Profiles of sleep status among older adults in New Zealand: The association between alcohol use and other health and lifestyle factors

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Abstract

Sleep is a crucial determinant and modifiable factor of health and well-being that changes continuously throughout life. Changes in sleep are partly owing to physiological ageing alongside individual-level, social-level and societal-level factors. By 2050, approximately one-quarter of people living in New Zealand will be 65 years or older. The ageing population structure of New Zealand is of interest given the numerous social, physiological and behavioural changes that occur with ageing, and impacts social, economic, and health landscapes in New Zealand. Older adults today drink more alcohol than previous generations have, and research shows that alcohol use is clearly associated with sleep disturbance in younger adults. Given the clear links between alcohol use, sleep and ageing, it is concerning that there is a paucity of research on older adults, despite older adults being at a significantly higher risk of alcohol-related harm and poor sleep.

The following thesis, therefore, investigated the role of alcohol on the sleep of older adults by (1) distinguishing profiles of sleep, (2) determining the sociodemographic and health differences that underpin each profile in older adulthood, and (3) investigating how alcohol use was associated with profiles of sleep status in older adult drinkers.

An analysis of 2013/2014 New Zealand Health Survey data was conducted. Information of 13,309 adults ≥ 15 years old was analysed, of whom 22% (2,932) were older adults (≥ 65 years; 56.51% female; 21.32% Māori). There were five sleep profiles established using available sleep items. These were established according to whether a respondent: (a) reported having a diagnosed sleep disorder; (b) experienced frequent daytime sleepiness; reported a usual sleep duration consistent with (c) short sleep; (d) long sleep, or (e) typical sleep as assessed against the National Sleep Foundation's 'Appropriate Sleep Duration' guidelines. Demographic, health and alcohol use differences between older (65+ years) and younger (15–64 years) participants and sleep profiles were explored Demographic and health differences between sleep profiles in the older sample were investigated. Multinomial models were performed to determine the key factors that underpinned each sleep profile in

older adulthood, followed by an assessment of how alcohol use altered the membership of factors that underpinned sleep profiles for older adults.

In this study, 21.21% of all respondents were categorised within the poor sleep profiles (i.e., presence of sleep disorder, frequent daytime sleepiness, short sleep or long sleep). The prevalence of poor sleep was significantly greater among older adults (27.76%) compared to younger adults (19.35%). Older adults were more likely to be associated with the 'sleep disorder', 'excessive sleepiness', or 'long sleep' profiles. By contrast, younger adults were more likely to be short or typical sleepers. Statistical models demonstrated multimorbidity and polypharmacy were significant predictors of the sleep disorder profile for older adults. Older adult long sleepers were more likely to be of later age, male and have poor nutrition intake. Typical sleep in older adulthood was significantly associated with better health and socioeconomic status. Older adults profiled as 'excessively sleepy' were more likely to be older, male, Māori or have a higher body mass index. Higher quantity consumption (three or more drinks) was a significant factor for membership of the excessive sleepiness profile among older adult drinkers.

This research progresses the understanding of the relationship between sleep and alcohol use among older adults in New Zealand. This thesis contributes to the understanding of the key demographic and health factors that coincide with profiles of sleep in older adults.

(567 words)

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List of terms and Abbreviations

AUDIT	Alcohol Use Disorder Identification Test
BMI	Body Mass Index
CI	Confidence Interval
CURF	Confidentialised Unit Record Files
ESS	Epworth Sleepiness Scale
K10	Kessler Psychological Distress Scale
N1	Stage N1 Sleep
N2	Stage N2 Sleep
NHANES	National Health and Nutrition Examination Survey
NHIS	National Health Interview Survey
NREM	Non-Rapid Eye Movement
NZ	New Zealand
NZDEPI	New Zealand Deprivation Index
NZHS	New Zealand Health Survey
OECD	Organisation for Economic Co-Operation and Development
OR	Odds Ratio
OSA	Obstructive Sleep Apnoea
Process C	Circadian Timing System
Process S	Homeostatic Sleep Pressure System
RDI	Respiratory Disturbance(s) Index
REM	Rapid Eye Movement
SF-36	Short Form Health Survey
SWS	Slow Wave Sleep
WASO	Wakefulness After Sleep Onset

1 Literature Review

Worldwide, people are living longer (World Health Organisation, 2021). A trend that is driven by slowing population growth, increasing life expectancy rates, and declining mortality rates (Stats NZ, 2020; Vollset et al., 2020; World Health Organisation, 2011). In 2020, one in six people living in New Zealand (NZ) were 65 years or older, and by 2050 it is estimated this could increase to one in four (Stats NZ, 2020). Population ageing introduces unprecedented challenges to the environmental, economic, health and societal landscape of NZ (OECD, 2017; United Nations Department of Economic and Social Affairs Population Division, 2017; World Health Organisation, 2011, 2021). The implications of this shift, and the extent to which it is occurring worldwide, are largely underappreciated (OECD, 2017; United Nations Department of Economic and Social Affairs Population Division, 2017; World Health Organisation, 2011, 2021). The transition to older adulthood involves many significant life changes. For some older adults, health and wellbeing may improve throughout retirement and older adulthood, for others the converse holds true (Szabó, Hyde, et al., 2021) Changes in life and attitudes toward older adults, can compound in different ways and impact their well-being and successful ageing variably (Stephens et al., 2020; Szabó, Hyde, et al., 2021; World Health Organisation, 2021). For example, changes in health and functioning, changes in social, home and physical environments and routines, exiting the workforce, children leaving or returning home, and the loss of family and friends can all impact later life (Bareham et al., 2019; United Nations Department of Economic and Social Affairs Population Division, 2017; World Health Organisation, 2021).

Older adults today drink more alcohol than previous generations have (Towers, Philipp, et al., 2018; Towers et al., 2011), and research shows that alcohol use is clearly associated with social opportunities, perceived health benefits, social issues and sleep disturbances (Aira et al., 2008; Bareham et al., 2019; Haighton et al., 2018). Sleep is a crucial determinant of health and wellbeing and a modifiable health risk factor that changes continuously over the course of life (Arble et al., 2015; Chattu et al., 2018; Dew et al., 2003; Grandner, 2019; Grandner, Hale, et al., 2010; Grandner et al., 2015; Hirshkowitz et al., 2015; Lee & Sibley, 2019; Sindi et al., 2020). While age-related

changes in sleep are well-documented there is still much about its role in successful healthy ageing that is unknown. A clear association between sleep disturbances and alcohol use has been observed in younger adult cohorts (Colrain et al., 2014; Ebrahim et al., 2013). Although older adults have an increased sensitivity to alcohol, there is an absence of research into the relationship between alcohol use and sleep disturbance in this cohort in NZ. This literature review will provide a brief overview of the current ageing context, and outline the current factors that impact the relationship between health, sleep and alcohol use in older adulthood. Throughout this review, and where available, information pertinent to the NZ context will be integrated.

1.1 Health and Ageing

Life-course epidemiology has increasingly demonstrated that health in older adulthood can be traced back to childhood socioeconomic conditions and experiences (OECD, 2017; Stephens et al., 2020; Szabó, Towers, et al., 2021; World Health Organisation, 2011). In Stephens et al. (2020), child socioeconomic status and education were important determinants of health on entry to older adulthood. There are, however, extraneous factors in older adulthood also important for good health and well-being. These extend beyond physical health and material living standards to include the maintenance of meaningful and positive social engagement, access to social supports, independence, employment and workforce participation, time with family, adequate nutrition, and the impact of maintaining an active lifestyle and the absence of functional limitation (Allen & Alpass, 2020; Bareham et al., 2019; Moschny et al., 2011; Noorwali et al., 2018; Rasinaho et al., 2007; Vanderlinden et al., 2020).

Life expectancy has increased steadily in NZ. However, medical interventions and the prevalence of non-communicable diseases, such as ischaemic heart disease, lung cancer, dementia, stroke, chronic obstructive pulmonary disease, and breast or prostate cancer, mean more years of life are lived in poor health (Ministry of Health, 2020). Non-communicable diseases account for 90% of the health loss among NZ older adults today (Ministry of Health, 2020). In NZ, Aminisani et al. (2020) found the incidence of multimorbidity in older adulthood was increased by childhood financial hardship, lower education attainment, lower-income quintiles, physical inactivity, obesity,

and hypertension, emphasising both the influence of modifiable health risk factors and childhood contexts in later-life health and wellbeing. Separately, sleep disturbances have been shown to increase the rate at which multimorbidity develops in a cohort of Swedish older adults (60+ years) (Sindi et al., 2020), highlighting the importance of good sleep for successful healthy ageing in older adulthood.

1.2 Sleep

Defining sleep

Sleep can be defined from both a behavioural and physiological perspective (Carskadon & Dement, 2017; Chokroverty, 2017a). Physiologically, sleep is an active anabolic state of recovery during which biological systems are repaired and restored, and memory consolidation and learning occur (Carskadon & Dement, 2017; Chokroverty, 2017a). From a behavioural perspective, sleep is a brief reversible state characterised by the absence of wakefulness, engagement and responsiveness to the surrounding environment, closed eyes, a resting posture and reduced levels of mobility (Carskadon & Dement, 2017; Chokroverty, 2017a).

Sleep Architecture

The architecture of sleep references the cyclical organisation of sleep states and stages over an episode of sleep (Carskadon & Dement, 2017; Chokroverty, 2017a; Sleep Foundation, 2022). Sleep is comprised of two states of sleep, of which one state can be broken down into three separate stages (see **Table 1**). Each sleep state and stage is marked by changes in a set of physiological parameters, including neurological activity, eye movement, body temperature, and muscular, cardiovascular and respiratory system activity (Carskadon & Dement, 2017; Chokroverty, 2017a).

Table 1

Overview of human sleep states and stages, their function and the approximate distribution of time over a typical episode of normal healthy adult sleep.

State	Stage	Description	Function	Time spent
Non-Rapid Eye Movement (NREM)				75%–80%
	Stage 1 (N1)	Stage 1 (N1) is the lightest stage and through which sleep is entered.	Transitional stage of sleep. [a, b]	2%–5%
	Stage 2 (N2	Stage 2 (N2) commences approximately after N1 sleep. N2 sleep lasts between 10–60 minutes and becomes progressively longer. During this stage, the body becomes less responsive. Brain activity, heart rate and breathing begin to slow, core body temperature drops, muscles relax and eye movement ceases.		45%–55%
	Slow Wave Sleep (SWS)	Entered after 30–60 minutes of Stage N2 sleep. It is the deepest stage of sleep and is the longest (approximately 20–40 minutes) during the first half of the night. [c] The length of time in SWS sleep becomes shorter over a typical period of sleep. During this stage, pulse and breathing slow further as the body becomes more relaxed. [c]	Recovery, growth, immune system function [a, b, c], visual and spatial memory [a, b]	15%–25%
Rapid Eye Movement (REM)				20%–25%
		Reached after 60–90 minutes of NREM sleep. [a] REM sleep becomes longer throughout a typical period of sleep. [a, b, c] and can last between 10 and 60 minutes. [c] This is a highly active state of sleep characterised by increased neurological activity, episodic bursts of rapid eye movement, and phasic changes in blood pressure, heart rate and breathing regularity. [a, b]	Memory consolidation, learning, creativity. [a, b]	

[a] (Carskadon & Dement, 2017). [b] (Chokroverty, 2017a). [c](Sleep Foundation, 2022).

In healthy normal human sleep, the body will enter through NREM sleep and move through the sleep stages sequentially; with each subsequent stage deeper than the last (Carskadon & Dement, 2017; Chokroverty, 2017a). The body then transitions to REM sleep through NREM SWS sleep (Carskadon & Dement, 2017; Chokroverty, 2017a). The distribution of time spent in the various states, stages, and cycles (i.e., the architecture of sleep) changes throughout an episode of sleep and seems to be intrinsically linked with how sleep is regulated (Carskadon & Dement, 2017). For instance, the distribution of Rapid Eye Movement (REM) sleep has been correlated with circadian oscillations (Achermann, 2017), while the distribution of SWS has been correlated with the length of the previous wakefulness period (Achermann, 2017).

Sleep Measurement

Sleep can be measured both objectively and subjectively. Polysomnography is the 'gold standard' objective measurement and is typically conducted in a controlled laboratory environment over one to two days (Rundo & Downey III, 2019). Several physiological parameters are recorded and then interpreted using a standardised scoring methodology to determine the occurrence of sleep states and stages and for how long they last. The limitations of polysomnography are that it is resource-intensive and timely to undertake (Rundo & Downey III, 2019). The laboratory setting may also influence typical sleep patterns as polysomnography studies are conducted outside of the person's typical sleeping environment (Ancoli-Israel et al., 2003; Hirshkowitz, 2022; Rundo & Downey III, 2019). For a comprehensive overview of polysomnography see Rundo and Downey III (2019).

Actigraphy is an alternative objective measurement method that infers when sleep occurs by monitoring movement. (Ancoli-Israel et al., 2003; Stone & Li, 2022). Its primary advantage is that it is a less invasive accelerometery-based in-field measurement method that can be utilised over several days or weeks, thereby providing a view of typical sleep patterns (Ancoli-Israel et al., 2003; Stone & Li, 2022). While less robust than polysomnography, as sleep architecture cannot be measured, it is possible to measure sleep timing, total time spent asleep, the number of awakenings,

sleep efficiency and sleep regulation (Ancoli-Israel et al., 2003; Stone & Li, 2022). Sleep diaries may be used in conjunction with actigraphy to confirm periods of sleep and wakefulness.

Subjective sleep measurement is more commonplace for large-scale community-based or population-wide studies, when objective measurement is typically less feasible to conduct (Ibáñez et al., 2018a). Subjective measurement methods, such as sleep diaries or sleep questionnaires, record self-reported details or perceptions of sleep and can offer an important point of comparison for objective measurement studies (Landry et al., 2015; O'Donnell et al., 2009; van den Berg, 2009; van den Berg et al., 2008). Sleep diaries are used to monitor sleep events over several days and are typically less susceptible to recall bias as information is recorded immediately before and after an episode of sleep (Ibáñez et al., 2018a). The information recorded includes bed and wakeup times, number and time of awakenings, sleep quality, and participant commentary (Carney et al., 2012; Ibáñez et al., 2018a). By comparison, sleep questionnaires can be designed to screen for sleep disorders, by measuring how often particular sleep events occur and general perceptions of sleep (Ibáñez et al., 2018a). Compared to other measurement methods sleep questionnaires are regarded as the least accurate as they capture personal perceptions of sleep over a generalised period, and can be influenced by various sources of bias (Ibáñez et al., 2018a). Despite this, validations studies have demonstrated several questionnaires to be ideal for screening for sleep disorders or specific dimensions of sleep, including the Pittsburgh Sleep Quality Index, Epworth Sleepiness Scale (ESS), and the Sleep Disorders Questionnaire (Ibáñez et al., 2018a). The primary advantage of sleep questionnaires is that they are inexpensive, do not require professional assistance to complete, and can complement objective studies to understand patient experiences (Ibáñez et al., 2018a, 2018b).

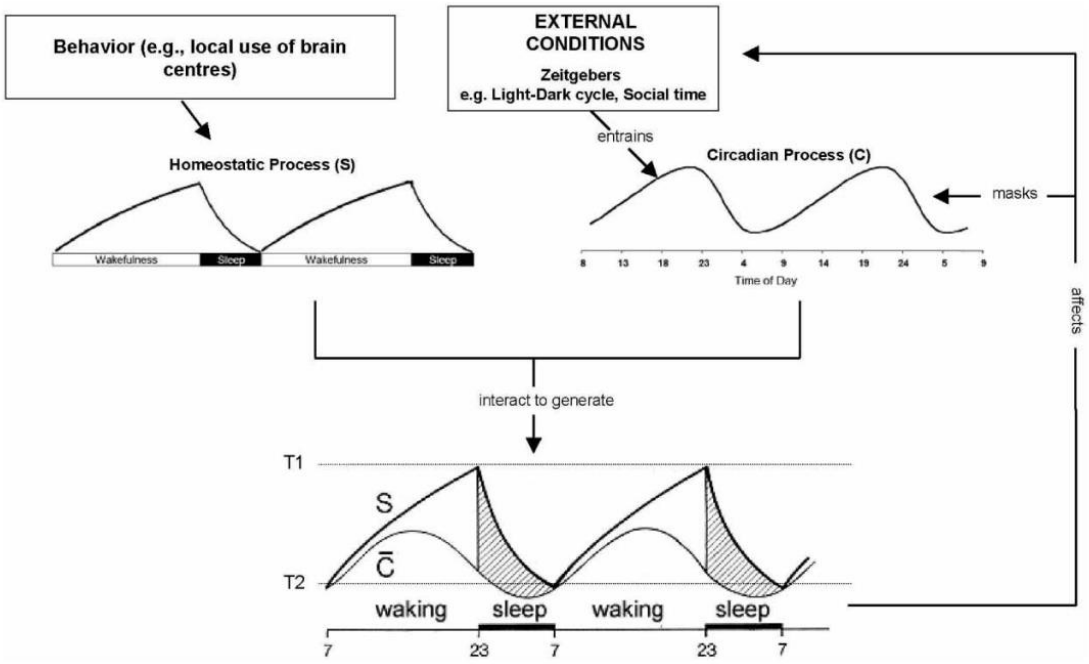
Sleep-Wake Regulation

Sleep is regulated by two separate cyclical biological mechanisms; the circadian timing system (Process C) and the homeostatic sleep pressure system (Process S) (Achermann & Borbely, 2003; Beersma, 1998; Borbely et al., 2016; Carskadon & Dement, 2017; Dijk & Czeisler, 1995; Dijk, 1999; Dijk & Lockley, 2002). The circadian timing system describes a collection of essential biological rhythms (circadian rhythms) that occur in most neurological and physiological processes and regulate neural cell activity, natural fluctuations in hormone levels, and body temperature (Cajochen et al., 2006; Dijk et al., 2012; Froy, 2011; Hood & Amir, 2017; Logan & McClung, 2019; Van Someren, 2000). The sleep homeostatic process acts as a pressure system, increasing the propensity for sleep as a function of time awake (Achermann, 2017; Borbely & Achermann, 1992; Borbély & Achermann, 1999). This 'sleep pressure' is alleviated after a consolidated period of sleep (Achermann & Borbely, 2003; Achermann, 2017; Beersma, 1998; Borbely et al., 2016; Cajochen et al., 2006; Dijk & Lockley, 2002).

The 'Two-Process Model' of sleep regulation poses that the sleep propensity is driven by the interaction between Process C and Process S. While synchronised, these systems have juxtaposed effects to establish a rhythm of sleep and wakefulness that coincides with the night and day cycles (Achermann & Borbely, 2003; Beersma, 1998; Borbely et al., 2016; Carskadon & Dement, 2017; Dijk, 1999; Dijk & Lockley, 2002). Together, they create the physiological need for sleep, as well as the propensity to fall asleep (Achermann & Borbely, 2003; Beersma, 1998; Borbely et al., 2016; Carskadon & Dement, 2017; Dijk, 1999; Dijk & Lockley, 2002) (see **Figure 1**).

Figure 1

The two-process model of sleep regulation.



Note. The figure represents the two-process model of sleep regulation as proposed by Borbely (1982) and Daan et al. (1984). The interaction between the circadian timing systems (Process C) and the homeostatic sleep pressure system (Process S). Down-regulation of alerting rhythms coincides with peak sleep pressure to promote and maintain sleep. Once pressure is alleviated, circadian rhythms are again up-regulated creating and maintaining the propensity for wakefulness allowing sleep pressure to accrue again.

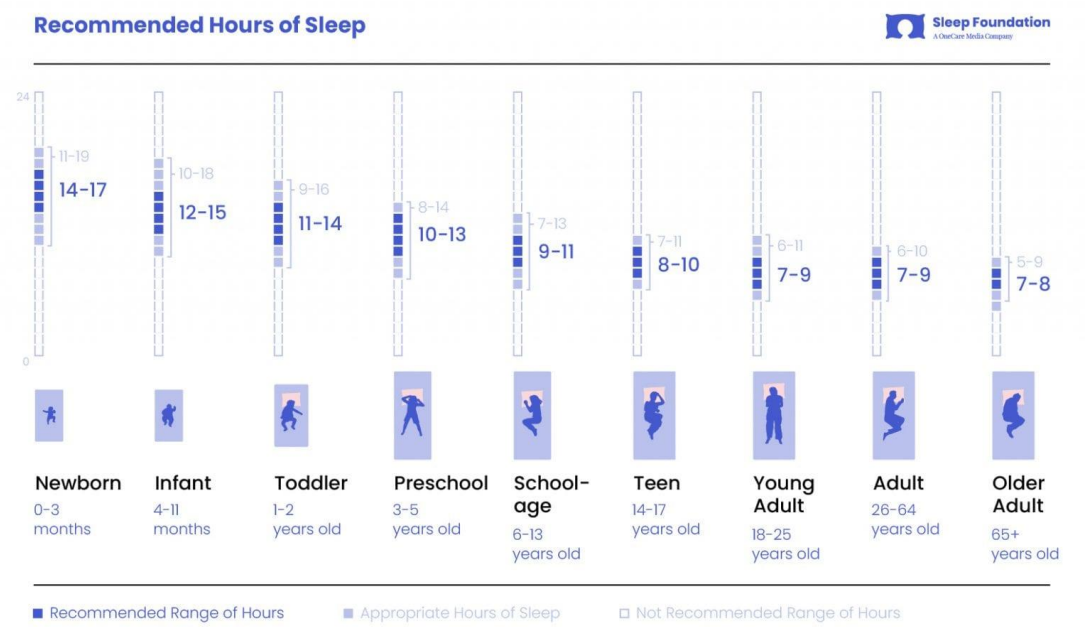
This image is taken from Schmidt et al. (2007) page 757. The image has been reproduced with the permission of Taylor and Francis.

Sleep Requirement

Sleep requirement, the amount of sleep needed to wake recovered, vitalised and rested for the period of wakefulness ahead, is intrinsic to each individual and largely reflective of their physiological requirements, health, lifestyle, activity, energy expenditure and the quantity, quality, timing and architecture of their sleep (Chaput et al., 2018). Sleep duration recommendations and guidelines, such as those produced by the Sleep Foundation (see **Figure 2**), provide a benchmark of the amount of sleep typically needed to support good health and well-being. The National Sleep Foundation's guidelines are grounded in epidemiological evidence and the recommendations that have been correlated with better cognition, mental and physical health, recovery and functioning (Hirshkowitz et al., 2015).

Figure 2

National Sleep Foundation life stage sleep duration recommendations and guidelines.



Note. Image from National Sleep Foundation, 2022, 'How much sleep do we really need?' from https://www.sleepfoundation.org/how-sleep-works/how-much-sleep-do-we-really-need#:~:text=National%20Sleep%20Foundation%20guidelines1,to%208%20hours%20per%20night

The image is available freely online from the link provided.

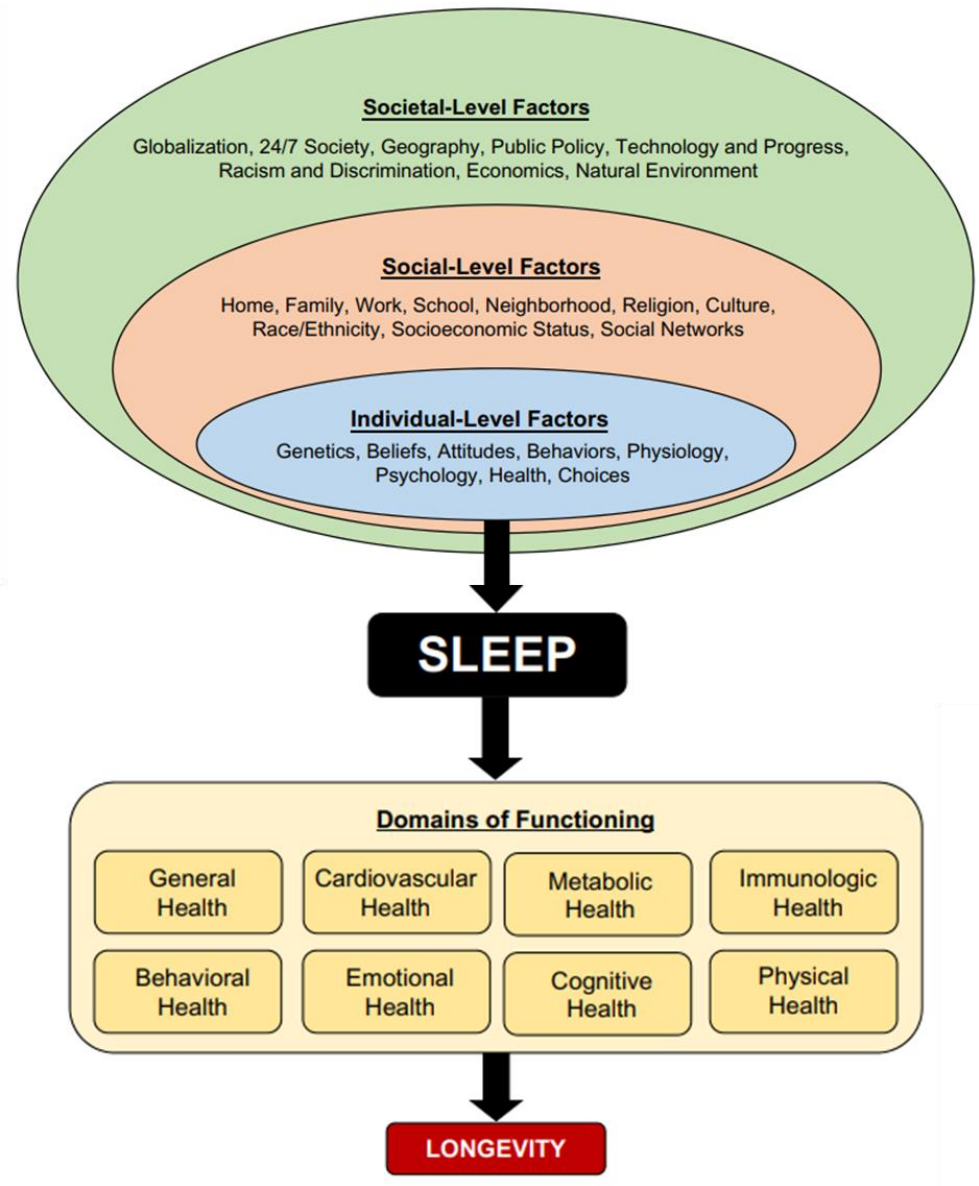
Sleep duration recommendations, therefore, provide a good level of guidance for population-level surveillance and sleep health monitoring (Chaput et al., 2018). While sleep durations recommended ranges decrease with age, it should not be assumed sleep requirement decreases too (Taillard et al., 2021).

1.3 Factors affecting sleep

There are many individuals, social, and societal factors that influence sleep across the span of life (Grandner, 2019). This has been summarised by Grandner (2019) using a socioecological model of sleep (see **Figure 3**). The model shows how factors coalesce and interact, highlighting the reciprocal nature of sleep and health (Grandner, 2019). The model identifies three spheres of influence. Individual-level factors are those intrinsic to the person and encompass personal and demographic characteristics, such as age, sex, genetics, physiology, health status (i.e., long-term health conditions, illness or a primary sleep disorder), nutrition, levels of physical activity, medication use, and personal attitudes toward sleep and sleep routines and hygiene practices (Aminisani et al., 2020; Ancoli-Israel & Ayalon, 2006; Ancoli-Israel et al., 2008; Crowley, 2011; Grandner, 2019; He et al., 2021; Madden et al., 2014; Partinen, 2017; Sindi et al., 2020). At the social level, factors include socioeconomic conditions such as area-level deprivation, service accessibility, work patterns, routines and schedules or caregiving demands. These factors can drive the conditions (i.e., light and noise), constraints (i.e., schedules) that influence attitudes toward sleep, and behaviours that influence sleep trade-off decisions. For instance, shift work schedules could dictate the requirement to wake early (Birth, 2007). Individual and social level factors are nested within wider societal systems. These systems set the rules and expectations that drive how societies function (Grandner, 2019) such as health care systems and economies (Birth, 2007).

Figure 3

Grandner's social-ecological model of sleep. This model illustrates how individual, social and societal level factors impact sleep and associated implications for domains of functioning and waking health.



Note. The figure represents the full sociological model, combining Figure 5.5 (pg. 49) and Figure 5.6 (pg. 50) from Grandner's Social-Ecological Model of Sleep Health (Grandner, 2019). Reproduced with permission of Elsevier and adapted with permission of Grandner, M. A.

Sleep disorders

Sleep disorders can impact the quality, timing and opportunity for sleep (Ancoli-Israel & Ayalon, 2006; Crowley, 2011; Roehrs & Roth, 2001), and can exist in the absence of underlying health conditions (e.g., primary) or be secondary to other medical or psychological conditions (Suzuki et al., 2017). Regardless of whether its aetiology is as a primary condition or as sequelae, sleep disorders may cause poor daytime functioning, sleepiness, poor quality sleep or shorter or longer sleep durations (Ancoli-Israel et al., 2008; Suzuki et al., 2017). As a consequence, they are known to cause poorer response times, performance, short-term memory, concentration, attention, energy, and motivation in both young and older adult populations (Ancoli-Israel et al., 2008; Lee & Sibley, 2019; Matsumoto & Chin, 2019; Medic et al., 2017; Rod et al., 2014; Suzuki et al., 2017). In older adults, sleep disorders and poor sleep have been correlated with the increased risk of falls and fractures, poorer quality of life, depression, anxiety, and greater cognitive decline, compared to healthy subjects (Ancoli-Israel et al., 2008).

Sleep disorders can occur at any age, although comparisons between younger and older adults suggest some become prevalent with age. A comparison of studies summarised in **Table 2** suggests that insomnia, sleep apnoea and restless legs syndrome all increase with age, while short sleeping is more of an issue for younger populations.

These differences may be in part due to the aetiology of sleep disorders, the reciprocal relationship between sleep and health, differences in definitions and diagnostic thresholds, and variations in measurement approaches and methodology between studies (Ohayon, 2011; Ohayon, 2004). Some studies define insomnia as the difficulty initiating and maintaining sleep that results in insufficient duration or quality of sleep, despite having a good opportunity for sleep (Ancoli-Israel & Ayalon, 2006; Paine et al., 2004; Suzuki et al., 2017).

Table 2

Comparison of estimates for sleep disorders (insomnia, sleep apnoea, restless legs syndrome), daytime sleepiness, and short and long sleep between general and older adult samples from studies done Internationally and in NZ.

	General adults		Older adults	
	International	**New Zealand**	**International**	**New Zealand**
Insomnia	10.00-30.00[a]	4.60-36.50[b]	30.00-50.00[a]	25.00-33.00 [b]
Sleep apnoea	0.89-15.00[a]	0.70-22.00[b]	24.00-62.00[a]	
Restless legs syndrome	3.00-15.00 [a]		16.60-67.20[a, d]	
Daytime sleepiness	2.80-26.10 [c]	8.80-24.6 [b]	5.20-6.00[c]	
Short sleep	7.70–53.30[a,d,e]	22.95-53.90 [b]	12.30[c]	37.00-38.20 [b]
Long sleep	2.80-9.50 [c]	3.20-6.10 [b]		5.90-7.30 [b]

[a](Ohayon, 2011); [b] Appendix 1; [c] (Ohayon, 2008); [d](Matsumoto & Chin, 2019), [e](Meers et al., 2019)

Other studies, however, apply more specific diagnostic criteria for insomnia such as: (1) learned sleep prevention (psychological insomnia), (2) sleep misperception and duration underestimation (paradoxical insomnia), or (3) where there are no clear signs of its cause (idiopathic insomnia) (Suzuki et al., 2017). Similar can be shown for sleep-related breathing disorders. Mihaere et al. (2009) reported varying prevalence estimates for obstructive sleep apnoea in NZ when different respiratory disturbance index (RDI) thresholds were used with and without the presence of excessive daytime sleepiness.

Table 3 and **Table 4** summarise the prevalence of self-reported sleep complaints in studies among community-dwelling older adult (65+ years) and general adult (15+ years) populations in NZ, respectively. Together, these tables highlight a paucity of research on older adults in the NZ context. Prevalence estimates for difficulty initiating, maintaining and resuming sleep, early morning

awakenings, and waking unrefreshed and commonplace sleep disorders are absent for older adults. Sleep complaints were measured in two studies, although exact figures were not reported (Gibson et al., 2020; Gibson et al., 2016). Given the disposition of older adults toward experiencing poor sleep, there is a case for further research on this population.

These tables also highlight differences in sleep by ethnicity. Disparities in sleep health have consistently been found, particularly in younger-middle-aged adults in NZ. A comprehensive table detailing the focus and results of prevalence studies in NZ summarised in Table 3 and Table 4 is available in Appendix 1.

Table 3

Summary of prevalence estimates (%) for symptoms of problem sleep and sleep complaints in the NZ older adult population (65+ years).

	Short sleep	Long Sleep	Current Sleeping Problem	Persistent Sleeping Problem	Feeling tired	Feeling worn out	Dissatisfied with sleep
Overall	37.00 **–** 38.20[a]	5.90 **–** 7.30[a]			50.00[b]	34.00[b]	18.00[b]
Male			25.30[c]				
Female			33.00[c]				
Māori			26.30[c]	29.40[d]			
Non-Māori			31.70[c]	26.50[d]			
Range	**37.00 – 38.20**	**5.90 – 7.30**	**25.30 – 33.00**	**26.40 – 29.40**	**50.00**	**34.00**	**18.00**

[a](Lee & Sibley, 2019); [b] (Myllyntausta, et al., 2021); [c](Gibson et al., 2016); [d](Gibson et al., 2020)

Table 4

Summary of prevalence estimates (%) for symptoms of problem sleep and sleep complaints in the NZ general adult population (±15 years and older).

	Difficulty initiating sleep	**Nocturnal awakenings**	**Difficulty returning to sleep**	**Waking too early in the morning**	**Never/rarely waking refreshed**	**Current Sleeping Problem** *(%chronic)*	**Daytime sleepiness**	**Insufficient sleep[+, •]**	**Long sleep**	**Obstructive Sleep Apnoea (OSA)[d ▲,■]**
Overall	29.60[a]	21.80[a] – 36.00[g]	34.00[g] – 49.20[a]	34.00[g] – 39.30[a]	54.50 [a]	25.10[a]	8.80[g] – 14.80[a]	37.10 – 37.50[e •]	4.20-5.10[e]	
Male								37.20 – 38.30[•]	3.90-4.90[e]	
Female								36.70 – 37.80[•]	5.00 – 5.20[e]	
Māori [b, c]	10.40[c] – 36.50[b]	12.70[c] – 28.40[b]	53.00[b]	14.80[c] – 48.80[b]	59.10[b]	33.00 *(28.60)*[b]		29.55[f] – 48.00[e•]		
Male [d]					45.13 – 46.61[d]		11.87 – 24.60[d]	39.84[d+]		4.40[▲] – 22.00[■]
Female [d]					42.12 – 47.85[d]		11.78 – 22.15[d]	38.16[d+]		2.00[▲]6.30[■]
Non-Māori [b]	28.70[b]	20.80[b]	48.60[b]	38.00[b]	53.80[b]	26.40 *(24.60)*[b]				
Male [d]					42.05 – 47.30[d]		15.58 – 17.68[d]	37.82[d+]		4.10[▲] – 11.40[■]
Female [d]					43.10 – 44.80[d]		10.99 – 12.06[d]	36.33[d+]		0.70[▲] – 3.00[■]
Pacific [c, e, f]	5.60	7.90		9.90				22.95[f] – 53.90[e•]	4.60 – 5.40[e]	
Asian [c, e]	5.60	6.90		4.90				36.20 – 40.80 [e•]	3.20 – 6.10[e]	
Other [c]	4.60	6.00		9.90						
European [c, e]	7.00	10.40		9.10				34.00 – 34.50 [e•]	4.40 – 5.00[e]	
Range	**4.60 – 36.50**	**6.90 – 36.00**	**34.00 – 53.00**	**4.90 – 48.80**	**42.05 – 59.10**	**25.10 – 33.00**	**8.80 – 24.60**	**22.95 – 53.90**	**3.20 – 6.10**	**0.70-22.00**

Note. 'Insufficient Sleep' reflects prevalence estimates reported as either 'never or rarely getting enough sleep'(+) or short sleep durations (•). Obstructive Sleep Apnoea (OSA) was either measured according to where the Respiratory Disturbance Index (RDI) ≥5 (▲); or where the RDI ≥5 and Epworth Sleepiness Scale (ESS) Score >10 (■).

[a](Paine et al, 2005); [b](Paine et al. , 2004); [c](Paine et al., 2019); [d](Mihaere et al.,2009); [e](Lee & Sibley, 2019); [f](Paine et al., 2016); [g](Wilsmore et al., 2013).

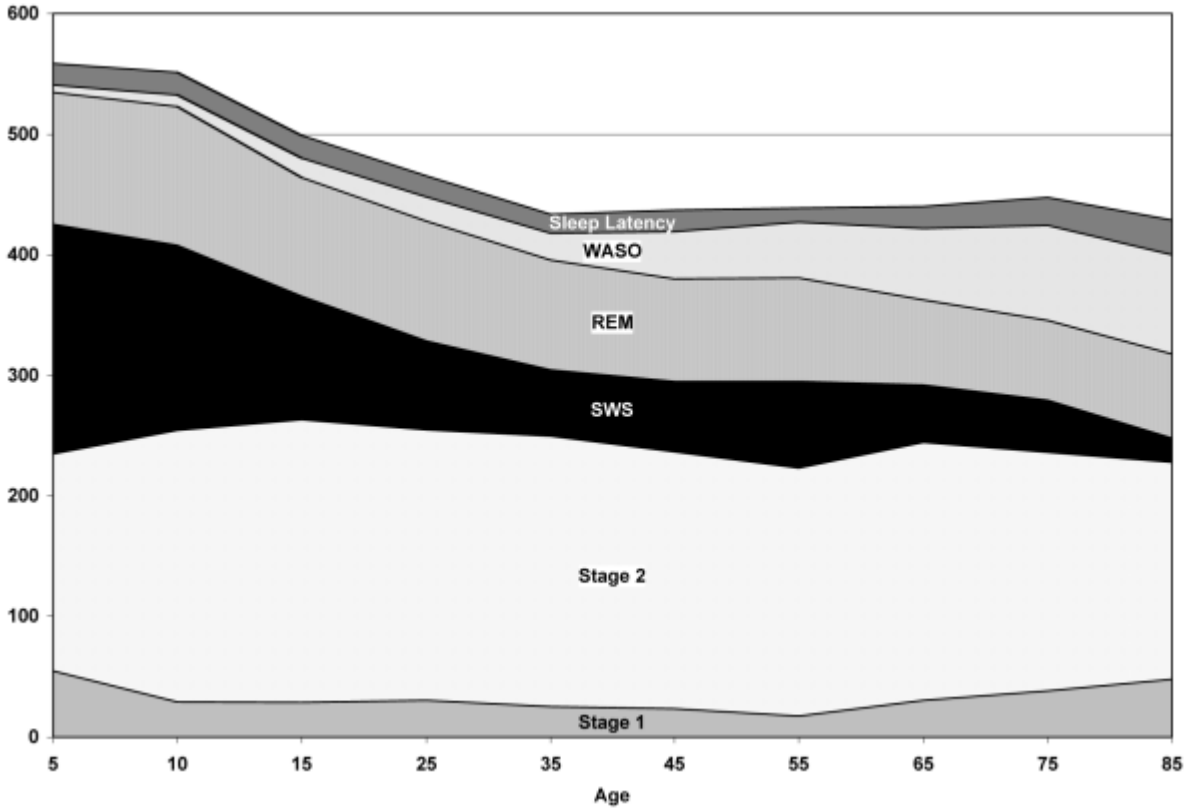
Ageing

With ageing, circadian rhythms become less pronounced and weaker than the juxtaposed homeostatic sleep pressure system (Taillard et al., 2021). This can result in greater sleep pressure when physiological systems are promoting wakefulness or physiological rhythms are unable to withstand lower sleep pressure thresholds (Taillard et al., 2021). This increases the propensity to fall asleep in either situation (Taillard et al., 2021). Age-related changes in sleep architecture are also well-documented (Aira et al., 2008; Carskadon & Dement, 2017; Chokroverty, 2017a; Hirshkowitz et al., 2015; Hood & Amir, 2017; Li et al., 2018; Logan & McClung, 2019; Miner & Kryger, 2020; Ohayon, 2004; Skeldon et al., 2016; Taillard et al., 2021; Van Someren, 2000). In one meta-analysis of objective sleep studies, Ohayon (2004) concluded older adults experienced less SWS and REM sleep, and more N1 and N2 NREM sleep. Sleep onset latency and awakenings after sleep onset were also more prominent in older adults (see **Figure 4**). These changes together mean sleep becomes lighter and more transitory with age.

These objective findings align with subjective experiences of sleep reported by older adults. It is commonplace for older adults to report difficulty initiating and maintaining sleep, more daytime napping, frequent night-time awakenings, and feeling as though it is more difficult to get the amount of sleep they feel they need (Ancoli-Israel et al., 2008; Carskadon & Dement, 2011; Chokroverty, 2017a, 2017b; Crowley, 2011; Li et al., 2018). The aforementioned sleep complaints may be mediated or moderated by various factors which can include (but are not limited to) light exposure, physiology, exercise, diet and meal times, socialisation, and socioeconomic factors. (Ancoli-Israel & Ayalon, 2006; Ancoli-Israel et al., 2008; Chokroverty, 2017b; Crowley, 2011; Dew et al., 2003; Gallicchio & Kalesan, 2009; Grandner, 2019; Logan & McClung, 2019; Ohayon, 2004; Rod et al., 2014)

Figure 4

The distribution of time (minutes) asleep across various states and stages of sleep across the lifespan in (years). The changes in sleep architecture across the lifespan mean the nature and quality of sleep differ between young and older adults.



Note. SWS: Slow wave sleep. REM: Rapid Eye Movement. WASO: Wakefulness After Sleep Onset. Image sourced from Ohayon et al. (2004). This image has been reproduced with permission given by SLEEP Journal.

Sex differences

Sex-specific differences in sleep become evident during adolescence (Meers et al., 2019). This is due to the regulation and functioning of the endocrine system, which is closely tied with sleep regulation, being intrinsically linked with biological sex (Meers et al., 2019). Therefore, sex-specific differences that appear in sleep coincide with the biological age at which puberty commences, and reflect differences in the reproductive and growth hormone fluctuations between males and females (Meers et al., 2019). Research investigating poor sleep in females has shown fluctuations in

menstruation coincide with shifts in circadian rhythms and sleep architecture. Equally, the incidence of insomnia coincides with menopause in women; and the incidence of poor sleep in males is correlated with declines in testosterone (Meers et al., 2019). Research investigating sex-specific differences in older adults has shown women experience subjectively worse sleep when compared with males (Meers et al., 2019; van den Berg, 2009). While older females are more likely to report difficulty falling asleep or worse quality sleep, older males have been found to have objectively worse sleep (Meers et al., 2019; van den Berg, 2009). Some objective sleep studies have found a more pronounced reduction in SWS and increases in N1 sleep in older males, compared to older females (Meers et al., 2019). In NZ, Mihaere et al. (2009) found obstructive sleep apnoea to be more prevalent among males, whereas Paine et al. (2004) found females more likely to self-report having a current sleeping problem, difficulty falling asleep and feeling unrefreshed when waking.

Ethnicity differences

Internationally, it has been shown that sleep health is not equitable across ethnicities (Johnson et al., 2019; OECD, 2017), and similar findings have been made in NZ (Gibson et al., 2020; Gibson et al., 2016; Mihaere et al., 2009; Paine & Gander, 2016; Paine et al., 2005; Paine et al., 2019; Stephens et al., 2020). Indigenous and immigrant adults in the United States are at greater risk of sleep short, excessive sleepiness and poorer sleep quality, compared to Caucasian adults (Johnson et al., 2019). Here in NZ, insufficient sleep and short sleep are more prevalent among Māori (Paine & Gander, 2016). Māori have also been found more likely to report long sleep on scheduled days (Paine & Gander, 2016). Increasingly, health disparities in indigenous populations, immigrant communities, and minority ethnic groups are recognised as a consequence of legacy social inequality (Grandner, Patel, et al., 2010; Johnson et al., 2019; Paine & Gander, 2016; Reid et al., 2017; Stephens et al., 2020). Socioeconomic disparities and social inequalities impact living standards, sleeping environments, physical and mental health and access to healthcare (Grandner, Patel, et al., 2010; Johnson et al., 2019; Paine & Gander, 2016; Stephens et al., 2020). Among many

things, these can coalesce to influence sleep health and access to services to identify and treat sleep disorders or manage poor sleep.

Socioeconomic conditions

Factors reflecting how life and livelihood are experienced at the individual and collective level include education achievement, income, employment status, occupation, access to services, and area deprivation (Dulin et al., 2011; Grandner, Patel, et al., 2010). Lower socio-economic status has been associated with poor sleep, internationally and in NZ (Gibson et al., 2016; Grandner, Patel, et al., 2010; Paine & Gander, 2016; Paine et al., 2004). A literature review by Grandner et al. (2010) signalled key issues such as long work hours, education achieved and income were correlated with short sleep or long.

Childhood socioeconomic status appears to be significantly associated with engagement in health behaviours and risk factors throughout life, as well as health status and health outcomes in older age (Aminisani et al., 2020; Dulin et al., 2011; OECD, 2017; Stephens et al., 2020; Szabó, Hyde, et al., 2021; Szabó, Towers, et al., 2021). Studies from NZ have found that indicators of poorer socioeconomic status (i.e., deprivation index, income, education level) are associated with poorer physical and mental health and access to services and supports (Allen & Alpass, 2020; Aminisani et al., 2020; Stephens et al., 2020; Szabó, Towers, et al., 2021). Stephens et al. (2020) demonstrated that higher childhood socioeconomic status was typically associated with better socioeconomic status in adulthood, which in turn contributed to better health status in older adulthood. In the study by Stephens et al. (2020) several dimensions of socioeconomic status were considered including material well-being, overcrowding, housing quality, education achievement, occupation grade and financial history. Cross-sectional and prospective cohort studies have demonstrated poorer socio-economic status (measured in terms of area deprivation, education, unemployment, and low income) are all associated with poorer sleep (Gibson et al., 2016; Mihaere et al., 2009; Paine & Gander, 2016; Paine et al., 2005; Paine et al., 2019). The available information suggests that socioeconomic conditions play an important role in healthy ageing trajectories, as well as the ability to attain enough

good quality sleep regularly. While the opportunities to influence good health status in later life may present as early as childhood the role of sleep as a mediator or moderator of health status in light of socioeconomic conditions requires more research.

Long-term health conditions

Physiological and psychological health has a bidirectional relationship with sleep (Ancoli-Israel & Ayalon, 2006; Sindi et al., 2020; Suzuki et al., 2017). Sleep disorders have been shown to precede physiological, psychological, or neurological diseases (Suzuki et al., 2017). As one example of this, Suzuki et al. (2017) reported half of the idiopathic REM Behaviour Disorder patients developed a parkinsonian disorder within ten years, and almost all patients with REM Behaviour Disorder developed a neurodegenerative disorder. Equally, challenges accruing sufficient quantity and quality sleep are associated with poorer health status and the incidence of mental and physical health conditions and multimorbidity (Aminisani et al., 2020; Ancoli-Israel & Ayalon, 2006; He et al., 2021; Sindi et al., 2020; Stewart et al., 2020; Suzuki et al., 2017).

In older populations, poor sleep and sleep disorders have been correlated with increased chronic disease accumulation (Ancoli-Israel & Ayalon, 2006; Ancoli-Israel et al., 2008; He et al., 2021; Sindi et al., 2020; Suzuki et al., 2017), which emphasises the importance of early sleep detection for healthy ageing. Sindi et al. (2020) found moderate to severe sleep disturbances in older adults was associated with a higher incidence of physiological and psychological conditions including cardiovascular disease, depression, dementia, osteoporosis and joint disease. (Suzuki et al., 2017) also reported older adults with insomnia or sleep-disordered breathing were at a greater risk of cardiovascular disease, metabolic syndromes, diabetes, hypertension and stroke. (Suzuki et al., 2017). A meta-analysis of epidemiological sleep duration studies by Gallicchio and Kalesan (2009) found short sleep duration was associated with cardiovascular and cancer-related mortality, whereas long sleepers were found to be at greater risk of all course mortality. The literature available demonstrates that sleep is a crucial determinant of well-being. Despite this, there is much to learn about the cumulative impact of poor sleep, sleep disturbance and sleep disorders in the aetiology of

long-term health condition and their co-occurrence. The accumulation of chronic conditions with ageing may mean older adults are at a greater risk of poor sleep due to the bi-directional relationship between sleep and health (Ancoli-Israel & Ayalon, 2006; Crowley, 2011; Foley et al., 2004).

Medications

Pharmaceutical management of chronic illness, conditions and diseases can negatively impact the quantity and quality of sleep. Where some medications have a stimulating effect (i.e., bronchodilators, corticosteroids, decongestant respiratory medications, antihypertensives, serotonin reuptake inhibitors thyroid medications), others have hypnotic or sedative effects that can promote daytime tiredness or drowsiness (i.e., prescription pain medications, first-generation antihistamines, some antipsychotics, antiparkinsonian and antidepressants) (Ancoli-Israel & Ayalon, 2006; Neikrug & Ancoli-Israel, 2010). Alone these medications may impact sleep, however, comorbidity and multimorbidity may require multiple pharmaceutical interventions. Polypharmacy describes the concurrent use of five or more medications (Health Quality & Safety Commission New Zealand, 2021). It may be appropriate for the treatment of complex conditions, or where there are multiple health conditions requiring management. Inappropriate combinations can, however, be harmful. Opposing or cumulative side-effects can increase the risk of excessive drowsiness or over-sedation, confusion, urine retention, hypotension, renal failure and falls (Health Quality & Safety Commission New Zealand, 2021). Older adults as a cohort are particularly susceptible to polypharmacy, in part owing to the increased prevalence of comorbidity for which pharmacological intervention is required (Ancoli-Israel & Ayalon, 2006; Crowley, 2011; Health Quality & Safety Commission New Zealand, 2021; Wallis, 2015). Available evidence suggests the risk of adverse reactions increases with the number of medicines taken and is more likely to be problematic in older adults of advanced age (e.g., 85 + years) as comorbidity is more likely (Health Quality & Safety Commission New Zealand, 2021).

Environmental factors

The circadian pacemaker is sensitive to both biological (internal) and environmental (external) factors such as light, temperature, exercise, meal timings, work schedules and social cues. These external factors, otherwise known as 'zeitgebers', are capable of entraining biological rhythms to the 24-hour cycle (Astiz et al., 2019; Dijk & Czeisler, 1995; Duffy & Wright Jr, 2005; Khalsa et al., 2003; Lane et al., 2016; Van Someren, 2000). These environmental factors are, therefore, capable of influencing the period, phase and amplitude of the circadian rhythms and can help to promote healthy sleep (Astiz et al., 2019; Chun et al., 2021; Dijk et al., 2012; Münch et al., 2020). Of these factors mentioned, light is the primary external time cue, and is considered to have the greatest influence on circadian rhythms (Dijk et al., 2012; Münch et al., 2020). This is owing to the mammalian visual system which moderates entrainment by light via the retinohypothalamic tract (Astiz et al., 2019; Duffy & Wright Jr, 2005; Froy, 2011). Light has been demonstrated to serve non-pharmacological interventions effective for entraining disturbed sleep patterns and reducing sleep disorders in older adult populations with dementia and Alzheimer's (Montgomery & Dennis, 2002).

Physical activity

Physical activity is another external cue to the circadian system (Astiz et al., 2019; Atkinson & Davenne, 2007; Driver & Taylor, 2000; Kredlow et al., 2015; Yang et al., 2012). Studies have shown physical activity to be associated with longer sleep duration and more SWS (Driver & Taylor, 2000). By contrast, sedentary behaviour has been demonstrated to increase the risk of insomnia and sleep disturbance (Seol et al., 2020; Yang et al., 2017). With age, participation in physical activities tends to decrease. For some older adults, exercise may support their health maintenance, cognition, well-being or disease management, and provide an enjoyable pastime or opportunity to socialise. For others, there may be significant barriers to maintaining good levels of activity (Rasinaho et al., 2007). Poor health, fear of injury, tiredness, poor eyesight, cost, insecurities and feeling vulnerable, or unsuitable environments can all impede engagement in regular activity or

exercise for older adults (Rasinaho et al., 2007). Studies that have investigated the effect of increased physical activity on sleep in sedentary older adults demonstrated improvements in sleep duration, efficiency, quality, daytime function and reduced use of sleep medication (Seol et al., 2020; Vanderlinden et al., 2020; Yang et al., 2012).

Nutrition

Several studies have investigated the relationship between nutrition and sleep (Dashti et al., 2015; Noorwali et al., 2018; Partinen, 2017; Patel et al., 2014). Together, these studies have demonstrated that good nutrition plays an important role in supporting sleep (Dashti et al., 2015; Noorwali et al., 2018; Partinen, 2017; Patel et al., 2014). For instance, fruits such as tart cherries, kiwifruit, chamomile tea or milk promote sleep by increasing plasma tryptophan, and nutrients like lycopene, magnesium, and adequate sodium may help to promote good sleep (Partinen, 2017). By contrast, lower fruit and vegetable consumption, poor quality diets and poor meal timing and irregular eating habits may deleteriously impact sleep (Dashti et al., 2015; Noorwali et al., 2018; Partinen, 2017; Patel et al., 2014). For instance, excessive sodium intake, insufficient ascorbic acid, or caffeine consumption can impact sleep initiation. Carbohydrates, fats and proteins impact sleep differentially, according to the ratio in which such meals are consumed and when such meals are consumed (Partinen, 2017).

Poor diets and poor sleep are both recognised risk factors for obesity (Dashti et al., 2015; Grandner et al., 2012; Johnson et al., 2019; Meers et al., 2019; Wheaton et al., 2011). Obesity has been recognised as a risk factor for sleep-disordered breathing (Mihaere et al., 2009) and to impact sleep pressure, sleep duration and daytime napping in general adult and older adult populations (Mihaere et al., 2009; Patel et al., 2014). There are several mechanisms for how the relationship between obesity and poor sleep may occur. Patel et al. (2014) proposed irregular sleep-wake rhythms may be synonymous with irregular eating habits, which themselves were independently associated with weight gain. Alternatively, higher night-time caloric intake is associated with later bed times, circadian dysfunction and dysregulation which impact metabolism and glucose regulation

to promote weight gain (Patel et al., 2014). Short sleep has also been found to alter levels of plasma ghrelin and leptin to increase appetite and the preference for energy-dense foods (Dashti et al., 2015; Noorwali et al., 2018; Partinen, 2017; Patel et al., 2014)

Smoking

Smoking is a well-recognised risk factor in several non-communicable diseases and is a leading cause of morbidity and mortality (Amiri & Behnezhad, 2020; Barnett et al., 2009; dos Reis Costa, 2017; LaCroix et al., 1991; Phillips & Danner, 1995). It has been shown to deleteriously impact sleep and alter sleep architecture, contributing to the occurrence of daytime sleepiness, shorter sleep durations and difficulty initiating sleep (Amiri & Behnezhad, 2020; dos Reis Costa, 2017). There are several mechanisms by which this relationship is proposed to occur. Nicotine may stimulate the release of neurotransmitters involved in the regulation of wakefulness (dos Reis Costa, 2017; Suzuki et al., 2017), and decreased plasma nicotine concentration can occur during sleep, driving cravings or symptoms of withdrawal (Amiri & Behnezhad, 2020; dos Reis Costa, 2017). Smoking also has a deleterious impact on the respiratory system, causing breathing difficulty or sleep-related breathing disorders. (Amiri & Behnezhad, 2020; dos Reis Costa, 2017). Habitual smoking can also contribute to the development of long-term health conditions to which sleep problems may be secondary morbidity causing diminished sleep quality and increased daytime sleepiness. (Amiri & Behnezhad, 2020; Brook et al., 2015; dos Reis Costa, 2017).

This relationship between sleep and smoking is largely understudied in older adults, and this may be due to the cessation of smoking (Ministry of Health, 2021). One study investigating the relationship between sleep and smoking in Chinese older adults determined that ex-smokers and current smokers were more likely to experience sleep durations outside of the recommended sleep ranges (i.e., short or long sleep) (Lee et al., 2021).

1.4 The role of alcohol in sleep disturbance

Older adults are at a significantly high risk of alcohol-related harm. This is primarily because ageing is associated with a decreased ability to metabolise alcohol, the presence of multiple long-term health conditions and concurrent use of medications (Cousins et al., 2014; Crowley, 2011; Szabo et al., 2019; Towers et al., 2011). This means that similar levels of alcohol consumed by younger and older people can result in a greater level of toxicity in an older person whose body cannot process ethanol as efficiently (Towers, Philipp, et al., 2018). Research in young-to-middle-age adult samples shows that alcohol has a deleterious effect on sleep (Colrain et al., 2014; Ebrahim et al., 2013; Garcia & Salloum, 2015). However, much less research is available among older adult samples. Ebrahim et al. (2013) synthesised the findings of studies on the effects of alcohol on normal sleep in young-to-middle-aged adult populations. Their study found at all dosages, night-time alcohol consumption reduced sleep onset latency (i.e., the time to fall asleep) and sleep was more consolidated (i.e., fewer awakenings after sleep onset and increased SWS) in the first half of the night. In the second half of the night, sleep was more fragmented (Ebrahim et al., 2013). At all dosages, Ebrahim et al. (2013) found the onset of the first REM sleep period was significantly delayed, and the total amount of REM sleep attained was reduced. In addition to the dose consumed, the time of consumption relative to when sleep occurs can also influence sleep. As outlined by Colrain (2014) blood alcohol levels may continue to rise after sleep onset and fall as it is metabolised. The variable concentrations throughout a sleep episode have a profound effect on sleep architecture, as might the secondary effects of alcohol consumption (i.e., the concentration and elimination of metabolites) (Colrain et al., 2014).

Despite the increased sensitivity and risks associated with drinking alcohol, emerging research shows that some older adults self-medicate with alcohol to combat their challenges with sleep (Aira et al., 2008; Bareham et al., 2019), as well as for health benefits or social reasons (Bareham et al., 2019; Canham & Mauro, 2016; Cousins et al., 2014; Haighton et al., 2018). While previous research highlighted that health benefits of moderate drinking exist (Bareham et al., 2019; Jaussent et al., 2011), Towers, Philip et al. (2018) found alcohol-related differences in health were

not significant when socioeconomic status was adequately controlled for. Therefore, concluding socioeconomic status was a key predictor of the health benefits of moderate-level alcohol consumption (Towers, Philipp, et al., 2018). Another NZ study by Szabó (2021) identified several significant childhood predictors for life-course drinking trajectories. For instance, childhood socioeconomic status, parental alcohol misuse, and the age of alcohol initiation determined the health impact of life-course drinking trajectories. The trajectories in this study spanned the age of initiation through to older adulthood. Differences in alcohol consumption behaviours and the relationship between health status in older adults have become more evident in recent years (Britton et al., 2020; Szabo et al., 2019). Studies have consistently determined profiles that characterise hazardous drinking to be associated with poorer health status, Szabó (2021) also emphasised that frequent light drinking was not necessarily low-risk. The study by Szabó (2021) identified a high proportion of frequent light drinkers who experienced alcohol-related comorbidities. In NZ studies have also demonstrated that alcohol consumption trajectories can show little to no change over the course of life (Szabó, Towers, et al., 2021; Szabo et al., 2019; Towers, Sheridan, et al., 2018a, 2018b). Therefore, interventions that address the role of alcohol in sleep disturbance observed in later life may require early life intervention to mitigate the long-term impacts of poor sleep and alcohol use patterns in older age.

1.5 Aims of this Thesis

This research will describe profiles of sleep in the NZ population and explore the demographic and health differences between sleep profiles in older adults. This thesis will investigate how alcohol use is associated with sleep profiles in older adult drinkers in NZ. There are three research objectives for this study:

1. To explore the extent to which distinct sleep profiles exist within the adult and older population
2. Identify the demographic and health factors that underpin sleep profile membership in older adulthood; and
3. Explore how alcohol use is related to sleep profile membership in older adulthood.

Based on the literature considered here, it was hypothesised that:

1. The prevalence of sleep profiles characteristic of poor sleep will be more prevalent among older adults, than the younger general adult population;
2. Factors indicative of poor health in older adulthood (i.e., multimorbidity, polypharmacy, poor nutrition, etc.) will be associated with profiles characteristic of poor sleep; and
3. More harmful alcohol consumption tendencies are associated with profiles of poor sleep among older adult drinkers.

2 Methodology

This section discusses the approach taken to quantitatively investigate factors associated with sleep profiles among older adults. Secondary data analysis of the Ministry of Health's 2013/2014 New Zealand Health Survey (NZHS) data was conducted to achieve the aims of this thesis.

2.1 The New Zealand Health Survey

The NZHS is a large sample survey of the resident population of NZ that is commissioned by the Ministry of Health. The survey is conducted on an annual basis and provides a mechanism through which population health data can be collected (Ministry of Health, 2011, 2014c).

Questionnaire

The survey consists of two components; the (1) core and (2) module questionnaire. The core questionnaire is intended to collect data for ongoing monitoring, such as long-term health conditions, health service utilisation, patient experience, protective and risk factors, health status, anthropometry, and sociodemographic information. For this reason, the core questionnaire is kept consistent across each survey wave (Ministry of Health, 2014c). The module questionnaire is used to assess emerging health trends or health topics of interest. These survey items typically change between survey waves (Ministry of Health, 2014c). The 2013/2014 NZHS presented five sleep items in the module questionnaire. These items were used to collect information on typical sleep durations, sleep disorders and daytime sleepiness in the NZ population.

Sample Design

The NZHS survey sample was drawn using a dual-frame complex multistage stratified probability proportion to size sampling process (Ministry of Health, 2011, 2014c). Participants were drawn either through area-based sampling (sampling frame one) or electoral roll sampling (sampling frame two) (Ministry of Health, 2014c). The dual sampling frame aimed to improve the representation of Māori and minority ethnicity groups to ensure the estimates derived and differences detected

could be achieved with the same degree of statistical precision (Ministry of Health, 2014c). See the Ministry of Health (2014c) for a detailed report on this methodology.

Target and Survey Population

The NZHS survey was designed to monitor the health status of the resident population of all ages living in NZ (Ministry of Health, 2011, 2014c). This extends to non-private dwellings (e.g., retirement facilities, student accommodation, apartment complexes, etc.) which were previously excluded from much earlier standalone versions of the NZHS (Ministry of Health, 2014c). A small number of households and facilities were excluded from the NZHS survey populations. These included households in remote areas or located off of the mainland of NZ, correctional facilities, hospitals, dementia care units and hospital-level care units in aged care and retirement institutions. Surveys were conducted in the home of respondents with trained interviewers present. Information was captured electronically and interviews presented showcards with possible response options. In addition to the survey questions, interviewers were required to capture objective anthropometry measurements, namely height, weight, waist circumference and blood pressure. The 2013/2014 NZHS was approved by the multi-region ethics committee (MEC/10/10/103) (Ministry of Health, 2014c).

2.2 Measures

Key items investigated as part of this thesis are summarised here. The measures investigated here align with Grandner's (2019) social-ecological model of sleep, although reflect the variables available under the NZHS.

For a detailed overview of all questions within the 2013/2014 survey see the Ministry of Health's website (Ministry of Health, 2014d). Furthermore, information on the variables, standards and technical definitions are available in the Ministry's methodology report, content guide and indicator interpretation guide (Ministry of Health, 2014a, 2014b, 2014c).

Demographics

Age

Age (in years), calculated as the difference between the participants' date of birth and the date the survey was completed was available on the dataset. Age was used to classify each respondent's life stage as either 'teenagers', 'young adults', 'adults' or 'older adults' according to their age at the time they participated in the survey. Life stages were defined according to the National Sleep Foundation Sleep Duration Recommendations and Guidelines (Figure 2) (Hirshkowitz et al., 2015).

Ethnicity

Ethnicity data were collected by asking participants to indicate "Which ethnicity group or groups do you belong to?". Participants could indicate belonging to one or multiple ethnicities. The dataset included a derived binary indicator ethnicity variable which indicated where a respondent identified as 'Māori'.

Sex

At the outset of the survey, participants were asked to indicate if they were male or female. Participants had the option to refuse this question. This item was retained for analysis to identify males from females.

Sociodemographic

Sociodemographic data collected included (but was not limited to) area-level deprivation, the highest level of education attained, employment status, and household level of income. Information retained for analysis follows.

Deprivation

The New Zealand Deprivation (NZDEP) Index was retained to provide an estimate of socio-economic deprivation for each respondent (Atkinson et al., 2014). The dataset included quintile and decile measures for the 2006 and 2013 versions of the deprivation index. The ordinal scale index reflects eight dimensions of deprivation and increases as the degree of deprivation. The NZDEP Index 2013 quintiles were retained for the current study, as this reflected the level of deprivation at the time the survey was conducted, and quintiles offered greater statistical power when analysing smaller subpopulation groups (e.g., the older adult cohort).

Education

Two survey items were used to determine each participant's level of education: (1) "What was your highest secondary school qualification?", and (2) "What was your highest completed qualification?". These were cross-referenced to determine the highest level of education a respondent had achieved, as follows: (1) Lower secondary, (2) Upper secondary, (3) Tertiary, and (4) Other. The category definitions derived were consistent with the education level variable available in the 2017/18 and 2018/19 NZHS.

Household Income

The equivalised household income according to the OECD modified approach using two survey items: (1) the combined annual household income from all sources, before tax, earned over the preceding 12-month period, and (2) the household occupancy (OECD; Stats NZ, 2019). As household income response options were categorical, the median household income value for each category was assigned as a proxy value with exception of the lowest and highest income categories. Instead, values were assigned according to a priori information (Perry, 2018). The median equivalised household income value was ($36,667), The 'low' income tercile was set at half of the median equivalised household income ($18,333.50), and the 'high-income tercile was set at 1.5 times the median equivalised income ($55,000.50). Tercile thresholds were informed by a priori information. See Ministry of Social Develop Income Report by Perry (2018)

Sleep

There were five sleep items administered in the NZHS 2013/2014 survey to assess the prevalence of problem sleep in NZ adults (see **Table 5**). Survey items were informed by questions administered in existing population health surveys, namely: the (1) National Health and Nutrition Examination Survey (NHANES) and (2) National Health Interview Survey (NHIS) conducted by the Centre for Disease Control and Prevention (Ministry of Health, 2014a). Amendments to the wording of questions were made in consultation with members of Massey University's Sleep-Wake Research Centre (Ministry of Health, 2014a).

Table 5

Summary of sleep items within the NZHS 2013/2014

Question	Response options	Question note
Sleep disorder		
Have you ever been told by a doctor or other health professional that you have a sleep disorder?	1 = Yes 2 = No	Taken from NHANES Abbreviated Sleep Disorder Questionnaire
What was the sleep disorder?	1 = Obstructive sleep apnoea 2 = Insomnia 3 = Restless legs 4 = Other [specify]	
What treatments do you now have for your sleep disorder(s)?	1 = No treatment 2 = Medicines, tablets, pills, or injections 3 = Diet 4 = Counselling 5 = Exercise or physiotherapy 77 = Other [specify]	
Excessive Sleepiness		
In the last four weeks, how often did you feel excessively sleepy during the day?	1 = Never 2 = 1 time a month 3 = 2 – 4 times a month 4 = 5 – 15 times a month 5 = 16 – 30 times a month	Amended from NHANES Questionnaire, "In the base month, how often did you feel excessively or overly sleepy during the day?"

Question	Response options	Question note
Sleep Duration		
How many hours of sleep do you usually get in a 24-hour period, including all naps and sleeps?	Recorded in one-hour increments. (1 – 24hrs).	Amended form NHIS Sleep Duration Question "On average, how many hours of sleep do you get in a 24-hour period

Note. The sleep duration question presented in the NZHS 2013/2014 survey was introduced for continuous monitoring in the NZHS 2017/2018.

Life stage-specific sleep duration

Life-stage-specific sleep durations were discussed earlier (see Figure 2). National Sleep Foundation guidelines outline two sets of guidelines, those that are (1) 'recommended range of hours' or (2) 'appropriate hours of sleep'. Sleep that falls outside of what 'might be appropriate' are not recommended (Hirshkowitz et al., 2015). This provides a basis for definitions of 'short' and 'long' sleep as durations outside of what 'may be appropriate' may point toward atypical sleep, sleep issues or undiagnosed sleep problems. For each respondent, the reported sleep duration was assessed against the appropriate hours of sleep guidelines for their age group. Responses to the sleep duration question (Table 5) that fell:

- below the bottom guideline were coded as 'short';
- above the top guideline were coded as 'long'; and
- within the guideline were coded as 'typical'.

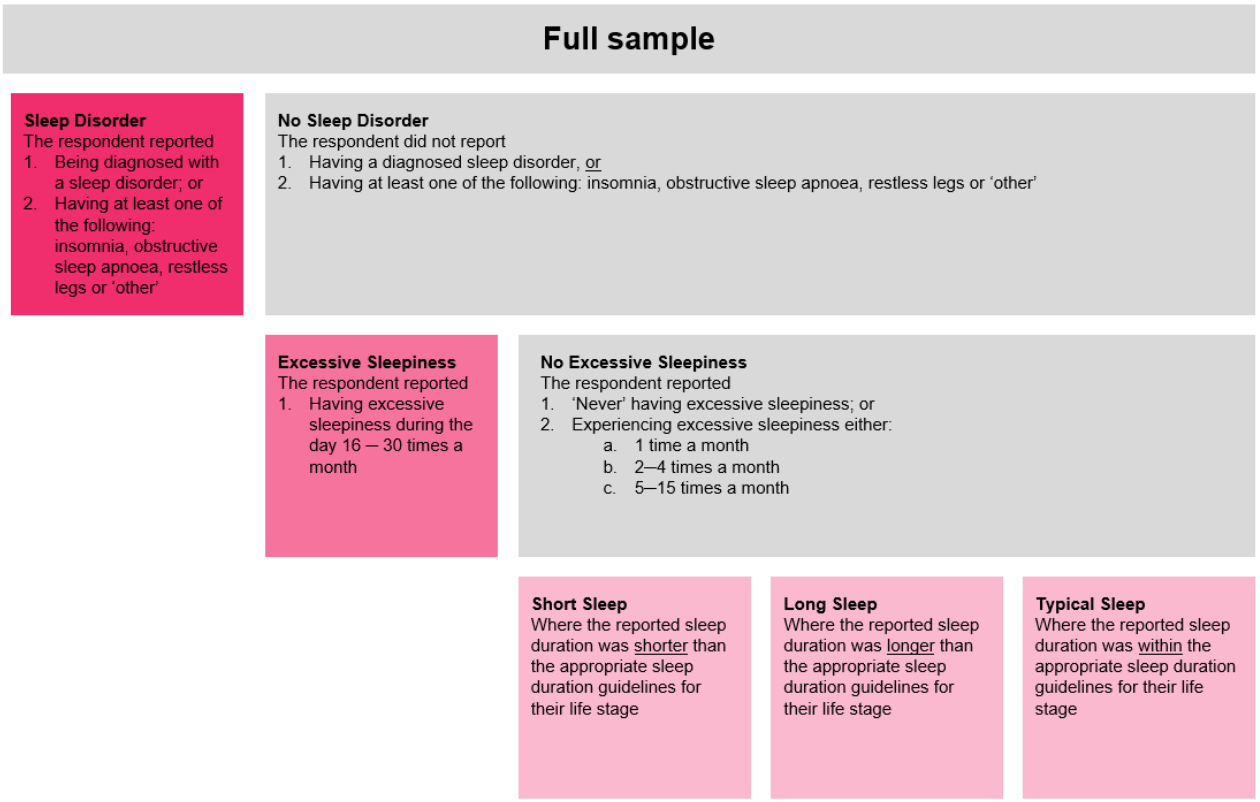
Sleep Profiles

Five mutually exclusive sleep profiles were developed using key sleep items (presence of sleep disorder, excessive daytime sleepiness) presented in the survey, and the derived indicators for short and long sleep (see **Figure 5**). The profiles were hierarchical and each respondent was categorised only once. The order of profiles in the hierarchy reflected (1) the strength of evidence of a sleep problem, and (2) the impact on functioning. Profiles characteristic of a sleep disorder,

excessive sleepiness, and short and long sleep were combined to gauge a crude estimate of the prevalence of ‘poor sleep’ in the study.

Figure 5

Analytical definitions for sleep profiles. The figure illustrates the order in which characteristics were prioritised according to the diagnosis of a sleep disorder. Where no disorder was diagnosed, characteristics were subsequently prioritised according to the possible impact on waking function.



Note. The diagram demonstrates how sleep profiles were developed. This image has been produced by the author of this thesis.

Lifestyle and health risk factors

A number of health behaviours and health risk factors were monitored by the NZHS, including patterns of consumption of alcohol, recreational use of illicit substances, fruit and vegetable intake,

activity levels, and smoking. This section provides detail of those retained for exploratory analysis based on a priori evidence.

Alcohol use and hazardous drinking

All respondents were screened for current alcohol use. Those that confirmed consuming 'a drink containing alcohol in the last year' were classified as a 'current drinker' and administered the Alcohol Use Disorder Identification Test (AUDIT) (Ministry of Health, 2014a). The AUDIT is a 10-item questionnaire that screens for hazardous or harmful alcohol consumption behaviours (Babor et al., 2001; Ministry of Health, 2014b). The AUDIT summary score offers a scale of drinking 'hazardousness' that reflects the combined interactions of the independent indicators of drinking frequency per week, typical drinking quantity per occasion, and evidence of binge drinking (Bush et al., 1998; Towers et al., 2011). The rationale for utilising this measure was to assess whether a single measure of 'hazardous' drinking currently utilised in primary healthcare offers the capacity to serve as a potential indicator of risk for alcohol-related sleep issues. The typical consumption quantity and frequency sub-measures of the AUDIT have been internationally validated for identifying hazardous drinking prevalence in older adults (Towers et al., 2011) and were also explored in this analysis:

- *Frequency*: 'How often do you have a drink containing alcohol' to which respondents could select from 'Monthly or less, 'Up to four times a month', 'Up to three times a week', or 'Four or more times a week'.
- *Quantity*: 'How many drinks containing alcohol do you have on a typical day when you are drinking' to which response options were '1 or 2', '3 or 4', '5 or 6', or '7 or more' alcohol drinks.

A binary indicator was derived to delineate low quantity consumption (i.e., 'one or two' drinks') from moderate to high quantity consumption (i.e., 'three or more 'drinks). This was necessary for data analysis as higher quantity consumption was less commonly reported among older adult respondents.

Smoking status

Smoking status was derived to classify respondents into one of three mutually exclusive groups using indicators available on the survey dataset:

- *Smokers*: Includes heavy smokers, daily smokers and current smokers.
- *Ex-smokers:* Respondents that stopped smoking for a month and had smoked more than 100 cigarettes in their life.
- *Non-smokers:* Never smokers and people that were not current smokers, and not ex-smokers.

Physical Activity

Physical activity (i.e., being physically active rather than sedentary) was assessed by an indicator available that identified which participants reported doing 30 minutes of brisk walking, or moderate or equivalent vigorous activity for at least ten minutes five days a week (Ministry of Health, 2014b).

Nutrition

Nutrition was defined in terms of fruit intake and vegetable intake. Participants were asked to report the average number of servings of fruit and vegetables they consumed, respectively. The NZHS 2013/2014 dataset included a binary indicator variable which identified where the reported fruit and vegetable intake met the Ministry of Health guidelines (Ministry of Health, 2014b).

Body Mass Index

Body mass index (BMI) was available as a continuous measure, calculated by dividing the respondent's weight (kilograms) by their height (centimetres) squared (Ministry of Health, 2014b). This was retained for analysis as it offers a general indicator of obesity.

High Cholesterol

The presence of high cholesterol was assessed with two survey items: whether the respondent had been diagnosed with high cholesterol, and/or whether they were receiving medication for the treatment of their high cholesterol. (Ministry of Health, 2014b).

High Blood Pressure

High blood pressure was retained for exploratory analysis. As above, this indicator variable was defined by two survey items and identified respondents diagnosed with high blood pressure and/or whether they were receiving medication for the treatment of their high blood pressure. (Ministry of Health, 2014b).

Health Outcomes

The survey collected information on a range of health outcomes, most of which are contained within the core module. Health outcomes pertain to long-term health conditions and measures of health status and psychological distress.

Comorbidities

As individual long-term health conditions did not possess sufficient explanatory power to be included and retained for analysis and modelling, a variable was defined tallying the number of long-term health conditions assessed by the survey for each respondent. The derived ordinal variable indicated where respondents had:

- no long-term health conditions;
- one long-term health condition,
- two long-term health conditions,
- three or more long-term health conditions

To determine the occurrence of multimorbidity, a dichotomous variable was derived which identified where respondents reported having three or more long-term health conditions assessed by the survey.

Polypharmacy

An indicator to gauge potential polypharmacy was derived by collating responses to treatment approaches for long-term health conditions assessed in the survey. Each time each respondent indicated receiving medications (tablets, inhalers, injections) for the treatment or management of the diagnosed health condition was tallied A binary polypharmacy variable was calculated to reflect where the total number was greater than or equal to five (Health Quality & Safety Commission New Zealand, 2021).

Short Form Health Survey

The self-reported health status of participants was assessed using all items from the Short Form Health Survey (SF-36). The survey assesses general health perceptions as well as limitations in physical and social activities due to physical, mental and emotional health, bodily pain, and energy and fatigue. Combined, the items measure eight domains of health and functioning. The SF-36 has been demonstrated to be valid in community-based older adult population studies (Walters et al., 2001). As such, the continuous scores of all eight domains available were retained for analysis. For each domain, a score between 0 and 100 is calculated with higher scores indicating a better degree of health or functioning (Stephens et al., 2013).

Kessler Psychological Distress Scale (K10)

The Kessler Psychological Distress Scale (K10) is a ten-item questionnaire which provides a measure of the likelihood of psychological distress (Kessler et al., 2003). The measure has been demonstrated to be valid and reliable among older adults (Anderson et al., 2013) and was, therefore, retained for exploratory analysis. Two measures of psychological distress were available on the dataset. The continuous variable person scores and the categorical variable identify respondents with a ‘high’ likelihood of psychological (i.e., K10 scores greater than or equal to 12).

2.3 Data Handling and Analysis

Ethics approval for these analyses was obtained from the Massey University Human Ethics Committee (*NOR 20/73)* (See **Appendix 2**). An application to access the NZHS Confidentialised Unit Record Files (CURF) was submitted to Stats NZ Data and approved gained in December 2020 (see **Appendix 3**).

Analytical Procedure

All data analyses were conducted using SAS Enterprise Guide version 8.2 of the SAS 9.4 (64-bit) system for Windows (SAS Institute Inc., 2014). The unit record datasets were read into the SAS environment and datasets were joined on the 'Household Identifier variable. No anomalies were noted in the combined data file. No records were removed during the data analysis, with exception of when data were missing. In these instances, records were removed if values were missing for variables included in the models. Where sufficient information was available for cross-tabulations and exploratory analysis, records were retained. Missing data arose when questions were refused or questions were not administered to the respondent. Unless otherwise indicated, the α-level for statistical significance was 0.05.

Data Analysis

In the full sample analysis, differences between the younger general adult (15–64 years) and the older adult population (65+ years) were summarised. There were two motivations for grouping the data this way. First, 'older adults' were the primary cohort of interest for this thesis. According to sleep duration recommendations, individuals are classified as older adults from 65 years and older. Accordingly, we assumed this definition of older adults. Second, the subgroup sample sizes did not allow the 'younger general adult' cohort to be separated into 'teenagers', 'young adults' and 'adult cohorts'. While there is clear evidence that sleep among these cohorts differs, for the purposes of exploratory analysis the binary categorisation identified those that were older adults from those who were not.

Differences in sleep profiles were then examined to ascertain general socio-demographic, health and alcohol consumption trends associated with specific profiles of sleep. Differences between sleep profiles were assessed specifically among older adults. Tests of normality were conducted for continuous variables. For non-parametric variables, median and interquartile ranges were reported. For categorical data, frequencies and percentages were reported. Missing data were excluded from the calculation of percentages and test statistics. Multinomial logistic regression models were conducted with typical sleep as the reference category to assess independent determinants of each sleep profile for older adults. The models selected for analysis were selected based on descriptive analysis. Where there were statistically significant associations with one or more sleep profiles detected the variables were included. Variables with low statistical power, or that were confounding with other predictors were not included. Decisions regarding which variables to exclude were informed by both descriptive analyses and a priori evidence.

3 Results

Analyses were undertaken to determine the overall characteristics of the 13,309 adults who participated in the 2013/2014 NZHS sample. The demographic breakdown of this sample is provided below (see **Table 6**).

Table 6

Demographic characteristics summary table for younger and older adults in the full 2013/2014 NZHS adult sample.

	Total	Younger Adults (15-64)		Older Adults (65+)		X^2
		Male	Female	Male	Female	
	n (%)	n (%)	n (%)	n (%)	n (%)	
Full Sample						
Total	13,309	4,540 (34.11)	5,837 (43.86)	1,249 (9.38)	1,683 (12.65)	
Ethnicity						
Māori	2,837 (21.32)	978 (21.54)	1494 (25.60)	150 (12.01)	215 (12.77)	0.31
Non-Māori	10,472 (78.68)	3,562 (78.46)	4,343 (74.40)	1,099 (87.99)	1,468 (87.23)	3.96*
NZDEP Index 2013 Quintiles						
1 (Least deprived)	1,683 (12.65)	573 (12.62)	697 (11.94)	172 (13.77)	241 (14.32)	1.52
2	2,000 (15.03)	695 (15.31)	844 (14.46)	223 (17.85)	238 (14.14)	1.48
3	2,685 (20.17)	974 (21.45)	1,116 (19.12)	238 (19.06)	357 (21.21)	8.15*
4	3,417 (25.67)	1,128 (24.85)	1,512 (25.90)	318 (25.46)	459 (27.27)	0.80
5 (Most deprived)	3,524 (26.48)	1,170 (25.77)	1,668 (28.58)	298 (23.86)	388 (23.05)	1.11
Level of Education						
Lower secondary	4,033 (30.64)	1,130 (25.20)	1,564 (27.04)	460 (37.22)	879 (53.02)	21.58***
Upper secondary	3,815 (28.99)	1,600 (35.68)	1,667 (28.83)	374 (30.26)	174 (10.49)	69.81***
Tertiary	4,238 (32.20)	1,436 (32.02)	2,156 (37.28)	267 (21.60)	379 (22.86)	0.42
Other	1,075 (8.17)	318 (7.09)	396 (6.85)	135 (10.92)	226 (13.63)	5.02*
Equivalised Household Income Terciles						
Low	2,033 (21.77)	472 (14.52)	838 (21.06)	276 (29.61)	447 (38.01)	0.92
Medium	4,522 (48.43)	1,484 (45.66)	1,914 (48.09)	494 (53.00)	630 (53.57)	0.03
High	2,783 (29.80)	1,294 (39.82)	1,228 (30.85)	162 (17.38)	99 (8.42)	10.98***
Current employment status						
Employed	7,665 (57.68)	3,463 (76.40)	3,679 (63.14)	293 (23.46)	230 (13.67)	11.07***
Unemployed	5,399 (40.62)	986 (21.75)	2,032 (34.87)	945 (75.66)	1,436 (85.43)	28.54***
Other	226 (1.70)	84 (1.85)	116 (1.99)	11 (0.88)	15 (0.89)	0.00

Note. Chi-squared test of independence * = p<.05; ** = p<.01; *** = p<.001

The analysis aimed to ascertain if health and demographic differences were evident between older adults (i.e., the subpopulation of interest in this study) and younger adults in the sample. The results indicate that just over half of the sample was female. Almost three-quarters were non-Māori, and approximately one-quarter were living in the highest deprivation quintile areas. Approximately 22% of the sample were aged over 65 years. While the gender balance was statistically similar between older and younger adults, older adults were far more likely than younger adults to be non-Māori, have a lower level of education level, be poorer, and not be in paid work.

Continuous measures were assessed to determine where differences between older and younger adults existed (see **Table 7**). As continuous variables were non-normally distributed, median and interquartile ranges are given, as opposed to means and standard deviations.

Table 7

Median and interquartile values for continuous measures in the full 2013/2014 NZHS sample and the younger and older adult subsamples.

	Total		Young Adults		Older Adults		Z
	Median	IQR	Median	IQR	Median	IQR	
Age	47.00	29.00	41.00	23.00	73.00	11.00	82.82***
AUDIT	3.00	5.00	3.00	6.00	1.00	4.00	-24.02***
Sleep duration	7.00	2.00	7.00	1.00	7.00	2.00	-3.25***
K10	1.00	4.00	1.00	4.00	1.00	3.00	-6.82***
BMI	27.72	7.90	27.60	8.24	27.99	6.81	1.39
SF-36 Mental Health	85.00	15.00	85.00	15.00	90.00	10.00	11.05***
SF-36 Physical Functioning	95.00	15.00	100.00	10.00	85.00	45.00	-46.71***
SF-36 Bodily Pain	84.00	39.00	84.00	38.00	72.00	49.00	-14.45***
SF-36 General Health	77.00	23.00	77.50	25.00	77.00	25.00	-11.47***
SF-36 Emotional Health	100.00	0.00	100.00	0.00	100.00	0.00	0.51
SF-36 Physical Health	100.00	18.75	100.00	12.50	93.75	43.75	-22.47***
SF-36 Social Functioning	100.00	12.50	100.00	12.50	100.00	12.50	-4.50***
SF-36 Vitality and Fatigue	62.50	25.00	62.50	25.00	68.75	25.00	-0.06

Note. Z = Mann-Whitney U tests. * = p<.05; ** = p<.01; *** = p<.001

BMI, SF-36 emotional health and SF-36 vitality and fatigue measures were similar between younger and older adults. Older adults experienced more limitations due to physical functioning, bodily pain, and physical health, compared to younger adults.

Differences in health and lifestyle factors and health outcomes were compared between younger and older adults (see **Table 8**).

Table 8

Comparison of health and lifestyle factors, and health outcomes between younger and older adults in the full 2013/2014 NZHS sample.

	Total **n(%)**	**Younger Adults** **n(%)**	**Older Adults** **n(%)**	**X^2**
Physically Active				
Active	6,613 (50.38)	5,395 (51.81)	1,318 (45.34)	37.91***
Non-active	6,514 (49.62)	4,925 (48.19)	1,589 (54.66)	
High cholesterol				
Yes	3,036 (23.12)	1,761 (17.19)	1,275 (44.18)	922.79***
No	10,095 (76.88)	8,484 (82.81)	1,611 (55.82)	
High blood pressure				
Yes	3,770 (28.50)	2099 (20.33)	1671 (57.54)	1,540.53***
No	9,460 (71.50)	8227 (79.67)	1233 (42.46)	
Fruit and vegetable intake				
Yes	5,432 (40.90)	3,933 (37.96)	1,499 (51.34)	168.51***
No	7,848 (59.10)	6,427 (62.04)	1,421 (48.66)	
Smoking status				
Ex-smoker	3,696 (27.83)	2,450 (23.66)	1,249 (42.60)	607.59***
Non-smoker	6,554 (49.35)	5,139 (49.62)	1,415 (48.38)	
Smoker	3,031 (22.82)	2,767 (26.72)	264 (09.02)	
Number of long-term health conditions				
None	3,699 (27.79)	2,475 (33.49)	224 (07.64)	1,736.28***
One	2,935 (22.05)	2,568 (24.75)	367 (12.52)	
Two	2,263 (17.00)	1,778 (17.13)	485 (16.54)	
Three or more	4,412 (33.15)	2,556 (24.63)	1,856 (63.30)	

	Total n(%)	Younger Adults n(%)	Older Adults n(%)	X^2
Multimorbidity				
Yes	8,897 (66.85)	2,556 (24.63)	1,856 (63.30)	1,542.60***
No	4,412 (33.15)	7,821 (75.37)	1,076 (36.70)	
Polypharmacy				
Yes	895 (6.72)	433 (4.17)	462 (15.76)	489.10***
No	12,414 (93.28)	9,944 (95.83)	2,470 (84.24)	
Diagnosed with a common mental health disorder				
Yes	2,799 (21.13)	2,240 (21.68)	559 (19.18)	8.52**
No	10,450 (78.87)	8,094 (78.32)	2,356 (80.82)	
Psychological Distress (high K10 Score)				
Yes	906 (6.9)	767 (7.48)	139 (4.82)	24.78***
No	12,230 (93.1)	9,486 (92.52)	2,744 (95.18)	

Note. X^2=Chi-squared test of independence. * = p<.05; ** = p<.01; *** = p<.001

Older adults were more likely than younger adults to: have multiple long-term health conditions, use multiple medications, meet fruit and vegetable intake requirements, and be ex-smokers. In contrast, younger adults were more likely than older adults to experience psychological distress or have a diagnosable mental health condition. The table below (see **Table 9**) summarises patterns of alcohol consumption reported by younger and older adults.

Table 9

Patterns of alcohol use between younger and older adults in the full 2013/2014 NZHS sample.

	Total n (%)	Younger Adults n (%)	Older Adults n (%)	X^2
Had a drink in the last year				
Yes	10,473 (21.25)	8,429 (81.29)	2,044 (69.76)	181.46*
No	2,826 (78.75)	1,940 (18.71)	886 (30.24)	
Number of alcoholic drinks				
1 or 2	6,123 (58.73)	4,422 (52.72)	1,701 (83.46)	679.07*
3 or 4	1,993 (19.12)	1,763 (21.02)	230 (11.29)	
5 or 6	959 (9.20)	889 (10.60)	70 (3.43)	
7 or more	1,350 (12.95)	1,313 (15.66)	37 (1.82)	

	Total n (%)	Younger Adults n (%)	Older Adults n (%)	X^2
Frequency of drinking				
Monthly or less	3,754 (35.94)	3,040 (36.16)	714 (35.00)	335.88*
Up to 4 times a month	2,406 (23.03)	2,118 (25.20)	288 (14.12)	
Up to 3 times a week	2,034 (19.470)	1,719 (20.45)	315 (15.44)	
4 or more times a week	2,252 (21.560)	1,529 (18.19)	723 (35.44)	
Frequency drinking six or more drinks on one occasion				
Never	5,228 (50.030)	3,556 (42.28)	1,672 (82.00)	1,049.14*
Less than monthly	2,674 (25.590)	2,475 (29.43)	199 (9.76)	
Monthly	1,169 (11.190)	1,103 (13.12)	66 (3.24)	
Weekly	1,218 (11.660)	1,144 (13.60)	74 (3.63)	
Daily	160 (1.530)	132 (1.57)	28 (1.37)	

Note. X^2=Chi-squared test of independence * = p<.05; ** = p<.01; *** = p<.001

For both younger and older adults, the majority of respondents were current drinkers. Older adults were less likely to be current drinkers. Older adults tended to consist of frequent light drinkers and infrequent light drinkers in comparison to the younger general adult cohort. In contrast, consumption tendencies for younger adults typified less frequent higher quantity alcohol consumption.

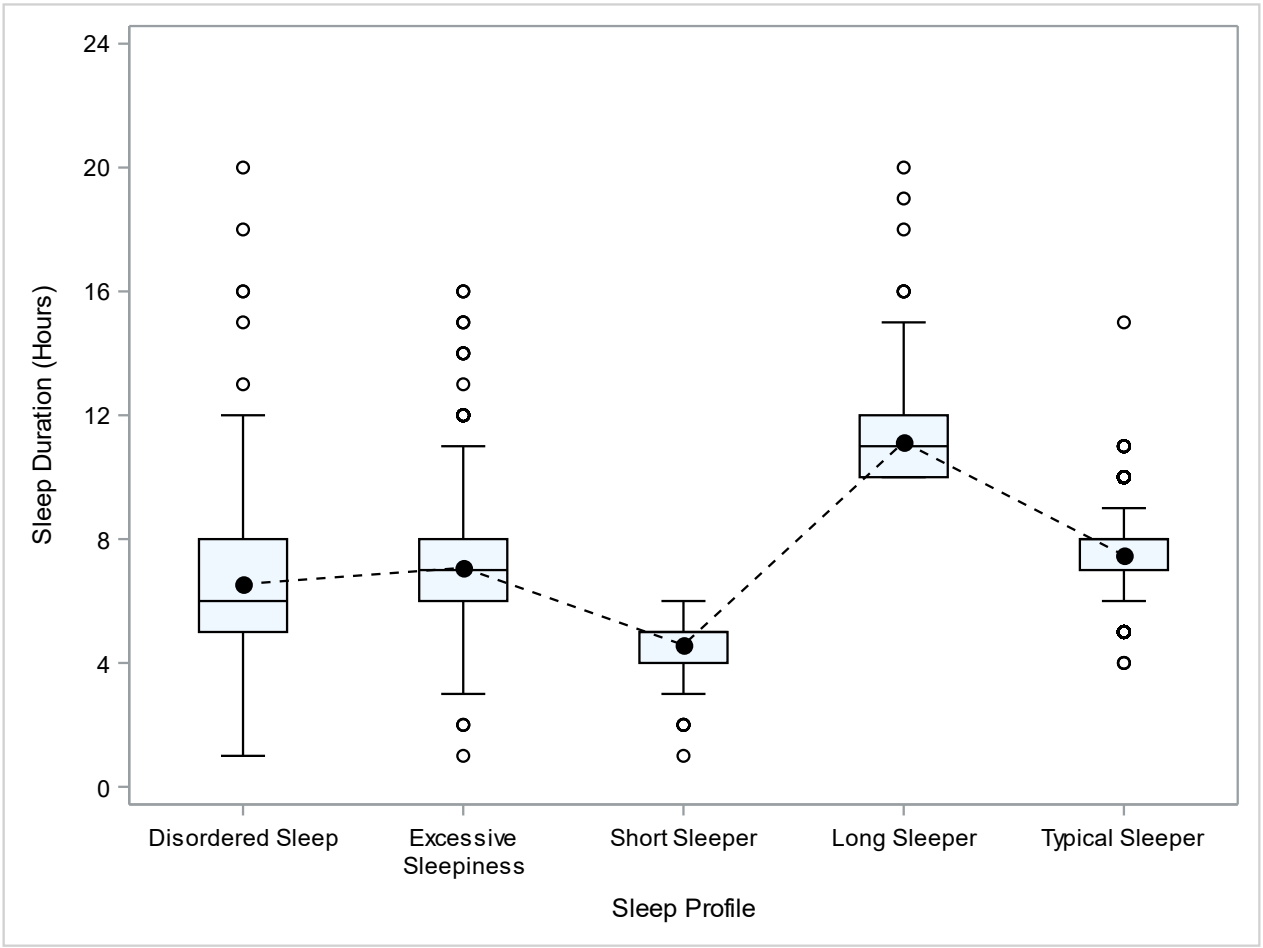
The results of this stage of exploratory analysis demonstrated clear sociodemographic, health and alcohol consumption differences between older adults and younger adults. Older adults tended to be non-Māori and have a lower socioeconomic standing and poorer health status and more physical limitations compared to their younger counterparts. Younger adults were more likely to experience psychological distress or have a diagnosable mental health condition. Older adults were also more likely to observe fruit and vegetable intake guidelines and those who did consume alcohol with closer adherence to low-risk drinking advice, compared to their younger counterparts.

3.1 Exploring distinct profiles of poor sleep in the adult population

Data from the entire NZHS sample was analysed to explore the presence of distinct profiles of sleep across the general adult population. Here two observations were excluded due to missing information reducing the sample available for analysis to 13,307. Median sleep durations differed significantly across sleep profiles (see **Figure 6)**. Group-wise comparison of sleep duration was conducted to ascertain where statistical differences in the median sleep duration exist between sleep profile pairs. To reiterate, duration was non-normally distributed. As such, the median values are illustrated with a black circle in the box plot figure.

Figure 6

Boxplot summary of reported sleep durations according to sleep profiles.



As ‘short’, ‘long’ and ‘typical’ sleepers are classified according to reported sleep durations, it is expected that statistically significant differences in median sleep durations exist. Those with a sleep disorder slept significantly shorter durations than those with ‘excessive sleepiness’ (see **Table 10**).

Table 10

Statistical differences between sleep duration, by sleep profiles.

Sleep Duration	Wilcoxon Z	DSCF	p-value
Typical Sleep vs. Excessive Sleepiness	11.34	16.03	<.0001
Typical Sleep vs. Sleep Disorder	18.63	26.35	<.0001
Typical Sleep vs. Short Sleep	39.87	56.38	<.0001
Typical Sleep vs. Long Sleep	-28.82	40.76	<.0001
Excessive Sleepiness vs. Sleep Disorder	6.14	8.68	<.0001
Excessive Sleepiness vs. Short Sleep	27.30	38.61	<.0001
Excessive Sleepiness vs. Long Sleep	-23.77	33.62	<.0001
Sleep Disorder vs. Short Sleep	22.58	31.94	<.0001
Sleep Disorder vs. Long Sleep	-23.93	33.84	<.0001
Short Sleep vs. Long Sleep	-24.09	34.07	<.0001

Note. DSCF = Dwass, Steel, Critchlow-Flinger test. * = p<.05; ** = p<.01; *** = p<.001

The demographic breakdown across the five sleep profiles is presented in **Table 11**. This table shows that 22.21% (2,822) of adults were profiled as ‘poor sleepers according to the presence of sleep disorder, excessive sleepiness or short or long sleep. The majority of respondents (87.33%; 724) had only one sleep disorder present. Insomnia was the most prevalent sleep condition among respondents with a sleep disorder. One quarter (27.76%) of older adults were profiled as poor sleepers compared to just 19.35% of younger adults (X^2 = 418.09, p<0.0001). Older adults were more likely to have a sleep disorder, excessive sleepiness or long sleep, whereas younger adults were more likely to be short or typical sleepers.

Table 11

Sleep profile sociodemographic characteristics for the full NZHS 13/14 adult sample.

	Total	Sleep Disorder	Excessive Sleepiness	Short Sleep	Long Sleep	Typical Sleep	X^2
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	
Full Sample							
Total	13,307	829 (6.23)	1,188 (8.93)	534 (4.01)	271 (2.04)	10,485 (78.79)	28,923.56***
Age							
Younger Adult	10,375 (77.97)	616 (74.31)	835 (70.29)	468 (87.64)	89 (32.84)	8,367 (79.80)	418.09***
Older Adult	2,932 (22.03)	213 (25.69)	353 (29.71)	66 (12.36)	182 (67.16)	2,118 (20.20)	
Ethnicity							
Māori	2,837 (27.34)	207 (24.97)	301 (25.34)	147 (27.53)	75 (27.68)	2,107 (20.10)	46.18***
Non-Māori	10,470 (78.68)	622 (75.03)	887 (74.66)	387 (72.47)	196 (72.32)	8,378 (79.90)	
Sex							
Male	5,789 (43.50)	358 (43.18)	461 (38.80)	235 (44.01)	141 (52.03)	4,594 (43.81)	19.19**
Female	7,518 (56.50)	471 (56.82)	727 (61.20)	299 (55.99)	130 (47.97)	5,891 (56.19)	
NZDEP Index 2013 Quintiles							
1	1,682 (12.64)	73 (8.81)	106 (8.92)	44 (8.24)	25 (9.23)	1,434 (13.68)	130.62***
2	2,000 (15.03)	107 (12.91)	166 (13.97)	65 (12.17)	32 (11.81)	1,630 (15.55)	
3	2,685 (20.18)	167 (20.14)	241 (20.29)	87 (16.29)	40 (14.76)	2,150 (20.51)	
4	3,416 (25.67)	265 (31.97)	295 (24.83)	144 (26.97)	70 (25.83)	2,642 (25.20)	
5	3,524 (26.48)	217 (26.18)	380 (31.99)	194 (36.33)	104 (38.38)	2,629 (25.07)	

	Total	Sleep Disorder	Excessive Sleepiness	Short Sleep	Long Sleep	Typical Sleep	X^2
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	
Level of Education							
Lower secondary	4,033 (30.64)	278 (33.83)	433 (36.45)	227 (43.31)	132 (50.19)	2,963 (28.56)	180.85***
Upper secondary	3,815 (28.99)	226 (27.53)	359 (30.55)	153 (29.20)	78 (29.66)	2,998 (28.89)	
Tertiary	4,238 (32.20)	251 (30.57)	303 (25.79)	109 (20.80)	32 (12.17)	3,543 (34.15)	
Other	1,075 (8.17)	66 (8.04)	80 (6.81)	35 (6.68)	21 (7.98)	872 (8.40)	
Equivalised Household Income Terciles							
Low	2,033 (21.78)	189 (32.03)	249 (30.93)	91 (26.92)	77 (47.83)	1,427 (19.17)	219.67***
Medium	4,522 (48.44)	259 (43.90)	389 (48.32)	166 (49.11)	77 (47.83)	3,631 (48.79)	
High	2,781 (29.79)	142 (24.07)	167 (20.75)	81 (23.96)	7 (4.35)	2,384 (32.03)	
Current employment status							
Employed	7,663 (57.59)	384 (46.32)	522 (43.94)	288 (53.93)	43 (15.87)	6,426 (61.29)	397.45***
Unemployed	5,399 (40.57)	424 (51.15)	648 (54.55)	231 (43.26)	224 (82.66)	3,872 (36.93)	

*Note. X^2=Chi-squared test of independence. * = p<.05; ** = p<.01; *** = p<.001.*

Note. With respect to current employment status, cell counts for the option 'Other' were lower than five which would produce invalid chi-squared test results. 'Other' was excluded removing 226 responses.

Note. Two people in the younger adult cohort (aged 15-64 years) did not answer any sleep items in the 2013/2014 survey. This reduces the available sample to 13,307.

The following analysis aimed to ascertain the extent to which health differences existed between sleep profiles. Statistically significant differences were evident for all continuous variables when compared between sleep profiles (Kruskal Wallis X^2 at the $p <= 0.01$ significance level) (See **Table 12**). The sleep disorder profile was associated with poorer mental health, general health and more bodily pain and higher body mass index. SF-36 health measures improved down profile hierarchy (i.e., were lowest for the sleep disorder profile with consecutive improvement in scores for excessive sleepiness, short, long and typical sleep, respectively).

Differences in health risk factors and health outcomes were subsequently assessed (see **Table 13**). Multimorbidity, polypharmacy and psychological distress were most likely among the sleep disorder profile. Long sleepers were also likely to have multiple long-term health conditions and be non-active. Unlike the sleep disorder profile, long sleepers were less likely to have a mental health condition, psychological distress or be subject to polypharmacy. Typical sleepers were also more likely to observe fruit and vegetable intake guidelines and have better health. Short and typical sleepers were most likely to keep physically active. However, proportionally more short-sleepers were current smokers, compared to all other sleep profiles.

Alcohol use was explored to determine if any differences in alcohol use behaviour between sleep profiles existed (see **Table 14**). The majority of people in each sleep profile were classified as current drinkers. The proportion of current drinkers was largely balanced. Typical sleepers were most likely to be current drinkers and tended to consume alcohol more frequently (i.e., three or more times a week) compared to other sleep profiles. By contrast, long sleepers had the largest proportion of abstainers (34.32%). Compared to the other sleep profiles, short-sleepers were more likely to consume moderate to high quantities (three or more drinks) of alcohol (49.22%). All other profiles tended to consume low quantities of alcohol typically ($X^2 = 12.82$; $p = 0.05$). Typical frequency varied significantly between sleep profiles, although was more nuanced and less obvious to distinguish ($X^2 = 53.80$; $p < 0.0001$).

Table 12

Median and interquartile values for sleep profiles in the full 2013/2014 NZHS sample.

	Sleep Disorder		Excessive Sleepiness		Short Sleep		Long Sleep		Typical Sleep		X^2
	Median	**IQR**	**Median**	**IQR**	**Median**	**IQR**	**Median**	**IQR**	**Median**	**IQR**	
Age	53.00	25.00	50.00	33.00	49.00	24.00	71.00	28.00	46.00	29.00	277.12***
AUDIT	3.00	4.00	3.00	5.00	3.00	6.00	2.00	5.00	3.00	5.00	30.20***
Sleep duration	6.00	3.00	7.00	2.00	5.00	1.00	11.00	2.00	8.00	1.00	2,642.38***
K10	4.00	9.00	4.00	8.00	2.00	6.00	2.00	5.00	1.00	3.00	778.00***
BMI	29.53	9.37	28.39	8.88	28.81	8.80	28.60	7.88	27.44	7.59	98.42***
SF-36 Mental Health	75.00	30.00	80.00	25.00	85.00	20.00	85.00	15.00	85.00	10.00	546.41***
SF-36 Physical Functioning	85.00	40.00	90.00	45.00	95.00	20.00	85.00	45.00	100.00	10.00	846.17***
SF-36 Bodily Pain	61.00	43.00	62.00	59.00	72.00	49.00	80.00	48.00	100.00	38.00	685.87***
SF-36 General Health	62.00	37.00	67.00	37.00	72.00	30.00	75.00	30.00	82.00	25.00	881.37***
SF-36 Emotional Health	100.00	33.33	100.00	25.00	100.00	0.00	100.00	0.00	100.00	0.00	657.54***
SF-36 Physical Health	87.50	50.00	87.50	50.00	100.00	31.25	96.88	43.75	100.00	12.50	807.63***
SF-36 Social Functioning	87.50	50.00	100.00	37.50	100.00	25.00	100.00	25.00	100.00	0.00	886.99***
SF-36 Vitality and Fatigue	50.00	28.13	43.75	31.25	62.50	25.00	65.63	31.25	68.75	25.00	1,327.57***

Note. $X^{2=}$ Kruskal-Wallis Test Chi Squared test. * = p<.05; ** = p<.01; *** = p<.001

Table 13

Health risks, lifestyle factors and diagnosed mental health conditions by sleep profiles in the NZHS 13/14 full sample.

	Total n (%)	Sleep Disorder n (%)	Excessive Sleepiness n (%)	Short Sleep n (%)	Long Sleep n (%)	Typical Sleep n (%)	X^2
Active							
Active	6,612 (50.38)	409 (49.82)	558 (47.61)	269 (51.83)	98 (36.98)	5,278 (51.05)	24.78***
Non-active	6,513 (49.62)	412 (50.18)	614 (52.39)	250 (48.17)	167 (63.02)	5,070 (48.99)	
High cholesterol							
Yes	3,036 (23.12)	293 (35.60)	331 (28.39)	127 (24.33)	90 (34.09)	2,195 (21.2)	130.11***
No	10,093 (76.88)	530 (64.40)	835 (71.61)	395 (75.67)	174 (65.91)	8,159 (78.8)	
High blood pressure							
Yes	3,769 (28.49)	376 (45.69)	433 (36.69)	175 (33.08)	122 (45.35)	2,663 (25.54)	246.01***
No	9,459 (71.51)	447 (54.31)	747 (63.31)	354 (66.92)	147 (54.65)	7,764 (74.46)	
Fruit and vegetable intake							
Yes	5,431 (40.90)	314 (37.97)	462 (38.89)	181 (34.28)	94 (35.21)	4,380 (41.84)	21.92***
No	7,847 (59.10)	513 (62.03)	726 (61.11)	347 (65.72)	173 (64.79)	6,088 (58.16)	
Smoking status							
Ex-smoker	3,696 (27.83)	287 (34.79)	371 (31.36)	140 (26.37)	101 (37.27)	2,797 (26.72)	182.61***
Non-smoker	6,552 (49.34)	310 (37.58)	484 (40.91)	202 (38.04)	102 (37.64)	5,454 (52.10)	
Smoker	3,031 (22.83)	228 (27.64)	328 (27.73)	189 (35.59)	68 (25.09)	2,218 (21.19)	

	Total n (%)	Sleep Disorder n (%)	Excessive Sleepiness n (%)	Short Sleep n (%)	Long Sleep n (%)	Typical Sleep n (%)	X^2
Number of long-term health conditions							
None	3,698 (27.79)	61 (7.36)	186 (15.66)	96 (17.98)	49 (18.08)	3,306 (31.53)	851.16***
One	2,935 (22.06)	107 (12.91)	204 (17.17)	118 (22.10)	38 (14.02)	2,468 (23.54)	
Two	2,262 (17.00)	117 (14.11)	188 (15.82)	105 (19.66)	44 (16.24)	1,808 (17.24)	
Three or more	4,412 (33.16)	544 (65.62)	610 (51.35)	215 (40.26)	140 (51.66)	2,903 (27.69)	
Multimorbidity							
Yes	4,412 (33.16)	544 (65.62)	610 (51.35)	215 (40.26)	140 (51.66)	2,903 (27.69)	767.16***
No	8,895 (66.84)	285 (34.38)	578 (48.65)	319 (59.74)	131 (48.34)	7,582 (75.31)	
Polypharmacy							
Yes	895 (6.73)	216 (26.06)	153 (12.88)	44 (8.24)	32 (11.81)	450 (4.29)	677.56***
No	12,412 (93.27)	613 (73.94)	1,035 (87.12)	490 (91.76)	239 (88.19)	10,035 (95.71)	
Diagnosed with a common mental health disorder							
Yes	2,799 (21.13)	446 (54.46)	375 (31.81)	138 (25.99)	44 (16.42)	1,796 (17.19)	735.09***
No	10,448 (78.87)	373 (45.54)	804 (68.19)	393 (74.01)	224 (83.58)	8,654 (82.81)	
Psychological Distress (high K10 Score)							
Yes	906 (6.9)	181 (22.13)	208 (17.93)	61 (11.62)	27 (10.11)	429 (4.14)	660.60***
No	12,228 (93.1)	637 (77.87)	952 (82.07)	464 (88.38)	240 (89.89)	9,935 (95.86)	

Note. X^2=Chi-squared test of independence * = p<.05; ** = p<.01; *** = p<.001

Table 14

Patterns of alcohol use by sleep profile across the full NZHS 13/14 sample.

	Total	Sleep Disorder	Excessive Sleepiness	Short Sleep	Long Sleep	Typical Sleep	X^2
	n (%)	n(%)	n(%)	n(%)	n(%)	n(%)	
Had a drink in the last year							
Yes	10,472 (78.75)	629 (75.97)	883 (74.39)	389 (73.12)	178 (65.68)	8,393 (80.09)	66.36***
No	2,825 (21.25)	199 (24.03)	304 (25.61)	143 (26.88)	93 (34.32)	2,086 (19.91)	
Number of alcoholic drinks							
1 or 2	6,122 (58.73)	385 (61.40)	503 (57.42)	195 (50.78)	105 (59.66)	4,934 (59.01)	12.82**
3 or more	4,302 (41.27)	242 (38.60)	373 (42.58)	189 (49.22)	71 (40.34)	3,427 (40.99)	
Frequency of drinking							
Monthly or less	3,753 (35.93)	256 (40.76)	369 (41.79)	169 (43.67)	73 (41.24)	2,886 (34.48)	53.80***
Up to 4 times a month	2,406 (23.03)	131 (20.86)	188 (21.29)	76 (19.64)	38 (21.47)	1,973 (23.57)	
Up to 3 times a week	2,034 (19.47)	100 (15.92)	146 (16.53)	61 (15.76)	20 (11.30)	1,707 (20.39)	
4 or more times a week	2,252 (21.56)	141 (22.45)	180 (20.39)	81 (20.93)	46 (25.99)	1,804 (21.55)	

Note. X^2=Chi-squared test of independence * = p<.05; ** = p<.01; *** = p<.001

In summary, the results support the presence of five distinct sleep profiles in the NZ general adult population. There are clear differences between these profiles with respect to behaviours and health risk factors, and health outcomes and well-being. The findings here suggest that health and health behaviours may play a significant role in specific profiles of sleep. The next step in this analysis was to focus specifically on the characteristics inherent in membership of these sleep profiles in older adults, and the degree to which key health behaviours (i.e., alcohol) play a role in determining group membership.

3.2 Key differences in sleep profiles unique to older adults.

Analyses were undertaken to determine health and demographic differences between sleep profiles among older adults (aged 65+ years) only (n = 2,932). Key demographic differences are presented below (see **Table 15**). When the profiles potentially characteristic of poor sleep are combined (i.e., sleep disorder, excessive sleepiness, short and long sleep), 27.76% of older adults were classified as having poor sleep. Māori older adults were more likely to experience poor sleep (35.90%), compared to 26.61% of Non-Māori ($X^2 = 15.89$; $p = 0.00$).

In the older adult sample, short sleepers were more likely to be female and have attained a lower secondary school level education. Whereas, the excessive sleepiness and long sleep profiles consisted of proportionally more males and respondents that had attained an upper secondary school level education. Older adult typical sleepers were more likely to be non-Māori and have better socioeconomic standing. Proportionally more were employed or lived in high or moderate-income households or areas of lower deprivation.

Table 15

Sociodemographic differences of older adults across sleep profiles

	Total n (%)	Sleep Disorder n (%)	Excessive Sleepiness n (%)	Short Sleep n (%)	Long Sleep n (%)	Typical Sleep n (%)	X^2
Total	2,932 (100.00)	213 (7.26)	353 (12.04)	66 (2.25)	182 (6.21)	2,118 (72.24)	
Ethnicity							
Māori	365 (12.32)	30 (14.08)	63 (17.85)	9 (13.64)	29 (15.93)	234 (11.05)	15.89**
Non-Māori	2,597 (87.68)	183 (85.92)	290 (82.15)	57 (86.36)	153 (84.07)	1,884 (88.95)	
Sex							
Male	1,249 (42.60)	87 (40.85)	154 (43.63)	23 (34.85)	99 (54.40)	886 (41.83)	12.91*
Female	1,683 (57.40)	126 (59.15)	199 (56.37)	43 (65.15)	83 (45.60)	1,232 (58.17)	
NZDEP Index 2013 Quintiles							
1	413 (16.09)	26 (12.21)	35 (9.92)	5 (7.58)	24 (13.19)	323 (15.25)	28.02
2	461 (15.72)	23 (10.80)	50 (14.16)	15 (22.73)	28 (15.38)	345 (16.29)	
3	595 (20.29)	44 (20.66)	81 (22.95)	10 (15.15)	30 (16.48)	430 (20.30)	
4	777 (26.50)	63 (29.58)	99 (28.05)	18 (27.27)	44 (24.18)	553 (26.11)	
5	686 (23.40)	57 (26.76)	88 (24.93)	18 (27.27)	56 (30.77)	467 (22.05)	
Level of Education							
Lower	1,339 (46.27)	91 (42.92)	169 (48.29)	39 (60.00)	92 (52.57)	948 (45.32)	24.73*
Upper	548 (18.94)	35 (16.51)	76 (21.71)	12 (18.46)	39 (22.29)	386 (18.45)	
Tertiary	646 (22.32)	53 (25.00)	74 (21.14)	8 (12.31)	26 (14.86)	485 (23.18)	
Other	361 (12.47)	33 (15.57)	31 (8.86)	6 (9.23)	18 (10.29)	273 (13.05)	
Equivalised Household Income Terciles							
Low	723 (34.30)	62 (38.04)	103 (41.04)	16 (43.24)	50 (43.10)	492 (31.93)	31.44***
Medium	1,124 (53.32)	83 (50.92)	134 (53.39)	18 (48.65)	61 (52.59)	828 (53.73)	
High	261 (12.38)	18 (11.04)	14 (5.58)	3 (8.11)	5 (4.31)	221 (14.34)	
Current employment status							
Employed	523 (17.85)	36 (16.90)	39 (11.05)	7 (10.61)	13 (7.14)	428 (20.23)	36.92***
Unemployed	2,381 (81.26)	172 (82.16)	312 (88.39)	58 (87.88)	167 (91.76)	1,669 (78.88)	

Note. X^2=Chi-squared test of independence * = p<.05; ** = p<.01; *** = p<.001.

Note. With respect to current employment status, cell values for 'Other' below five may produce invalid chi-squared test results. When excluded the chi-squared test of independence for current employment status (employed or unemployed) by sleep profile is X^2= 36.12; p<0.0001.

Analysis of continuous measures demonstrated statistically significant differences (Kruskal-Wallis Chi-Squared at the p <0.0001) between profiles for the older adult sample (see **Table 16**). The excessive sleepiness profile was associated with poorer physical functioning and physical health, general health, social functioning, and worse body pain compared to other sleep profiles. Furthermore, the sleep disorder and excessive sleepiness profiles both had the lowest mental health and vitality and fatigue score compared to the other sleep profiles.

There was a clear difference in the health characteristics between sleep profiles of the older adult sample (see **Table 17**). Health profiles for older adult typical sleepers were consistent with good health and well-being. Similar to the whole sample results, the sleep disorder profile was more likely to have multiple long-term health conditions, mental health conditions and polypharmacy, compared to all other sleep profiles. For older adults, inactivity was associated with the 'excessive sleepiness', 'short sleep' and 'long sleep' profiles. Long sleepers also tended to have poor nutrition.

The balance of ex-smokers was consistent across sleep profiles, whereas proportionally more older adult short (17.19%) and long (14.84%) sleepers were current smokers. For older adults, typical sleepers were more likely to be non-smokers compared to other sleep profiles.

The comparison of alcohol use behaviours between sleep profiles for older adults is summarised in **Table** 18. For older adults, the sleep disorder and typical sleep profiles were more likely to report being current drinkers (X^2 = 35.87; p < 0.0001) than the remaining sleep profiles. Across all profiles, the majority of current drinkers consumed low quantities of alcohol (i.e., one or two drinks), although, proportionally more long sleepers reported consuming higher quantities of alcohol (27.03%). The frequency of consumption was not statistically different between sleep profiles. Proportionally fewer older adult short-sleepers were likely to consume alcohol as frequently as four or more times a week, compared to the remaining four sleep profiles. Older adults of the excessive sleepiness profile were more likely to report consuming alcohol on an infrequent (monthly or less) basis.

Table 16

Median and interquartile values for sleep profiles for the 2013/2014 NZHS older adult sample.

	Sleep Disorder		Excessive Sleepiness		Short Sleep		Long Sleep		Typical Sleep		X^2
	Median	**IQR**	**Median**	**IQR**	**Median**	**IQR**	**Median**	**IQR**	**Median**	**IQR**	
Age	72.00	11.00	76.00	12.00	74.50	12.00	76.00	11.00	73.00	10.00	68.28***
AUDIT	2.00	4.00	1.00	4.00	1.00	3.00	1.00	4.00	2.00	4.00	23.91***
Sleep duration	6.00	3.00	7.00	2.00	4.00	0.00	10.00	1.00	7.00	2.00	727.41***
K10	2.00	7.00	3.00	7.00	1.50	5.00	1.00	4.00	1.00	3.00	114.40***
BMI	29.31	9.28	28.79	7.17	28.78	8.65	28.19	7.01	27.77	6.61	18.18***
SF-36 Mental Health	85.00	20.00	85.00	20.00	87.50	15.00	90.00	10.00	90.00	10.00	92.16***
SF-36 Physical Functioning	67.50	55.00	55.00	65.00	65.00	55.00	80.00	54.44	90.00	30.00	210.02***
SF-36 Bodily Pain	61.50	43.00	53.00	53.00	61.00	42.00	74.00	40.00	74.00	48.00	136.01***
SF-36 General Health	67.00	32.00	62.00	37.00	72.00	40.00	77.00	25.00	77.00	20.00	202.84***
SF-36 Emotional Health	100.00	25.00	100.00	16.67	100.00	0.00	100.00	0.00	100.00	0.00	82.54***
SF-36 Physical Health	75.00	50.00	62.50	75.00	87.50	50.00	93.75	43.75	100.00	25.00	196.14***
SF-36 Social Functioning	100.00	37.50	87.50	50.00	100.00	25.00	100.00	12.50	100.00	0.00	162.95***
SF-36 Vitality and Fatigue	50.00	37.50	50.00	31.25	62.50	43.75	68.75	31.25	68.75	25.00	289.79***

Note. X^2=Kruskal-Wallis Chi-Squared * = p<.05; ** = p<.01; *** = p<.001.

Table 17

Differences in determinants of health in older adults across sleep profiles.

	Total	Sleep Disorder	Excessive Sleepiness	Short Sleeper	Long Sleeper	Typical Sleeper	X^2
	n(%)	n(%)	n(%)	n(%)	n(%)	n(%)	
Total	2,932	213 (7.26)	353 (12.04)	66 (2.25)	182 (6.21)	2118 (72.24)	
Active							
Active	1,318 (45.34)	103 (48.36)	128 (36.68)	22 (34.38)	63 (35.39)	1,002 (47.95)	26.08***
Non-active	1,589 (54.66)	110 (51.64)	221 (63.32)	42 (65.63)	115 (64.61)	1,101 (52.35)	
High cholesterol							
Yes	1,275 (44.18)	104 (49.29)	157 (45.24)	30 (48.39)	72 (40.91)	912 (43.64)	3.85
No	1,611 (55.82)	107 (50.71)	190 (54.76)	32 (51.61)	104 (59.09)	1,178 (56.36)	
High blood pressure							
Yes	1671 (57.54)	136 (65.07)	221 (62.96)	43 (68.25)	98 (54.44)	1173 (55.83)	15.26***
No	1233 (42.46)	73 (34.93)	130 (37.04)	20 (31.75)	82 (45.56)	928 (44.17)	
Fruit and vegetable intake							
Yes	1,499 (51.34)	96 (45.28)	175 (49.58)	28 (44.44)	62 (34.83)	1,138 (53.83)	29.42***
No	1,421 (48.66)	116 (54.72)	178 (50.42)	35 (55.56)	116 (65.17)	976 (46.17)	
Smoking status							
Ex-smoker	1,246 (42.60)	104 (49.29)	162 (45.89)	26 (40.63)	83 (45.60)	871 (41.18)	24.84**
Non-smoker	1,415 (48.38)	89 (42.18)	160 (45.33)	27 (42.19)	72 (39.56)	1,067 (50.45)	
Smoker	264 (9.03)	18 (8.53)	31 (8.78)	11 (17.19)	27 (14.84)	177 (8.37)	
Number of long-term health conditions							
None	224 (7.64)	7 (3.29)	9 (2.55)	2 (3.03)	21 (11.54)	185 (8.73)	110.91***
One	367 (12.52)	11 (5.16)	22 (6.23)	7 (10.61)	22 (12.09)	305 (14.40)	
Two	485 (16.54)	18 (8.45)	40 (11.33)	8 (12.12)	27 (14.84)	392 (18.51)	
Three or more	1,856 (63.30)	177 (83.10)	282 (79.89)	49 (74.24)	112 (61.54)	1,236 (58.36)	
Multimorbidity							
Yes	1,856 (63.30)	177 (83.10)	282 (79.89)	49 (74.24)	112 (61.54)	1,236 (58.36)	103.67***
No	1,076 (36.70)	36 (16.90)	71 (20.11)	17 (25.76)	70 (38.46)	882 (41.64)	

	Total	Sleep Disorder	Excessive Sleepiness	Short Sleeper	Long Sleeper	Typical Sleeper	X^2
	n(%)	n(%)	n(%)	n(%)	n(%)	n(%)	
Polypharmacy							
Yes	462 (15.76)	85 (39.91)	92 (26.06)	16 (24.24)	24 (13.19)	245 (11.57)	154.31***
No	2,470 (84.24)	128 (60.09)	261 (73.94)	50 (75.76)	158 (86.81)	1,873 (88.43)	
Diagnosed mental health condition							
Yes	559 (19.18)	84 (40.19)	89 (25.36)	12 (18.46)	24 (13.33)	350 (16.59)	81.31***
No	2,356 (80.82)	125 (59.81)	262 (74.64)	53 (81.54)	156 (86.67)	1,760 (83.41)	
High psychological distress							
Yes	139 (4.82)	25 (12.02)	40 (11.76)	5 (7.81)	14 (7.82)	55 (2.63)	85.87***
No	2,744 (95.18)	183 (87.98)	300 (88.24)	59 (92.19)	165 (92.18)	2,037 (97.37)	

Note. X^2=Chi-squared test of independence * = p<.05; ** = p<.01; *** = p<.001

Table 18

Patterns of alcohol use between of alcohol use among older adults by sleep profile

	Total	Disordered Sleep	Excessive Sleepiness	Short Sleeper	Long Sleeper	Typical Sleeper	X^2
	n (%)	n(%)	n(%)	n(%)	n(%)	n(%)	
Had a drink in the last year							
Yes	2,044 (69.76)	146 (68.87)	211 (59.77)	37 (56.92)	112 (61.54)	1,538 (72.62)	35.87***
No	886 (30.24)	66 (31.13)	142 (40.23)	28 (43.08)	70 (38.46)	580 (27.38)	
Number of drinks							
1 or 2	1,701 (83.46)	119 (82.07)	169 (80.09)	30 (81.08)	81 (72.97)	1,302 (84.88)	13.16**
3 or more	337 (16.54)	26 (17.93)	42 (19.91)	7 (18.92)	30 (27.03)	232 (15.12)	
Frequency of drinking							
Monthly or less	714 (35.00)	53 (36.55)	85 (40.28)	14 (37.84)	40 (35.71)	522 (34.01)	9.93
Up to 4 times a month	288 (14.12)	25 (17.24)	30 (14.22)	6 (16.22)	15 (13.39)	212 (13.81)	
Up to 3 times a week	315 (15.44)	16 (11.03)	24 (11.37)	7 (18.92)	16 (14.29)	252 (16.42)	
4 or more times a week	723 (35.44)	51 (35.17)	72 (34.12)	10 (27.03)	41 (36.61)	549 (35.77)	

Note. X^2=Chi-squared test of independence * = p<.05; ** = p<.01; *** = p<.001

3.3 Independent factors that determine sleep profile membership in older adults

Multinomial models were conducted to assess independent predictors of sleep profile among the older adult (aged 65+ years) population (n = 2,932). Here, 198 observations were removed due to missing variables. As such, the records of 2,734 individuals informed the initial model.

To eliminate confounding, correlations between continuous variables were checked to ascertain which measures were best retained for statistical modelling. Variables selected for correlation analysis were statistically significant for sleep profile comparison in either the full or older adult sample (see **Sections 3.2 and 3.3**). The K10 psychological distress score was correlated with the SF-36 Mental Health and Emotional Functioning ($|\rho| = 0.61$, $p = <0.0001$) in the full sample. The following SF-36 measures were also found to be correlated:

- mental health and emotional role limitations ($|\rho| = 0.58$, $p = <0.0001$);
- physical functioning and physical role limitations ($|\rho| = 0.70$, $p = <0.0001$);
- bodily pain and physical role limitations ($|\rho| = 0.57$, $p = <0.0001$); and
- emotional role limitations and energy/vitality ($|\rho| = 0.61$, $p = <0.0001$).

In the older adult sample, the K10 and the SF-36 Mental Health scores were also correlated. ($|\rho| = 0.71$, $p = <0.0001$).

Accordingly, SF-36 emotional role limitation and physical role limitations and K10 scores were removed. Categorical variables identifying instances of diagnosed mental health disorders or psychological distress (K10 categorical variable) were also excluded. The indicators of high blood pressure and high cholesterol were excluded from statistical modelling as these were confounded with the multimorbidity and polypharmacy variables.

Table 19 shows the results of multinomial models investigating the association between sleep status and health and sociodemographic factors. This shows that multimorbidity and polypharmacy were significant predictors of disordered sleep among older

adults. Equally, being inactive was associated with the sleep disorder profile. Lower vitality, fatigue and energy scores were independently associated with a sleep disorder and excessive sleepiness profiles. Older age and higher body mass index were significant predictors of excessive sleepiness. Being female, however, reduced the odds of excessive sleepiness. Short sleep was associated with being a current smoker and living in less deprived areas (quintile 2). Bodily pain was independently associated with short sleep. Insufficient fruit and vegetable intake requirements and older age increased the odds of long sleep. Older women we less likely than males to experience long sleep.

3.4 Alcohol use and sleep profile membership in older adulthood

This section relates to older adults who were self-reported ‘current drinkers’ (n = 2,044). Current drinkers were those who confirmed ‘consuming a drink containing alcohol in the last year’ at the time of completing the survey. Multinomial models were run to measure typical alcohol use measures and their relationship with sleep profile membership. Two different models were undertaken based on the use of two distinct indicators of alcohol use: (a) AUDIT summary score, and (b) independent indicators of alcohol use frequency and quantity. The initial model utilised the AUDIT summary score which is a well-recognised primary healthcare measure of hazardous drinking. The AUDIT summary score offers a scale of drinking ‘hazardousness’ that reflects the combined interactions of the independent indicators of drinking frequency per week, typical drinking quantity per occasion, and evidence of binge drinking. The rationale for this measure was to assess whether a single measure of ‘hazardous’ drinking currently utilised in primary healthcare offers the capacity to serve as a potential indicator of risk for alcohol-related sleep issues. The second model utilised in this analysis differentiated specifically between (a) drinking frequency and (b) typical quantity consumed per occasion which are distinct indicators that might relate to sleep outcomes. This is based on recent research in NZ highlighting that drinking frequency and typical quantity

consumed are not correlated, and can follow distinct and even divergent patterns across the lifespan (Szabó, Towers, et al., 2021).

In the first instance, **Table 20** presents the significant independent predictors of sleep profile membership where alcohol consumption in older adult current drinkers is characterised by the AUDIT summary score. In this model, 127 many records were excluded due to information missing from one or more variables included in the model. In total 1,917 or 2,044 records were retained this model.

Independent predictors of disordered sleep and long sleep among older adult drinkers were consistent with those among the full older adult sample. Multimorbidity and polypharmacy were significant predictors of a sleep disorder among older adult drinkers, whereas older adult long sleepers were more likely to be of later age, male and have poorer nutrition. There were no independent predictors of short sleep among older adult drinkers. Those with excessive sleepiness in this cohort were more likely to be of later age, Māori and male. Bodily pain and lower energy and vitality were also independent predictors of excessive sleepiness among older adult drinkers.

When controlling for typical quantity and frequency, high quantity alcohol consumption (3 or more drinks) increased the odds of excessive sleepiness (OR =1.69, p = 0.05) in older adult current drinkers (see **Table 21**). In total 1,925 records of the available 2,044 informed the model, with 119 records excluded due to missing information. Those classified as having excessive sleepiness were also more likely to be of advanced age, identify as Māori, or likely to report lower energy, vitality, and fatigue scores. Multimorbidity, polypharmacy, being inactive and lower fatigue and vitality scores continued to be the only significant predictors of a sleep disorder. Older age and poor nutrition were significant predictors of long sleep in older adult drinkers, although females were less likely to be at risk of long sleep. No independent predictors assessed in the typical quantity and frequency models were significant predictors of short sleep among older adult drinkers.

Table 19

Odds ratios (95% confidence intervals) of multinomial models showing the association between sleep profiles and sets of demographic, lifestyle and health risks, and health outcome variables for the full 2013/2014 NZHS older adult sample.

Independent variables	Sleep Disorder OR (CI)		Excessive sleepiness OR (CI)		Short Sleep OR (CI)		Long Sleep OR (CI)	
Intercept				***		***		***
Demographic variables								
Age	1.00 (0.98, 1.03)		**1.05 (1.03, 1.07)**	***	**1.05 (1.00, 1.09)**	**	**1.05 (1.02, 1.07)**	***
Sex (Female)	0.94 (0.68, 1.31)		**0.72 (0.55, 0.95)**	**	1.65 (0.89, 3.05)		**0.54 (0.38, 0.77)**	***
Ethnicity (Māori)	1.08 (0.68, 1.72)		**1.92 (1.33, 2.76)**	***	1.02 (0.43, 2.40)		1.40 (0.86, 2.27)	
NZDEP 2013 Quintile (2)	0.72 (0.39, 1.34)		1.12 (0.67, 1.87)		**2.45 (0.85, 7.05)**	**	1.09 (0.60, 2.00)	
NZDEP 2013 Quintile (3)	1.09 (0.63, 1.87)		1.43 (0.89, 2.29)		0.91 (0.28, 2.92)		0.85 (0.47, 1.54)	
NZDEP 2013 Quintile (4)	1.11 (0.66, 1.86)		1.38 (0.87, 2.17)		1.58 (0.57, 4.42)		0.99 (0.57, 1.73)	
NZDEP 2013 Quintile (5)	1.25 (0.74, 2.13)		1.14 (0.71, 1.84)		1.45 (0.50, 4.19)		1.07 (0.61, 1.88)	
Lifestyle and health risk factor variables								
Smoking Status (Ex-Smoker)	1.15 (0.82, 1.61)		0.92 (0.70, 1.22)		1.33 (0.72, 2.47)		1.14 (0.79, 1.64)	
Smoking Status (Smoker)	0.90 (0.48, 1.68)		1.19 (0.73, 1.95)		**3.09 (1.33, 7.19)**	**	1.71 (0.97, 3.00)	
Body Mass Index	1.02 (0.99, 1.05)		**1.03 (1.01, 1.06)**	***	1.01 (0.96, 1.06)		1.00 (0.97, 1.04)	
Active (No)	**0.69 (0.49, 0.96)**	**	0.85 (0.64, 1.12)		1.15 (0.63, 2.08)		1.29 (0.90, 1.84)	
Fruit and Vegetable Intake (No)	1.15 (0.84, 1.57)		0.93 (0.71, 1.20)		1.39 (0.80, 2.44)		**1.92 (1.36, 2.72**	***
Health outcome variables								
Multimorbidity (Yes)	**1.73 (1.12, 2.68)**	**	1.20 (0.87, 1.66)		1.74 (0.85, 3.56)		1.11 (0.77, 1.62)	
SF-36 Mental Health	1.00 (0.99, 1.01)		1.00 (0.99, 1.01)		1.00 (0.98, 1.03)		1.00 (0.98, 1.01)	
SF-36 Physical Functioning	1.00 (1.00, 1.01)		1.00 (0.99, 1.00)		1.00 (0.99, 1.01)		0.99 (0.99, 1.00)	
SF-36 Bodily Pain	1.00 (0.99, 1.01)		1.00 (0.99, 1.00)		0.99 (0.98, 1.00)		1.00 (0.99, 1.01)	
SF-36 General Health	0.99 (0.98, 1.00)		**0.99 (0.98, 1.00)**	**	1.00 (0.98, 1.02)		1.01 (1.00, 1.02)	
SF-36 Vitality, Fatigue and Energy	**0.97 (0.96, 0.98)**	***	**0.96 (0.96, 0.97)**	***	1.00 (0.98, 1.02)		1.00 (0.99, 1.01)	
Polypharmacy (Yes)	**2.32 (1.59, 3.37)**	***	1.01 (0.72, 1.43)		1.38 (0.68, 2.79)		1.09 (0.65, 1.85)	

Note. X^2=Wald chi-squared test of independence * = p<.05; ** = p<.01; *** = p<.001

Table 20

Odds ratios (95% confidence intervals) of multinomial models for predictors of demographic, lifestyle and health risks, and health outcome variables for sleep profiles for older adult current drinkers only when controlling for alcohol consumption as measured by the AUDIT summary score.

Independent variables	**Sleep Disorder OR (CI)**		**Excessive sleepiness OR (CI)**		**Short Sleep OR (CI)**	**Long Sleep OR (CI)**	
Intercept							***
Demographic variables							
Age	0.99 (0.96, 1.02)		**1.04 (1.01, 1.07)**	***	1.04 (0.98, 1.10)	**1.05 (1.01, 1.08)**	***
Sex (Female)	0.99 (0.66, 1.49)		0.73 (0.52, 1.05)		1.54 (0.68, 3.48)	**0.43 (0.27, 0.68)**	***
Ethnicity (Māori)	1.38 (0.78, 2.43)		**1.99 (1.22, 3.24)**	***	1.02 (0.28, 3.63)	1.44 (0.77, 2.69)	
NZDEP Index 2013 Quintile (2)	0.71 (0.35, 1.45)		0.93 (0.51, 1.69)		2.49 (0.64, 9.71)	1.08 (0.52, 2.26)	
NZDEP Index 2013 Quintile (3)	1.17 (0.62, 2.21)		1.13 (0.64, 1.99)		1.14 (0.27, 4.89)	0.77 (0.36, 1.63)	
NZDEP Index 2013 Quintile (4)	1.20 (0.65, 2.21)		1.30 (0.76, 2.24)		1.77 (0.47, 6.77)	1.34 (0.69, 2.62)	
NZDEP Index 2013 Quintile (5)	1.23 (0.64, 2.36)		0.97 (0.54, 1.76)		1.22 (0.28, 5.28)	1.05 (0.51, 2.15)	
Lifestyle and health risk factor variables							
Smoking Status (Ex-Smoker)	1.29 (0.86, 1.93)		1.08 (0.76, 1.54)		1.35 (0.59, 3.07)	1.30 (0.82, 2.07)	
Smoking Status (Smoker)	0.82 (0.38, 1.77)		0.95 (0.49, 1.85)		2.45 (0.74, 8.07)	1.62 (0.77, 3.40)	
Body Mass Index	1.02 (0.99, 1.06)		1.03 (1.00, 1.06)		1.00 (0.93, 1.08)	1.01 (0.97, 1.06)	
Active (No)	**0.66 (0.44, 0.97)**	**	0.78 (0.55, 1.10)		1.40 (0.63, 3.13)	1.36 (0.88, 2.12)	
Fruit and Vegetable Intake (No)	1.35 (0.92, 1.98)		1.18 (0.84, 1.64)		0.99 (0.47, 2.07)	**1.78 (1.16, 2.74)**	***
Health outcome variables							
Multimorbidity (Yes)	**1.78 (1.06, 2.99)**	**	1.13 (0.75, 1.71)		1.27 (0.48, 3.34)	1.39 (0.87, 2.23)	
SF-36 Mental Health	1.00 (0.98, 1.01)		1.01 (0.99, 1.02)		1.00 (0.97, 1.04)	1.00 (0.98, 1.02)	
SF-36 Physical Functioning	1.00 (0.99, 1.01)		1.00 (0.99, 1.01)		1.00 (0.98, 1.02)	0.99 (0.98, 1.01)	
SF-36 Bodily Pain	1.00 (0.99, 1.01)		**0.99 (0.99, 1.00)**	**	0.99 (0.97, 1.01)	1.00 (0.99, 1.01)	
SF-36 General Health	0.99 (0.98, 1.00)		0.99 (0.98, 1.00)		1.00 (0.97, 1.02)	1.01 (1.00, 1.03)	
SF-36 Vitality, Fatigue and Energy	**0.97 (0.95, 0.98)**	***	**0.96 (0.95, 0.97)**	***	0.98 (0.96, 1.01)	1.00 (0.98, 1.01)	
Polypharmacy (Yes)	**2.06 (1.31, 3.25)**	***	1.01 (0.64, 1.57)		1.99 (0.81, 4.90)	1.01 (0.52, 1.98)	
Alcohol use							
AUDIT	1.00 (0.94, 1.08)		1.04 (0.98, 1.10)		1.01 (0.87, 1.17)	1.04 (0.97, 1.12)	

Note. X^2=Wald chi-squared test of independence * = p<.05; ** = p<.01; *** = p<.001

Table 21

Odds ratios (95% confidence intervals) of multinomial models for predictors of demographic, lifestyle and health risks, and health outcome variables for sleep profiles for older adult current drinkers only when controlling for alcohol consumption as measured by their typical quantity and frequency consumption.

Independent variables	Sleep Disorder OR (CI)		Excessive sleepiness OR (CI)		Short Sleep OR (CI)	Long Sleep OR (CI)	
Intercept							***
Demographic variables							
Age	0.99 (0.96, 1.02)		**1.04 (1.01, 1.07)**	*	1.05 (0.99, 1.11)	**1.05 (1.02, 1.09)**	*
Sex (Female)	1.04 (0.69, 1.57)		0.74 (0.52, 1.06)		1.59 (0.71, 3.55)	**0.43 (0.27, 0.68)**	*
Ethnicity (Māori)	1.42 (0.80, 2.52)		**1.91 (1.16, 3.14)**	*	1.28 (0.40, 4.06)	1.36 (0.72, 2.58)	
NZ Deprivation Index 2013 Quintile (2)	0.70 (0.34, 1.44)		0.92 (0.50, 1.69)		2.33 (0.60, 9.10)	1.09 (0.52, 2.28)	
NZ Deprivation Index 2013 Quintile (3)	1.17 (0.62, 2.21)		1.14 (0.65, 2.01)		1.10 (0.26, 4.75)	0.79 (0.37, 1.68)	
NZ Deprivation Index 2013 Quintile (4)	1.18 (0.64, 2.19)		1.31 (0.76, 2.25)		1.84 (0.49, 6.92)	1.32 (0.67, 2.57)	
NZ Deprivation Index 2013 Quintile (5)	1.24 (0.64, 2.39)		0.96 (0.53, 1.74)		1.07 (0.24, 4.67)	1.01 (0.49, 2.07)	
Lifestyle and health risk factor variables							
Smoking Status (Ex-Smoker)	1.24 (0.83, 1.87)		1.04 (0.73, 1.49)		1.32 (0.58, 3.00)	1.34 (0.84, 2.13)	
Smoking Status (Smoker)	0.76 (0.35, 1.65)		0.87 (0.45, 1.69)		2.97 (0.94, 9.32)	1.55 (0.73, 3.27)	
Body Mass Index	1.02 (0.99, 1.06)		1.03 (1.00, 1.06)		1.02 (0.95, 1.09)	1.01 (0.97, 1.06)	
Active (No)	**0.64 (0.43, 0.95)**	*	0.78 (0.55, 1.11)		1.31 (0.60, 2.86)	1.34 (0.86, 2.09)	
Fruit and Vegetable Intake (No)	1.31 (0.90, 1.93)		1.19 (0.85, 1.65)		1.07 (0.52, 2.23)	**1.75 (1.14, 2.70)**	*
Health outcome variables							
Multimorbidity (Yes)	**1.76 (1.05, 2.95)**	*	1.15 (0.77, 1.74)		1.36 (0.52, 3.54)	1.38 (0.86, 2.22)	
SF-36 Mental Health	1.00 (0.98, 1.01)		1.01 (0.99, 1.02)		1.00 (0.97, 1.04)	1.00 (0.98, 1.02)	
SF-36 Physical Functioning	1.00 (0.99, 1.01)		1.00 (0.99, 1.01)		1.00 (0.99, 1.02)	1.00 (0.98, 1.01)	
SF-36 Bodily Pain	1.00 (0.99, 1.01)		0.99 (0.99, 1.00)		0.99 (0.97, 1.00)	1.00 (0.99, 1.01)	
SF-36 General Health	0.99 (0.98, 1.00)		0.99 (0.98, 1.00)		0.99 (0.97, 1.02)	1.01 (1.00, 1.03)	
SF-36 Vitality, Fatigue and Energy	**0.97 (0.95, 0.98)**	***	**0.96 (0.95, 0.97)**	***	0.98 (0.96, 1.01)	1.00 (0.98, 1.01)	
Polypharmacy (Yes)	**2.13 (1.35, 3.36)**	***	1.00 (0.64, 1.56)		1.90 (0.78, 4.62)	1.01 (0.52, 1.98)	
Alcohol use: typical quantity							
Number of Drinks (3 or more)	1.23 (0.72, 2.08)		**1.59 (1.00, 2.51)**	*	1.35 (0.49, 3.76)	1.78 (1.05, 3.01)	

Independent variables	Sleep Disorder OR (CI)	Excessive sleepiness OR (CI)	Short Sleep OR (CI)	Long Sleep OR (CI)
Alcohol use: typical frequency				
Frequency (Up to 4 times a month)	1.49 (0.85, 2.62)	1.10 (0.66, 1.82)	1.78 (0.62, 5.15)	0.68 (0.34, 1.39)
Frequency (Up to 3 times a week)	0.75 (0.40, 1.43)	0.77 (0.45, 1.32)	1.51 (0.52, 4.35)	0.81 (0.42, 1.55)
Frequency (4 or more times a week)	1.25 (0.79, 2.00)	1.00 (0.67, 1.50)	0.93 (0.36, 2.42)	0.88 (0.52, 1.47)

Note. X^2=Wald chi-squared test of independence * = p<.05; ** = p<.01; *** = p<.001

4 Discussion

The primary aim of this thesis was to explore the prevalence of poor sleep in later life and to determine how alcohol use influences the factors that correlate with profiles indicative of poor sleep among New Zealand older adults. Five mutually exclusive sleep profiles were developed and the differential prevalence of their membership was compared between younger and older adults. Alcohol use alongside sociodemographic and health factors was considered in this study. The following section will discuss the key findings of this investigation.

4.1 The prevalence of poor sleep

The first objective of this study was to determine the extent to which distinct sleep profiles existed within the New Zealand adult and older adult populations. On the basis of existing literature, it was hypothesised that poor sleep would be more prevalent among older adults. Findings from this study suggest that approximately 1-in-5 adults (15 years and older) were classified as having poor sleep. Poor sleep was shown to be more prevalent among older than younger adults. These findings are consistent with prevalence estimates previously reported, ranging from between 20 and 50 percent (Ancoli-Israel et al., 2008; Gibson et al., 2020; Li et al., 2018; Meaklim et al., 2020; Neikrug & Ancoli-Israel, 2010; Paine et al., 2005; Paine et al., 2019).

There were five evidence-based sleep profiles explored in this thesis. These were (a) sleep disorder, (b) excessive sleepiness, (c) short sleep, (d) long sleep and (e) typical sleep. Specific to age-group differences in sleep, older adults were much more likely to experience a sleep disorder, excessive sleepiness and long sleep than were younger adults in this study. In contrast, younger adults were more likely to experience short sleep or have typical sleep compared to older adults. Reported sleep disorder prevalence rates observed in the present sample were significantly lower, for both the older and younger adult cohorts than those summarised in previous studies conducted. In New Zealand, prior research indicated as many as 1-in-4 adults have a current sleep problem

(Paine et al., 2004). Gibson et. al. (2020) determined that 3-in-10 advanced-aged adults reported having a sleep problem. In the present study, only 5.93% of younger adults (15–64 years) and 7.26% of older adults reported having a diagnosed sleep disorder. One possible explanation for the comparatively low prevalence estimates in this study compared to previous studies might be prevalence previously reported was based on subjective experiences or complaints. This study, however, relied on the sleep disorder having been diagnosed by a health professional, a far stricter criterion. Previous research highlights the potential variability in identifying sleep disturbance prevalence in the same population when using clinical diagnosis rather than alternative methods. For example, Sharwood et al. (2012), found that in a sample of over 500 long-distance truck drivers in Australia approximately 41% met the criteria for sleep apnoea, yet only 4.4% had been previously diagnosed with this condition by a health professional (Sharwood et al., 2012). The operationalisation of sleep disturbance used in the current study may, therefore, have under-estimated the prevalence of sleep issues and these five sleep profiles in NZ older adults.

In the present study, approximately 1-in-8 older adults were profiled as ‘excessively sleepy’ which was measured by one survey item that measured general fatigue, sleepiness, drowsiness or tiredness. Paine et al. (2005) reported that 1-in-7 NZ adults experienced excessive daytime sleepiness. In their study, excessive daytime sleepiness was measured by the Epworth Sleepiness Scale (Paine et al., 2005). The Epworth Sleepiness Scale measures situational sleep propensity (Johns, 2008) by asking participants to rate their propensity to fall asleep in common daytime activities. While prevalence estimates in this study are similar to that reported previously, the broader definition applied here may capture more diverse experiences of excessive sleepiness.

The prevalence of short and long sleep reported in the current study is lower than observed in previous NZ research. A pooled analysis of 48,187 NZ adults (18+years) conducted by Lee and Sibley (2019) classified one-third of respondents' nocturnal sleep durations as ‘short’ (i.e., less than seven hours) and a further 4.80% as ‘long’ (i.e., more than nine hours) (Lee & Sibley, 2019). Although there are differences in the sampling methodologies between studies, variances in estimates may in part be due to the survey items used to assess sleep durations (Robbins et al., 2021). In the study

by Lee and Sibley (2019), sleep duration was limited to the hours of sleep attained during the night. By comparison, the present study assessed sleep duration as the combined total duration for sleep episodes and naps that occurred within a 24-hour period. Measures of nocturnal sleep duration can be challenging to answer (Robbins et al., 2021). This is particularly the case when sleep occurs outside of night-time hours, or sleep requirement is met over multiple bouts of sleep throughout the day (Robbins et al., 2021). Such may be the case for shift workers or those who sleep during the day (Robbins et al., 2021). For instance, older adults who have assumed a biphasic sleep rhythm. Sleep durations reported in the study by Lee and Sibley (2019) may under capture total sleep duration, and could overestimate the prevalence of short sleep among older adults, as their sleep requirement is increasingly met over multiple episodes of sleep within a 24-hour period due to changes in the architecture of their sleep (Carskadon & Dement, 2017; Chokroverty, 2017a). Of further note, the definitions of short and long sleep applied in the current study employed stricter criteria of short and long sleep than that operationalised by Lee and Sibley (2019). Differences in definitions could contribute to the variances in estimates of short sleep observed in the study by Lee and Sibley (2019) and the current study. Further research should endeavour to test the validity of estimates produced and the sleep duration survey items to strengthen evidence regarding the correlation between sleep duration and all-cause and cause-specific morbidity and mortality within the NZ context. Regardless, of methodological and measurement differences, correlations between short and long sleep, and employment status and socio-economic status identified in the present study are consistent with that reported by Lee and Sibley (2019).

In the present study, short sleep was most evident among the younger adult cohort, who also had a higher rate of employment compared to older adults. Previous research in NZ has found short sleep to be correlated with employment status and working hours (Lee & Sibley, 2019; Paine & Gander, 2016). Paine and Gander (2016) found employment status, neighbourhood deprivation and self-rated health were independent predictors of short and long sleep, on free and scheduled (i.e., days where work or social commitments dictate bed and wake-up times) days. Work patterns have an important impact on sleep (Kecklund & Axelsson, 2016). Shift work, night work or long work hours

have been associated with short sleep and insufficient sleep (Paine & Gander, 2016). Night-time work has been correlated with several non-communicable diseases including cardiovascular disease, hypertension, and diabetes (Paine & Gander, 2016). Equally, shift work has been shown to increase the risk of heart disease, stroke, cancer, type 2 diabetes and accidents (Kecklund & Axelsson, 2016). Unfortunately, it was not possible to assess the degree to which work patterns among older adults impacted sleep in the current study as this information was not collected. The extent to which disparities in work-life balance, shift work, night work, long hours, and manual work may impact sleep could not be assessed. Existing research by Denison et al. (2018) concluded night-time work was a more prominent occupation risk factor among Māori than non-Māori. Night-time work and short and insufficient sleep have been individually associated with deleterious health outcomes (Denison et al., 2018; Kecklund & Axelsson, 2016; Paine & Gander, 2016). If Māori are more likely to be exposed to night-time work then this may exacerbate health inequalities between Māori and Non-Māori (Paine & Gander, 2016; Paine et al., 2005).

4.2 Differences between sleep profiles for older adults

The second objective of this study was to identify which demographic and health factors underpinned sleep profile membership in older adulthood. On the basis of existing literature, it was hypothesised that factors indicative of poor health (i.e., multimorbidity, polypharmacy, poor nutrition, etc.) would be associated with profiles of poor sleep.

Results from the current study found multimorbidity, polypharmacy and psychological distress most likely among older adults within the sleep disorder profile, compared to older adults that were classified as having typical sleep. While age-related changes in sleep are well-evidenced (Ancoli-Israel et al., 2008; Carskadon & Dement, 2017; Chokroverty, 2017a), the results here demonstrate that causes of disordered sleep may be multifactorial and underpinned by physical and mental health factors and the possible use of multiple medications. Consistent with the existing evidence base (Ancoli-Israel et al., 2008; Chaput et al., 2018; Stewart et al., 2020) the disordered sleep profile for older adults was correlated with poorer health status. It was not possible to ascertain

the directional nature of this relationship due to the cross-sectional nature of this study. As such the sleep disorder profile may have consisted of people with a primary or secondary sleep disorder.

Older adults within the excessive sleepiness profile were more likely to be older, have a higher body mass index or be male. Excessive sleepiness was also more likely among older adult Māori. Ethnicity was not an independent predictor for any other sleep profiles when health outcomes and health risk factors were accounted for. There is a strong body of literature that evidences ethnic disparities in sleep and health in NZ (Gibson et al., 2020; Mihaere et al., 2009; Paine & Gander, 2016; Paine et al., 2004; Paine et al., 2005; Paine et al., 2019). While not as evident within the present study, the findings here suggest that sleep disparities between Māori and Non-Māori older adults may be intrinsically linked to health inequality or larger systemic socioeconomic inequality. Stephens et al. (2020) investigated the cumulative effect of long-term social inequalities on the health of Māori and Non-Māori, males and females. The study by Stephens et al. (2020) found childhood socioeconomic status was a significant predictor of late-life health, but also that education attainment mediated health inequalities at entry to older adulthood. While sleep was absent from this study by Stephen et al. (2020), their findings might suggest that persistent effort is needed to create environments and habits that support good health across all stages of life (including older adulthood). Such an approach may come to mitigate health inequality in older adult life. Further research would is needed to expand the study by Stephens et al. (2020) to determine the role of sleep in modifying health trajectories and reducing health inequality.

Older adult long sleepers also tended to be male and to have poor nutrition. This is consistent with previous research findings (Beydoun et al., 2014; Noorwali et al., 2018). For example, a nationally representative health study of American adults by Beydoun et al. (2014) found several nutritional biomarkers were correlated with long sleep (9 hours or more). Examples of such biomarkers include lower fruit, fibre, vegetable and caloric intake. Lower lutein and zeaxanthin serum and vitamin B-12 were also significantly associated with long sleep (Beydoun et al., 2014). Beydoun et al. (2014) also found higher total caloric, caffeine, and vitamin B-12 intake, but lower folate, fruit and vegetable intake were risk factors for very short (less than 5 hours) and/or short sleep (5-6

hours). Folate and vitamin B-12 are important precursors for biological reactions that support the daily regulation of the body's circadian rhythms and thereby for sleep propensity (Beydoun et al., 2014) Vitamin B-12 possesses a psychotropic alerting effect and may lead to faster metabolism of melatonin. In abundance, vitamin B-12 could therefore act to disrupt sleep-wake regulation (Beydoun et al., 2014). These findings emphasise the role of good nutrition in supporting healthy sleep. In this study long sleep was characterised by poorer health and socioeconomic status (living in areas of greater deprivation, unemployment, lower-income households, and lower education level attainment). It might be the case that their socioeconomic circumstances limit the affordability and access to healthier food and meal options. Locher et al. (2009) investigated food choice barriers and motivations in 185 American homebound older adults and found that cost, taste, and ease of access and preparation were important determinants for food choices (Locher et al., 2009). Locher et al. (2009) learned that 'healthy eating' was a perceived barrier to the participant's preferred food options. The findings of the study by Locher et al. (2009) highlighted the interaction between microeconomics and the psychosocial nature of food choices. In NZ, research investigating the nutrition risk of older adults determined one in three community-dwelling older adults, and older adults of advanced age were at greater risk of poor nutrition (Wham et al., 2014; Wham et al., 2015). To encourage healthy eating among older adults food must, therefore, be affordable, easy to prepare, nutritionally balanced accessible and appetising. Higher nutritional risk has also been shown to be associated with depressive symptoms, loneliness, poorer health status and polypharmacy (Tkatch et al., 2022; Wham et al., 2014; Wham et al., 2015), and the present research introduces the element of sleep into this relationship.

Current smoking was a key factor for members of the short sleep profile among older adults. The odds of short sleep were three-fold greater for older adult current smokers, compared to non-smoking older adult typical sleepers. These findings are consistent with evidence that smoking reduces sleep duration, alters sleep architecture, and can increase the frequency of awakenings at night (Amiri & Behnezhad, 2020; dos Reis Costa, 2017; Phillips & Danner, 1995). Nicotine is capable of stimulating wakefulness (dos Reis Costa, 2017; Suzuki et al., 2017), while decreased plasma

nicotine concentrations can drive cravings during sleep (dos Reis Costa, 2017; Suzuki et al., 2017). Habitual smoking has been shown to have a deleterious impact on health, contributing to the onset of long-term health conditions contributing to the occurrence of sleep disorders or poor sleep (Amiri & Behnezhad, 2020; dos Reis Costa, 2017). This too contributes to diminished sleep quality and increased daytime sleepiness (Amiri & Behnezhad, 2020; Brook et al., 2015; dos Reis Costa, 2017). Given the effect size observed in the current study, further exploration is warranted.

Existing literature outlines several age-related changes in sleep and the increased likelihood of poor sleep among older adults (Ancoli-Israel et al., 2008; Cajochen et al., 2006; Dijk, 1999; Dijk et al., 2000). Poor sleep can be subsequent to the presence of a primary or secondary sleep disordered (Suzuki et al., 2017) and characterised by insufficient quantity, quality or poor sleep timing. These can result in light transitory sleep or broken sleep, poor daytime functioning and excessive sleepiness (Ancoli-Israel et al., 2008; Suzuki et al., 2017)Age, in and of itself, is not principally responsible for the prevalence of poor or problem sleep observed in older adulthood (Ancoli-Israel & Ayalon, 2006; Ancoli-Israel et al., 2008). Instead, this thesis demonstrated factors such as multimorbidity, polypharmacy, nutrition, smoking status, age and sex underpinned profiles of poor sleep. The findings here highlight several avenues of further intervention to support successful ageing and better health in later life.

4.3 The role of alcohol use in poor sleep in older adult drinkers.

The third objective of this study was to explore the degree to which alcohol use was related to membership of these sleep profiles in older adulthood. Alcohol is well-known for its sedative properties and prior research has highlighted its use as a sleep aid among older adult cohorts (Aira et al., 2008; Bareham et al., 2019; Ebrahim et al., 2013; Roehrs & Roth, 2001; Van Reen et al., 2006; Vitiello, 1997). Much of the concern about alcohol consumption in older adulthood stems from concerns that age-related physiological changes can increase sensitivity to alcohol (Aira et al., 2008; Canham & Mauro, 2016; Cousins et al., 2014). For instance, reduced alcohol metabolism can prolong plasma concentrations of alcohol increasing the potential adverse reactions to medications,

poorer health, and unintentional injury (Ancoli-Israel & Ayalon, 2006; Barczi & Teodorescu, 2017; Ministry of Health, 2020). On the basis of existing literature, it was hypothesised that older adult drinkers with more harmful consumption tendencies would be more likely to have poor sleep compared to those that do not consume alcohol in a harmful way.

In this study, the AUDIT summary score was not a significant risk factor for any profiles of poor sleep. The absence of association between AUDIT score and these profiles is perhaps understandable given that this screening score is a public health indicator of a broad range of drinking patterns (Bush et al., 1998), and the specificity of hazardous or harmful drinking patterns specifically for older adults was lost. When alcohol consumption was described in terms of typical quantity and frequency, higher quantity alcohol consumption increased the odds of excessive sleepiness in older adult current drinkers. A study in Germany by Lydon-Staley et al. (2017) reported older adults were less susceptible to next-day tiredness when consuming greater quantities of alcohol. The contrary findings here may reflect differences in study methodologies and how sleepiness was measured and treated.

In NZ, previous research investigating longitudinal alcohol consumption trends among older adults concluded that life-course consumption trajectories demonstrated little to no change over time (Szabo et al., 2019; Towers, Sheridan, et al., 2018a, 2018b). The existing research determined low quantity and low frequency, and low quantity and high-frequency consumption trends were more commonplace, and this was seen in the present study too. Previous NZ literature found high quantity moderate frequency drinkers were more likely to develop multimorbidity and have poor physical and mental health (Szabo et al., 2019; Towers, Sheridan, et al., 2018a, 2018b). Szabo et al. (2019) also concluded older adult drinkers with low-quantity and low-frequency consumption patterns suffered poorer health and multimorbidity too. In this study, poorer health status was associated with the sleep disorder profile (Szabo et al., 2019; Towers, Sheridan, et al., 2018a, 2018b). The exploratory analysis in the current study revealed older adult drinkers within the sleep disorder profile consumed low quantities of alcohol either frequently (i.e., four or more times a week) or infrequently (i.e., monthly or less). Alcohol use was not a significant predictor of the sleep disorder profile in this study.

These findings may support the view of Szabo et al. (2019) that older adult current drinkers with low-quantity and low-frequency consumption patterns may consist of people who had come to refrain from drinking due to health deterioration. The cross-sectional nature of the study means it is not possible to assess the cumulative effect of life-course drinking habits or how these could impact sleep throughout life.

In this study, higher alcohol consumption was a significant predictor of excessive sleepiness among older adult current drinkers. Older adult drinkers constituted 15.36% (2,044) of the full sample, of whom only 506 older adult drinkers were classified as having poor sleep. This is approximately one-quarter of older adult drinkers, just four percent of the total sample. The comparatively small sample size raises questions as to whether the model applied was overfitted to the data. Future work could further investigate the use of other statistical modelling selection methodologies to identify which variables are the most pertinent predictors for assessing the role of alcohol in the sleep profiles of older adult drinkers.

4.4 What does this research say about sleep disturbance in older adults?

The findings reported here elaborate on the current knowledge on the prevalence of poor sleep in older adulthood. Where previous NZ studies have tended to focus on the general adult population or older adults of advanced age (Gibson et al., 2016; Mihaere et al., 2009; Paine & Gander, 2016; Paine et al., 2004; Paine et al., 2005; Paine et al., 2019), this work gives insight to the sleep of NZ older adults more generally. The study demonstrated sleep problems, excessive sleepiness and long sleep were more prevalent among the older population. This bears important consequences for the health system in light of the older adult population growth projected. The low population prevalence of diagnosed sleep disorders could be a consequence of service accessibility. Sleep studies are required for the diagnosis of many sleep disorders including sleep-disordered breathing, restless legs syndrome, periodic limb movement disorder and REM sleep disorder. Anecdotally, services for diagnosing sleep disorders in New Zealand are limited and may require a referral from a general practitioner (Gibson et al., 2018). Referrals to sleep clinics have been stated

in New Zealand research to attract further costs (Gibson et al., 2018). which may serve as an added barrier to accessibility for some This may be particularly the case for those who are in retirement or unemployed or living in lower-income households, such as the sample of older adults investigated in this study. Excessive sleepiness is a common symptom of sleep disorders and a predictor of retirement in older adults (Myllyntausta et al., 2021). This could further limit the ability to afford or access proper diagnosis and treatment through the current referral pathways to successfully identify, manage or treat sleep disorders. As such it may be that limited access and affordability is one cause of the under-representation of diagnosed sleep disorders seen in this study.

4.5 Strengths and limitations of the current study

The information investigated in this study was supplied by participants involved in a population-wide health survey. The sampling methodology was designed to ensure that the sample selected was structured to ensure comparison across sociodemographic factors, and to ensure sufficient sample sizes for sub-population groups including older adults, which is the target subpopulation of this study (Ministry of Health, 2011, 2014c). One strength of this study is, therefore, the ability to investigate sleep and health in a large nationally representative sample of NZ older adults compared to previous studies conducted among this cohort. Despite the representative nature of the study and comparatively larger older adult sample, the sample size for the short and long sleep profiles among older adult current drinkers was small. While results reported in this study are consistent with, or supported by, previous research, the findings for older adult current drinkers should be treated with caution. Further research with larger samples is recommended before findings are used to inform clinical recommendations.

Another strength of this study is that long and short-sleepers were defined based on their life stage. This novel approach is perhaps more reliable than previous research (Lee & Sibley, 2019), and the definitions of long and short sleep here may offer a proxy measure of poor sleep or potentially an undiagnosed sleep disorder. Future work could investigate the tailored approach employed here in larger samples to assess the sociodemographic and health differences reported here. Future work

could also look to assess the sleep duration thresholds for short and long sleep applied here. The 'appropriate sleep durations' guidelines used here provide a stricter threshold than recommended sleep durations. This may have limited the detection of health behaviours and risk factors associated with short and long sleep observed in previous studies.

The hierarchical order of the sleep profiles may have influenced the prevalence of the profiles of excessive sleepiness and short or long sleep. This is because someone with a sleep disorder may regularly experience excessive sleepiness, and short or long sleep as well. This could have influenced the ability to detect statistically significant predictors of short or long sleep in the older adult sample or detect the role of alcohol in these profiles.

The response categories for the excessive sleepiness survey item made it challenging to define the excessive sleepiness profile. There is no general indication of 'how much sleepiness is too much sleepiness' and the broad response categories lacked specificity to how excessive sleepiness may have impacted general tasks or daily activities. Should excessive sleepiness be introduced for continuous health monitoring, it is recommended a review of subjective measures of excessive sleepiness be conducted to inform the survey item selected or to refine response categories.

Another strength of this study was the investigation of the AUDIT sub-measures, typical quantity, and typical frequency. This recognises that the AUDIT summary score threshold may not recognise the factors that place older adults at greater risk even when alcohol is consumed within the recommended guidelines.

It is important to highlight that subjective measures are susceptible to bias (Ibáñez et al., 2018a, 2018b). This could be out of concern of judgement, or misinterpretation or comprehension of the question. In other instances (i.e., self-reporting characteristics of sleep) misreporting may be due to limited recall (i.e., not remembering awakenings). Studies have often found participants may differentially under or overestimate sleep duration, sleep start and end times, the length of time taken to fall asleep, the number of night-time awakenings and the amount of time spent awake at night (Landry et al., 2015; van den Berg, 2009; van den Berg et al., 2008). Objective and subjective sleep

measure agreement studies have found self-reported sleep quality to be inconsistent with individual or composite objective parameters of sleep quality (Jeon et al., 2019; Landry et al., 2015; O'Donnell et al., 2009). Similarly, self-reported alcohol consumption may underestimate true levels of consumption due to differences in what constitutes a 'typical day, 'typical consumption, or 'standard amounts'. Despite the limitations of self-report, subjective measurement methods remain valuable for understanding the factors that impact sleep. The survey methodology provides a practical and efficient method for collecting data on sleep duration, excessive sleepiness, and sleep complaints and disorders (Clark et al., 2013; Ibáñez et al., 2018a). Particularly when assessed among large communities, geographical basis or groups of people, or to supplement objective measurement studies. Understanding the degree to which subjective measurement methods agree with objective measurement methods would be important for assessing the validity of self-reported sleep, alcohol consumption, physical activity, and nutrition collected as part of the NZHS.

In the present study, multimorbidity and polypharmacy were derived by tallying survey responses for each respondent concerning health conditions assessed by the survey. Although more long-term health conditions were assessed in the 2013/2014 NZHS compared to other iterations of the survey, it is not feasible to account for every health condition in large-scale population health surveys (Ministry of Health, 2014a, 2014d, 2017, 2018, 2019). It is, therefore, possible that the prevalence of multimorbidity and polypharmacy has been underestimated in the current study. Due to the way questions regarding pharmaceutical treatment were asked, it was not possible to ascertain where: (1) sedative medications were prescribed, (2) multiple medications were used to manage a single health condition, (3) one medication was used to manage multiple health conditions, or (4) whether medications were taken as prescribed. The true extent of polypharmacy may be underestimated accordingly. The derivation of the polypharmacy variable may in some instances simultaneously identify respondents with five or long-term health conditions. However, treatment options assessed in the survey included non-pharmacological interventions as well. As such, there are two avenues of further research. Future work could investigate (1) the extent to which non-pharmacological interventions are employed to ascertain the degree to which multimorbidity and

polypharmacy are confounded, and (2) how multimorbidity and polypharmacy are be described for health surveillance and their suitability as population health indicators more generally.

4.6 Future direction for new research

Based on the findings of the present study, it is recommended that future public health research establish a more comprehensive understanding of the prevalence of sleep disorders, sleep complaints, sleep quality, and short and long sleep. Future work could look to refine and validate sleep questions presented in population health studies to produce more accurate estimates for population health monitoring and health surveillance. Expanding on this, future work should aim to understand the role of sleep as a modifiable health factor to understand how sleep modifies the health trajectories while accounting for life course alcohol consumption and socioeconomic trajectories. Studies of this nature would inform the growing body of national research that together could inform a socioecological framework of sleep relevant for NZ. This would describe the individual, social and societal-level factors that influence sleep in NZ and potentially the strength of influence over the course of life. Such work would help to understand the role of sleep as a modifiable health risk factor and consolidate the factors that influence sleep. The research here demonstrates the need for sleep health as a health monitoring and population health surveillance. Sleep duration alone describes only one aspect of 'poor' sleep and, therefore, is an inadequate measure of the sleep health of the general population. Population health monitoring would benefit from the inclusion of additional measures that capture the other aspects of poor sleep, such as sleep quality and sleep timing, the prevalence of sleep disorders, excessive sleepiness, sleep complaints and barriers to investigating concerns of poor sleep.

The findings here suggest alcohol consumption guidelines for general adult populations may not adequately reflect the factors that place older adults at greater adverse risk due to the prevalence. This study builds on prior research by broadening considerations to include the relationship with poor sleep. This study echoes the need for guidelines dedicated to older adults and reflects the factors that place them at greater risk. This research also emphasises the need for

screening tools that detect the prevalence of consumption patterns that are harmful or hazardous specifically among the older adult population.

4.7 Conclusion

Regarding the aims of this thesis, the present study identified five sleep profiles within the NZ context and employed a novel approach by classifying short and long sleep durations according to life stage guidelines. Sleep profiles were determined hierarchically according to the surety of a sleep disorder and the likely impact on everyday life. The results of this study found older adults were more evident among the sleep disorder, excessive sleepiness and long sleep profiles, whereas younger adults were more likely to be short or typical sleepers.

Concerning sleep profile membership, the results of this study demonstrated that:

- Multimorbidity and polypharmacy increased the likelihood of sleep disorder profile membership in older adulthood.
- Older adult typical sleepers reflected better health and socioeconomic status.
- Long sleepers were more likely to be male and have poorer nutrition
- Being a current smoker was a significant factor for short sleep profile membership in older adulthood.

The role of alcohol use in sleep profiles of older adult current drinkers was assessed in terms of (a) the AUDIT summary score and (b) the typical quantity and frequency of consumption. When assessed in terms of the AUDIT summary score, alcohol use was not a significant independent factor among any sleep profile characteristic of poor sleep. However, higher quantity consumption increased the likelihood of excessive sleepiness profile membership among older adult drinkers. These findings here challenge previous assertions that moderate level alcohol use benefits sleep in older adulthood, and contributes to the understanding of the key demographic and health factors that coincide with profiles of poor sleep in older adults in NZ. These findings highlight important areas for consideration in light of the older adult population growth projected, which may include

improvement to population-level sleep health surveillance, improving service accessibility for the diagnosis and treatment of sleep disorders and expanding life course epidemiological studies to include consideration for the role of alcohol use and sleep

5 References

Achermann, P., & Borbely, A. A. (2003). Mathematical model of sleep regulation. *Frontiers in Bioscience, 8*, 683-693.

Achermann, P., Borbély, A. A.,. (2017). Sleep Homeostasis and Models of Sleep Regulation. In E. Saunder (Ed.), *Principles and practice of sleep medicine* (6th edition ed.). Elsevier.

Aira, M., Hartikainen, S., & Sulkava, R. (2008, Dec). Drinking alcohol for medicinal purposes by people aged over 75: a community-based interview study. *Family Practice, 25*(6), 445-449. https://doi.org/10.1093/fampra/cmn065

Allen, J., & Alpass, F. (2020). Trajectories of material living standards, physical health and mental health under a universal pension. *Journal of Epidemiology and Community Health, 74*(4), 362-368.

Aminisani, N., Stephens, C., Allen, J., Alpass, F., & Shamshirgaran, S. M. (2020). Socio-demographic and lifestyle factors associated with multimorbidity in New Zealand. *Epidemiology and health, 42*.

Amiri, S., & Behnezhad, S. (2020, 2020/10/01). Smoking and risk of sleep-related issues: a systematic review and meta-analysis of prospective studies. *Canadian Journal of Public Health, 111*(5), 775-786. https://doi.org/https://doi.org/10.17269/s41997-020-00308-3

Ancoli-Israel, S., & Ayalon, L. (2006, Feb). Diagnosis and treatment of sleep disorders in older adults. *The American Journal of Geriatric Psychiatry, 14*(2), 95-103. https://doi.org/10.1097/01.JGP.0000196627.12010.d1

Ancoli-Israel, S., Ayalon, L., & Salzman, C. (2008). Sleep in the elderly: normal variations and common sleep disorders. *Harvard Review of Psychiatry, 16*(5), 279-286. https://doi.org/10.1080/10673220802432210

Ancoli-Israel, S., Cole, R., Alessi, C., Chambers, M., Moorcroft, W., & Pollak, C. P. (2003). The role of actigraphy in the study of sleep and circadian rhythms. *SLEEP, 26*(3), 342-392.

Anderson, T. M., Sunderland M Fau - Andrews, G., Andrews G Fau - Titov, N., Titov N Fau - Dear, B. F., Dear Bf Fau - Sachdev, P. S., & Sachdev, P. S. (2013). The 10-item Kessler psychological distress scale (K10) as a screening instrument in older

individuals. *The American Journal of Geriatric Psychiatry, 21*(1545-7214 (Electronic)), 596-606.

Arble, D. M., Bass, J., Behn, C. D., Butler, M. P., Challet, E., Czeisler, C., Depner, C. M., Elmquist, J., Franken, P., Grandner, M. A., Hanlon, E. C., Keene, A. C., Joyner, M. J., Karatsoreos, I., Kern, P. A., Klein, S., Morris, C. J., Pack, A. I., Panda, S., Ptacek, L. J., Punjabi, N. M., Sassone-Corsi, P., Scheer, F. A., Saxena, R., Seaquest, E. R., Thimgan, M. S., Van Cauter, E., & Wright, K. P. (2015, Dec 1). Impact of Sleep and Circadian Disruption on Energy Balance and Diabetes: A Summary of Workshop Discussions. *SLEEP, 38*(12), 1849-1860. https://doi.org/10.5665/sleep.5226

Astiz, M., Heyde, I., & Oster, H. (2019). Mechanisms of Communication in the Mammalian Circadian Timing System. *International Journal of Molecular Sciences, 20*(2). https://doi.org/10.3390/ijms20020343

Atkinson, G., & Davenne, D. (2007). Relationships between sleep, physical activity and human health. *Physiology & behavior, 90*(2-3), 229-235. https://doi.org/https://doi.org/10.1016/j.physbeh.2006.09.015

Atkinson, J., Salmond, C., & Crampton, P. (2014). *NZDep2013 Index of Deprivation User's Manual*. https://www.otago.ac.nz/wellington/otago069936.pdf

Babor, T. F., Higgins-Biddle, J. C., Saunders, J. B., & Monteiro, M. G. (2001). *The Alcohol Use Disorders Identification Test. Guidelines for Use in Primary Care* (World Health Organisation, Ed. Second ed.)

Barczi, S. R., & Teodorescu, M. C. (2017). Psychiatric and medical comorbidities and effects of medications in older adults. In *Principles and practice of sleep medicine* (pp. 1484-1495. e1486). Elsevier.

Bareham, B. K., Kaner, E., Spencer, L. P., & Hanratty, B. (2019). Drinking in later life: a systematic review and thematic synthesis of qualitative studies exploring older people's perceptions and experiences. *Age Ageing, 48*(1), 134-146. https://doi.org/10.1093/ageing/afy069

Barnett, R., Pearce, J., & Moon, G. (2009, 2009/03/01/). Community inequality and smoking cessation in New Zealand, 1981–2006. *Social Science & Medicine, 68*(5), 876-884. https://doi.org/https://doi.org/10.1016/j.socscimed.2008.12.012

Beersma, D. G. M. (1998). Models of human sleep regulation. *Sleep Medicine Reviews, 2*(1), 31-43. https://doi.org/10.1016/s1087-0792(98)90052-1

Beydoun, M. A., Gamaldo, A. A., Canas, J. A., Beydoun, H. A., Shah, M. T., McNeely, J. M., & Zonderman, A. B. (2014). Serum nutritional biomarkers and their associations with sleep among US adults in recent national surveys. *PLoS One, 9*(1932-6203 (Electronic)), 19. https://doi.org/10.1371/journal.pone.0103490

Birth, b. K. (2007). Time and the biological consequences of globalization. *Current Anthropology, 48*(2), 215-236.

Borbely, A. A., & Achermann, P. (1992). Concepts and models of sleep regulation: an overview. *Journal of Sleep Research, 1*, 63-79.

Borbély, A. A., & Achermann, P. (1999). Sleep Homeostasis and Models of Sleep Regulation. *Journal of Biological Rhythms, 14*(6), 559-568. https://doi.org/https://doi.org/10.1016/b0-72-160797-7/50040-9

Borbely, A. A., Daan, S., Wirz-Justice, A., & Deboer, T. (2016, Apr). The two-process model of sleep regulation: a reappraisal. *Journal of Sleep Research, 25*(2), 131-143. https://doi.org/10.1111/jsr.12371

Brook, J. S., Zhang, C., Rubenstone, E., & Brook, D. W. (2015, Jan-Feb). Insomnia in adults: the impact of earlier cigarette smoking from adolescence to adulthood. *Journal of addiction medicine, 9*(1), 40-45. https://doi.org/10.1097/ADM.0000000000000083

Bush, K., Kivlahan, D. R., McDonell, M. B., Fihn, S. D., Bradley, K. A., & Project, A. C. Q. I. (1998). The AUDIT alcohol consumption questions (AUDIT-C): an effective brief screening test for problem drinking. *Archives of Internal Medicine, 158*(16), 1789-1795.

Cajochen, C., Munch, M., Knoblauch, V., Blatter, K., & Wirz-Justice, A. (2006). Age-related changes in the circadian and homeostatic regulation of human sleep. *Chronobiology International,, 23*(1-2), 461-474. https://doi.org/10.1080/07420520500545813

Canham, S. L., & Mauro, P. M. (2016). Self-medication with alcohol: Aging issues. In *Alcohol and Aging* (pp. 201-214). Springer.

Carney, C. E., Buysse, D. J., Ancoli-Israel, S., Edinger, J. D., Krystal, A. D., Lichstein, K. L., & Morin, C. M. (2012, Feb 1). The consensus sleep diary: standardizing prospective sleep self-monitoring. *SLEEP, 35*(2), 287-302. https://doi.org/10.5665/sleep.1642

Carskadon, M. A., & Dement, W. C. (2017). Normal Human Sleep: An Overview. In E. Saunder (Ed.), *Principles and practice of sleep medicine* (6th edition ed., pp. 16-26). https://doi.org/https://doi.org/10.1016/b0-72-160797-7/50009-4

Chaput, J.-P., Dutil, C., & Sampasa-Kanyinga, H. (2018). Sleeping hours: what is the ideal number and how does age impact this? *Nature and Science of Sleep, 10*, 421-430. https://doi.org/https://doi.org/10.2147/nss.s163071

Chattu, V. K., Manzar, M. D., Kumary, S., Burman, D., Spence, D. W., & Pandi-Perumal, S. R. (2018). The global problem of insufficient sleep and its serious public health implications. Healthcare,

Chokroverty, S. (2017a). Overview of Normal Sleep. In S. Chokroverty (Ed.), *Sleep Disorders Medicine* (4th ed., pp. 5-28). Springer.

Chokroverty, S. (2017b). Sleep Disorders in the Elderly. In S. Chokroverty (Ed.), *Sleep Disorders Medicine* (4th ed., pp. 1115-1138). Springer.

Chun, W., Chao, D., Qi, H., Dongliang, Z., Zhenmei, L., & Jia, L. (2021). Pharmacological and non-pharmacological treatments for insomnia: A protocol for a systematic review and network meta-analysis. *Medicine, 100*(31), e26678-e26678. https://doi.org/10.1097/MD.0000000000026678

Clark, R. G., Templeton, R., & McNicholas, A. (2013). Developing the design of a continuous national health survey for New Zealand. *Population health metrics, 11*(1), 25. https://ro.uow.edu.au/cgi/viewcontent.cgi?article=2842&context=eispapers

Colrain, I. M., Nicholas, C. L., & Baker, F. C. (2014). Alcohol and the sleeping brain. *Handbook of Clinical Neurology, 125*, 415-431. https://doi.org/10.1016/B978-0-444-62619-6.00024-0

Cousins, G., Galvin, R., Flood, M., Kennedy, M.-C., Motterlini, N., Henman, M. C., Kenny, R.-A., & Fahey, T. (2014). Potential for alcohol and drug interactions in older adults: evidence from the Irish longitudinal study on ageing. *BMC geriatrics, 14*(1), 1-10.

Crowley, K. (2011). Sleep and sleep disorders in older adults. *Neuropsychology Review, 21*(1), 41-53. https://doi.org/10.1007/s11065-010-9154-6

Dashti, H. S., Scheer, F. A., Jacques, P. F., Lamon-Fava, S., & Ordovás, J. M. (2015). Short Sleep Duration and Dietary Intake: Epidemiologic Evidence, Mechanisms, and Health

Implications. *Advances in Nutrition, 6*(6), 648-659. https://doi.org/10.3945/an.115.008623

Denison, H. J., Eng, A., Barnes, L. A., Cheng, S., Haddock, K., Douwes, J., Pearce, N., & Ellison-Loschmann, L. (2018). Inequities in exposure to occupational risk factors between Māori and non-Māori workers in Aotearoa New Zealand. *Journal of Epidemiology & Community Health, 72*(9), 809-816.

Dew, M. A., Hoch, C. C., Buysse, D. J., Monk, T. H., Begley, A. E., Houck, P. R., Hall, M., Kupfer, D. J., & Reynolds, C. F. (2003, Jan-Feb). Healthy older adults' sleep predicts all-cause mortality at 4 to 19 years of follow-up. *Psychosomatic Medicine, 65*(1), 63-73. https://doi.org/10.1097/01.psy.0000039756.23250.7c

Dijk, D.-J., & Czeisler, C. A. (1995). Contribution of the circadian pacemaker and the sleep homeostat to sleep propensity, sleep structure, electroencephalographic slow waves, and sleep spindle activity in humans. *Journal of Neuroscience, 15*(5), 3526-3538.

Dijk, D.-J., Duffy, J. F., Silva, E. J., Shanahan, T. L., Boivin, D. B., & Czeisler, C. A. (2012). Amplitude Reduction and Phase Shifts of Melatonin, Cortisol and Other Circadian Rhythms after a Gradual Advance of Sleep and Light Exposure in Humans. *PLoS One, 7*(2), e30037. https://doi.org/10.1371/journal.pone.0030037

Dijk, D.-J., Duffy, J. F., Riel, E., Shanahan, T. L., Czeisler, C. A. . (1999). Ageing and the circadian and homeostatic regulation of human sleep during forced desynchrony. *Journal of Physiology, 516*(2), 611-627.

Dijk, D.-J., & Lockley, S. W. (2002). Integration of human sleep-wake regulation and circadian rhythmicity. *Journal of Applied Physiology, 92*, 825-862. https://doi.org/10.1152/japplphysiol.00924.2001

Dijk, D. J., Duffy, J. F., & Czeisler, C. A. (2000, May). Contribution of circadian physiology and sleep homeostasis to age-related changes in human sleep. *Chronobiology international, 17*(3), 285-311. https://doi.org/10.1081/cbi-100101049

dos Reis Costa, M. J. (2017). Cigarette smoking and sleep disturbance: a systematic review. https://doi.org/https://doi.org/10.1097/adt.0000000000000123

Driver, H. S., & Taylor, S. R. (2000). Exercise and sleep. *Sleep Medicine Reviews, 4*(4), 387-402.

Duffy, J. F., & Wright Jr, K. P. (2005). Entrainment of the human circadian system by light. *Journal of Biological Rhythms, 20*(4), 326-338.

Dulin, P. L., Stephens, C., Alpass, F., Hill, R. D., & Stevenson, B. (2011). The impact of socio-contextual, physical and lifestyle variables on measures of physical and psychological wellbeing among Māori and non-Māori: the New Zealand Health, Work and Retirement Study. *Ageing & Society, 31*(8), 1406-1424. https://doi.org/https://doi.org/10.1017/s0144686x10001479

Ebrahim, I. O., Shapiro, C. M., Williams, A. J., & Fenwick, P. B. (2013). Alcohol and sleep I: Effects on normal sleep. *Alcoholism: Clinical and Experimental Research, 37*(4), 539-549. https://doi.org/10.1111/acer.12006

Foley, D. J., Ancoli-Israel, S., Britz, P., & Walsh, J. (2004). Sleep disturbances and chronic disease in older adults: results of the 2003 National Sleep Foundation Sleep in America Survey. *Journal of psychosomatic research, 56*(5), 497-502.

Froy, O. (2011, Aug). Circadian rhythms, aging, and life span in mammals. *Physiology, 26*(4), 225-235. https://doi.org/10.1152/physiol.00012.2011

Gallicchio, L., & Kalesan, B. (2009, Jun). Sleep duration and mortality: a systematic review and meta-analysis. *Journal of Sleep Research, 18*(2), 148-158. https://doi.org/https://doi.org/10.1111/j.1365-2869.2008.00732.x

Garcia, A. N., & Salloum, I. M. (2015). Polysomnographic sleep disturbances in nicotine, caffeine, alcohol, cocaine, opioid, and cannabis use: A focused review. *The American Journal on Addictions, 24*(7), 590-598. https://doi.org/10.1111/ajad.12291

Gibson, R., Gander, P., Kepa, M., Moyes, S., & Kerse, N. (2020, Aug). Self-reported sleep problems and their relationship to life and living of Maori and non-Maori in advanced age. *Sleep Health, 6*(4), 522-528. https://doi.org/https://doi.org/10.1016/j.sleh.2019.11.002

Gibson, R., Gander, P., Paine, S.-J., Kepa, M., Dyall, L., Moyes, S., & Kerse, N. (2016). Sleep of Māori and non-Māori of advanced age. *New Zealand Medical Journal, 129*(1436). https://researchspace.auckland.ac.nz/bitstream/handle/2292/44716/Gibson-1646-NZMJ-1436-FINAL.pdf?sequence=2&isAllowed=y

Gibson, R. H., Campbell, A., Mather, S., & Neill, A. M. (2018). From diagnosis to long-term management: the experiences of older New Zealanders with obstructive sleep

apnoea. *Journal of primary health care, 10 2*, 140-149. https://doi.org/https://doi.org/10.1111/jsr.67_12619

Grandner, M. A. (2019). Social-ecological model of sleep health. In *Sleep and health* (pp. 45-53). Elsevier. https://doi.org/https://doi.org/10.1016/b978-0-12-815373-4.00005-8

Grandner, M. A., Hale, L., Moore, M., & Patel, N. P. (2010, Jun). Mortality associated with short sleep duration: The evidence, the possible mechanisms, and the future. *Sleep Medicine Reviews, 14*(3), 191-203. https://doi.org/10.1016/j.smrv.2009.07.006

Grandner, M. A., Jackson, N. J., Izci-Balserak, B., Gallagher, R. A., Murray-Bachmann, R., Williams, N. J., Patel, N. P., & Jean-Louis, G. (2015). Social and behavioral determinants of perceived insufficient sleep. *Frontiers in neurology, 6*, 112. https://doi.org/10.3389/fneur.2015.00112

Grandner, M. A., Jackson, N. J., Pak, V. M., & Gehrman, P. R. (2012, Aug). Sleep disturbance is associated with cardiovascular and metabolic disorders. *Journal of Sleep Research, 21*(4), 427-433. https://doi.org/10.1111/j.1365-2869.2011.00990.x

Grandner, M. A., Patel, N. P., Gehrman, P. R., Xie, D., Sha, D., Weaver, T., & Gooneratne, N. (2010, May). Who gets the best sleep? Ethnic and socioeconomic factors related to sleep complaints. *Sleep Medicine, 11*(5), 470-478. https://doi.org/10.1016/j.sleep.2009.10.006

Haighton, C., Kidd, J., O'Donnell, A., Wilson, G., McCabe, K., & Ling, J. (2018). 'I take my tablets with the whiskey': A qualitative study of alcohol and medication use in mid to later life. *PLoS One, 13*(10), e0205956. https://doi.org/10.1371/journal.pone.0205956

He, L., Biddle, S. J. H., Lee, J. T., Duolikun, N., Zhang, L., Wang, Z., & Zhao, Y. (2021, 2021/06/10). The prevalence of multimorbidity and its association with physical activity and sleep duration in middle aged and elderly adults: a longitudinal analysis from China. *International Journal of Behavioral Nutrition and Physical Activity, 18*(1), 77. https://doi.org/10.1186/s12966-021-01150-7

Health Quality & Safety Commission New Zealand. (2021, 3 December 2021). *Polypharmacy in people aged 65 and over*. Health Quality & Safety Commission New Zealand. https://www.hqsc.govt.nz/our-data/atlas-of-healthcare-variation/polypharmacy-in-people-aged-65-and-over/

Hirshkowitz, M. (2022). Section Introduction: Polysomnography and Beyond. In *Principles and Practice of Sleep Medicine* (7th ed., pp. 1835-1838). Elsevier.

Hirshkowitz, M., Whiton, K., Albert, S. M., Alessi, C., Bruni, O., DonCarlos, L., Hazen, N., Herman, J., Katz, E. S., Kheirandish-Gozal, L., Neubauer, D. N., O'Donnell, A. E., Ohayon, M., Peever, J., Rawding, R., Sachdeva, R. C., Setters, B., Vitiello, M. V., Ware, J. C., & Adams Hillard, P. J. (2015, Mar). National Sleep Foundation's sleep time duration recommendations: methodology and results summary. *Sleep Health, 1*(1), 40-43. https://doi.org/https://doi.org/10.1016/j.sleh.2014.12.010

Hood, S., & Amir, S. (2017, Feb 1). The aging clock: circadian rhythms and later life. *The Journal of Clinical Investigation, 127*(2), 437-446. https://doi.org/10.1172/JCI90328

Ibáñez, V., Silva, J., & Cauli, O. (2018a). A survey on sleep assessment methods. *PeerJ, 6*, e4849-e4849. https://doi.org/10.7717/peerj.4849

Ibáñez, V., Silva, J., & Cauli, O. (2018b). A survey on sleep questionnaires and diaries. *Sleep Medicine, 42*(1878-5506 (Electronic)), 90-96.

Jaussent, I., Dauvilliers, Y., Ancelin, M. L., Dartigues, J. F., Tavernier, B., Touchon, J., Ritchie, K., & Besset, A. (2011). Insomnia symptoms in older adults: associated factors and gender differences. *The American Journal of Geriatric Psychiatry, 19*(1), 88-97. https://doi.org/10.1097/JGP.0b013e3181e049b6

Jeon, S., Conley, S., & Redeker, N. S. (2019). Discrepancy between wrist-actigraph and polysomnographic measures of sleep in patients with stable heart failure and a novel approach to evaluating discrepancy. *Journal of Sleep Research, 28*(2), e12717. https://doi.org/10.1111/jsr.12717

Johns, M. W. (2008). *Appendix I: The subjective measurement of excessive daytime sleepiness*. CRC Press.

Johnson, D. A., Jackson, C. L., Williams, N. J., & Alcántara, C. (2019). Are sleep patterns influenced by race/ethnicity–a marker of relative advantage or disadvantage? Evidence to date. *Nature and Science of Sleep, 11*, 79.

Kecklund, G., & Axelsson, J. (2016). Health consequences of shift work and insufficient sleep. *BMJ, 355*.

Kessler, R. C., Barker, P. R., Colpe, L. J., Epstein, J. F., Gfroerer, J. C., Hiripi, E., Howes, M. J., Normand, S.-L. T., Manderscheid, R. W., Walters, E. E., & Zaslavsky, A. M. (2003). Screening for Serious Mental Illness in the General Population. *Archives of General Psychiatry, 60*(2), 184-189. https://doi.org/10.1001/archpsyc.60.2.184

Khalsa, S. B. S., Jewett, M. E., Cajochen, C., & Czeisler, C. A. (2003). A phase response curve to single bright light pulses in human subjects. *The Journal of physiology, 549*(3), 945-952.

Kredlow, M. A., Capozzoli Mc Fau - Hearon, B. A., Hearon Ba Fau - Calkins, A. W., Calkins Aw Fau - Otto, M. W., & Otto, M. W. (2015). The effects of physical activity on sleep: a meta-analytic review. *Journal of Behavioral Medicine, 38*(1573-3521), 427-449.

LaCroix, A. Z., Lang, J., Scherr, P., Wallace, R. B., Cornoni-Huntley, J., Berkman, L., Curb, J. D., Evans, D., & Hennekens, C. H. (1991). Smoking and mortality among older men and women in three communities. *New England Journal of Medicine, 324*(23), 1619-1625.

Landry, G. J., Best, J. R., & Liu-Ambrose, T. (2015). Measuring sleep quality in older adults: a comparison using subjective and objective methods. *Frontiers in Aging Neuroscience, 7*, 166. https://doi.org/10.3389/fnagi.2015.00166

Lane, J. M., Chang, A. M., Bjonnes, A. C., Aeschbach, D., Anderson, C., Cade, B. E., Cain, S. W., Czeisler, C. A., Gharib, S. A., Gooley, J. J., Gottlieb, D. J., Grant, S. F., Klerman, E. B., Lauderdale, D. S., Lockley, S. W., Munch, M., Patel, S., Punjabi, N. M., Rajaratnam, S. M., Rueger, M., St Hilaire, M. A., Santhi, N., Scheuermaier, K., Van Reen, E., Zee, P. C., Shea, S. A., Duffy, J. F., Buxton, O. M., Redline, S., Scheer, F. A., & Saxena, R. (2016, Jun). Impact of Common Diabetes Risk Variant in MTNR1B on Sleep, Circadian, and Melatonin Physiology. *Diabetes, 65*(6), 1741-1751. https://doi.org/10.2337/db15-0999

Lee, C. H., & Sibley, C. G. (2019, Dec). Sleep duration and psychological well-being among New Zealanders. *Sleep Health, 5*(6), 606-614. https://doi.org/https://doi.org/10.1016/j.sleh.2019.06.008

Lee, Y.-H., Wu, Y.-H., Shelley, M., Arndt, S., & Chang, Y.-C. (2021, 2021/11/15). The Effects of Cigarette Smoking, Alcohol Consumption, and Use of Both Cigarettes and Alcohol on Chinese Older Adults' Sleep: Results from a Longitudinal Study *International Journal of Mental Health and Addiction*. https://doi.org/10.1007/s11469-021-00697-7

Li, J., Vitiello, M. V., & Gooneratne, N. S. (2018). Sleep in Normal Aging. *Sleep Medicine Clinics, 13*(1), 1-11. https://doi.org/10.1016/j.jsmc.2017.09.001

Locher, J., Ritchie, C., Roth, D., Sen, B., Vickers, K., & Vailas, L. I. (2009, 02/01). Food choice among homebound older adults: Motivations and perceived barriers. *The*

journal of nutrition, health & aging, 13, 659-664. https://doi.org/10.1007/s12603-009-0150-6

Logan, R. W., & McClung, C. A. (2019, Jan). Rhythms of life: circadian disruption and brain disorders across the lifespan. *Nature Reviews Neuroscience, 20*(1), 49-65. https://doi.org/10.1038/s41583-018-0088-y

Lydon-Staley, D. M., Ram, N., Brose, A., & Schmiedek, F. (2017). Reduced impact of alcohol use on next-day tiredness in older relative to younger adults: A role for sleep duration. *Psychology and Aging, 32*(7), 642-653. https://doi.org/10.1037/pag0000198

Madden, K. M., Ashe, M. C., Lockhart, C., & Chase, J. M. (2014, Jun). Sedentary behavior and sleep efficiency in active community-dwelling older adults. *Sleep Science, 7*(2), 82-88. https://doi.org/10.1016/j.slsci.2014.09.009

Matsumoto, T., & Chin, K. (2019, 2019/05/01/). Prevalence of sleep disturbances: Sleep disordered breathing, short sleep duration, and non-restorative sleep. *Respiratory Investigation, 57*(3), 227-237. https://doi.org/https://doi.org/10.1016/j.resinv.2019.01.008

Meaklim, H., Jackson, M. L., Bartlett, D., Saini, B., Falloon, K., Junge, M., Slater, J., Rehm, I. C., & Meltzer, L. J. (2020). Sleep education for healthcare providers: Addressing deficient sleep in Australia and New Zealand. *Sleep Health, 6*(5), 636-650.

Medic, G., Wille, M., & Hemels, M. E. (2017). Short- and long-term health consequences of sleep disruption. *Nature and Science of Sleep, 9*, 151-161. https://doi.org/10.2147/NSS.S134864

Meers, J., Stout-Aguilar, J., & Nowakowski, S. (2019). Sex differences in sleep health. *Sleep and Health* 21-29. https://doi.org/https://doi.org/10.1016/b978-0-12-815373-4.00003-4

Mihaere, K. M., Harris, R., Gander, P. H., Reid, P. M., Purdie, G., Robson, B., & Neill, A. (2009). Obstructive sleep apnea in New Zealand adults: prevalence and risk factors among Māori and non-Māori. *SLEEP, 32*(7), 949-956.

Miner, B., & Kryger, M. H. (2020). Sleep in the aging population. *Sleep Medicine Clinics, 15*(2), 311-318.

Ministry of Health. (2011). *The New Zealand Health Survey: Sample design, Years 1–3 (2011–2013)* (Ministry of Health, Ed.). Ministry of Health.

https://www.health.govt.nz/system/files/documents/publications/nzhs-design-5dec-2011.pdf

Ministry of Health. (2014a). *Content Guide 2013/14*. Ministry of Health. https://www.health.govt.nz/system/files/documents/publications/content-guide-2013-14-nzhs-dec14-v3.pdf

Ministry of Health. (2014b). *Indicator Interpretation Guide 2013/14*. Ministry of Health. https://www.moh.govt.nz/notebook/nbbooks.nsf/0/D43DFC51164D786BCC257DC6000D4A0A/$file/indicator-interpretation-guide-2013-14-nzhs-dec14.pdf

Ministry of Health. (2014c). *Methodology Report 2013/2014*. Ministry of Health,. https://www.moh.govt.nz/NoteBook/nbbooks.nsf/0/38A0B04E793F5F1ECC257DC60008B736/$file/methodology-report-2013-14-nzhs-dec14.pdf

Ministry of Health. (2014d). *Questionnaires and Content Guide 2013/14: New Zealand Health Survey*. Ministry of Health. Retrieved 10 February 2022 from https://www.health.govt.nz/publication/questionnaires-and-content-guide-2013-14-new-zealand-health-survey

Ministry of Health. (2017). *Content Guide 2016/17*. Ministry of Health. https://www.health.govt.nz/system/files/documents/publications/methodology-report-2016-17-nzhs-dec17v2.pdf

Ministry of Health. (2018). *Content Guide 2017/18*. Ministry of Health,. https://www.health.govt.nz/system/files/documents/publications/content-guide-2017-18-new-zealand-health-survey-nov18.pdf

Ministry of Health. (2019). *Content Guide 2018/2019*. Ministry of Health,. https://www.health.govt.nz/system/files/documents/publications/content-guide-2018-19-new-zealand-health-survey-nov19.pdf

Ministry of Health. (2020). *Longer, Healthier Lives: New Zealand's Health 1990-2017*. https://www.health.govt.nz/publication/longer-healthier-lives-new-zealands-health-1990-2017

Ministry of Health. (2021). *Annual Data Explorer 2020/21: New Zealand Health Survey (Changes over time: Tobacco Use - Current Smokers)*. Ministry of Health Retrieved June 2022 from https://minhealthnz.shinyapps.io/nz-health-survey-2020-21-annual-data-explorer

Montgomery, P., & Dennis, J. A. (2002). Bright light therapy for sleep problems in adults aged 60+. *Cochrane Database of Systematic Reviews*(2).

Moschny, A., Platen, P., Klaaßen-Mielke, R., Trampisch, U., & Hinrichs, T. (2011, 2011/11/02). Barriers to physical activity in older adults in Germany: a cross-sectional study. *International Journal of Behavioral Nutrition and Physical Activity, 8*(1), 121. https://doi.org/10.1186/1479-5868-8-121

Münch, M., Wirz-Justice, A., Brown, S. A., Kantermann, T., Martiny, K., Stefani, O., Vetter, C., Wright, K. P., Wulff, K., & Skene, D. J. (2020). The Role of Daylight for Humans: Gaps in Current Knowledge. *Clocks & Sleep, 2*(1), 61-85. https://doi.org/10.3390/clockssleep2010008

Myllyntausta, S., Gibson, R., Salo, P., Allen, J., Gander, P., Alpass, F., & Stephens, C. (2021). Daytime fatigue as a predictor for subsequent retirement among older New Zealand workers. *Sleep Health, 7*(6), 742-748.

Neikrug, A. B., & Ancoli-Israel, S. (2010). Sleep disorders in the older adult - a mini-review. *Gerontology, 56*(2), 181-189. https://doi.org/10.1159/000236900

Noorwali, E. A., Cade, J. E., Burley, V. J., & Hardie, L. J. (2018). The relationship between sleep duration and fruit/vegetable intakes in UK adults: a cross-sectional study from the National Diet and Nutrition Survey. *British Medical Journal Open, 8*(4), e020810. https://doi.org/10.1136/bmjopen-2017-020810

O'Donnell, D., Silva, E. J., Munch, M., Ronda, J. M., Wang, W., & Duffy, J. F. (2009, Jun). Comparison of subjective and objective assessments of sleep in healthy older subjects without sleep complaints. *Journal of Sleep Research, 18*(2), 254-263. https://doi.org/10.1111/j.1365-2869.2008.00719.x

OECD. *What are Equivalence Scales?* OECD Publishing. https://www.oecd.org/economy/growth/OECD-Note-EquivalenceScales.pdf

OECD. (2017). *Preventing Ageing Unequally*.

Ohayon, M. M. (2008, 2008/04/01/). From wakefulness to excessive sleepiness: What we know and still need to know. *Sleep Medicine Reviews, 12*(2), 129-141. https://doi.org/https://doi.org/10.1016/j.smrv.2008.01.001

Ohayon, M. M. (2011). Epidemiological overview of sleep disorders in the general population. *Sleep Medicine Reviews, 2*(1), 1-9.

Ohayon, M. M., Carskadon, M. A., Guilleminault, C., & Vitiello, M. V. . (2004). Meta-Analysis of Quantitative Sleep Parameters From Childhood to Old Age in Healthy Individuals: Developing Normative Sleep Values Across the Human Lifespan. *SLEEP, 27*(7), 1255-1273. https://doi.org/https://doi-org.ezproxy.massey.ac.nz/10.1093/sleep/27.7.1255

Paine, S. J., & Gander, P. H. (2016). Explaining ethnic inequities in sleep duration: a cross-sectional survey of Māori and non-Māori adults in New Zealand. *Sleep Health, 2*(2), 109-115. https://doi.org/https://doi.org/10.1016/j.sleh.2016.01.005

Paine, S. J., Gander, P. H., Harris, R., & Reid, P. (2004). Who reports insomnia? Relationships with age, sex, ethnicity, and socioeconomic deprivation. *SLEEP, 27*(6), 1163-1169. https://doi.org/https://doi.org/10.1093/sleep/27.6.1163

Paine, S. J., Gander, P. H., Harris, R. B., & Reid, P. (2005). Prevalence and consequences of insomnia in New Zealand: disparities between Māori and non-Māori. *Australian and New Zealand Journal of Public Health, 29*(1), 22-28. https://doi.org/https://doi.org/10.1111/j.1467-842X.2005.tb00743.x

Paine, S. J., Harris, R., Cormack, D., & Stanley, J. (2019). Self-reported sleep complaints are associated with adverse health outcomes: cross-sectional analysis of the 2002/03 New Zealand Health Survey. *Ethnicity & Health, 24*(1), 44-56. https://doi.org/https://doi.org/10.1080/13557858.2017.1315368

Partinen, M. (2017). Nutrition and Sleep. In S. Chokroverty (Ed.), *Sleep Disorders Medicine. Basic Science, Technical Considerations and Clinical Aspects* (4th edition ed., pp. 539-558). Springer. https://doi.org/10.1007/978-1-4939-6578-6

Patel, S., Hayes, A., Blackwell, T., Evans, D., Ancoli-Israel, S., Wing, Y., & Stone, K. (2014). The association between sleep patterns and obesity in older adults. *International Journal of Obesity, 38*(9), 1159-1164. https://doi.org/https://doi.org/10.1038/ijo.2014.13

Perry, B. (2018). *Household incomes in New Zealand: Trends in indicators of inequality and hardship 1982 to 2017*. https://www.msd.govt.nz/about-msd-and-our-work/publications-resources/monitoring/household-incomes/household-incomes-1982-2017.html

Phillips, B. A., & Danner, F. J. (1995). Cigarette smoking and sleep disturbance. *Archives of Internal Medicine, 155*(7), 734-737.

Rasinaho, M., Hirvensalo, M., Leinonen, R., Lintunen, T., & Rantanen, T. (2007). Motives for and barriers to physical activity among older adults with mobility limitations. *Journal of aging and physical activity, 15*(1), 90-102.

Reid, P., Paine, S.-J., Curtis, E., Jones, R., Anderson, A., Willing, E., & Harwood, M. (2017, October). Achieving health equity in Aotearoa: strengthening responsiveness to Māori in health research. *The New Zealand medical journal, 130*, 96-103.

Robbins, R., Quan, S. F., Barger, L. K., Czeisler, C. A., Fray-Witzer, M., Weaver, M. D., Zhang, Y., Redline, S., & Klerman, E. B. (2021, 2021/12/01/). Self-reported sleep duration and timing: A methodological review of event definitions, context, and timeframe of related questions. *Sleep Epidemiology, 1*, 100016. https://doi.org/https://doi.org/10.1016/j.sleepe.2021.100016

Rod, N. H., Kumari, M., Lange, T., Kivimaki, M., Shipley, M., & Ferrie, J. (2014). The joint effect of sleep duration and disturbed sleep on cause-specific mortality: results from the Whitehall II cohort study. *PLoS One, 9*(4), e91965. https://doi.org/10.1371/journal.pone.0091965

Roehrs, T., & Roth, T. (2001, Aug). Sleep, sleepiness, sleep disorders and alcohol use and abuse. *Sleep Medicine Reviews, 5*(4), 287-297. https://doi.org/10.1053/smrv.2001.0162

Rundo, J. V., & Downey III, R. (2019). Polysomnography. *Handbook of Clinical Neurology, 160*, 381-392.

SAS Institute Inc. (2014). *Enterprise Guide.* In (Version 8.2) SAS Institute Inc.,.

Schmidt, C., Collette, F., Cajochen, C., & Peigneux, P. (2007). A time to think: circadian rhythms in human cognition. *Cognitive neuropsychology, 24*(7), 755-789.

Seol, J. A.-O., Abe, T., Fujii, Y., Joho, K., & Okura, T. (2020). Effects of sedentary behavior and physical activity on sleep quality in older people: A cross-sectional study. *Nursing and Health Science,, 22*(1442-2018), 64-71.

Sharwood, L. N., Elkington, J., Stevenson, M., Grunstein, R. R., Meuleners, L., Ivers, R. Q., Haworth, N., Norton, R., & Wong, K. K. (2012). Assessing sleepiness and sleep disorders in Australian long-distance commercial vehicle drivers: self-report versus an “at home” monitoring device. *SLEEP, 35*(4), 469-475.

Sindi, S., Pérez, L. M., Vetrano, D. L., Triolo, F., Kåreholt, I., Sjöberg, L., Darin-Mattsson, A., Kivipelto, M., Inzitari, M., & Calderón-Larrañaga, A. (2020, 2020/12/07). Sleep disturbances and the speed of multimorbidity development in old age: results from a longitudinal population-based study. *BMC Medicine, 18*(1), 382. https://doi.org/https://doi.org/10.1186/s12916-020-01846-w

Skeldon, A. C., Derks, G., & Dijk, D. J. (2016, Aug). Modelling changes in sleep timing and duration across the lifespan: Changes in circadian rhythmicity or sleep homeostasis? *Sleep Medicine Reviews, 28*, 96-107. https://doi.org/10.1016/j.smrv.2015.05.011

Sleep Foundation. (2022). *Stages of Sleep*. OneCare Media. https://www.sleepfoundation.org/stages-of-sleep#:~:text=Stage%202%20sleep%20can%20last,sleep%20time%20in%20N2%20sleep.

Stats NZ. (2019). *Measuring child poverty: Equivalence scale*. Statistics New Zealand,. https://www.stats.govt.nz/methods/measuring-child-poverty-equivalence-scale#:~:text=The%20modified%20OECD%20scale%20does,and%200.3%20to%20each%20child.

Stats NZ. (2020). *National population projections: 2020(base)-2073*. Stats NZ. https://www.stats.govt.nz/information-releases/national-population-projections-2020base2073#fig1-right

Stephens, C., Alpass, F., Baars, M., Towers, A., & Stevenson, B. (2013). SF-36v2 norms for New Zealanders aged 55-69 years. *The New Zealand medical journal, 123*(1175-8716 (Electronic)), 45-57.

Stephens, C., Szabó, Á., & Breheny, M. (2020). Social inequalities over the lifecourse and healthy ageing in Aotearoa/New Zealand: Differences by Māori ethnicity and gender. *Ageing & Society*, 1-20. https://doi.org/https://doi.org/10.1017/s0144686x20001130

Stewart, E. M., Landry, S., Edwards, B. A., & Drummond, S. P. (2020). The bidirectional relationship between sleep and health. *The Wiley encyclopedia of health psychology*, 165-188.

Stone, K. L., & Li, V. (2022). Actigraphy Methods and Technical Issues. In *Principles and Practice of Sleep Medicine,* (7th ed., pp. 1984-1991). Elsevier.

Suzuki, K., Miyamoto, M., & Hirata, K. (2017, April). Sleep disorders in the elderly: Diagnosis and management. *Journal General and Family Medicine, 18*(2), 61-71. https://doi.org/10.1002/jgf2.27

Szabó, Á., Hyde, M., & Towers, A. (2021, 2021/08/01). One slope does not fit all: longitudinal trajectories of quality of life in older adulthood. *Quality of Life Research, 30*(8), 2161-2170. https://doi.org/10.1007/s11136-021-02827-z

Szabó, Á., Towers, A., Newcombe, D., & Sheridan, J. (2021). Alcohol use trajectories across the life course: Influences of childhood predictors and consequences for late-life health. *Drug and Alcohol Dependence, 224*, 108713. https://doi.org/https://doi.org/10.1016/j.drugalcdep.2021.108713

Szabo, A., Towers, A., Sheridan, J., & Newcombe, D. (2019). Ten-year Trajectories of Alcohol Consumption in Older Adult New Zealanders. *Journal of Gerontology Psychological Science*. https://doi.org/10.1093/geronb/gbz143

Taillard, J., Gronfier, C., Bioulac, S., Philip, P., & Sagaspe, P. (2021). Sleep in Normal Aging, Homeostatic and Circadian Regulation and Vulnerability to Sleep Deprivation. *Brain sciences, 11*(8), 1003. https://doi.org/10.3390/brainsci11081003

Tkatch, M. T., Towers, A. J., Keller, H. H., & Wham, C. A. (2022). Nutrition risk prevalence and associated health and social risk factors in Māori and non-Māori: Results from the New Zealand Health, Work and Retirement Study. *Australasian journal on ageing, 41*(1), 59-69.

Towers, A., Philipp, M., Dulin, P., & Allen, J. (2018). The “health benefits” of moderate drinking in older adults may be better explained by socioeconomic status. *The Journals of Gerontology: Series B, 73*(4), 649-654.

Towers, A., Sheridan, J., Newcombe, D., & Szabo, A. (2018a). *Longitudinal patterns of alcohol use in older New Zealanders*. Health Promotion Agency.

Towers, A., Sheridan, J., Newcombe, D., & Szabo, A. (2018b). *New Zealander's alcohol consumption across the lifespan*. Health Promotion Agency.

Towers, A., Stephens, C., Dulin, P., Kostick, M., Noone, J., & Alpass, F. (2011, Sep 1). Estimating older hazardous and binge drinking prevalence using AUDIT-C and AUDIT-3 thresholds specific to older adults. *Drug and Alcohol Dependence, 117*(2-3), 211-218. https://doi.org/10.1016/j.drugalcdep.2011.02.008

United Nations Department of Economic and Social Affairs Population Division. (2017). *World Population Ageing 2017 - Highlights* https://www.un.org/en/development/desa/population/publications/pdf/ageing/WPA2017_Highlights.pdf

van den Berg, J. F., Miedema, H. M. E., Tulen J. H. M., Hofman, A., Knuistingh Neven, A., Tiemeier, H. (2009). Sex Differences in Subjective and Actigraphic Sleep Measures A Population-Based Study of Elderly Persons. *SLEEP, 32*(10), 1367-1375. https://doi.org/https://doi.org/10.1093/sleep/32.10.1367

van den Berg, J. F., Van Rooij, F. J., Vos, H., Tulen, J. H., Hofman, A., Miedema, H. M., Neven, A. K., & Tiemeier, H. (2008). Disagreement between subjective and actigraphic measures of sleep duration in a population-based study of elderly persons. *Journal of Sleep Research, 17*(3), 295-302.

Van Reen, E., Jenni, O. G., & Carskadon, M. A. (2006, Jun). Effects of alcohol on sleep and the sleep electroencephalogram in healthy young women. *Alcoholism: Clinical and Experimental Research, 30*(6), 974-981. https://doi.org/10.1111/j.1530-0277.2006.00111.x

Van Someren, E. J. (2000, May). Circadian rhythms and sleep in human aging. *Chronobiology international, 17*(3), 233-243. https://doi.org/10.1081/cbi-100101046

Vanderlinden, J., Boen, F., & van Uffelen, J. G. Z. (2020, 2020/02/05). Effects of physical activity programs on sleep outcomes in older adults: a systematic review. *International Journal of Behavioral Nutrition and Physical Activity, 17*(1), 11. https://doi.org/10.1186/s12966-020-0913-3

Vitiello, M. V. (1997). Sleep, alcohol and alcohol abuse. *Addiction Biology, 2*(2), 151-158. https://doi.org/10.1080/13556219772697

Vollset, S. E., Goren, E., Yuan, C.-W., Cao, J., Smith, A. E., Hsiao, T., Bisignano, C., Azhar, G. S., Castro, E., Chalek, J., Dolgart, A. J., Frank, T., Fukutaki, K., Hay, S. I., Lozano, R., Mokdad, A. H., Nandakumar, V., Pierce, M., Pletcher, M., Robalik, T., Steuben, K. M., Wunrow, H. Y., Zlavog, B. S., & Murray, C. J. L. (2020). Fertility, mortality, migration, and population scenarios for 195 countries and territories from 2017 to 2100: a forecasting analysis for the Global Burden of Disease Study. *The Lancet*. https://doi.org/10.1016/S0140-6736(20)30677-2.

Wallis, K. (2015, 06/30). Ageing is not for the faint-hearted: Are we making it worse? Polypharmacy-related harm in the elderly. *Journal of Primary Health Care,, 7*, 167-169.

Walters, S. J., Munro, J. F., & Brazier, J. E. (2001). Using the SF-36 with older adults: a cross-sectional community-based survey. *Age and ageing, 30*(4), 337-343.

Wham, C., McLean, C., Teh, R., Moyes, S., Peri, K., & Kerse, N. (2014). The BRIGHT trial: what are the factors associated with nutrition risk? *The journal of nutrition, health & aging, 18*(7), 692-697.

Wham, C., Teh, R., Moyes, S., Dyall, L., Kepa, M., Hayman, K., & Kerse, N. (2015). Health and social factors associated with nutrition risk: results from life and living in advanced age: a cohort study in New Zealand (LiLACS NZ). *The journal of nutrition, health & aging, 19*(6), 637-645. https://doi.org/https://doi.org/10.1007/s12603-015-0514-z

Wheaton, A. G., Perry, G. S., Chapman, D. P., McKnight-Eily, L. R., Presley-Cantrell L. R., & Croft, J. B. (2011). Relationship between body mass index and perceived insufficient sleep among US adults: an analysis of 2008 BRFSS data. *BMC Public Health, 11*. http://www.biomedcentral.com/1471-2458/11/295

Wilsmore, B. R., Grunstein, R. R., Fransen, M., Woodward, M., Norton, R., & Ameratunga, S. (2013). Sleep habits, insomnia, and daytime sleepiness in a large and healthy community-based sample of New Zealanders. *Journal of Clinical Sleep Medicine, 9*(6), 559-566.

World Health Organisation. (2011). *Global Health and Ageing*. https://www.who.int/ageing/publications/global_health.pdf

World Health Organisation. (2021). *Ageing and Health*. World Health Organisation, . https://www.who.int/news-room/fact-sheets/detail/ageing-and-health#:~:text=At%20this%20time%20the%20share,2050%20to%20reach%20426%20million.

Yang, P.-Y., Ho, K.-H., Chen, H.-C., & Chien, M.-Y. (2012, 2012/09/01/). Exercise training improves sleep quality in middle-aged and older adults with sleep problems: a systematic review. *Journal of Physiotherapy, 58*(3), 157-163. https://doi.org/https://doi.org/10.1016/S1836-9553(12)70106-6

Yang, Y., Shin, J. C., Li, D., & An, R. (2017). Sedentary Behavior and Sleep Problems: a Systematic Review and Meta-Analysis. *International Journal of Behavioral Medicine,*(1532-7558).

Appendix 1: Table Sleep Problem Prevalence Studies in NZ

The following table reflects a summary of studies investigating the prevalence of insomnia, obstructive sleep apnoea, short and long sleep, and daytime sleepiness among NZ adults. Please note: Prevalence of restless legs, periodic limb movement and REM sleep behaviour disorders were not found to have been conducted among the general adult or older adult NZ population. As a consequence, these are absent from the above table.

Author (s)	Sample Size (n)	Age Range	Study Summary	Criteria/Assessment	Prevalence Estimates
Insomnia and problems with sleep					
Paine et al. (2005)	2,603	20-59	A random sample of 4,000 adults (20–59 years) was selected from the NZ electoral roll in June 2001. Each participant was asked to complete a survey, which was designed to assess the prevalence of symptoms of insomnia and daytime.	**Insomnia symptoms** • Difficulty falling asleep (often/always) • Frequent nocturnal awakenings (≥ 3 times) • Difficulty falling back to sleep after waking in the night (often/always) • Waking too early in the morning (often/always) • Waking feeling refreshed (never/rarely) • Sleep problem present • Chronic Sleep problem (e.g., lasting six months or more) **Daytime sleepiness** • Epworth Sleepiness Scale (ESS) >10;	**Total population prevalence of insomnia symptoms** • Difficulty falling asleep: 29.6% • Frequent nocturnal awakenings: 21.8% • Difficulty falling back to sleep after waking in the night: 49.2% • Waking too early in the morning: 39.3% • Never or rarely waking feeling refreshed: 54.5% • Current sleeping problem: 27.2% • Sleep problem (chronic) : 25.1% • Daytime Sleepiness : 14.8%
Paine et al.(2004)	"	"	As above	As above, however, daytime sleepiness was not reported.	**Weighted population prevalence estimates for insomnia symptoms, for Māori and Non-Māori** • **Difficulty falling asleep**: Māori (36.5%), Non-Māori (28.7%) • **Frequent nocturnal awakenings**: Māori (28.4%), Non-Māori (20.8%) • **Difficulty falling back to sleep after waking in the night**: Māori (53.0%); Non-Māori (48.6%) • **Waking too early in the morning**: Māori (48.8%), Non-Māori (38.0%) • **Never or rarely waking feeling refreshed**: Māori (59.1 %), Non-Māori (53.8%) • **Current sleeping problem:** Māori (33.0 %), Non-Māori (26.4&) • **Sleep problem (chronic):** Māori (28.6 %), Non-Māori (24.6%)

Author (s)	Sample Size (n)	Age Range	Study Summary	Criteria/Assessment	Prevalence Estimates
Paine et al. (2019)	12,500	Adults, ≥15 years	**2002/2003 NZHS** The 2002/03 NZHS data was used to investigate the prevalence of sleep complaints in NZ adults by ethnicity.	**Sleep items** • "During the past 4 weeks, how much of the time did you have a problem: (1) falling asleep (i.e., *difficulty falling asleep*); (2) waking up frequently during the night (i.e., *frequent nocturnal awakenings*), and; (3) waking up too early (i.e., *early morning awakenings*)? Where participants responded 'all' or 'most' of the time was a positive indication of the presence of a sleep complaint. **Derived variables** • Any complaints with sleep • The number of sleep complaints reported.	**Prevalence estimates were reported according to self-reported ethnicity** • **Difficulty falling asleep:** Māori (10.4%), Pacific (5.6%), Asian (5.6%), Other (4.6%) European (7.0%) • **Nocturnal awakenings**: Māori (12.7%), Pacific (7.9%), Asian (6.9%), Other (6.0%) European (10.4%) • **Early morning awakenings**: Māori (14.8%), Pacific (9.9%), Asian (4.9%), Other (9.9%) European (9.1%) • **Any sleep complaint:** Māori (23.6%), Pacific (15.3%), Asian (10.4%), Other (17.4%) European (16.9%) • **One sleep complaint present**: Māori (13.4%). Pacific (8.9%), Asian (5.4%) Other (14.2%) European (9.8%) • **Two or more sleep complaints present**: Māori (10.3%), Pacific (5.4%), Asian (5.0%), Other (3.2%) European (7.1%)

Wilsmore et al. (2013)
 	
**Derived from sample size reported as*
'96% of 22,389'
	21,493*	16-84	**NZ Blood Donors Health Study**
			The study opportunistically recruited participants, from fixed and mobile blood donation collection points situated in the Northland, Auckland, Waikato and Bay of Plenty regions between April and October 1998. This cohort study assessed the prevalence of sleep problems in a community-based setting and is not generalisable to the population.
			The height, weight, and neck circumference were recorded. A survey was administered to study participants to capture the occurrence of snoring, sleep apnoea, sleep complaints (satisfaction, quantity, and insomnia), and alcohol consumption, among other factors. Overall 96% of the possible sample completed the survey.
			Of the sample, 60% were younger than 40 years of age and 81% of the sample self-reported as being of European descent.
			Insomnia was classified according to the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV)10 and the International Classification of Sleep Disorders (ICSD)
				Primary insomnia
				Identified according to the following criteria
				(i) Report having experienced any of the following ≥ 4 times per month
				• Difficulty initiating asleep,
				• Difficulty maintaining sleep (e.g., frequent nocturnal awakenings),
				• Early morning awakenings with difficulty falling back to sleep, or
				• Waking feeling unrefreshed after adequate opportunity for sleep
				and (ii)
				• Feeling dissatisfied with sleep quantity, or
				• Using medication to encourage or aid sleep
				Daytime sleepiness
				• Daytime sleepiness: Epworth Sleepiness Scale (ESS) >10;
				Sleep Quantity
				• Measured as the number of nights participants reported having 7–8 hours of sleep a night.
					Prevalence of sleep problems
					• Less than 7-8 hours of sleep: 34.0%
					• Insomnia present: 20.0%
					• Daytime sleepiness 8.80%
					• Snoring present: 33.0%
					• Sleep apnoea presented: 6.0%
					• Dissatisfied sleep quantity: 60.0%
					Sleep Quantity
					• Only 4.0% slept less than 1 full night of sleep; 74.0% of participants reported having 1–6 full nights of sleep. The remaining 22.0% had 6+ full nights of sleep.
					Insomnia
					• 93% of respondents experienced at least four symptoms of insomnia once or more a month, and 45% of respondents experienced one or more symptoms multiple times a week.
					• 20% (4,511) of the 21,493 respondents were classified as having insomnia. Symptom prevalences for this cohort were:
					  ○ Difficulty initiating sleep: 44.0%
					  ○ Difficulty maintaining sleep: 36.0%
					  ○ Early morning awakenings: 34%
					  ○ Difficulty resuming sleep: 34.0%.
					  ○ One symptom only: 52.0%
					  ○ Two symptoms only: 27.0%
					  ○ Three or four symptoms: 21.0%
					  ○ One symptoms half of the month: 27.0%

Author (s)	Sample Size (n)	Age Range	Study Summary	Criteria/Assessment	Prevalence Estimates
Gibson et al. (2016)	649	79-90	**Puāwaitanga o Ngā Tapuwae Kia Ora Tonu. Life and Living in Advanced Age: A Cohort Study in NZ (LiLACS NZ)** The LiLACS NZ study explores factors that contribute to successful ageing among NZ older adults. Eligible participants (Māori born January 1920-December 1930 and non-Māori born in 1925) were identified by the NZ electoral roll, primary care databases, iwi networks, local publicity and word-of-mouth. Information was collected through a face-to-face survey conducted in the participant's home with a trained interviewer. Inception surveys (W1) were completed with 937 older adults (aged 79–90 years) who were living in the Bay of Plenty and Lakes District Health Board areas in 2010, and comprised of: • 421 Māori (aged 79–90 years) and • 516 non-Māori (aged 84–86 years). The study sample consisted of 649 respondents • 251 Māori aged 79–90 years (153 women, 98 males) • 398 non-Māori aged 84–86 years (211 women, 187 males)	**Current sleeping problem** • "Do you have trouble with your sleeping (on at least 3 nights per week) such that it interferes with your activities the following day (e.g., unrefreshed in the morning, fatigue, poor concentration, or irritability)?" (yes/no). Those who reported a current sleeping problem were asked to indicate which of the following symptoms they experienced: • Waking up in the early hours of the morning; • Taking a long time to get to sleep; • Lying awake for most of the night; • Getting up at night to go to the toilet; • Worry keeping you awake at night; • Snoring; • Sleepwalking/ sleep talking; or • Other problems. ('other' problems reported included aches, pains, symptoms of restless legs, sleep-disordered breathing, hallucinations, medication, and care duties) **History of problem sleep** • "How much trouble did you have with sleeping when you were young?" (where "a little", "some", or "a lot" was an affirmative response).	**The prevalence estimates of current sleep problems among those of advanced age** • Māori 26.3% • Non-Māori 31.7% (χ^2 =2.13, p=0.145). • Women 33.0% • Men 25.3% (χ^2 =4.55, p=0.033). **Prevalence of past sleep problems among those of advanced age** • Māori 5.2% • Non-Māori 6.8% **Additional findings reported** • Those with a current problem reported at least one symptom of insomnia (e.g., waking up too early, taking a long time to get to sleep, and/or lying awake for most of the night). Symptoms of snoring or other sleeping problems were reported by 10–30% of respondents with a current sleep problem. • The presence of a past sleeping problem was a significant predictor of a current problem. • Both Māori and non-Māori problem sleepers reported a median of three sleep symptoms.

Author (s)	Sample Size (n)	Age Range	Study Summary	Criteria/Assessment	Prevalence Estimates
Gibson et al. (2020)	649 (W1) 285 (W5)	79-90	**Puāwaitanga o Ngā Tapuwae Kia Ora Tonu. Life and Living in Advanced Age: A Cohort Study in NZ (LiLACS NZ)** The LiLACS NZ inception survey (W1) was completed by 937 older adults, of whom 649 responded to sleep items. See Gibson et al. (2016) above. Four years later (W5), data of 285 participants (from the initial 649) was analysed. The study sample consisted of: • 85 Māori aged 79–90 years (153 women, 98 males) • 200 non-Māori aged 84–86 years (211 women, 187 males)	As above	**Prevalence of current sleep problems among for W1 and W5** • Māori (W1) - Sleep Problem 26.3% (251) • Māori (W5) - Sleep Problem 29.4% (85) • Non-Māori (W1) - Sleep Problem 31.7% (398) • Non-Māori (W5) - Sleep Problem 26.5% (200) **Prevalence of three or more symptoms of problem sleep** • Māori 8.0%i • Non-Māori 9.4% **Prevalence of Insomnia** Across both ethnic groups, 79.5% reported at least one symptom of insomnia (waking too early, taking a long time to get to sleep, and/ or lying awake most of the night). **Additional Findings** • Pain was the most common 'other sleep problem' (56%). The remaining 'other' sleep problems included noise, heat, unexplained wakefulness, and personal care needs. • The severity and type of reported symptoms changed between W1 and W5. At W1, problem sleepers identified an average of 3 symptoms, which reduced to 1 at W5. • Those who reported a sleep problem at W1 were more likely to report having a sleep problem four years on.

Author (s)	Sample Size (n)	Age Range	Study Summary	Criteria/Assessment	Prevalence Estimates
Obstructive Sleep Apnoea					
Mihaere et al. (2009)	6,928	30-59	**National Survey Study (Part I)** Mail-out survey to a stratified random sample from the electoral roll of 10,000 people aged 30-59 years old. There were 7,048 surveys returned once deceased respondents and those no longer residents in NZ were removed. After exclusions were applied 6,928 questionnaires were included in the analyses: • 1,463 Māori men (21%), • 1,732 Māori women (25%), • 1,714 non-Māori men (25%), and • 2,019 non-Māori women (29%)	**Obstructive Sleep Apnoea Symptoms** • How often participants had: ○ Enough sleep (never/rarely), ○ Woke refreshed (never/rarely), and ○ Snore (always) • Daytime sleepiness: Epworth Sleepiness Scale (ESS) >10; • A witness apnoea: Participants that reported they have been told that they stop breathing sometimes during sleep	**Estimated Population Prevalence of OSAS Symptoms** **Māori Men** • Witnessed apnoea: 30.3% • Always snore: 16.2% • Never or rarely wake refreshed: 46.6% • Never or rarely getting enough sleep: 39.8% • ESS > 10: 24.6% **Māori Women** • Witnessed apnoea: 11.5% • Always snore: 6.9% • Never or rarely wake refreshed: 47.9% • Never or rarely getting enough sleep: 38.2% • ESS > 10: 22.2% **Non-Māori Men** • Witnessed apnoea: 18.3% • Always snore: 10.1% • Never or rarely wake refreshed: 47.3% • Never or rarely getting enough sleep: 37.8% • ESS > 10: 15.6% **Non-Māori Women** • Witnessed apnoea: 6.2% • Always snore: 4.1% • Never or rarely wake refreshed: 44.8% • Never or rarely getting enough sleep: 36.3% • ESS > 10: 12.1%
Mihaere et al. (2009)	358	30-59	**Regional Sleep Study (Part II)** A sample of 1,200 people was selected from the Wellington electoral roll. Study packs were sent to all 1,200 people randomly selected, which included a letter and information sheet and consent form. Participants were asked to complete the same survey questionnaire conducted as part of the National Study (Part I) Successful telephone contact was made with 786 people of the 1,200 selected. Of those reached: • 364 persons (Māori = 169, non-Māori = 195) agreed to an unattended overnight home monitoring. • 341 (Māori = 137, non-Māori = 204) participants declined overnight monitoring but agreed to complete the study questionnaire over the phone. • 81 contacts declined all participation.	**Obstructive Sleep Apnoea Symptoms** *Definitions as per those for the National Study (Part 1)* • Witnessed apnoea: • Always snore: • Never or rarely wake refreshed • ESS > 10: **Objective measurement criteria for obstructive sleep apnoea included:** • Respiratory disturbance index (RDI), • 4% oxygen desaturations per hour of sleep, and • Bursts of snoring or ≥ 10/min increase in heart rate. Prevalence estimates were reported for Māori and Non-Māori men and women by: • RDI ≥ 5. • RDI ≥ 10,	**Regional Study Prevalence of OSAS Symptoms** *Survey* **Māori Men** • Witnessed apnoea: 24.8% • Always snore: 17.0% • Never or rarely wake refreshed: 45.1% • ESS > 10: 11.9% **Māori Women** • Witnessed apnoea: 5.8% • Always snore: 6.9% • Never or rarely wake refreshed: 42.1% • ESS > 10: 11.8% **Non-Māori Men** • Witnessed apnoea: 16.0% • Always snore: 12.7% • Never or rarely wake refreshed: 42.1%

Author (s)	Sample Size (n)	Age Range	Study Summary	Criteria/Assessment	Prevalence Estimates
			Overnight monitoring was conducted by fitting an ambulatory monitoring device which captured snoring, heart rate, arterial oxygen saturation and body position. Participants were also asked to record their height, weight and neck circumference. Of those who agreed to participate in the overnight monitoring study, the results of six participants were excluded as insufficient monitoring data was collected.	• RDI ≥ 15, • RDI ≥ 5 plus ESS, • RDI ≥ 10 plus ESS, • RDI ≥ 15 plus ESS	• ESS > 10: 17.7% **Non-Māori Women** • Witnessed apnoea: 3.4% • Always snore: 1.9% • Never or rarely wake refreshed: 43.1% • ESS > 10: 11.0% *Objective Measurement* **Estimate Prevalence of OSA (RDI≥ 5)** • Māori men 22.0% • Non-Māori men 11.4% • Māori women 6.3% • Non-Māori women 3.0% **Estimate Prevalence of OSA (RDI≥ 5 + ESS>10)** • Māori Men 4.4% • Non-Māori Men 4.1% • Māori Women, 2.0% • Non-Māori women 0.7% **Estimate Prevalence of OSA (RDI ≥ 15 and ESS > 10)** • Māori 1.3% • Non-Māori (0.0%) **Māori were significantly more likely than non-Māori to have:** • RDI ≥ 10 (10.9% vs. 3.3%, P = 0.02) and • RDI ≥ 15 (6.5% vs. 1.5%, P = 0.03). **Men were more likely than women to have:** • RDI ≥ 5 (12.5% vs. 3.4%, P = 0.01), and • RDI ≥ 10 (7.0% vs. 1.4%, P = 0.03), and • RDI ≥ 15 (3.9% vs. 0.2%, P = 0.01)

Author (s)	Sample Size (n)	Age Range	Study Summary	Criteria/Assessment	Prevalence Estimates
Short and Long Sleep					
Paine et al. (2016)	4,330	20-59	**NZ Sleep Timing Study.** A nationwide survey study was conducted among 9,100 adults (5,100 Māori and 4,000 non-Māori) randomly sampled from the NZ Electoral Roll. Data were collected between October 2008 and March 2009. Each participant in the sample received a study package which included a questionnaire and an envelope to return the survey.	**Sleep duration** • "How many hours of sleep do you usually get in 24 hours (counting all naps and sleeps)?" Responses were recorded separately for where sleep occurred on days with work, study or other regular commitments that determined their routine (scheduled days) and free days. **Derived variables** • Short sleep: (< 7 hours sleep) • Long sleep: (≥ 9 hours sleep). • Insufficient sleep: Extension of sleep by ≥2 hours on free days compared with scheduled days (i.*e., indicates where free days are used to catch up on lost sleep on scheduled days*).	**Sleep Duration Estimates for Māori** • Insufficient Sleep : 29.6% • Short Sleep - Scheduled Days : 28.6% • Short Sleep - Free Days : 13.4% • Long Sleep - Scheduled Days : 15.9% • Long Sleep - Free Days : 41.6% **Sleep Duration Estimates for Non Māori** • Insufficient Sleep : 23.% • Short Sleep - Scheduled Days : 22.1% • Short Sleep - Free Days : 10.4% • Long Sleep - Scheduled Days : 11.5% (• Long Sleep - Free Days: 38.7%
Lee & Sibley (2019)	51,699	Adults ≥18 years	**NZ Attitudes Values Study** A longitudinal panel study dedicated to investigating social attitudes, personality and health outcomes in NZ. The study aims to track social psychological and health factors between 2009-2029. The information of participants included in this study was retained from one or more previous waves of the study. Those initially recruited into the survey were randomly selected from the NZ Electoral Roll (2009) with additional booster samples recruited in 2011, 2012 and 2014. Of relevance to this study, responses from three consecutive surveys [2014 (15,820), 2015 (13,942) and 2016 (21,937)] were analysed. Participants were classified as younger, middle-aged or older according to whether they were between the ages of 18-40, 41-64 or 65 years old, respectively. Ethnicity and sex were self-reported by participants.	**Sleep duration** • "During the past month, on average, how many hours of actual sleep did you get per night? **Derived variables** Responses to the above survey item were categorised as either: • Short sleep: (<7 hours) • Optimal sleep (7 – 9 hours) • Long sleep: (≥9 hours).	**Prevalence of short, long and optimal sleep** The mean sleep duration between 2014-2016 when calculated including all participants was between 6.85 and 6.88 hours (e.g., 6 hours and 51–53 minutes). • Prevalence of short sleep 37.0% • Prevalence of long sleep 4.5% • Prevalence of optimal sleep 58.0% **Additional findings** • For older adults were more likely to report short sleep (37.0% – 38.2%) compared to middle aged (38.3% – 39.0%) and younger (33.8% – 35.0%) aged individuals. • Older adults were also more likely to report long sleep (5.9% – 7.3%) compared to those who were middle-aged (3.9% – 4.0%) or younger (5.0% – 6.5%). • Europeans reported the highest prevalence of optimal sleep (60.5%-61.1%), compared to all other ethnicities. Māori (46.4% – 48.0%) and Pacific (49.6% – 53.9%) were more likely to report short sleep durations/ • The distribution of participants across the sleep duration groups was very similar to that seen in the total sample for both males and females.

Author (s)	Sample Size (n)	Age Range	Study Summary	Criteria/Assessment	Prevalence Estimates
Day-time sleepiness					
Myllyntausta, et al. (2021)	1,140	55 – 70	**NZ Health Work and Retirement Longitudinal Study** This is a population-based longitudinal study of people 55 years and older designed to investigate factors that influence health in later life (e.g., health, well-being, retirement, housing, workforce participation, social isolation, hardship, alcohol use, views, attitudes, norms, etc.) Participants were initially selected from the NZ Electoral Roll. The study involves a biennial survey, although information is collective via five other modes including data linkages, interviews and screenings. The information from two consecutive surveys (2008 and 2010) was used. Participants that answered questions relating to dissatisfaction with sleep and fatigue presented in the 2008 study and subsequently participated in the 2010 study were retained for analysis. Three-quarters of those who participated in the study were between 55 and 64 years old Sample characteristics: • Male (560) 49.0% • Female (580) 51.0% • Māori (430) 38.0% • Non-Māori (710) 62.0%	*SF-36 Health Survey Questions:* **Feeling tired** • "How much of the time during the past four weeks did you feel tired?" **Feeling worn out** • How much of the time during the past four weeks did you feel worn out?" Responses were coded as 'yes' where participants indicated feeling tired or worn out 'some', ' a good bit', 'most' or 'all' of the time. *World Health Organisation Quality of Life* Survey *(Brief Version)* **Dissatisfaction with sleep** • "How satisfied are you with your sleep?" Responses were coded as 'they indicated feeling 'dissatisfied' or 'very dissatisfied with their sleep.	**Prevalence of daytime fatigue symptoms** **Feeling tired** • No 543 (48.0%) • Yes 573 (50.0%) **Feeling worn out** • No 726 (64.0%) • Yes 387 (34.0%) **Dissatisfaction with sleep** • Not dissatisfied 906 (79.0%) • Dissatisfied 207 (18.0%) Among those that were classified as feeling tired or worn out, over half (57%) reported feeling both tired and worn out. Approximately one-quarter (27%) of participants that reported feeling tired were dissatisfied with their sleep. Whereas one-third (31%) of those that indicated feeling worn out, were dissatisfied with their sleep.

Appendix 2: Ethics Approval

Figure 7

Profiles of Sleep Disturbances with Ageing Ethics Approval Notification (NOR 20/73).

Date: 18 January 2021

Dear Dr Rosie Gibson

Re: Ethics Notification - **NOR 20/73 - Profiles of Sleep Disturbances with Ageing**

Thank you for the above application that was considered by the Massey University Human Ethics Committee: **Human Ethics Northern Committee** at their meeting held on **Monday, 18 January, 2021**.
On behalf of the Committee I am pleased to advise you that the ethics of your application are approved.

Approval is for three years. If this project has not been completed within three years from the date of this letter, reapproval must be requested.

If the nature, content, location, procedures or personnel of your approved application change, please advise the Secretary of the Committee.

Yours sincerely

Professor Craig Johnson
Chair, Human Ethics Chairs' Committee and Director (Research Ethics)

Research Ethics Office, Research and Enterprise
Massey University, Private Bag 11 222, Palmerston North, 4442, New Zealand **T** 06 350 5573; 06 350 5575 **F** 06 355 7973
E humanethics@massey.ac.nz **W** http://humanethics.massey.ac.nz

Appendix 3: Confidential Unit Record File Application Approval

Figure 8

Profiles of Sleep Disturbances with Ageing CURF 2020-29 Approval Letter.

Approval Status of CURF2020-29 Profiles of Sleep Disturbances with Ageing

Microdata <access2microdata@stats.govt.nz>

Wed 16/12/2020 8:26 AM

To: Gibson, Rosemary <R.Gibson@massey.ac.nz>

Dear Rosemary Gibson,

This is an update on the status of your application CURF2020-29, Profiles of Sleep Disturbances with Ageing.
We are pleased to inform you that your application has been approved by Microdata Access Manager.

We will contact you shortly to arrange a license and prepare CURF files for your project.

Ngā Mihi Nui,
Karina Romero
Microdata Access Coordinator
Statistics NZ