paid advertising targeting men and Māori on social media.

Lastly, the cross-sectional research design limits the insight into the causal relationships between mood and loneliness on subjective sleep quality during the COVID-19 lockdown. Whilst the direction of the predictive relationship (i.e., mood predicting sleep status) was

supported by this research as well as previous studies (Johnson et al., 2006; Kurina et al., 2011), it does not exclude the existence of bidirectional relationships during the pandemic lockdown. Furthermore, this study did not consider the role of other intervening variables in the relationships between mood, loneliness and subjective sleep quality such as age, household size, work status, social interactions, caffeine consumption, physical activity, time spent outdoors etc. As such, this study cannot conclusively infer causation or claim that the statistical models were proven but it can conclude that the models were generally consistent with the data. The incorporation of pre- and post-lockdown surveys in an ABA design would have made it a true natural experiment, and controlling for confounding variables would have enabled stronger causal inferences. However, given the limited time prior the lockdown announcement this was outside the scope of the original study. Pre-existing longitudinal studies, such as the NZ Health, Work and Retirement Study (Massey University, 2022) and the NZ based Dunedin Multidisciplinary Health and Development Study (Dunedin Multidisciplinary Health and Development Research Unit, 2022) may help disentangle these relationships further with help of their pre, during and post-pandemic data.

Practical Implications of the Research

This study offered a unique insight into how social restrictions and lack of connection impacted sleep and well-being in working women in NZ. This could inform the type and timing of health interventions. It could also extend beyond a pandemic context to help increase the sleep and mental health status of NZ women. Public health campaigns could address how women can support their sleep and mental health early in general crisis situations. For example, given the high prevalence of emotional loneliness found in this study, public health campaigns could focus on the importance of social connection and relationships, and encourage scheduling time each day to stay connected with family, friends

and neighbours. Other health interventions could target behaviours, such as the right amount and timing of exercise and caffeine consumption for faster sleep onset latency, to increase sleep drive to enable improved slow-wave sleep. Given the increasing research concerning the relationship between slow-wave sleep deprivation and cognitive impairment (Lucey et al., 2018; Rasmussen et al., 2018), this would be a particularly important health intervention.

Although the PSQI measure is commonly used in research settings and is considered reliable and well-validated across age and different populations, there were limited COVID-19 studies that conducted CFA and this type of quality assessment of the measure. This indicated that the PSQI reliability and validity in a pandemic context were assumed. The results from this study showed that in different contexts and special populations, the weighting and interpretation of PSQI will need consideration. Further research is recommended to determine whether it is reliable in a NZ context, as well as in crisis situations such as the pandemic. Furthermore, using multiple measures for sleep status and mixed methods in future study design is recommended.

Further research is also warranted into gender disparities in NZ. For example, this could be comparing men and women's household responsibilities and the time spent on childcare, school-support and chores in dual income families. This would help inform gender norms, the type of stressors and the possible support that is required in general crises situations.

Conclusion

The COVID-19 pandemic and associated lockdowns impacted heavily on the lives of people globally. New Zealanders were subject to some of the most severe lockdown restrictions whilst infection rates remained low. This presented a novel population from which to study the effects of social isolation on sleep quality, mood, loneliness, and the relationships between these variables, specifically in working women.

This present study found that the COVID-19 lockdown contributed to poor mood, increased levels of loneliness and poor subjective sleep quality for the majority of a sample of working women in NZ. Specifically, levels of anxiety were significantly higher during the pandemic compared to pre-pandemic, perhaps due to increased levels of stress from having to quickly adapt to working from home with added demands of childcare and home-schooling. Rates of depression also increased, reflecting the loss of social interaction, the ability to move around freely or participate in activities. This may also be contributed to increased levels of both social and emotional loneliness reported during the pandemic. These findings highlight the importance of stress management and social interaction for well-being and health in this population. Some participants did however, experience increased sleep quality and mood during lockdown. Further investigations into what factors may have contributed to this could also help shed light on how working females in NZ can better look after themselves on a day-to-day basis as well as in general crises situations.

There are well established links between mood, loneliness, and sleep quality from previous research but the directional relationships remained inconclusive. The present study found significant individually predictive relationships between anxiety, depression on subjective sleep quality with medium effects. The regression estimates on social and emotional loneliness were not significant and there was therefore no evidence to suggest there is a predictive relationship between loneliness and subjective sleep quality. This

suggests that interventions that reduce anxiety, e.g., stress mitigation, may help improve sleep quality in this population.

The fit of the predictive model provided a good overall fit given its complexity. The CFA results indicated all the key measures did not perform particularly well in a pandemic context. The PSQI, HADS and GLS-6 measures are commonly used in research settings, and considered reliable and well-validated across age and different populations. Yet, few studies have conducted CFA and this type of quality assessment on the measures during the COVID-19 lockdown. The results from current study therefore indicate that the weighting and interpretation of them need consideration in different contexts and special populations. Further research is recommended to determine whether these measures are reliable in a NZ context as well as in crisis situations such as a pandemic.

In summary, this study offered a unique insight into how social restrictions and lack of connection impacted sleep and well-being in working women in NZ during the COVID-19 lockdown. These findings may help promote practices that support well-being and subsequent sleep health for working women both in day-today life as well in crises situations, such as a pandemic or natural disaster.

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Appendix A. Original Survey Questionnaire

Sleep and Well-being Survey during the COVID-19 Pandemic (Gibson et al., 2022)

Sleep_Wellbeing_During_the_COVID-19_Pandemic_final

Start of Block: Graphics/logos

Q101

QInfo

Sleep and wellbeing during the COVID-19 pandemic
Online survey information sheet The current Covid-19 pandemic and associated restrictions have created a unique situation for New Zealanders. Physical distancing, activity restrictions and self-isolation have forced us to change the way we

live for at least a month. These changes may also affect our sleep and wellbeing. To better understand the impact of these changes, we have developed an online survey for New Zealand adults to share their experience. **Purpose of the survey:** We would like to know how your sleep and waking routines may have changed since the beginning of the restrictions due to the COVID-19 pandemic and their relationship to your situation and how you feel. **How can you help?** We are seeking adults (aged 18+) living in New Zealand to participate in this online survey. This includes those working in essential services as well as in isolation. The survey is in English. **The survey includes** questions about who you are, your current living and working situation, your sleep and wake routine, as well as how you have been feeling. There are also opportunities for you to write about your situation in more detail. If answering these questions raises any concerns or creates distress, there are links for further information and contacts on COVID-19, sleep and mental health below and at the conclusion of the survey. The survey should take 20-25 minutes to complete. The information you provide will be combined with that from others to help us understand how the COVID-19 pandemic is impacting sleep and wellbeing. No names, family names or place names will be required in any of the answers to the questions so you will not be personally identifiable in any reports. All data will be kept confidential in a secure location only accessible by the research team. It is possible that in the future, the data will be available to other researchers on request or placed in an online repository. The data may also be retained for use in future research. Anonymity and confidentiality of participants will be maintained. When complete, a summary of the research findings will be made available on the Sleep/Wake Research Centre website. You can also sign up to a mailing list to receive this directly. It is possible that we will conduct follow-on research in the area of sleep and the pandemic. Please let us know if you agree to be contacted again after the COVID-19 pandemic restrictions for a follow-up. You will be able to check this possibility at the end of the survey. If you agree to be contacted again, please leave your email or phone number. Your email will be saved independently from the responses to this survey.

Your rights: You are under no obligation to accept this invitation to be involved in the online survey. Consent to participate is implied by completing the survey. If you decide to participate, you have the right to: Stop answering questions at any time Ask any questions about the study at any time during participation Provide information on the understanding that your name will not be used

Please consider this information carefully before deciding whether you would like to participate. If you have any questions or would like to receive further information regarding this research, please feel free to contact us using the details below.

Associate Professor Mirjam Munch Director Circadian Health Research Sleep/Wake Research Centre Massey University Wellington Phone: 04 9793262 / 022 5321894 Email: m.munch@massey.ac.nz **Dr Rosie Gibson** Research Officer Sleep/Wake Research Centre Massey University Wellington Phone: 04 9793258 Email: r.gibson@massey.ac.nz This project has been reviewed and approved by the Massey University Human Ethics Committee: Northern, Application NOR 20/14. If you have any concerns about the conduct of this research, please contact Dr Fiona Te Momo, Chair, Massey University Human Ethics Committee: Northern, telephone 09 414 0800 x 43347, email humanethicsnorth@massey.ac.nz

Qinfo2
If you wish to participate in this online survey, please click the arrow button below to continue to the questions

Links for further information follow the following links: Ministry of Health New Zealand. COVID-19 Wellbeing at Alert Level 4 Health Promotion Agency. Coping with COVID-19 Mental Health Foundation. Looking after mental health and wellbeing during COVID-19 The Sleep/Wake Research Centre (Massey University) have produced information sheets about sleep health during the COVID-19 pandemic

End of Block: Graphics/logos

Start of Block: Section 1: About yourself and your current situation

QS1 This first section asks about you and your **current** situation:

Q1 What is your gender?

- Male (1)
- Female (2)
- Non-binary / third gender (3)
- Prefer to self describe: (4) _____
- Prefer not to answer (5)

Skip To: Q2 If What is your gender? = Male
Skip To: Q2 If What is your gender? = Female
Skip To: Q2 If What is your gender? = Non-binary / third gender
Skip To: Q2 If What is your gender? = Prefer to self describe:
Skip To: Q2 If Condition: Prefer to self describe: Is Not Empty. Skip To: What year were you born? (yyyy).
Skip To: Q2 If What is your gender? = Prefer not to answer

Q2 What year were you born? (yyyy)

_____

Skip To: Q3 If Condition: What year were you born? (y... Is Equal to 2002. Skip To: In which region do you currently live? .
Skip To: End of Survey If Condition: What year were you born? (y... Is Greater Than 2002. Skip To: End of Survey.

Q3 In which region do you **currently** live?

- ○ Northland (1)
- ○ Auckland (2)
- ○ Waikato (3)
- ○ Bay of Plenty (4)
- ○ Gisborne (5)
- ○ Taranaki (6)
- ○ Hawkes Bay (7)
- ○ Manawatu/Whanganui (8)
- ○ Wellington (9)
- ○ Marlborough (10)
- ○ Nelson/Tasman (11)
- ○ Canterbury (12)
- ○ West Coast (13)
- ○ Otago (14)
- ○ Southland (15)
- ○ Outside New Zealand (16)

Skip To: End of Survey If In which region do you currently live? = Outside New Zealand

Q5 Are you a New Zealand citizen or permanent resident?

- ○ Yes (1)
- ○ No (2)

Q6 Which one of these statements is true about your **current** marriage, partnership or situation?

- ○ I am married (1)
- ○ I am in a civil union/de facto/partnered relationship (2)
- ○ I am divorced or permanently separated from my legal husband or wife (3)
- ○ I am a widow or widower (4)
- ○ I am single (5)
- ○ Prefer not to answer (6)

Q4 To which ethnic group(s) do you belong? *(Please select all that apply)*

- ☐ New Zealand European (1)
- ☐ Māori (2)
- ☐ Cook Island Māori (3)
- ☐ Samoan (4)
- ☐ Chinese (5)
- ☐ Tongan (6)
- ☐ Niuean (7)
- ☐ Indian (8)
- ☐ Other (such as Dutch, Japanese, Tokelauan), please describe: (9) _____

Page Break

Q7 Which best describes the highest educational qualification you have obtained?

- No qualifications (1)
- Secondary school qualifications (e.g., School Certificate, University entrance, National Certificate of Education Achievement) (2)
- Post-secondary certificate, diploma, or trade diploma (3)
- University degree (4)
- Prefer not to answer (5)

Q8 What was your employment status **before** the COVID-19 pandemic (i.e. before self-isolation and/or Alert Level 4 restrictions)?
Were you…

(Please select all that apply)

- ☐ Working full-time (1)
- ☐ Working part-time (2)
- ☐ Self employed / contractor (13)
- ☐ A student (3)
- ☐ A homemaker (4)
- ☐ Unemployed (5)
- ☐ Retired (6)
- ☐ Unable to work due to disability (7)
- ☐ Volunteer (8)
- ☐ A paid carer (i.e. you receive payments from the government to provide care for a family member/friend (9)
- ☐ Other (please specify) (10) _____
- ☐ Don't know (11)
- ☐ Prefer not to answer (12)

Skip To: Q9a If What was your employment status before the COVID-19 pandemic (i.e. before self-isolation and/or A... = Working full-time

Skip To: Q9a If What was your employment status before the COVID-19 pandemic (i.e. before self-isolation and/or A... = Working part-time

Skip To: Q9a If What was your employment status before the COVID-19 pandemic (i.e. before self-isolation and/or A... = A homemaker

Skip To: Q11 If What was your employment status before the COVID-19 pandemic (i.e. before self-isolation and/or A... = Retired

Skip To: Q11 If What was your employment status before the COVID-19 pandemic (i.e. before self-isolation and/or A... = Unable to work due to disability

Skip To: Q9a If What was your employment status before the COVID-19 pandemic (i.e. before self-isolation and/or A... = Volunteer

Skip To: Q9a If What was your employment status before the COVID-19 pandemic (i.e. before self-isolation and/or A... = A paid carer (i.e. you receive payments from the government to provide care for a family member/friend

Skip To: Q9a If What was your employment status before the COVID-19 pandemic (i.e. before self-isolation and/or A... = Other (please specify)

Skip To: Q11 If What was your employment status before the COVID-19 pandemic (i.e. before self-isolation and/or A... = Don't know

Skip To: Q11 If What was your employment status before the COVID-19 pandemic (i.e. before self-isolation and/or A... = Prefer not to answer

Skip To: Q11 If What was your employment status before the COVID-19 pandemic (i.e. before self-isolation and/or A... = Unemployed

Skip To: Q11 If What was your employment status before the COVID-19 pandemic (i.e. before self-isolation and/or A... = A student

*

Q9a What is your usual occupation?

_____

Q9b What was your usual work pattern **before** the COVID-19 pandemic (i.e. before self-isolation and/or Alert Level 4 restrictions)?

- ○ Daytime with no shifts (1)
- ○ Rotating shifts with nights (2)
- ○ Rotating shifts without nights (3)
- ○ Permanent nights (4)
- ○ Irregular or variable work pattern (5)
- ○ Other work pattern (please specify) (6) _____
- ○ Not applicable (7)

Q10 How has your work status **currently** been impacted by the COVID-19 pandemic restrictions? *(Please select all that apply)*

- ☐ I am considered an essential worker* and am required to continue working outside of the home in times of national Alert Level 4 *(*essential e.g. working in currently open essential business such as food supply, pharmacy etc. or working as health service provider, or general essential service such as police etc.)* What essential service do you work in? (1) _____
- ☐ I was not impacted (was working remotely prior to pandemic) (2)
- ☐ I have transitioned my usual role to working remotely from home (3)
- ☐ I am unable to transition to work my usual role remotely from home (4)
- ☐ I have lost income, eligible for government subsidy (5)
- ☐ I have lost income, ineligible for government subsidy (6)
- ☐ I have had a change of position (7)
- ☐ I have had a change of employer (8)
- ☐ I have lost my position (9)
- ☐ Other (please describe) (10)

_____

Page Break

Page Break

Q11 Are you **currently** in physical isolation associated with the COVID-19 pandemic restrictions?

- ○ Yes (1)
- ○ No (2)

Display This Question:
If Are you currently in physical isolation associated with the COVID-19 pandemic restrictions? = Yes

Q11a For how long have you been in physical isolation?

- ○ Less than a week (1)
- ○ 1-2 weeks (2)
- ○ 2-3 weeks (3)
- ○ 3-4 weeks (4)
- ○ More than 4 weeks (5)

Display This Question:
If Are you currently in physical isolation associated with the COVID-19 pandemic restrictions? = Yes

Q11b
What is/are the reason(s) for your current restrictions?
(Please select all that apply)

- ☐ Government enforced (1)
- ☐ Recent travel (2)
- ☐ Being over 70 years old (3)
- ☐ Compromised immune system (4)
- ☐ Pre-existing respiratory disease (5)
- ☐ Pre-existing heart disease (6)
- ☐ Feeling unwell (7)
- ☐ Pregnant (8)
- ☐ Contact with someone with COVID-19 (9)
- ☐ Diagnosis of COVID-19 (10)
- ☐ Self-isolating for other reasons (please specify) (11) _____

Page Break

Qinfo **The following set of questions are about where you live and who you live with in the CURRENT situation.**

Q12
Which of the following options best describes you **current** residence?
(Please select all that apply)

- ○ House or townhouse (detached or 'stand alone') (1)
- ○ House, townhouse, unit or apartment (joined to one or more other houses, townhouses, units or apartments) (2)
- ○ Unit, villa or apartment in Retirement Village (3)
- ○ Moveable dwelling (e.g. caravan, motor home, boat, tent) (4)
- ○ Rest home or continuing care hospital (5)
- ○ Other (please specify) (6) _____

Q13 At your home, do you have direct access to a balcony, garden or green space?

- ○ Yes (1)
- ○ No (2)

Q14 Who do you **currently** live with? *(Please indicate the number of people in each age group, without counting yourself)*

	How many
Children aged 0-5 years: (1)	▼ 1 (1 ... 11 (11)
Children aged 6-10 years: (2)	▼ 1 (1 ... 11 (11)
Children aged 11-17 years: (3)	▼ 1 (1 ... 11 (11)
Adults aged 18-49 years (8)	▼ 1 (1 ... 11 (11)
Adults aged 50-64 years: (4)	▼ 1 (1 ... 11 (11)
Adults aged 65-79 years: (5)	▼ 1 (1 ... 11 (11)
Adults aged 80+ years: (6)	▼ 1 (1 ... 11 (11)

Q15 Is your **current** living situation different from usual, e.g. are you separated from family members, partners or have extra people in your household?

- ○ Yes (1)
- ○ No (2)

Skip To: Q16 If Is your current living situation different from usual, e.g. are you separated from family members... = No

Q15a Please describe how your current living situation is different from usual:

_____

Page Break

Q16 Do you regularly provide unpaid care or assistance (e.g. personal care or support) to any of the following people because of their long-term illness, disability or frailty? *Please indicate all that apply:*

- ☐ Someone who lives with you (13)
- ☐ Someone who lives elsewhere, and I **can** access during COVID-19 pandemic restrictions (14)
- ☐ Someone who lives elsewhere, and I **cannot** access during COVID-19 pandemic restrictions (15)
- ☐ Someone who is now in a nursing home or hospital, and I **can** access during COVID-19 pandemic restrictions (16)
- ☐ Someone who is now in a nursing home or hospital, and I **cannot** access during COVID-19 pandemic restrictions (17)
- ☐ No, this does not apply (19)

Q17 Do you have pets in your household?

- ○ Yes (1)
- ○ No (2)

Display This Question:
If Do you have pets in your household? = Yes

Q17a What type(s) of pet(s) do you have?

- ☐ Cat(s) (1)
- ☐ Dog(s) (2)
- ☐ Other (please specify) (3) _____

Page Break

The following set of questions are about your general health:

Q18 In general, would you say your health is:

- Excellent (1)
- Very good (2)
- Good (3)
- Fair (4)
- Poor (5)

Q19 Have you ever been diagnosed with a chronic disease (e.g. heart condition, diabetes, cancer)?

- Yes (1)
- No (2)
- Don't know (3)

Skip To: Q20 If Have you ever been diagnosed with a chronic disease (e.g. heart condition, diabetes, cancer)? = No

Skip To: Q20 If Have you ever been diagnosed with a chronic disease (e.g. heart condition, diabetes, cancer)? = Don't know

Display This Question:

If Have you ever been diagnosed with a chronic disease (e.g. heart condition, diabetes, cancer)? = Yes

*

Q19a If yes, what was the diagnosis?

_____

_____

_____

_____

_____

Display This Question:

If Have you ever been diagnosed with a chronic disease (e.g. heart condition, diabetes, cancer)? = Yes

*

Q19b What treatment, if any, have you used for this?

_____

_____

_____

_____

_____

Q20 Have you ever been diagnosed with a mental illness (e.g. depression, anxiety, bipolar)?

- Yes (1)
- No (2)
- Don't know (3)

Skip To: Q21 If Have you ever been diagnosed with a mental illness (e.g. depression, anxiety, bipolar)? = No

Skip To: Q21 If Have you ever been diagnosed with a mental illness (e.g. depression, anxiety, bipolar)? = Don't know

Display This Question:

If Have you ever been diagnosed with a mental illness (e.g. depression, anxiety, bipolar)? = Yes

*

Q20a If yes, what was the diagnosis?

_____

_____

_____

_____

_____

Display This Question:

If Have you ever been diagnosed with a mental illness (e.g. depression, anxiety, bipolar)? = Yes

*

Q20b What treatment, if any, have you used for this?

_____

Q21 Have you ever been diagnosed with a sleep disorder (e.g. sleep apnea, chronic insomnia, restless legs)?

- Yes (1)
- No (2)
- Don't know (3)

Skip To: Q22 If Have you ever been diagnosed with a sleep disorder (e.g. sleep apnea, chronic insomnia, restless... = No

Skip To: Q22 If Have you ever been diagnosed with a sleep disorder (e.g. sleep apnea, chronic insomnia, restless... = Don't know

Display This Question:

If Have you ever been diagnosed with a sleep disorder (e.g. sleep apnea, chronic insomnia, restless... = Yes

*

Q21a If yes, what was the diagnosis?

_____

_____

_____

_____

_____

Display This Question:

If Have you ever been diagnosed with a sleep disorder (e.g. sleep apnea, chronic insomnia, restless... = Yes

*

Q21b What treatment, if any, have you used for this?

_____

Q22 Do you currently have an acute illness (e.g. infection, cold/flu)?

- Yes (1)
- No (2)
- Don't know (3)

Skip To: Q23 If Do you currently have an acute illness (e.g. infection, cold/flu)? = No

Skip To: Q23 If Do you currently have an acute illness (e.g. infection, cold/flu)? = Don't know

Display This Question:

If Do you currently have an acute illness (e.g. infection, cold/flu)? = Yes

*

Q22a If yes, what is your current acute illness?

_____

Display This Question:

If Do you currently have an acute illness (e.g. infection, cold/flu)? = Yes

*

Q22b What treatment, if any have you used for this?

_____

Page Break

*

Q23 Is there any additional information you would like to tell us about who you are, your situation or general health? This might include your current situation and how it has changed since the beginning of the COVID-19 pandemic.

_____

_____

_____

_____

_____

End of Block: Section 1: About yourself and your current situation

Start of Block: Section 2a. Your sleep and wake routine BEFORE the COVID-19 pandemic

Thank you for your responses so far! This set of questions will ask about your sleep and wake routine BEFORE the COVID-19 pandemic restrictions. Please answer the following questions about your 'normal' sleep behaviour relating to the 6 weeks BEFORE **any restrictions associated with the COVID-19 pandemic (i.e. before your period of physical self-isolation or national Alert 4 Level restrictions).** Note, you will be asked some of these questions again in the next section, regarding your current status.

Q24 Normally, I worked ____ day(s) per week

▼ 1 (2) ... I did not work (9)

Skip To: Q28 If Normally, I worked ____ day(s) per week = I did not work

Page Break

Q25 **Before the COVID-19 pandemic,** on WORKDAYS:

	Hour	Minutes	AM / PM	
			AM (1)	PM (2)
I usually went to bed at night at... (1)	▼ 1 (1 ... 12 (12)	▼ 0 (1 ... 59 (60)	○	○
I normally fell asleep at ... *(note, this is NOT when you got into bed, but rather when you fell asleep)* (2)	▼ 1 (1 ... 12 (12)	▼ 0 (1 ... 59 (60)	○	○
I normally woke up at ...*(note, this is NOT when you got out of bed, but rather when you woke up)* (3)	▼ 1 (1 ... 12 (12)	▼ 0 (1 ... 59 (60)	○	○
I usually got up in the morning at ... (4)	▼ 1 (1 ... 12 (12)	▼ 0 (1 ... 59 (60)	○	○

Q26 **Before the COVID-19** pandemic, on WORKDAYS:

	Hours	Minutes
How many hours of actual sleep did you get at night? (1)	▼ 1 (1 ... 12 (12)	▼ 0 (1 ... 59 (60)

Q27 **Before the COVID-19** pandemic, on WORKDAYS:

	Minutes
It usually took me .... minutes to fall asleep each night (1)	▼ 0 (1 ... 120 (121)

Page Break

Q28 **Before the COVID-19** pandemic, on WORK-FREE DAYS when I didn't use an alarm clock:

	Hour	Minutes	AM / PM	
			AM (1)	PM (2)
I usually went to bed at night at ... (1)	▼ 1 (1 ... 12 (12)	▼ 0 (1 ... 59 (60)	○	○
I normally fell asleep at ... *(note, this is NOT when you got into bed, but rather when you fell asleep)* (2)	▼ 1 (1 ... 12 (12)	▼ 0 (1 ... 59 (60)	○	○
I normally woke up at ...*(note, this is NOT when you got out of bed, but rather when you woke)* (3)	▼ 1 (1 ... 12 (12)	▼ 0 (1 ... 59 (60)	○	○
I usually got up in the morning at ... (5)	▼ 1 (1 ... 12 (12)	▼ 0 (1 ... 59 (60)	○	○

Q29 **Before the COVID-19** pandemic, on WORK-FREE DAYS:

	Hours	Minutes
How many hours of actual sleep did you get at night? (1)	▼ 0 (1 ... 12 (13)	▼ 0 (1 ... 59 (60)

Q30 **Before the COVID-19** pandemic, on WORK-FREE DAYS:

	Minutes
It usually took me .... minutes to fall asleep each night (1)	▼ 0 (1 ... 120 (121)

Page Break

Q31 **Before the COVID-19 pandemic,** did you nap during the day?

- ○ Every day/Most days (1)
- ○ Occasionally (2)
- ○ Not at all (3)

Skip To: Q32 If Before the COVID-19 pandemic, did you nap during the day? = Not at all

Q31a If you napped...

	Hours	Minutes
Before the COVID-19 pandemic, approximately how long do you typically nap for? (hours/mins) (10)	▼ 0 (1 ... 12 (12)	▼ 0 (1 ... 59 (60)

Page Break

Q32 **Before the COVID-19** pandemic, did you use sleeping medication (prescribed or "over the counter") to help you sleep?

- ○ Not at all (1)
- ○ Less than once a week (2)
- ○ Once or twice a week (3)
- ○ Three or more times a week (4)

Skip To: Q33 If Before the COVID-19 pandemic, did you use sleeping medication (prescribed or "over the counter")... = Not at all

Q32a Please specify the type of medication:

_____

Page Break

Q33 **The next questions are about general waking activities BEFORE the COVID-19 pandemic and any physical self-isolation/Alert Level 4 restrictions.**
Thinking about your general waking activities **BEFORE the COVID-19 pandemic:**

	Hours	Minutes
On average, how much time per day did you spend outdoors in daylight (without a roof above your head)? (1)	▼ 0 (1 ... 24 (25)	▼ 0 (1 ... 59 (60)
On average, how much time per day did you spend doing physical activities (e.g. walking or other exercise inside or outside of the house)? (8)	▼ 0 (1 ... 24 (25)	▼ 0 (1 ... 59 (60)
On average, how much time per day did you spend socially interacting (e.g. talking or interacting with family, friends, colleagues or neighbours, in person or remotely)? (9)	▼ 0 (1 ... 24 (25)	▼ 0 (1 ... 59 (60)
On average, how much time per day did you spend keeping up with the news (e.g. watching or reading the news on television, newspapers or from online sources)? (10)	▼ 0 (1 ... 24 (25)	▼ 0 (1 ... 59 (60)

End of Block: Section 2a. Your sleep and wake routine BEFORE the COVID-19 pandemic

Start of Block: Section 2b. Your CURRENT sleep and wake routine (i.e. during the recent weeks as

Section 2b. Please answer the following questions about your sleep and waking routines relating to your **CURRENT situation i.e. since the beginning of physical self-isolation/Alert Level 4 restrictions.** Please estimate averages for this time. Please tell us about your current sleep schedule on work days and free days:

Q34 I am **currently** working ___ day(s) per week

▼ 1 (1) ... I am not currently working (8)

Skip To: Q38 If I am currently working ___ day(s) per week = I am not currently working

Q34a What is your **current** work pattern?

- ○ Daytime with no shifts (1)
- ○ Rotating shifts with nights (2)
- ○ Rotating shifts without nights (3)
- ○ Permanent nights (4)
- ○ Irregular or variable work pattern (5)
- ○ Other work pattern (please specify) (6) _____

Page Break

Q35 **Currently,** on WORKDAYS:

	Hour	Minutes	AM / PM	
			AM (1)	PM (2)
I usually go to bed at night at ... (1)	▼ 1 (1 ... 12 (12)	▼ 0 (1 ... 59 (60)	○	○
I normally fall asleep at ...*(note, this is NOT when you get into bed, but rather when you fall asleep)* (2)	▼ 1 (1 ... 12 (12)	▼ 0 (1 ... 59 (60)	○	○
I normally wake up at ... *(note, this is NOT when you get out of bed, but rather when you wake up)* (3)	▼ 1 (1 ... 12 (12)	▼ 0 (1 ... 59 (60)	○	○
I usually get up in the morning at ... (4)	▼ 1 (1 ... 12 (12)	▼ 0 (1 ... 59 (60)	○	○

Q36 **Currently** on WORKDAYS:

	Hours	Minutes
How many hours of actual sleep do you get at night? (1)	▼ 1 (1 ... 12 (12)	▼ 0 (1 ... 59 (60)

Q37 **Currently** on WORKDAYS:

	Minutes

It usually takes me .... minutes to fall asleep each night (1)	▼ 0 (1 ... 120 (121)

Page Break

Q38 **Currently,** on WORK-FREE days when I don't use an alarm clock...

	Hour	Minutes	AM / PM	
			AM (1)	PM (2)
I usually go to bed at night at ... (1)	▼ 1 (1 ... 12 (12)	▼ 0 (1 ... 59 (60)	○	○
I normally fall asleep at ...*(note, this is NOT when you get into bed, but rather when you fall asleep)* (2)	▼ 1 (1 ... 12 (12)	▼ 0 (1 ... 59 (60)	○	○
I normally wake up at ... *(note, this is NOT when you get out of bed, but rather when you wake up)* (3)	▼ 1 (1 ... 12 (12)	▼ 0 (1 ... 59 (60)	○	○
I usually get up in the morning at ... (4)	▼ 1 (1 ... 12 (12)	▼ 0 (1 ... 59 (60)	○	○

Q39 **Currently** on WORK-FREE days:

	Hours	Minutes
How many hours of actual sleep do you get at night? (1)	▼ 1 (1 ... 12 (12)	▼ 0 (1 ... 59 (60)

Q40 **Currently** on WORK-FREE days:

	Minutes

It usually takes me .... minutes to fall asleep each night (1)	▼ 0 (1 ... 120 (121)

Page Break

Q41 Do you **currently** nap during the day?

- ○ Every day/Most days (1)
- ○ Occasionally (2)
- ○ Not at all (3)

Skip To: Q42 If Do you currently nap during the day? = Not at all

Q41a If you **currently** nap....

	Hours	Minutes
Currently, approximately how long do you typically nap for? (hours/mins) (1)	▼ 0 (1 ... 12 (13)	▼ 0 (1 ... 59 (60)

Page Break

Q42 Do you **currently** use sleeping medication (prescribed or "over the counter") to help you sleep?

- ○ Not at all (1)
- ○ Less than once a week (2)
- ○ Once or twice a week (3)
- ○ Three or more times a week (4)

Skip To: Q43 If Do you currently use sleeping medication (prescribed or "over the counter") to help you sleep? = Not at all

Display This Question:

If Do you currently use sleeping medication (prescribed or "over the counter") to help you sleep? = Less than once a week

Or Do you currently use sleeping medication (prescribed or "over the counter") to help you sleep? = Once or twice a week

Or Do you currently use sleeping medication (prescribed or "over the counter") to help you sleep? = Three or more times a week

Q42a Please specify the type of medication:

_____

Page Break

Q43 The next set of questions are concerning factors affecting your CURRENT sleep, including sleep quality and dreaming

Currently, how often have you had trouble sleeping because you...

	Not at all (1)	Less than once a week (2)	Once or twice a week (3)	Three or more times a week (4)
a) Cannot get to sleep within 30 minutes (1)	○	○	○	○
b) Wake up in the middle of the night or early morning (2)	○	○	○	○
c) Have to get up to use the bathroom (3)	○	○	○	○
d) Cannot breathe comfortably (4)	○	○	○	○
e) Cough or snore loudly (5)	○	○	○	○
f) Feel too cold (6)	○	○	○	○
g) Feel too hot (7)	○	○	○	○
h) Have bad dreams (8)	○	○	○	○
i) Have pain (9)	○	○	○	○

Q43a If you **currently** have trouble sleeping for any other reason(s) please describe them below, including how often you have trouble sleeping because of this:

	Not at all (1)	Less than once a week (2)	Once or twice a week (3)	Three or more times a week (4)
Other (please describe) (1)	○	○	○	○
Other (please describe) (2)	○	○	○	○
Other (please describe) (3)	○	○	○	○

Page Break

Q44 **Currently,** how often do you have had trouble staying awake while driving, eating meals or engaging in social activity?

- Not at all (1)
- Less than once a week (2)
- Once or twice a week (3)
- Three or more times a week (4)

Q45 **Currently,** how much of a problem has it been to keep up enough enthusiasm to get things done?

- No problem at all (1)
- Only a very slight problem (2)
- Somewhat of a problem (3)
- A very big problem (4)

Q46 How would you rate your **current** sleep quality overall?

- Very good (1)
- Fairly good (2)
- Fairly bad (3)
- Very bad (4)

Page Break

Q47 How often have you recalled your dreams recently?

- Almost every morning (1)
- Several times a week (2)
- About once a week (3)
- Two or three times a month (4)
- About once a month (5)
- Less than once a month (6)
- Never (7)

Skip To: Q48 If How often have you recalled your dreams recently? = Never

Q47a How intense are your dreams emotionally?

- Not at all intense (1)
- Not that intense (2)
- Somewhat intense (3)
- Quite intense (4)
- Very intense (5)

Q48 How has your general sleep quality **changed since the beginning of the COVID-19 pandemic restrictions** (i.e. physical self-isolation or national Alert 4 Level restrictions)?

- ○ It is better (1)
- ○ It has not changed (2)
- ○ It is worse (3)

Page Break

Q49 Do you currently consume any of the following and if so, how much per week?
(Please select all that apply)

Tobacco products (including cigarettes, cigars, vapes, pipes) (1)	▼ 0 (1 ... 50+ (51)
Beer (how many glasses) (14)	▼ 0 (1 ... 50+ (51)
Wine (how many glasses) (8)	▼ 0 (1 ... 50+ (51)
Liquor / Whisky / Gin (how many glasses) (9)	▼ 0 (1 ... 50+ (51)
Coffee (how many cups) (15)	▼ 0 (1 ... 50+ (51)
Black Tea (how many cups) (10)	▼ 0 (1 ... 50+ (51)
Caffeinated soft drinks (cans or equivalent) (11)	▼ 0 (1 ... 50+ (51)

*

Q49A How do you feel your consumption of these items **has changed** since the beginning of physical self-isolation / Alert Level 4 restrictions?
(Please describe)

_____

_____

_____

_____

_____

Page Break

Q50 The next questions are about general waking activities in your **CURRENT situation** i.e. since the beginning of physical self-isolation / Alert Level 4 restrictions.

Thinking about your general waking activities **CURRENTLY:**

	Hours	Minutes
On average, how much time per day do you spend outdoors in daylight (without a roof above your head)? (1)	▼ 0 (1 ... 24 (26)	▼ 0 (1 ... 59 (60)
On average, how much time per day do you spend doing physical activities (e.g. walking or other exercise inside or outside of the house)? (8)	▼ 0 (1 ... 24 (26)	▼ 0 (1 ... 59 (60)
On average, how much time per day do you spend socially interacting (e.g. talking or interacting with family, friends, colleagues or neighbours, in person or remotely)? (9)	▼ 0 (1 ... 24 (26)	▼ 0 (1 ... 59 (60)
On average, how much time per day do you spend keeping up with the news (e.g. watching or reading the news on television, newspapers or from online sources)? (10)	▼ 0 (1 ... 24 (26)	▼ 0 (1 ... 59 (60)

Page Break

Q51 Is there any additional information you would like to tell us about your sleep, dreaming, or daily routine? This might include your current situation and especially how it has changed since the COVID-19 pandemic/Alert Level 4 restrictions.

Q52 Is there anything you would like to tell us about the sleep of people you live with or care for in the current situation (e.g. the current or changing sleep status of children or elderly)?

End of Block: Section 2b. Your CURRENT sleep and wake routine (i.e. during the recent weeks as

Start of Block: Section 3. How are you CURRENTLY feeling?

Section 3. **Thank you for your responses so far. The following questions focus on how you would CURRENTLY describe your mood and feelings.**
Please click the response that most applies to you for each feeling listed below, giving your most immediate response.

Q53a I feel tense or 'wound up'

- Most of the time (4)
- A lot of the time (3)
- From time to time, occasionally (2)
- Not at all (1)

Q53b I still enjoy the things I used to enjoy

- Definitely as much (4)
- Not quite as much (3)
- Only a little (2)
- Hardly at all (1)

Q53c I get a sort of frightened feeling as if something awful is about to happen

- Very definitely and quite badly (4)
- Yes, but not badly (3)
- A little, it doesn't worry me (2)
- Not at all (1)

Q53d I can laugh and see the funny side of things

- As much as I always could (4)
- Not quite as much now (3)
- Definitely not so much now (2)
- Not at all (1)

Page Break

Q53e Worrying thoughts go through my mind

- A great deal of the time (4)
- A lot of the time (3)
- From time to time, not too often (2)
- Only occasionally (1)

Q53f I feel cheerful

- Not at all (1)
- Not often (2)
- Sometimes (3)
- Most of the time (4)

Q53g I can sit at ease and feel relaxed

- Definitely (4)
- Usually (3)
- Not often (2)
- Not at all (1)

Q53h I feel as if I am slowed down

- Nearly all the time (4)
- Very often (3)
- Sometimes (2)
- Not at all (1)

Page Break

Q53i I get a sort of frightened feeling like 'butterflies' in my stomach

- Not at all (1)
- Occasionally (2)
- Quite often (3)
- Very often (4)

Q53j I have lost interest in my appearance

- Definitely (4)
- I don't take as much care as I should (3)
- I may not take quite as much care (2)
- I take as much care as ever (1)

Q53k I feel restless as I have to be on the move

- Very much indeed (4)
- Quite a lot (3)
- Not very much (2)
- Not at all (1)

Q53l I look forward with enjoyment to things

- As much as I ever did (4)
- Rather less than I used to (3)
- Definitely less than I used to (2)
- Hardly at all (1)

Page Break

Q53m I get sudden feelings of panic

- Very often indeed (4)
- Quite often (3)
- Not very often (2)
- Not at all (1)

Q53m I can enjoy a good book or radio or TV program

- Often (4)
- Sometimes (3)
- Not often (2)
- Very seldom (1)

Page Break

Q54 Please indicate for each of the following statements the extent to which they apply to your situation, the way you feel now.

	Yes (1)	More or less (2)	No (3)
I experience a general sense of emptiness (1)	○	○	○
There are plenty of people I can rely on when I have problems (2)	○	○	○
There are many people I can trust completely (3)	○	○	○
There are enough people I feel close to (4)	○	○	○
I miss having people around (5)	○	○	○
I often feel rejected (6)	○	○	○

Q55 How much during the past week have you felt lonely?

- None or almost none of the time (1)
- Some of the time (2)
- Most of the time (3)
- All or almost all of the time (4)
- I don't know (5)

Page Break

Q56 How has your general wellbeing and mood changed since the beginning of the COVID-19 pandemic restrictions (i.e. physical self-isolation or national Alert 4 Level restrictions)?

- It is better (1)
- It has not changed (2)
- It is worse (3)
- I don't know (4)

Q57 Is there any additional information you would like to tell us about how you feel? This might include your current situation and how it has changed since the COVID-19 pandemic restrictions / Alert Level 4.

_____

_____

_____

_____

_____

Page Break

Q58 **Thank you for taking part in this research at this time!** Feel free to use this link to share this opportunity with your contacts https://www.sleepwake.ac.nz/ We appreciate your contribution to understanding the effects of the COVID-19 pandemic on the sleep and wellbeing of people living in New Zealand. It is possible that we will conduct follow-on research in the area of sleep and the COVID-10 pandemic. Please let us know if you would like to be included in the mailing list for future research opportunities by checking the box below and providing your contact details.

- Yes, I agree to be included on the mailing list (please indicate your email and/or phone number in the next text field). (1)
- No, I do not wish to be contacted again. (2)

Skip To: Q58a If Thank you for taking part in this research at this time! Feel free to use this link to share thi... = Yes, I agree to be included on the mailing list (please indicate your email and/or phone number in the next text field).

Q58a My email and/or phone number are:

_____

Skip To: Qinfoend If Condition: My email and/or phone numbe... Is Equal to. Skip To: Links for further information fol....

Qinfoend

Links for further information follow the following links: Ministry of Health New Zealand, COVID-19 Wellbeing at Alert Level 4 Health Promotion Agency, Coping with COVID-19 Mental Health Foundation, Looking after mental health and wellbeing during COVID-19 The Sleep/Wake Research Centre (Massey University) have produced information sheets about sleep health during the COVID-19 pandemic

End of Block: Section 3. How are you CURRENTLY feeling?

Appendix B. Abbreviations of the Key Measures

De Jong Gierveld Loneliness 6- item scale Abbreviations	
GLS1:	I experience a general sense of emptiness
GLS2:	I miss having people around
GLS3:	I often feel rejected
GLS4:	There are plenty of people I can rely on when I have problems
GLS5:	There are many people I can trust completely
GLS6:	There are enough people I feel close to
Hospital Anxiety and Depression Scale Abbreviations	
A1:	I feel tense or 'wound up'
A3:	I get a sort of frightened feeling as if something awful is about to happen
A5:	Worrying thoughts go through my mind
A7:	I can sit at ease and feel relaxed
A9:	I get a sort of frightened feeling like 'butterflies' in the stomach
A11:	I feel restless as I have to be on the move
A13:	I get sudden feelings of panic
D2:	I still enjoy the things I used to enjoy
D4:	I can laugh and see the funny side of things
D6:	I feel cheerful
D8:	I feel as if I have slowed down
D10:	I have lost interest in my appearance
D12:	I look forward with enjoyment to things
D14:	I can enjoy a good book or radio or TV program
Pittsburgh Sleep Quality Index Abbreviations	
PSQI1:	Sleep Duration
PSQI2:	Habitual Sleep Efficiency
PSQI3:	Sleep Latency
PSQI4:	Use of Sleep Medication
PSQI5:	Daytime Dysfunction
PSQI6:	Sleep Quality
PSQI7:	Sleep Disturbances

Appendix C. Detailed Descriptive Results

Table C1 *Distribution of Key Demographic Variables and Health Status*

	N	%	*M*	*SD*	*Mdn*	*IQR*	*Skewness*	*Kurtosis*
Female	498	100.00%						
Age (years)	498	100.00%	44.56	12.62	44.5	19	0.21	-0.65
Marital Status:	498	100.00%						
Married	232	46.60%						
Civil Union / de facto relationship	112	22.50%						
Divorced / separated	41	8.20%						
Widowed	8	1.60%						
Single	100	20.10%						
Ethnicity:	448	90.00%						
New Zealand European	326	72.80%						
Māori	12	2.70%						
Cook Island Māori	1	0.20%						
Samoan	2	0.40%						
Chinese	9	2.00%						
Tongan	1	0.20%						
Indian	8	1.80%						
Other (e.g. Dutch, Japanese, Tokelauan)	89	19.90%						
Education / Qualification:	498	100.00%						
Secondary school qualifications	34	6.80%						
Post-secondary certificate, or trade diploma	66	13.30%						
University degree	395	79.30%						
Employment Status:	498	100.00%						
Full time work	316	63.50%						
Part time work	122	24.50%						
Self-employed / contractor	45	9.00%						
Multiple work roles (e.g. part-time and self- employed)	15	3.00%						
Work Pattern Pre-COVID:	494	99.20%						
Daytime w no shifts	419	84.80%						
Rotating shifts w nights	8	1.60%						
Rotating shifts without nights	12	2.40%						
Permanent nights	2	0.40%						
Irregular or variable work pattern	35	7.10%						
Other work pattern	16	3.20%						
Work Status During- Covid:	383	76.90%						
Essential worker	0	0.00%						
Not impacted (working remotely prior)	21	5.50%						
Transitioned usual role to work remotely	304	79.40%						
Unable to transition working from home	16	4.20%						
Lost income, eligible for government subsidy	24	6.30%						
Lost income, ineligible for subsidy	3	0.80%						
Change of position	3	0.80%						
Lost position	2	0.50%						
Other	10	2.60%						
Current residence:	498	100.00%						
House or townhouse (detached)	405	81.30%						
House, townhouse or apartment (Attached)	86	17.30%						
Unit, villa or apartment in Retirement Village	1	0.20%						
Moveable dwelling (e.g. caravan, boat)	1	0.20%						
Other	5	1.00%						

Total number of people they are living with:	498	100.00%	1	1.26	1	2	1.42	2.022
0 people	236	47.40%						
1 person	131	26.30%						
2 people	59	11.80%						
3 people	50	10.00%						
4 people	15	3.00%						
5+ people	7	1.40%						
Living with pets:	498	100.00%						
yes	212	42.60%						
No	286	57.40%						
Health status:	498	100.00%						
Excellent	131	26.30%						
Very good	217	43.60%						
Good	108	21.70%						
Fair	38	7.60%						
Poor	4	0.80%						
PSQI Global Score [1]	498	100.00%	6.63	3.55	6	5	0.864	0.612
PSQI Global > 5 (“poor sleeper”)	273	54.80%						
Better Sleep Quality since lockdown restrictions	119	23.90%						
Worse Sleep Quality since lockdown restrictions	226	45.50%						
HADS Anxiety; absolutes (0-21) [2]	490	98.40%	7.29	4.38	6.5	6	0.629	-0.024
HADS Anxiety >8 (“at risk/ borderline”)	208	42.40%						
HADS Depression (%); absolutes (0-21) [2]	490	98.40%	6.03	3.79	6	5	0.719	0.34
HADS Depression >8 (“at risk/ borderline”)	152	31.00%						
Global loneliness score (0-6) [3]	486	97.60%	2.67	1.7	2	3	0.464	-0.892
Global Loneliness ≥ 2 (“lonely”)	230	47.30%						
Social loneliness score (0-3) [3]	486	97.60%	1.15	1.25	1	2	0.476	-1.457
Social Loneliness ≥ 1 (“Socially lonely”)	256	52.70%						
Emotional loneliness score (0-3) [3]	486	97.60%	1.52	0.89	1	1	0.178	-0.766
Emotional Loneliness ≥ 1 (“Emotionally lonely”)	434	89.30%						
Lonely- Some-almost all of the past week [4]	254	51.00%						
Poorer mood (lockdown vs pre-lockdown)	224	46.20%						
Better mood (lockdown vs pre-lockdown)	79	16.40%						
During Covid estimates (in hours/ day):								
Daylight exposure	493	99.00%	1.68	1.42	1	1.25	2.077	6.583
Physical activity	493	99.00%	1.322	1.28	1	1.5	4.423	33.907
Social interaction	492	98.80%	3.15	3.2	2	3	2.087	4.557
Checking news	493	99.00%	2.1	1.98	1	1.5	4.557	32.405
During Covid Consumables per day:								
Tobacco	479	96.20%	1.1	5.54	0	0	6.46	46.02
Alcohol in total	498	100.00%	4.96	6.51	3	7	2.113	5.58
Caffeinated drinks in total	498	100.00%	13.64	11.86	11	16	1.296	2.08

1. PSQI: Pittsburgh Sleep Quality Index, 2. HADS: Hospital Anxiety and Depression Scale, 3. De Jong Gierveld’s Loneliness Scale-6, 4. General Social Survey, N= Number of participants, M= Mean, SD= Standard deviation, Mdn= Median, IQR= Interquartile range

Figure C1 *Histogram Plots of Participants Scores on PSQI Global*

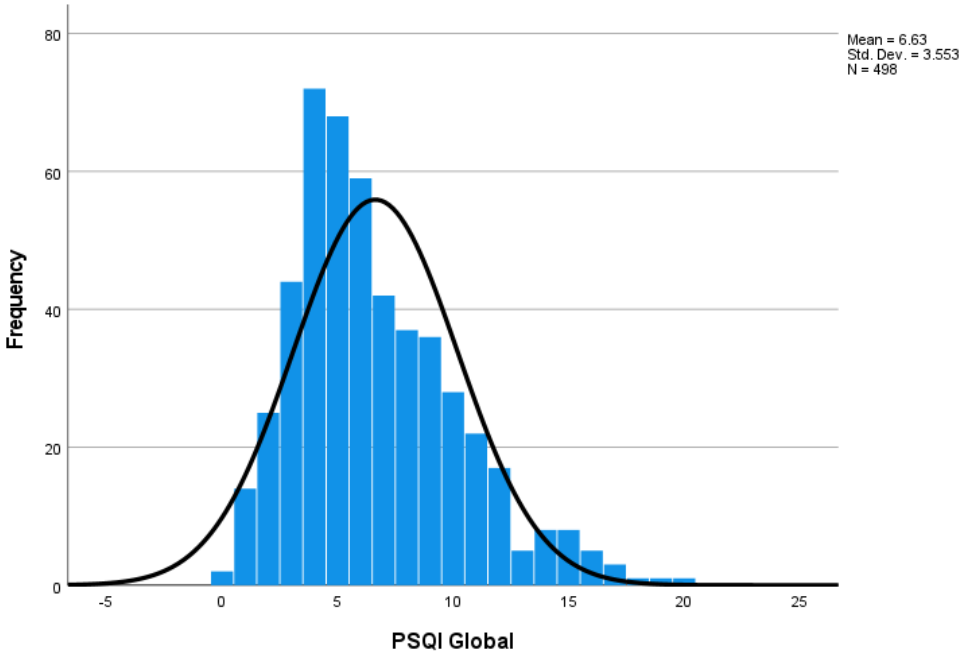


Figure C2 *Histogram Plot of Participants Scores on HADS Depression*

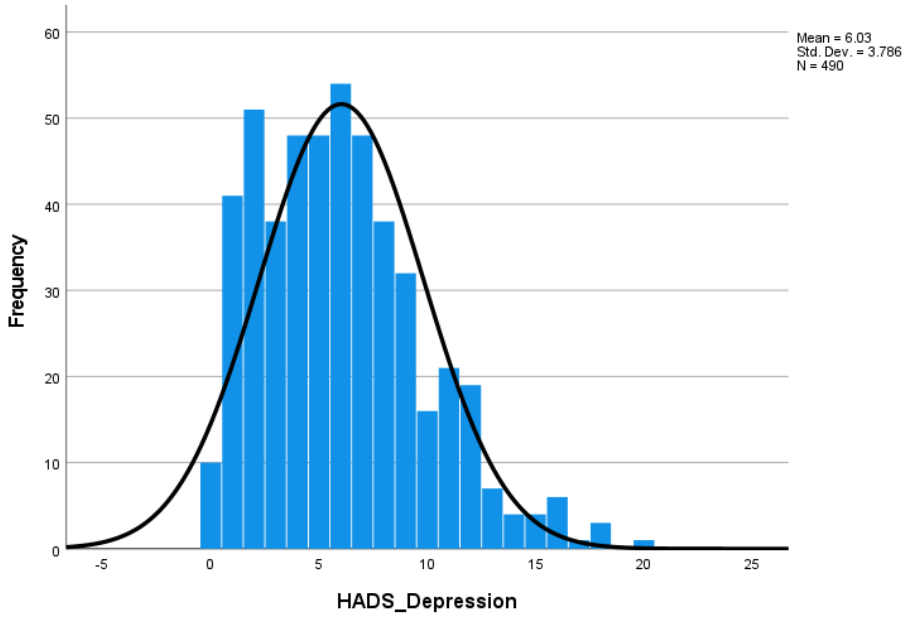


Figure C3 *Histogram Plot of Participants Scores on HADS Anxiety*

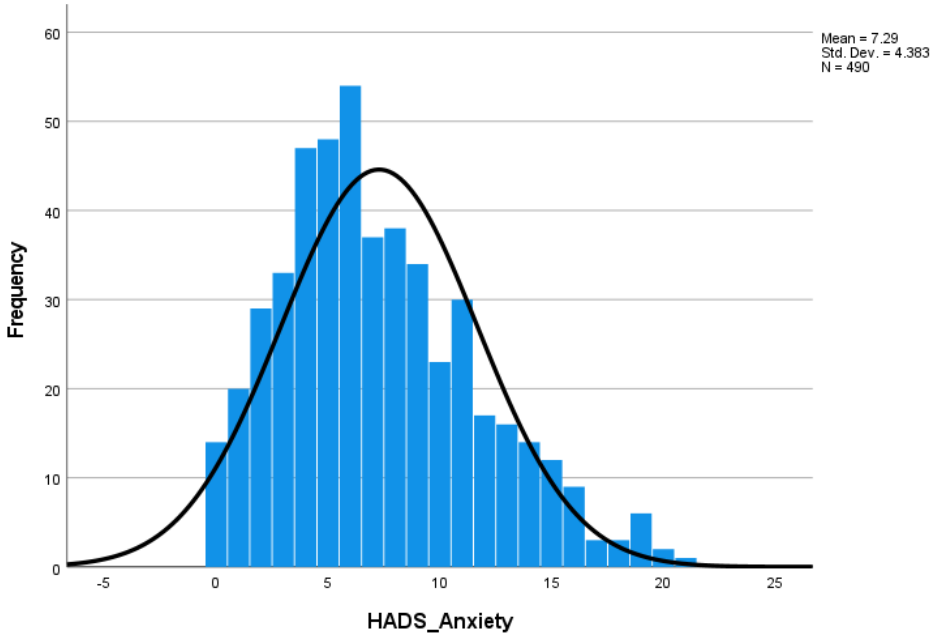


Figure C4 *Histogram Plot of Participants Scores on Social Loneliness*

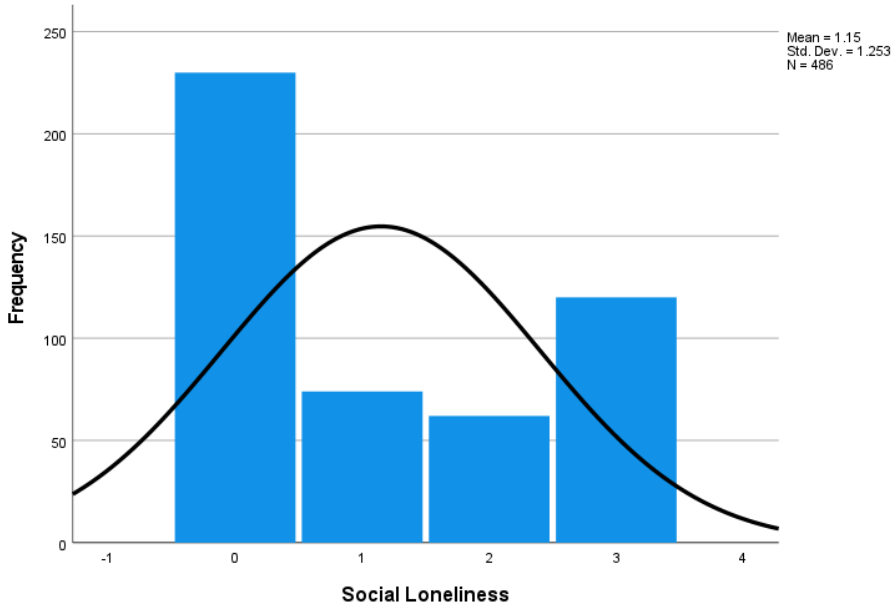
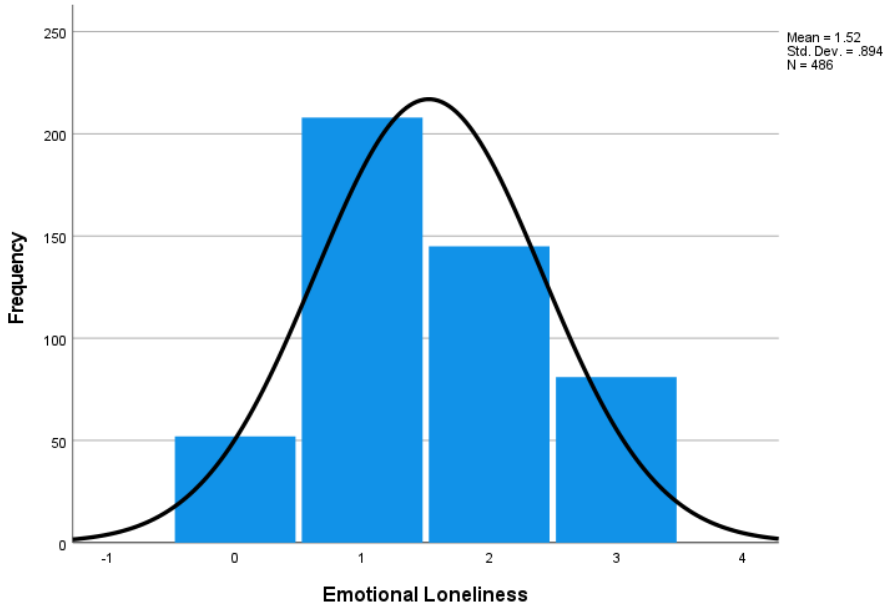
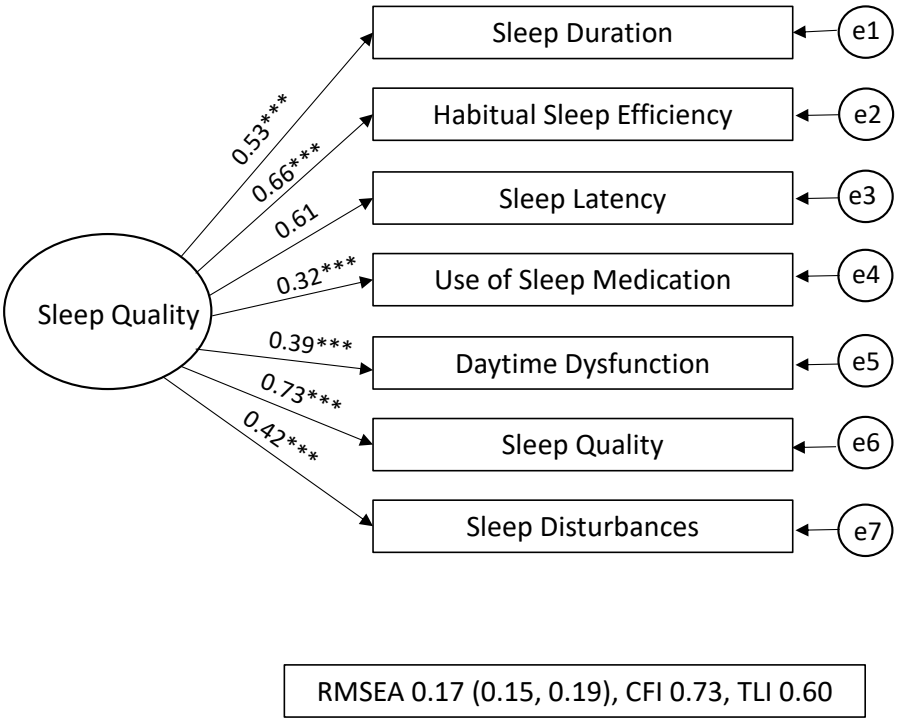


Figure C5 *Histogram Plots of Participants Scores on Emotional Loneliness*



Appendix D. CFA Models and Factor Loadings

Figure D1 *PSQI Unidimensional Model with Standardised Path Coefficients*



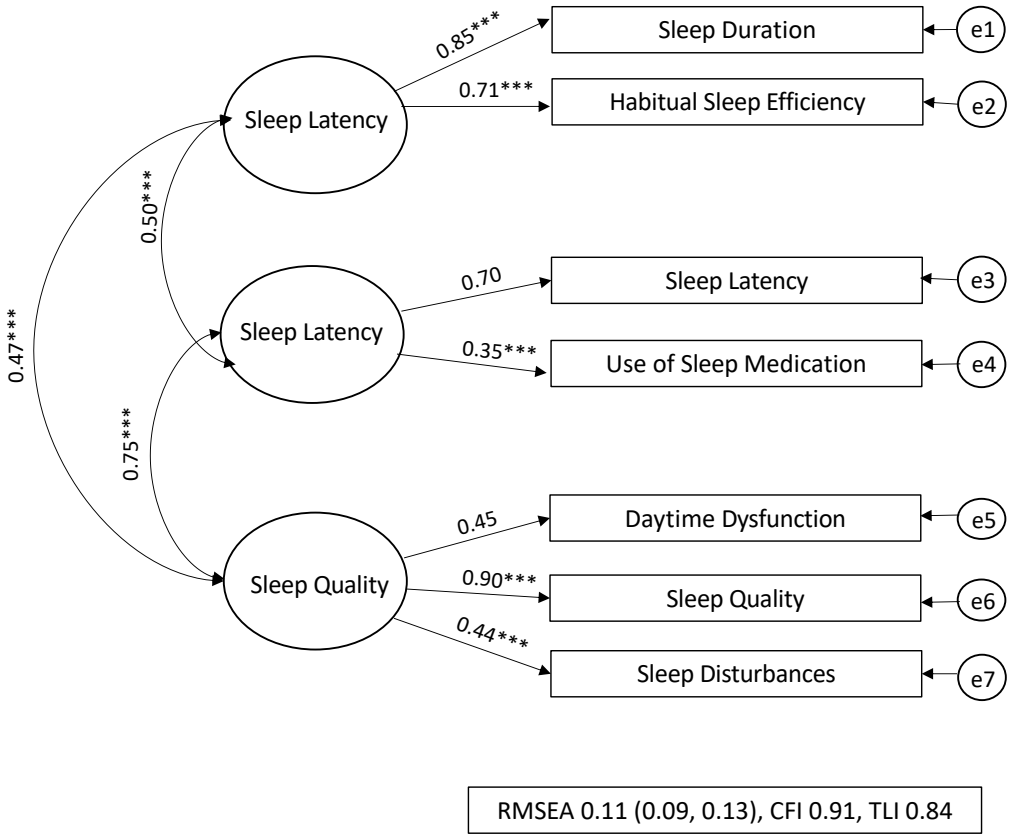
RMSEA*:* Root-mean-square error of approximation, CFI*:* Comparative Fit Index, TLI: Tucker-Lewis Index, *$p < 0.05$, **$p < 0.01$, *** $p < 0.001$

Table D1 *Factor Loading in CFA for the PSQI Models*

Unidimensional Model		Est.
Factor 1	PSQI1: Sleep duration	0.53***
	PSQI2: Habitual sleep efficiency	0.66***
	PSQI3: Sleep latency	0.61
	PSQI4: Use of sleep medication	0.32***
	PSQI5: Daytime dysfunction	0.39***
	PSQI6: Sleep quality	0.73***
	PSQI7: Sleep disturbances	0.42***
Three-Factor Model		
Factor 1 Sleep efficiency	PSQI1: Sleep duration	0.85***
	PSQI2: Habitual sleep efficiency	0.71***
Factor 2 Sleep latency	PSQI3: Sleep latency	0.70
	PSQI4: Use of sleep medication	0.35***
Factor 3 Sleep Quality	PSQI5: Daytime dysfunction	0.45
	PSQI6: Sleep quality	0.90***
	PSQI7: Sleep disturbances	0.44***
Higher Second-Order Model		
PSQI Global	Sleep Efficiency	0.56***
	Sleep Latency	0.90***
	Sleep Quality	0.84
Sleep Efficiency	PSQI1: Sleep duration	0.85***
	PSQI2: Habitual sleep efficiency	0.71***
Sleep Latency	PSQI3: Sleep latency	0.70
	PSQI4: Use of sleep medication	0.35***
Sleep Quality	PSQI5: Daytime dysfunction	0.45
	PSQI6: Sleep quality	0.90***
	PSQI7: Sleep disturbances	0.44***

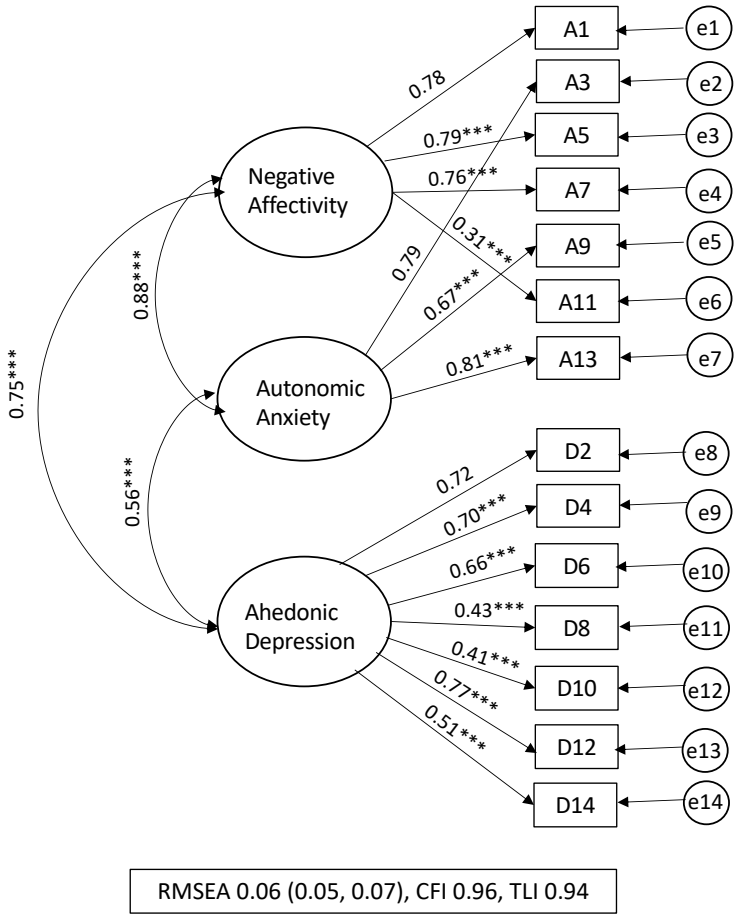
PSQI: Pittsburgh Sleep Quality Index , $*p < 0.05$,$**p < 0.01$, *** $p < 0.001$

Figure D2 *PSQI Three-Factor Model with Standardised Path Coefficients*



RMSEA*:* Root-mean-square error of approximation, CFI*:* Comparative Fit Index, TLI: Tucker-Lewis Index, *$p < 0.05$, **$p < 0.01$, *** $p < 0.001$

Figure D3 *HADS Three-Factor Model with Standardised Path Coefficients*



RMSEA*:* Root-mean-square error of approximation, CFI*:* Comparative Fit Index, TLI: Tucker-Lewis Index, A1: I feel tense or 'wound up', A3: I get a sort of frightened feeling as if something awful is about to happen, A5: Worrying thoughts go through my mind, A7: I can sit at ease and feel relaxed, A9: I get a sort of frightened feeling like 'butterflies' in the stomach, A11: I feel restless as I have to be on the move, A13: I get sudden feelings of panic, D2: I still enjoy the things I used to enjoy, D4: I can laugh and see the funny side of things, D6: I feel cheerful, D8: I feel as if I have slowed down, D10: I have lost interest in my appearance, D12: I look forward with enjoyment to things, D14: I can enjoy a good book or radio or TV program.
$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

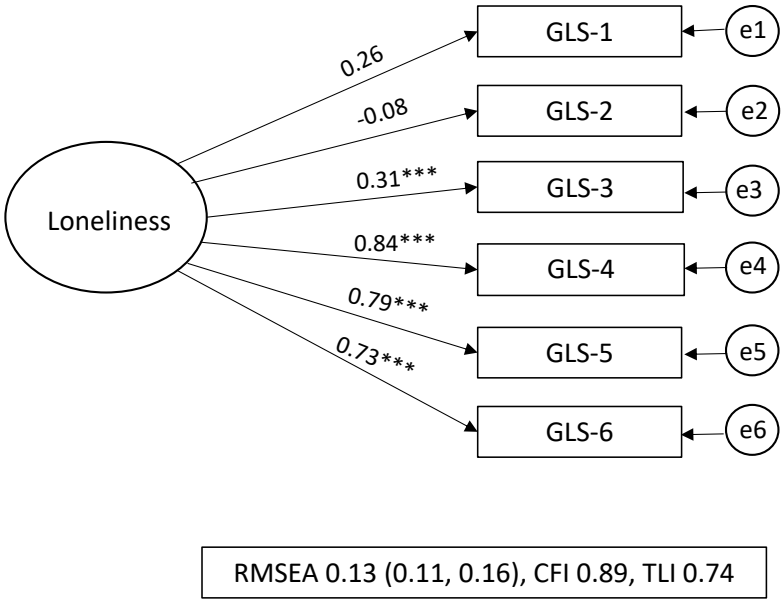
Table D2 *Factor Loading in CFA for the HADS Models*

HADS Two-factor Model (Zigmond & Snaith, 1983)		est.
Factor 1 Anxiety	A1: I feel tense or 'wound up'	0.76
	A3: I get a sort of frightened feeling as if something awful is about to happen	0.75***
	A5: Worrying thoughts go through my mind	0.80***
	A7: I can sit at ease and feel relaxed	0.72***
	A9: I get a sort of frightened feeling like 'butterflies' in the stomach	0.62***
	A11: I feel restless as I have to be on the move	0.38***
	A13: I get sudden feelings of panic	0.76***
Factor 2 Depression	D2: I still enjoy the things I used to enjoy	0.72
	D4: I can laugh and see the funny side of things	0.70***
	D6: I feel cheerful	0.66***
	D8: I feel as if I am slowed down	0.43***
	D10: I have lost interest in my appearance	0.42***
	D12: I look forward with enjoyment to things	0.76***
	D14: I can enjoy a good book or radio or TV programs	0.51***

HADS Three-factor Model (Dunbar et al., 2000)		est.
Factor 1: Negative Affectivity	A1: I feel tense or 'wound up'	0.78
	A5: Worrying thoughts go through my mind	0.79***
	A7: I can sit at ease and feel relaxed	0.76***
	A11: I feel restless as I have to be on the move	0.31***
Factor 2: Autonomic Anxiety	A3: I get a sort of frightened feeling as if something awful is about to happen	0.79
	A9: I get a sort of frightened feeling like 'butterflies' in the stomach	0.67***
	A13: I get sudden feelings of panic	0.81***
Factor 3: Depression	D2: I still enjoy the things I used to enjoy	0.72
	D4: I can laugh and see the funny side of things	0.70***
	D6: I feel cheerful	0.66***
	D8: I feel as if I am slowed down	0.43***
	D10: I have lost interest in my appearance	0.41***
	D12: I look forward with enjoyment to things	0.77***
	D14: I can enjoy a good book or radio or TV programs	0.51***

HADS: Hospital Anxiety and Depression Scale, *$p < 0.05$,**$p < 0.01$, *** $p < 0.001$

Figure D4 *GLS Unidimensional Model of Loneliness with Standardised Path Coefficients*



RMSEA*:* Root-mean-square error of approximation, CFI*:* Comparative Fit Index, TLI: Tucker-Lewis Index, GLS1: I experience a general sense of emptiness, GLS2: I miss having people around, GLS3: I often feel rejected, GLS4: There are plenty of people I can rely on when I have problems, GLS5: There are many people I can trust completely, GLS6: There are enough people I feel close to. *$p < 0.05$, **$p < 0.01$, *** $p < 0.001$

Table D3 *Factor Loading in CFA for the GLS-6 Loneliness Models*

Unidimensional Model		est.
Factor 1:	GLS1: I experience a general sense of emptiness	0.26
Global loneliness	GLS2: I miss having people around me	-0.08
	GLS3: I often feel rejected	0.31***
	GLS4: There are plenty of people I can lean on when I have problems	0.84***
	GLS5: There are many people I can trust completely	0.79***
	GLS6: There are enough people I feel close to	0.73***

Two-factor Model (Gierveld & Tilburg, 2006)		est.
Factor 1:	GLS1: I experience a general sense of emptiness	0.56
Emotional loneliness	GLS2: I miss having people around me	0.06
	GLS3: I often feel rejected	0.67***
Factor 2:	GLS4: There are plenty of people I can lean on when I have problems	0.84
Social Loneliness	GLS5: There are many people I can trust completely	0.79***
	GLS6: There are enough people I feel close to	0.73***

GLS: De Jong Gierveld Scale, *$p < 0.05$,**$p < 0.01$, *** $p < 0.001$

Table D4 *Correlations Between the Main Variables of the Full Structural Model*

		est.
Emotional Loneliness	<--> Social Loneliness	0.38***
Anxiety	<--> Depression	0.69***
Anxiety	<--> Emotional Loneliness	0.68***
Anxiety	<--> Social Loneliness	0.78***
Depression	<--> Emotional Loneliness	0.32***
Depression	<--> Social Loneliness	0.45***

*$p < 0.05$,**$p < 0.01$, *** $p < 0.001$