Sleep/Wake Patterns and Sleep Problems in South Australian Children Aged 5-10 Years: Biopsychosocial Determinants and Effects on Behaviour

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABSTRACT

In 1913, Lewis Terman and his colleague, Adeline Hocking published a paper asking a seemingly simple question “But exactly how much sleep is required by this developing organism *(child)* for its healthy functioning and growth?” (Bracketed italics added). Almost 100 years later, this question remains largely unanswered. Whilst it is well acknowledged that sleep duration decreases as a child ages, changing sleep practices are determined not only by biological processes, but also by cultural and social influences. Few studies to date have adequately addressed this. It is also well acknowledged that sleep problems in childhood are common, yet research is limited due to lack of standard methodological protocols. Accurate knowledge of poor sleep/wake habits and prevalence of sleep problems may be vital to ensuring the behavioural well-being of many children.

The following thesis presents the results of the South Australian Paediatric Sleep Survey (SAPSS); a study designed to address the above limitations and examine sleep/wake patterns, sleep problems and behavioural associates in a large community sample of school-aged children in Australia. Using a combination of previous tools and author devised items, a sleep, health and behaviour questionnaire was developed and subjected to rigourous psychometric testing. Exploratory factor analysis revealed six robust factors: Sleep Routine, Bedtime Anxiety, Morning Tiredness, Night Arousals, Sleep Disordered Breathing, and Restless Sleep. These sub-scales demonstrated good internal reliability, face validity, and test-retest reliability at 6, 12 and 18 months.

The SAPSS questionnaire was distributed to parents of children through schools and provides the first indication of normative sleep/wake patterns in a representative sample of school-aged children in Australia (N=1904; mean age 7.7±1.7yrs). The results of this study add to the discussion that the process of sleep is embedded in cultural and social norms, with differences reported between Non-Caucasian and Caucasian children, as well as between weekend and school nights. These results also confirm the postulation that sleep and behaviour are inextricably linked. Bedtime anxiety, restless sleep, night arousals, bruxism, hyperhydrosis and sleepwalking were all associated with behavioural deficits, either independently or comorbidly.

Moreover, the SAPSS adds considerably to the current state of knowledge by revealing a regular sleep routine, in otherwise healthy children, has the strongest effect on daytime functioning. In addition to the traditional indicators of sleep/wake patterns, the current study examined sleep schedules, in particular the consistency of bedtimes, risetimes and sleep duration. More children reported poor sleep schedules than traditional indicators of poor sleep habits and a change in bedtimes greater than 2 hours across the week or a poor sleep routine resulted in up to four times the risk of reported behavioural problems.

The current paradigm regarding sleep in children is that „one size fits all", however the current study demonstrates that sleep/wake patterns are largely dependent on cultural and social norms, and that there is a need for a focussed debate on what constitutes healthy sleep in children. The thesis presented below argues that new strategies for education and health information addressing healthy sleep in children are needed.

DECLARATION

I declare that this work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

I give consent to this copy of my thesis, when deposited in the University Library, being made available for loan and photocopying, subject to the provisions of the Copyright Act 1968.

Sarah Biggs   Date

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The amount of sleep required by the average person is five minutes more – Wison Mizener

CHAPTER 1: THE SLEEP OF SCHOOL-AGED CHILDREN

Lewis Terman, founder of the Stanford-Binet Intelligence Test, and his colleague, Adeline Hocking (1913) posed a series of questions almost 100 years ago regarding sleep in school-aged children.

1. *"What is the optimum amount of sleep for physical and mental efficiency, and how are we affected by variations above or below this amount?*
2. *How great are the normal individual differences?*
3. *To what extent is the instinct of sleep educable?*
4. *How is it influenced by food habits, by rise and fall of barametric pressure or by changes in humidity and other weather conditions? How is it affected in quantity and quality by ventilation, by light, by the presence of others in the same bed or rooms, etc?*
5. *How is it influenced by various evening occupations? How much and what kind of home study can be assigned by the school without a detrimental effect upon sleep?*
6. *But exactly how much sleep is required by this developing organism* (the child) *for its healthy functioning and growth?" (p138)*

They went on to lament: "We have a large number of *estimates based upon opinion and loose observation,* but no answer based on data of scientific validity" (p 138; original italics). The study of sleep has progressed substantially over the last 100 years, however these questions remain largely unanswered, and sadly, so too does the issue of scientific validity.

The following review discusses the epidemiological research that has been conducted examining sleep and daytime behaviour in school-aged children since

Terman and Hocking"s article, focusing particularly on the research of the last 25 years. After a short summary of the physiological mechanisms of sleep and current understanding of the development of sleep/wake patterns in children, a comprehensive review of previous epidemiological studies examining sleep habits and prevalence of sleep disturbance in school-aged children will be undertaken.

The latter is a particular focus as numerous studies have examined infant (Adair et al., 1991; Anuntaseree et al., 2008; Davis et al., 2004; Eaton-Evans & Dugdale, 1988; Jenni et al., 2004; Lam et al., 2003; Montgomery-Downs & Gozal, 2006), pre-school children (Bax, 1980; Beltramini & Hertzig, 1983; Bruni et al., 2000; Fukuda & Sakashita, 2002; Hawkins & Williams, 1992; Minde et al., 1994; Simard et al., 2008; Tikotzky & Sadeh, 2001; Ward et al., 2008; Zuckerman et al., 1987) and adolescent (Arakawa et al., 2001; Carskadon, 1990; Chung & Cheung, 2008; S. F. Gau & Soong, 1995; Giannotti et al., 2002; Gupta et al., 2008; Hansen et al., 2005; Laberge et al., 2001; LeBourgeois et al., 2004; Lee et al., 1999; Noland et al., 2009; Pallesen et al., 2008; Wolfson & Carskadon, 2003; Yang et al., 2005) sleep, but relatively little attention has been paid to the sleep patterns and concerns of school-aged children, perhaps due to the traditional paradigm that this is a latent period of development in childhood (Kahn et al., 1996). However, a growing body of evidence suggests that sleep patterns in middle-childhood are far from latent with substantive changes and disturbance occurring as the result of biopsychosocial influences.

The physiological need for sleep is a biological process (Borbély, 1982), yet how, when and where children sleep is heavily influenced by social and cultural expectations (Jenni & O'Connor, 2005). Thus, this review will

a) discuss the age, sex, social and cultural influences of the normal development of sleep/wake patterns and prevalence of sleep problems in school-aged children as found in the scarce epidemiological research.

Poor sleep quality is generally acknowledged as having a substantial influence on daytime functioning in children, yet methodological limitations of current research mar scientific consensus. In an attempt to address some of the major issues regarding the current state of knowledge, this review will also:

b) examine the behavioural deficits currently reported to be associated with sleep disturbance in middle-childhood, and
c) provide a critical examination of the methodological difficulties of epidemiological paediatric sleep research.

1.1 SLEEP PHYSIOLOGY

The physiology of sleep is defined by two distinct states: rapid eye movement (REM) and non-REM (NREM) sleep. These states are determined by differences in electroencephalographic (EEG) patterns, eye movement and muscle tone.

NREM sleep contains three or four stages, depending on the choice of staging criteria (Grigg-Damberger et al., 2007). Stage 1 is observed at the transition between wake and sleep. Stage 2 is characterised by sleep spindles – frequent bursts of rhythmic EEG activity – and K-complexes – high-voltage slow spikes. Stage 3 and 4 are known as slow wave sleep (SWS) and are characterised by predominantly continuous high-voltage EEG activity in the slowest frequency range (Rechtschaffen & Kales, 1968). Current recommendations for sleep scoring have these two stages combined into one (Grigg-Damberger et al., 2007).

REM sleep gets its name from the frequent burst of phasic eye movements exclusive to this stage of sleep. It is also characterised by mixed frequencies of EEG activity with relative low voltage, an absence of muscle tone, and irregular heart rate and respiration (Rechtschaffen & Kales, 1968).

NREM and REM sleep are distributed evenly during the first few months after birth. During childhood the proportion of REM sleep decreases until it reaches adult level of about 20-25% of total nocturnal sleep. Amount and amplitude of SWS is greatest during childhood, rapidly declines during puberty and then continues to gradually decline over the lifespan (Ohayon et al., 2004; Sheldon et al., 1992).

Throughout the sleep period, NREM and REM cycle a number of times. The length of each REM/NREM cycle, known as the ultradian sleep rhythm, also changes over childhood. During infancy the ultradian rhythm has a cycle length of approximately 50 minute. During childhood this increases to between 90 and 110 minute cycles which is maintained throughout adulthood (Kahn et al., 1996; Roffwarg et al., 1966). Thus, healthy children and adults will experience 4 to 5 periods of NREM and REM throughout an 8-hour sleep period. The proportion of NREM is greatest early in the sleep period, whereas the greatest proportion of REM occurs late in the sleep period (Roffwarg et al., 1966).

1.2 TWO PROCESS MODEL OF SLEEP REGULATION

The most widely accepted theoretical model of sleep regulation posits that there are two independent, but interacting processes that ensure optimal vigilance during waking and determine the timing, intensity and duration of sleep (Borbély, 1982; Borbély et al., 1989). The first of these processes is the homeostatic drive for sleep, commonly known as „Process S" or sleep pressure. According to the Process S theory, sleep pressure accumulates during wakefulness and then dissipates over the course of a sleep period (Borbély, 1982). That is, the longer one stays awake, the more one will feel the need to sleep. It has been postulated that the homeostatic drive for sleep is caused by neuromodulating sleep-promoting substances such as adenosine (Porkka-Heiskanen et al., 1997). It has been suggested that both the increase and dissipation of sleep pressure in infants and young children is greater than in adults. This may account for the frequent sleep/wake bouts in infants, and the need for regular naps in younger children (Jenni & Carskadon, 2007).

The second process of sleep regulation is called Process C and describes the circadian regulation of physiological activity and rest (Borbély, 1982). The circadian timing, or biological clock, is not sychronised at birth, with infants displaying irregular daily rhythms, including random sleep/wake cycles across the 24-hour period. However, with neuronal development and exposure to social and environmental time cues, such as feedings and light-dark cycles, by three months of age, hormonal and sleep cycles consolidate and begin to show a regular 24-hour rhythm (de Weerd & van den Bossche, 2003). There is a common understanding that after 6-months of age, the circadian system appears to become stable and remain that way until puberty (Kahn et al., 1996). However, it must be noted here that research examining circadian entrainment in early to mid childhood is too limited to make any conclusive assertions.

1.3 'NORMAL' SLEEP IN CHILDREN

Describing „normal" sleep in children is complex, hence the inverted commas. As Owens (2005) comments, childhood is a time marked by rapid physiological and neurocognitive growth of which any description of sleep patterns must include. With relatively few large scale epidemiological studies examining normal sleep and wakefulness in children, and even less with objective measures of sleep, our understanding of what constitutes normal sleep in children is limited and based predominantly on Western literature.

From this limited research, it is now accepted that from infancy to adolescence, sleep duration over the 24-hour period decreases, which corresponds with a consolidation of sleep periods and a dramatic decline in napping during early childhood. Total sleep time in a healthy full-term newborn infant is reported at approximately 16-17 hours over a 24 hour period, consisting of multiple short sleep bouts. By 6-8 months of age, total sleep time decreases to 13-14 hours over 24, with a longer nocturnal sleep period and one or two shorter diurnal sleep periods as children become entrained to the light/dark cycle and adapt to parent enforced daily activities (de Weerd & van den Bossche, 2003). Sleep patterns in the first year of life are marked by great inter-individual differences with some infants sleeping as little as 10 hours in 24 whereas others will sleep up to 18 hours (see Figure 1.1).

It is postulated that this variability reflects differences in maturation speed of circadian organisation (Jenni & Carskadon, 2007). Compared to the first year of life, sleep patterns are reported to become relatively stable between the ages of 2-5 years. Total sleep time gradually decreases as children adopt a pattern of one long nocturnal period of approximately 10-12 hours and one short nap period (Sheldon et al., 1992). Sleep behaviour during this time is postulated to be largely driven by physical and cognitive development. For example, there is an increase in the number and length of night arousals as children begin to experience nightmares and have the ability to independently move from one bed to another (Jenni & Carskadon, 2007).

NOTE:
This figure is included on page 7 of the print copy of the thesis held in the University of Adelaide Library.

Figure 1.1: *Mean, 2^{nd} and 98^{th} percentiles for total sleep duration in a 24 hour period from infancy to adolescence. Adapted from Iglowstein et al. (2003).*

In Western cultures, by the age of five, very few children continue napping (Iglowstein et al., 2003). As a child ages, nocturnal bedtimes and sleep onset becomes later, resulting in a decrease in total sleep time. This shift is gradual during middle childhood – approximately 30-40 minutes from 5-10 years (Iglowstein et al., 2003; Thorleifsdottir et al., 2002) – and then occurs more rapidly in early to mid-adolescence. The pattern of development appears consistent across children, however variability in sleep duration continues, albeit not as pronounced as in infancy. That is, some children are naturally short sleepers whilst others are considered long sleepers, and this pattern of short, optimal or long sleep tends to remain stable across childhood (Touchette et al., 2007). There is some evidence that this pattern of sleep duration may be genetically imprinted (He et al., 2009; Hor & Tafti, 2009).

Adolescence is the second period in the life-span which shows great changes in sleep patterns over a short period of time. During this period, a phase shift occurs where adolescents have a tendency to stay up late at night and sleep late in the morning (Carskadon et al., 1993). This phase shift occurs due to a combination of psychosocial and biological factors. Psychosocially, bedtimes get later as the teenager asserts automony and independence from parental controls as well as succumbs to social, peer and academic pressures (Jenni & Carskadon, 2007). In addition, towards puberty, children begin to display a circadian sleep phase preference of „night owl‟ (Carskadon et al., 1993). Night owl‟s or evening types have a preference for late nights and late mornings, whereas morning lark‟s or morning types have a preference for early bed and rise times. Carskadon and colleagues have shown in a series of elegant studies that delayed phase is indicated by later melatonin secretion onset and offset (Carskadon et al., 1998) and slower increase in homeostatic pressure (Jenni & Carskadon, 2004) which results in the night owl preference. In a large archival study (N=25,000) of chronotype – an individual‟s endogenous circadian rhythm – Roenneberg et al. (2004) demonstrated that children exhibit an early chronotype which progressively becomes later over adolescence, reaching a peak at approximately 20 years old, and then advances again through adulthood. Taken together these data are suggestive of a biological determinant for circadian phase delay during adolescence.

This phase delay has a substantial influence on sleep length and sleep patterns. During the school week, preferred late sleep onset and early school start times can lead to reduced nocturnal sleep duration (Carskadon et al., 1993; Epstein et al., 1998; Wolfson & Carskadon, 1998). However, the need for sleep does not change during puberty (Carskadon et al., 1980), and this reduced sleep duration usually leads to an accumulated sleep debt and substantial daytime sleepiness (Carskadon et al., 1998; Wolfson & Carskadon, 1998). As a result, adolescents show increased irregularity in sleep/wake patterns across the week with non-school night sleep duration significantly longer than school-night sleep in order to recover from sleep debt (Bearpark & Michie, 1987; Petta et al., 1984).

1.4 ONE SIZE FITS ALL?

Recommendations given to parents regarding what is the optimal sleep pattern and sleep length in children have been developed based on the research outlined above. For example, the National Sleep Foundation (NSF) recommends the following amounts of sleep for:

- newborns - 10.5-18 hours throughout the day,
- infants - 9-12 hours at night; 30 min – 2 hour nap
- toddlers – 12-14 hours throughout a 24 hour period
- pre-schoolers – 11-13 hours per night
- school-aged children (5-12 years) – 10-11 hours per night
- teenagers – 9¼ hours per night (www.sleepfoundation.org/article/sleep-topics)

However, even since the fledgling years of sleep research in children, debate has ensued as to what exactly is the optimal amount of sleep in children. In the early 1900‟s, optimal sleep lengths for children were accepted as the theoretical norms put forth by Dr. Clement Dukes (cited in Terman & Hocking, 1913). According to Dukes, 5-7 year-olds needed 13 hours sleep, 8-9 year-olds 12 hours, 10-11 year-olds 11 hours, 12-14 year-olds 10 hours, and 15-18 year-olds 8-9 hours. In their study of 2,692 American children aged 6- to 20-years between 1911 and 1912, Terman and Hocking reported the average sleep obtained was approximately 11 hours at 6-7 years old, 10½ hours at 7-9 years, 10 hours at 9-12 years, 9½ hours at 12-14 years, and less than 9 hours at 15-19 years. Terman and Hocking also compared their results with the studies of Bernard, who reported average sleep duration in German children, and Ravenhill, who reported the same in English children (cited in Terman & Hocking, 1913). As can be seen in Figure 1.2, Terman and Hocking found that while American children appeared to get more sleep than European children, they were sleeping significantly less than recommended. The large difference between actual and recommended sleep times led the authors to claim:

> "… the theoretical and traditionally accepted norms of Dukes are so high that we may safely dismiss them as worthless and misleading." (p147)

NOTE:
This figure is included on page 11 of the print copy of the thesis held in the University of Adelaide Library.

Figure 1.2: *Comparison of Dukes recommended sleep duration in children with actual average sleep durations as measured in studies of Terman & Hocking (USA), Bernard (Germany) and Ravenhill (England). Original figure as presented in Terman & Hocking (1913).*

The following review of the paediatric literature examines sleep/wake patterns and prevalence of sleep disorders in large community samples within the context of developmental (age), biological (sex), social (socioeconomic status: SES) and cultural (ethnicity) determinants of sleep in school-aged children.

In order to comprehensively describe sleep/wake patterns and sleep problems in school-aged children, a literature search of the electronic databases PubMed and Web of Science was conducted using a combination of the key words including but not limited to “children”, “sleep”, “sleep duration”, “sleep patterns”, “sleep problems”, “sleep disorders” “parasomias”, “dyssomnias”. “developmental”, “behaviour”, “epidemiology”, “population” and “community”. A further search was conducted with the names of known authors in the field. All reference lists of obtained articles were scanned for additional relevant studies. Articles not available on-line or through library services were requested from the authors.

1.5 SLEEP/WAKE PATTERNS IN SCHOOL-AGED CHILDREN

The literature examining sleep/wake patterns in school-aged children predominately describe nocturnal sleep and as such have been chosen as the focus of this review. Sleep/wake patterns include bedtime, risetime and nocturnal sleep duration as well as changes across week days and weekends.

Table 1.1 summarises the literature regarding reported nocturnal sleep durations in children around the world from 1913. This table is not exhaustive as only studies published in English language journals with samples of children between the ages of 4-13 years were included. Where the listed studies also report sleep durations for children outside this age range, these have not been included in the table. In addition, only studies with sample sizes over 100 have been included. Studies reporting sleep duration in 24 hours without separation of nocturnal and diurnal sleep have also been excluded (eg: Klackenberg, 1982). Table legend is as follows:

a. Part sample numbers of inclusive age range.
b. Full sample numbers. Includes children outside age range. Numbers for part sample unknown.
c. Sample split by school grade, not age. Age has been approximated based on range reported.
d. Approximates based on visual determination of data points plotted on figures.

e. Switch from parent to self report

N/A = Not Available

Table 1.1: *Reported time in bed or total sleep time in school-aged children by year of study*

Author et al. (Year)	Location	N	Design	Method	Measurement Period	TST/TIB	Age	Weekday Mean(hr.min) ±SD (min)	Weekend Change (min)
Terman & Hocking, 1913	USA	1594[a]	Cross-sectional	Self-report	One night	TIB	6-7	11.14	N/A
							7-8	10.41	
							8-9	10.42	
							9-10	10.13	
							10-11	9.56	
							11-12	10.00	
							12-13	9.36	
Anders et al., 1978	USA	171[a]	Cross-sectional	Self-report	Average school night	TIB	10	9.40[d]	+15
							11	9.30	0
							12	9.20	+25
Gulliford et al., 1990	UK	9913	Cross-sectional	Parent report	Overall average	TIB	5	11.16 (44)	-7
							6	11.08 (43)	-11
							7	10.53 (43)	-3
							8	10.47 (42)	0
							9	10.38 (37)	+1
							10	10.28 (39)	+9
							11	10.16 (38)	+21

Author et al. (Year)	Location	N	Design	Method	Measurement Period	TST/TIB	Age	Weekday Mean(hr.min) ±SD (min)	Weekend Change (min)
Tynjala et al., 1993	Switzerland	40,202[b]	Cross-sectional	Self-report	Overall average	TIB	11-12	10.00	N/A
	Belgium						11-12	9.48	
	Scotland						11-12	9.48	
	Norway						11-12	9.36	
	Spain						11-12	9.36	
	Sweden						11-12	9.36	
	Wales						11-12	9.24	
	Hungry						11-12	9.24	
	Finland						11-12	9.18	
	Israel						11-12	9.00	
Ottaviano et al., 1996	Italy	530[a]	Cross-sectional	Parent interview	Overall average	TIB	4-6	9.36 (52)	N/A
Sadeh et al., 2000	Israel	148	Cross-sectional	Actigraphy	4-5 consecutive nights	TST	7-8	9.12 (29)	N/A
							9-10	8.42 (22)	
							10-12	8.12 (32)	
Shinkoda et al., 2000	Japan	330[a]	Cross-sectional	Self-report	Average for week	Not specified	~6[c]	9.31 (57)	+62
							~7	9.32 (61)	+62
							~8	9.30 (23)	+59
							~9	9.14 (39)	+65
							~10	9.10 (45)	+70
							~11	8.43 (38)	+89

Author et al. (Year)	Location	N	Design	Method	Measurement Period	TST/TIB	Age	Weekday Mean(hr.min) ±SD (min)	Weekend Change (min)
Arakawa et al., 2001	Japan	1279[a]	Cross-sectional	Self report	Average of past month	TIB	12	7.54 (58)	N/A
Laberge et al., 2001	Canada	1146[b]	Longitudinal	Parent report	Average for previous year	TIB	10	10.30 (31)	-6
							11	10.12 (34)	+12
							12	9.54 (34)	+30
Thorleifsdottir et al., 2002	Iceland	668[b]	Mixed	Parent or child reported sleep diary	1 week	TIB	4-5	10.48[d]	0
							6-7	10.12	0
							8-9	9.50	+6
							10-11	9.10	+36
							12-13	8.40[e]	+60
Iglowstein et al., 2003	Switzerland	493[b]	Mixed	Parent interview	Average in previous 3 mths	TIB	4	11.12 (48)	N/A
							5	11.06 (42)	
							6	10.54 (42)	
							7	10.48 (48)	
							8	10.24 (36)	
							9	10.12 (36)	
							10	9.54 (36)	
							11	9.36 (36)	
							12	9.18 (42)	

Author et al. (Year)	Location	N	Design	Method	Measurement Period	TST/TIB	Age	Weekday Mean(hr.min) ±SD (min)	Weekend Change (min)
Liu et al., 2003	China	517[b]	Cross-sectional	Parent report	Average over previous week	TIB	7	9.17 (40)	N/A
							8	9.32 (45)	
							9	9.04 (40)	
							10	9.16 (52)	
							11	9.13 (40)	
							12	8.53 (43)	
Spilsbury et al., 2004	USA	755	Cross-sectional	Child reported sleep diary	7 days	TST	8	9.44 (41)	+2
							9	9.39 (41)	-3
							10-11	9.26 (49)	+8
Yang et al., 2005	Korea	525[a]	Cross-sectional	Child report	Previous two weeks	TIB	9-13	8.18 (72)	+42
Ng et al., 2005	Hong Kong	3047	Cross-sectional	Parent interview	Previous week	TIB	6	9.06 (59)	N/A
							7	8.54 (56)	
							8	8.52 (56)	
							9	8.48 (57)	
							10	8.43 (55)	
							11	8.33 (59)	
							12	8.36 (59)	
Liu et al., 2005a	China	292	Cross-sectional	Parent report	Typical recent week	TIB	~5-10	9.08 (44)	N/A
	USA	380					~5-10	10.38 (40)	

Author et al. (Year)	Location	N	Design	Method	Measurement Period	TST/TIB	Age	Weekday Mean(hr.min) ±SD (min)	Weekend Change (min)
Spruyt et al., 2005	Belgium	3045	Cross-Sectional	Parent report	Previous 6 mths	TST	6	10.24 (50)	+8
							7	10.11 (58)	+19
							8	10.02 (52)	+20
							9	9.54 (47)	+24
							10	9.48 (50)	+26
							11	9.39 (47)	+32
							12	9.24 (49)	+44
BaHammam et al., 2006	Saudi Arabia	1012[a]	Cross-sectional	Parent report	Average in previous 4 mths	TIB	5-6	8.48 (78)	+84
							7	8.42 (60)	+78
							8	8.24 (60)	+108
							9	8.30 (66)	+82
							10	8.22 (71)	+110
Russo et al., 2007	Italy	835[a]	Cross-sectional	Self-report	Average weekly	TIB	8	9.28 (55)	+52
							9	9.18 (54)	+55
							10	9.12 (51)	+54
							11	8.44 (44)	+75
							12	8.35 (46)	+80
Dollman et al., 2007	Australia	390[b] (1985)	Cross-sectional	Self-report	Previous night	TIB	10-12	9.36 (72)	N/A
		510[b] (2004)					10-12	9.12 (78)	

Author et al. (Year)	Location	N	Design	Method	Measurement Period	TST/TIB	Age	Weekday Mean(hr.min) ±SD (min)	Weekend Change (min)
Adam et al., 2007	USA	1267[a]	Cross-sectional	Parent report time diary	One randomly selected week & weekend night	TIB	5-11.9	9.49 (66)	+58
Nixon et al., 2008	New Zealand	519	Cross-sectional	Actigraphy	24 hours	TST	7	10.06 (48)	-27

1.5.1 Developmental and historical changes in sleep/wake behaviours

Without exception, time in bed (TIB) and total sleep time (TST) reduces with age. As can be seen clearly in Table 1.1, this is a consistent finding worldwide in both longitudinal and cross-sectional studies. Invariably this decrease is due to later bedtimes, although earlier school start times due to transition from primary to high school have also been implicated (Carskadon et al., 1998).

There is emerging evidence that children are now getting less opportunity to sleep than ever before. Dollman et al. (2007) examined the secular trends of TIB in two cohorts of South Australian children aged 10-15 years between 1985 and 2004. These data found that self-reported TIB had decreased an average of 30 minutes over the 20 year period. Iglowstein et al. (2003) also found a cohort effect in TIB. In that study, 2-year-olds in 1974 were reported by parents to spend almost 1 hour longer in bed than 2-year-olds in 1986. The difference in TIB between the two cohorts decreased exponentially as the children aged, with a reported 12 minute difference in 14-year-olds over the 22-year span of the studies. Examination of three studies using child-report data conducted in the USA support this decreasing trend in TIB over time. According to Terman and Hocking (1913), 8-9 year-olds had an average TIB of 10 hours and 41 minutes. In 2004, 8 year-olds" mean TST was reported to be 9 hours and 44 minutes (Spilsbury et al., 2004). This suggests a reduction of approximately one hour over the 90 year period, although the actual difference may be less than one hour due to the different measures of TIB and TST employed (see 1.5.5 below). Consistent with Iglowstein and colleague"s findings, the mean difference between the two time periods diminished with increasing age. That is, compared with the 60 minute difference in 8-9 year-olds, 10-11 year-olds were reported to spend only 30 minutes longer in bed in 1913 than in 2004. Anders et al. (1978) reported 10-year-olds" mean TIB to be 9 hours and 40 minutes – 16 minutes shorter than Terman and Hocking and 14 minutes longer than Spilsbury et al. Despite the difference in measurement period – one night versus one week – these results together lend support to the suggestion that average sleep duration during childhood is getting shorter.

1.5.2 Sex differences in sleep/wake pattern

In many aspects, the daily activities of boys and girls differ substantially. For example, Olds et al. (2009) recently reported sex differences in daytime activity patterns in adolescents in Australia (N=6,024; age=10-18 years) with boys engaging in more structured and vigorous physical activity than girls. Boys also reported more time in front of a screen than girls (Olds et al., 2009). Girls spent more time talking on the phone, shopping, doing chores and playing with pets. Hofferth and Sandberg (2001) also found sex differences in daily activities in American children under 12 years old, although not as pronounced as in teens. Whilst these differences may be socially entrained to develop gender roles, gender-bound activities may also have an impact on sleep/wake patterns. Sex differences in sleep/wake patterns, especially in school-aged children are not well explored. Currently, the reported differences in sleep/wake patterns between boys and girls are inconsistent and relatively small.

Thorleifsdottir et al. (2002) reports no sex difference in bedtime, wake-up time, nocturnal sleep time or napping at any age over a 10-year period. BaHammam et al. (2006) reported no sex difference in sleep/wake patterns within age groups between

5 and 10 years, however analysis of the total cohort reported girls to spend 12 minutes longer in bed than boys on weekdays. Liu et al. (2005a) did not report any sex difference in sleep/wake patterns in a Chinese sample of children but in their American counterparts, girls reported an average of 8 minutes longer in bed than boys. Sadeh et al. (2000) reported no sex difference in actigraphically measured sleep onset or wake-time. Total time spent asleep, however, was significantly longer in girls than boys, most likely the result of less night awakenings (although the difference in night awakenings was not statistically significant).

Yang et al. (2005) does report a sex difference in TIB on weekends with girls spending almost 30 minutes longer in bed as a result of later wake times. No sex difference was found in weekend bedtimes between girls and boys. Russo et al. (2007) also reported a longer TIB for girls on weekends, however this was the result of earlier bedtimes rather than later wake-times. Gulliford et al. (1990) reported the longer sleep opportunity in females was the result of both earlier bedtimes and later risetimes. Unlike the above studies, this trend was observed on both school days and weekends, although it was more pronounced on weekends.

Contrary to these studies, Ng et al. (2005) reported that overall, boys spent significantly longer in bed than girls. The actual reported difference was 6 minutes however, and considering the size of the sample (N=3047), a Type I error – finding a statistical difference when a true difference does not exist – is likely here.

Thus, where a sex difference in sleep/wake patterns is observed, a longer TIB for girls than boys is more consistently reported. Whether this is the result of earlier bedtimes or later rise-times is unclear and may depend on whether the difference occurs on weekdays or weekends. However, although statistically significant sex differences have been reported, questions remain as to the practical importance of these differences. As already mentioned, the average difference in the Ng et al. study was 6 minutes. In Liu et al."s study the difference was 8 minutes, and in Gulliford et al."s study an average of 2 minutes on school days and 12 minutes on weekends separated the girls from the boys. It is unlikely that a 2 minute, and perhaps not even a 12 minute difference, will be meaningful in regards to daytime sequelae.

1.5.3 Cultural differences in sleep/wake patterns

The definition of culture is complex. One common understanding of culture is as a set of socially constructed and learned beliefs, norms and expectations that reflect a continuity of tradition. Cultural influences on various aspects of child development, such as behavioural, emotional or psychosocial development, are well studied (Pachter & Harwood, 1996). However, the study of cultural influences on the developmental aspects of sleep is still in its infancy (Jenni & O'Connor, 2005; Owens, 2005). Table 1.1 clearly shows that nocturnal sleep duration varies across countries, however closer examination suggests that sleep duration over 24 hours may not be as disparate as first appears.

In the study of sleep habits of children across Europe, Tynjala et al. (1993) reported an hour difference between the longest (Switzerland) and shortest (Israel) time in bed. Some of this difference may be explained by seasonal variations in sleep time. Sleep duration has been reported to be shorter during the summer months (Szymczak et al., 1993) and the authors noted that Finland, Sweden and Norway completed the study during the winter. Geography may also have an influence. Overall, Israel is much warmer than the other European countries. Average annual temperature for Israel ranges between 12-26ºC, whereas Switzerland, for example, ranges between -1-18ºC (www.eurometero.com/english/climate). As a result, children may be spending more time in bed due to the differences in the light/dark cycle or simply to stay warm. However, neither of these possibilities explain why Finland reported the second shortest time in bed. In Finland, the study was conducted in the dark of winter when average temperatures are -3ºC (www.eurometero.com/english/climate). Thus, while climate and light exposure will have some impact on sleeping patterns, cultural and social factors may be more salient influences.

As can be seen in Table 1.1, most Asian-based studies reported shorter nocturnal sleep time than Western studies. For example, Liu et al. (2005a) reported a TIB difference of over an hour between Chinese and American cohorts. The authors speculated that the shorter sleep opportunity in Chinese children is due to earlier school start times, increased homework loads, differences in parental perceptions regarding importance of academic success over sleep, and room sharing.

However, examining only nocturnal sleep duration in many countries is limiting as napping is accepted and encouraged as part of the cultural norm (Crosby et al., 2005; Steger, 2006; Worthman & Brown, 2007). In Table 1.1, BaHammam et al.'s (2006) study reported the shortest nocturnal sleep time for age. In that study, the authors also examined total sleep time over a 24 hour period. In 5-8 year olds, TST increased to 9 hours 24 minutes, in 9-year-olds to 9 hours 9 minutes and in 10-year-olds to 9 hours 12 minutes. Thus, over a 24 hours period the amount of sleep obtained by these children was similar to that reported by others even though the distribution differed (e.g. Liu et al., 2005a; Russo et al., 2007).

In China, it is a common for schools to schedule a 2 hour lunch break so that children can have a 30-60 minute nap during the day (Liu et al., 2005a). In Japan, many children take a short nap prior to dinner and then study late into the night (Steger, 2006). Japan also encourages the practice of *inemuri*, being asleep while present. That is, it is perfectly acceptable for children to fall asleep in class, so long as they remain upright and do not make sleep-related respiratory noises such as snoring or snorting (Steger, 2006).

Cultural differences can also be observed within multi-cultural societies. Crosby et al. (2005) reported significant differences in napping behaviour and nocturnal sleep duration between African American and Caucasian American children aged 2-8 years. In this study, more African American children continued to nap until 8 years old. Nocturnal sleep duration was also shorter in African American children at all age groups. These cultural practices will result in shorter nocturnal sleep, but not necessarily total sleep time over a 24 hour period. Thus, comparisons of only nocturnal sleep times in children from different cultures or cultural backgrounds may not be appropriate.

Current recommendations for optimal sleep in school-aged children are based on Western literature where there is a predominance of one long nocturnal sleep duration and no nap. Considering the different cultural sleep practices and the limited knowledge of the effects of these different practices on daytime sequale, prescribing an optimal nocturnal sleep time for children may be restrictive.

1.5.4 Weekly changes in sleep/wake patterns

In Western society, a clear delineation exists between week days (Mon-Fri) and weekends (Sat-Sun) with school, and majority of work, schedules running on a week/weekend pattern. This results in a difference in behaviours over the 7-day period. For example, weekends are usually reserved for leisure or social pursuits whereas weekdays are dominated by functional duties (Hofferth & Sandberg, 2001). In regards to children, routines that are enforced by parents during the week may not necessarily be maintained for the weekend. This can substantially affect sleep/wake patterns.

It is well established that in adolescence, sleep duration on weekends is longer than during the week (Wolfson & Carskadon, 1998). It is proposed that the circadian phase shift in adolescence results in an accumulated sleep debt over the school week when adolescents are staying up late and being forced to get up early for school. This sleep debt is then paid off on the weekends (Carskadon, 1990). The patterns of weekday and weekend sleep duration in school-aged children, however, are not so clear (Table 1.1).

Nixon et al. (2008) reported that 7-year-olds in New Zealand slept an average of 30 minutes *less* on weekends than school days. Gulliford et al. (1990) reported children between the ages of 5 and 8 years either have less sleep on weekends or show no change. In Gilford et al.‟s study, there was a shift at 10 years where children began to sleep longer on weekends. Laberge et al. (2001) also reported a shift to longer sleep on weekends after 10 years of age. Thorleifsdottir et al. (2002) showed a similar pattern with no difference in TIB between school day and weekend sleep until 8 years old when weekend sleep became longer. In this study, the increase in weekend sleep was proportional to the decrease in weekday sleep, supporting Carskadon et al. (1981) claim that as children reach puberty and experience a phase shift, their sleep need does not reduce.

This pattern is not consistent across all studies however. Spruyt et al. (2005) reported that the difference between weekday and weekend sleep duration incrementally increased from 8 minutes at age 6 to 44 minutes at age 12. Shinkoda et al. (2000) reported children in Japan from the age of 6 years have TIB in excess of 60 minutes longer on weekends than weekdays. BaHammam et al. (2006), Russo et al. (2007) and Adam et al. (2007) also reported consistently longer sleep opportunities on weekends in children less than 10 years old. In general, these studies also report a shorter TIB on school days than the ones mentioned above. For example, Shinkoda et al. reported a TIB of approximately 9 hours 30 minutes in 6-year-olds and 7-year-olds whereas Gulliford et al. reported 11 hours 7 minutes and 10 hours 53 minutes in the same two age groups respectively. Time in bed reported by Bahammam et al., even when napping is taken into account, is still up to 40 minutes less than that reported by Thorleifsdottir et al. in the same age group.

These trends suggest that sleep need is biologically driven and thus generally consistent throughout the world, yet how this need is fulfilled is culturally or socially entrained. It may be that in countries where longer sleep durations during the week are encouraged, children have their sleep need fulfilled and thus require less sleep on weekends, whereas where sleep is truncated during the week, children accumulate a sleep debt that is repaid on weekends.

What is unknown is whether these differing patterns have a detrimental effect on child development. Is a longer nocturnal sleep duration with no nap on school days and shorter sleep duration on weekends, better developmentally than short nocturnal sleep duration plus a nap on school days with catch-up sleep on weekends? Adult sleep deprivation and recovery literature tends to suggest that patterns of sleep and recovery are important for optimal functioning. For example, Rupp et al. (2009) recently reported that performance and alertness after sleep restriction and subsequent recovery was a function of the amount of prior sleep. In that study, healthy adult subjects were given a sleep extension (~8hrs/night) or habitual sleep (~6hrs/night) protocol prior to 7-days chronic sleep restriction (3hr/night) and 5-day recovery (8hr/night). Subjects in the sleep extension condition were more resilient to sleep restriction and recovered more quickly than those in the habitual sleep condition. Sallinen et al. (2008) reported that one night of recovery sleep (8hr) after just one night of sleep restriction (2hr) was not sufficient in returning performance or self-reported sleepiness to baseline levels (N=16; age=19-22 years). Whilst extreme sleep restriction such as this is unlikely in otherwise healthy school-aged children, these studies highlight the importance of sleep/wake patterns for daytime functioning.

Consideration of patterns of sleep over a 24 hour period as well as cultural variations in the current paediatric literature is limited. Future studies would do well to include this when examining normative sleep patterns in children.

1.5.5 Methodological Considerations

Undoubtedly Table 1.1 shows some interesting trends and raises numerous questions to be explored in future research. Caution must be taken, however, when making direct comparisons across these studies. The operationalisation of nocturnal sleep duration is inconsistent across studies with both time in bed (TIB) and total sleep time (TST) being commonly used to define „sleep duration‟. Time in bed is calculated as the time between going to bed and getting out of bed in the morning, and does not take into account pre-sleep activities (eg watching television in bed), the amount of time taken to fall asleep, nocturnal arousals, or the amount of time spent in awake bed before rising. Total sleep time is the difference between actually falling asleep and waking, less any night-time arousals (Sadeh et al., 1994). By definition TIB, sometimes labeled „sleep opportunity‟, will always be longer than TST and as such, studies defining sleep duration as TIB overestimate actual sleep time. The discrepancy may not be as pronounced in school-aged children as adolescents, however it is a noteworthy consideration when attempting to make comparisons across studies.

Discrepancies will also arise depending on the method used to gather the sleep information. Werner et al. (2008) recently examined the level of agreement between three sleep measurement methods in a cohort of pre-school children (N=50; age 4-7 years). In this study, children were asked to wear an actiwatch for a period of 6-8 days during which time parents kept a detailed sleep diary. Parents were also requested to complete a sleep questionnaire asking about the child‟s usual sleep/wake behaviours over school days and weekends. Agreement between actigraphy monitoring and sleep diary measures was satisfactory for assumed sleep duration, sleep start and end times, but not for nocturnal awakenings. Poor agreement was found between questionnaire data and the other measures, with sleep time significantly overestimated on the questionnaire compared to actigraphy or sleep diary (Werner et al., 2008). This result was supported by Nixon et al. (2008) who reported parents to overestimate children‟s sleep time, as measured with actigraphy, by 50 minutes. Taken together, these results suggest that total sleep time is only accurate when measured objectively, however information on TIB can sufficiently be obtained using a sleep diary over an extended period of time. Sleep information obtained from questionnaires is adequate for determining differences within groups but caution must be taken when comparing to other methods.

Due to the limited epidemiological research and the methodological differences across questionnaire reports, an informed commentary on normative sleep/wake patterns in school-aged children is difficult. More consistent measures are required before informed recommendations of optimal sleep behaviours can be made.

1.6 PREVALENCE OF SLEEP PROBLEMS IN SCHOOL-AGED CHILDREN

There are three major categories of sleep problems in children:

a. dyssomnias, associated with initiating and/or maintaining sleep or producing excessive daytime sleepiness;
b. parasomnias, associated with arousal, both full and partial, and sleep-state transitions; and,
c. medical or psychiatric associated sleep problems (Kohrman, 1999).

A full discussion of all categories is beyond the scope of this review so detailed descriptions are limited to those sleep problems directly relevant to this thesis, in particular dyssomnias and parasomnias. However, in brief, medical sleep problems are defined by any fragmentation or disruption of sleep cause by conditions such as epilepsy, gastroesophageal reflux, eczema, or pain related conditions such as cerebal palsy. Psychiatric sleep problems are those associated with psychiatric concerns such as depression, attention-deficit-hyperactivity disorder (ADHD) and Tourette syndrome (Kohrman, 1999).

A description of the sleep disorders listed under the dyssomnia and parasomnia categories are listed in Table 1.2.

Table 1.2: *Description of sleep disorders classed as dysommnias and parasomnias. Adapted from Kohrman (1999)*

Sleep Disorder	Description
Dyssomnias – Intrinsic	
Narcolepsy	• Sudden intrusion of REM sleep behaviours into the waking state consisting of the following symptoms: excessive daytime sleepiness, hypnagogic hallucinations, sleep paralysis, and cataplexy
Sleep Apnoea	• Respiratory disturbance during sleep caused by obstruction of the airway (obstructive apnoea) or loss of motivation to breath (central apnoea). Snoring is the most common symptom of obstructive apnoea.
Central hypoventilation syndrome	• Control of respiration during NREM sleep is affected with episode of hypoventilation or apnoea occurring during this sleep stage.
Periodic limb movement	• Repetitive muscle contractions (3 or more consecutively) in the legs during sleep lasting up to 5 seconds.
Restless leg syndrome	• Overwhelming urge to move the legs as a result of an uncomfortable, often painful, sensation at sleep onset.
Insomnia	• Inability to fall or stay asleep. May be psychophysiologic resulting from psychologic factors, perceptual resultant of a misperception that sleep has not occurred when it has, or idiopathic which is a life-long inability to fall or stay asleep.

Sleep Disorder	Description
Dyssomnias – Extrinsic	
Limit-setting sleep disorder	• Refusal to go to bed due to the inadequate implementation of sleep-time boundaries by the care-giver.
Sleep-onset association disorder	• A sleep-associated object or circumstance is needed before sleep will occur. If absent, insomnia results.
Adjustment sleep disorder	• Sleep is disturbed due to acute stress, conflict or environmental change.
Environmental sleep disorder	• Insomnia or sleep disturbance is caused by environmental factors such as bedroom environment or external noise.
Insufficient sleep disorder	• Lack of sufficient sleep resulting in excessive daytime sleepiness
Dyssomnias – Circadian rhythm sleep disorders	
Delayed or advanced sleep phase syndrome	• Sleep and wake times either become considerably later (delayed) or earlier (advanced) than what is considered customary for age
Irregular sleep-wake pattern	• Episodes of sleep and wakefulness occur randomly throughout a 24 hour period
Non-24-hour sleep-wake disorder	• An inability to synchronise circadian rhythms with the external environment resulting in continual shifts in sleep phases.
Time-zone change syndrome	• Inability to sleep due to rapid changes in day-night cycle that outpace circadian synchronization. Otherwise known as jetlag.

Sleep Disorder	Description
Parasomnias	
Sleep walking (somnambulism)	• Complex motor behaviours, usually walking, during NREM sleep
Night terrors (pavor nocturnus)	• Sudden, confused and agitated arousal, though not full wakefulness, from NREM sleep in which the child is often inconsolable. Usually occurs during the first few hours of the sleep period. The episode is generally not recalled in the morning.
Parasomnias	
Confusional arousals	• Full wakefulness from NREM into a crying, frightened state. Child is easily consolable and returns to sleep quickly.
Rhythmic movement disorders	• Rhythmic movements of head, neck and body at sleep onset.
Sleep talking	• Words or speech sounds made during sleep
Nightmares	• Frightening dreams during REM sleep that cause arousal. Distinct from night terrors as child is able to vividly remember the dream and usually occurs during early morning hours.
REM sleep behaviour disorder	• Loss of muscle atonia during REM resulting in motor activity presumably associated with dream behaviour
Enuresis	• Bedwetting
Benign neonatal sleep myoclonus	• Synchronous myoclonic jerks of the arms and legs during the first few weeks of life

There is a large body of literature examining the prevalence, developmental process and aetiology of a single sleep problem (e.g. enuresis; for review see Hjalmas, 1998; SDB, for review see Lumeng & Chervin, 2008). Studies which attempt an omnibus approach to the examination of prevalence of dysomnias and parasomnias in the community however are limited and not well reviewed. In an effort to rectify this, Table 1.3 summarises the main epidemiological omnibus sleep problem prevalence studies that have been conducted in school-aged children the previous 25 years.

A notable omission to the following table is sleep disordered breathing (SDB), arguably, the most extensively studied sleep problem in the community setting. In epidemiological studies SDB is usually labelled as habitual snoring due to the absence of confirmatory polysomnography (PSG). Julie Lumeng and Ronald Chervin (2008) have conducted an exceptional comprehensive review of the epidemiological studies of habitual snoring, thus has not been repeated in the following Table.

To summarise Lumeng and Chervin"s review however, between 1.5 and 34.5% of community-sampled children were reported to snore. The difference in prevalence rate was largely dependent on the definition used. A higher prevalence of SDB was reported in boys in more than half the studies examined, of which there appeared to be an interaction with age. That is, proportionately more studies involving children older than 12 years reported higher snoring rates in boys than those less than 12. Overall however, the prevalence of snoring did not appear to change with age. According to this review, very little evidence exists to suggest any particular race at higher risk of SDB, except perhaps in African-American populations. This however may be mediated by socio-economic status which was not explored.

Table 1.3 details the prevalence rates of various parasomnias and dyssomnias, excluding SDB, in children from approximately 4-12 years as described in omnibus studies. There are two exceptions to this age limit: Simonds and Parraga (1982: 5-18 years) and Ipsiroglu et al. (2002: 10-15 years). It was considered important to include Simonds and Parraga as it was one of the first studies to take an omnibus approach to sleep problems. The Ipsiroglu et al. study was included as it is one of the few that uses, and thus highlights the implications of, child self-report.

The following table also describes whether a developmental change or sex difference was observed in the reported prevalence rate. Studies are tabled according to the definition used by the authors to determine the existence of a sleep problem. Only studies detailing the prevalence of 3 or more sleep problems have been included.

Table key is as follows:

a. Longitudinal cohort from Smedje et al., 1999;
b. Retrospective at age 10;
c. Longitudinal;
d. Longitudinal every 12 mths from 2.5 yrs;
e. Both nocturnal and diurnal enuresis included;
f. trend only, significance not reported;
g. difference reported for ages 2.5-6 years;

↓decreasing prevalence with age;

↑increasing prevalence with age;

↔ no clear pattern;

= no difference;

NR Not Reported;

NA Not Applicable;

♂ higher prevalence reported in boys;

♀ higher prevalence reported in girls.

Table 1.3: *Prevalence of parasomnias and dyssomnias by definition in children aged ~4-12 years.*

Enuresis

Definition	Retrospective period	Author et al., Year	Location	N	Age	Reported	Prevalence	Age change	Sex diff
Every night	6 mths	Stein et al., 2001	USA	472	4-12	Parent	4.9	↓[f]	NR
	NR	Neveus et al., 2001	Sweden	1413	6-10	Child	1.3	NR	=
Many or every night	NR	Paavonen et al., 2000	Finland	5813	8-9	Parent	9.5[e]	NA	♂
Frequently/always	6 mths	Agargun et al., 2004	Turkey	971	7-11	Parent	5.8	↓	=
5-7 x/wk	1 week	Liu et al., 2005a	USA	391	~5-9	Parent	3.3	NR	NR
	1 week	Liu et al., 2005a	China	292	~5-9	Parent	1.4	NR	NR
	6 mths	Smedje et al., 1999a	Sweden	1844	5-7	Parent	2.8	NR	♂
	6 mths	Smedje et al., 2001a[a]	Sweden	635	6-8	Parent	1.1	NR	NR
Frequently	NR	Carvalho Bos et al., 2009	Portugal	779	6-11	Parent	15	NR	NR
Usually	1 week	Gregory et al., 2006	UK	600	8	Parent	2.0	NA	NR
> 4 x /wk	6 mths	Blader et al., 1997	USA	987	5-12	Parent	1.8	↓	♂
Several times a week	6 mths	Quine, 2001	UK	576	4-12	Parent	5.0	=	♂
Often	6 mths	Liu et al., 2000a	China	2004	6-12	Parent	0.4	=	♂
	NR	Wiater et al., 2005	Germany	4531	8-11	Parent	2.0	NR	♂
						Child	1.0	NR	=
Sometimes/frequently	7 years[b]	Laberge et al., 2000	Canada	870	3-10[b]	Parent	15.4		NR
	12 mths[c]				11		3.8		♂
					12		2.3	↓	NR
					13		2.0		NR
2-4 x/wk	1 week	Liu et al., 2005a	USA	391	~5-9	Parent	4.3	NR	NR
	1 week	Liu et al., 2005a	China	292	~5-9	Parent	7.5	NR	NR
Sometimes	6 mths	Liu et al., 2000a	China	2004	6-12	Parent	4.0	=	♂
	NR	Wiater et al., 2005	Germany	4531	8-11	Parent	4.0	NR	♂
						Child	4.0	NR	=

Enuresis (continued)

Definition	Retrospective period	Author et al., Year	Location	N	Age	Reported	Prevalence	Age change	Sex diff
Occasionally	1 week	Gregory et al., 2006	UK	600	8	Parent	8.0	NA	NR
	12 mths[d]	Petit et al., 2007	Canada	1137	5	Parent	21.4	↓	NR
					6		16.1		♂
	6 mths	Smedje et al., 1999a	Sweden	1844	5-7	Parent	15.8	NR	♂
	6 mths	Smedje et al., 2001a	Sweden	635	6-8	Parent	13.9	NR	NR
1-2 x /wk	6 mths	Blader et al., 1997	USA	987	5-12	Parent	2.5	↓	♂
> Once/wk	6 mths	Stein et al., 2001	USA	472	4-12	Parent	5.1	↓[f]	NR
Once/wk	6 mths	Simonds & Parraga, 1982	USA	309	5-18	Parent	4.3	↓	♂
Every week	NR	Neveus et al., 2001	Sweden	1413	6-10	Child	1.9	NR	=
> 12 nights / mth	6 mths	Kahn et al., 1989b	Belgium	972	8-10	Parent	2.0	NR	NR

Bruxism

Definition	Retrospective period	Author et al., Year	Location	N	Age	Reported	Prevalence	Age change	Sex diff
Every night	6 mths	Stein et al., 2001	USA	472	4-12	Parent	7.0	↔[f]	NR
	N/A	Neveus et al., 2001	Sweden	1413	6-10	Child	1.1	NR	=
Frequently/always	6 mths	Agargun et al., 2004	Turkey	971	7-11	Parent	6.4	↑ until 9 ↓	=
5-7 x/wk	1 week	Liu et al., 2005a	USA	397	~5-9	Parent	4.8	NR	NR
	1 week	Liu et al., 2005a	China	292	~5-9	Parent	6.5	NR	NR
	6 mths	Smedje et al., 1999a	Sweden	1844	5-7	Parent	2.7	NR	NR
	6 mths	Smedje et al., 2001a[a]	Sweden	635	6-8	Parent	2.9	NR	NR
Often	N/A	Wiater et al., 2005	Germany	4531	8-11	Parent	4.0	NR	=
Frequently	N/A	Carvalho Bos et al., 2009	Portugal	779	6-11	Parent	7.3	NR	NR
Several times a week	6 mths	Quine, 2001	UK	576	4-12	Parent	10.0	=	=
Usually	1 week	Gregory et al., 2006	UK	600	8	Parent	3.0	NA	NR
Sometimes/frequently	7 yrs [b]	Laberge et al., 2000	Canada	870	3-10	Parent	19.2		NR
	12 mths[c]				11^		13.8		=
					12^		11.2	↓	NR
					13^		9.3		NR
Sometimes	N/A	Wiater et al., 2005	Germany	4531	8-11	Parent	18.0		=
2-4 x/wk	1 week	Liu et al., 2005a	USA	397	~5-9	Parent	15.9	NR	NR
	1 week	Liu et al., 2005a	China	292	~5-9	Parent	15.1	NR	NR
Occasionally	1 week	Gregory et al., 2006	UK	600	8	Parent	12.0	NA	NR
	12 mths[d]	Petit et al., 2007	Canada	1062	5	Parent	27.8	↑[g]	NR
					6		32.6		=
	6 mths	Smedje et al., 1999a	Sweden	1844	5-7	Parent	22.6	NR	NR
	6 mths	Smedje et al., 2001a	Sweden	635	6-8	Parent	24.8	NR	NR
> Once/wk	6 mths	Stein et al., 2001	USA	472	4-12	Parent	7.8	↓[f]	NR
Once/wk	6 mths	Simonds & Parraga, 1982	USA	309	5-18	Parent	7.5	↓	=
Every week	N/A	Neveus et al., 2001	Sweden	1413	6-10	Child	4.4	NR	=
Yes/No	12 mths	Liu et al., 2005b	China	2001	3-5	Parent	8.5		=
				2439	6-10		6.7	↓	=
				904	11-12		3.7		=

Nightmares

Definition	Retrospective period	Author et al., Year	Location	N	Age	Reported	Prevalence	Age change	Sex diff
Every night	6 mths	Stein et al., 2001	USA	472	4-12	Parent	2.1	↔[f]	NR
	N/A	Neveus et al., 2001	Sweden	1413	6-10	Child	0.5	NR	=
Many or every night	N/A	Paavonen et al., 2000	Finland	5813	8-9	Parent	5.4	NA	♂
5-7 x/wk	1 week	Liu et al., 2005a	USA	399	~5-9	Parent	0.0	NR	NR
	1 week	Liu et al., 2005a	China	292	~5-9	Parent	1.7	NR	NR
	6 mths	Smedje et al., 1999a	Sweden	1844	5-7	Parent	0.2	NR	♀
	6 mths	Smedje et al., 2001a[a]	Sweden	635	6-8	Parent	0.3	NR	NR
Frequently	N/A	Carvalho Bos et al., 2009	Portugal	779	6-11	Parent	4.6	NR	NR
Frequently/always	6 mths	Agargun et al., 2004	Turkey	971	7-11	Parent	1.0#	↑	=
Several times a week	6 mths	Quine, 2001	UK	576	4-12	Parent	4.0	=	=
Often	6 mths	Liu et al., 2000a	China	2004	6-12	Parent	1.9	=	♂
	N/A	Wiater et al., 2005	Germany	4531	8-11	Parent	2.0	NR	=
						Child	4.0	NR	=
Usually	1 week	Gregory et al., 2006	UK	600	8	Parent	1.0	NA	NR
2-4 x/wk	6 mths	Liu et al., 2000a	China	2004	6-12	Parent	10.1	=	♂
Sometimes	1 week	Liu et al., 2005a	USA	399	~5-9	Parent	9.8	NR	NR
	1 week	Liu et al., 2005a	China	292	~5-9	Parent	8.2	NR	NR
	N/A	Wiater et al., 2005	Germany	4531	8-11	Parent	27.0		=
						Child	40.0		=
Occasionally	1 week	Gregory et al., 2006	UK	600	8	Parent	29.0	NA	NR
	6 mths	Smedje et al., 1999a	Sweden	1844	5-7	Parent	57.6	NR	NR
	6 mths	Smedje et al., 2001a	Sweden	635	6-8	Parent	55.9	NR	NR
> Once/wk	6 mths	Stein et al., 2001	USA	472	4-12	Parent	6.4	=[f]	NR
Once/wk	6 mths	Simonds & Parraga, 1982	USA	309	5-18	Parent	1.7	↓	♀
Every week	N/A	Neveus et al., 2001	Sweden	1413	6-10	Child	4.9	NR	=
> twice / mth	6 mths	Kahn et al., 1989b	Belgium	972	8-10	Parent	15.0	NR	NR
>7/year	N/A	Ipsiroglu et al., 2002	Austria	332	10-15	Self	3.6	NR	NR

Night Terrors

Definition	Retrospective period	Author et al., Year	Location	N	Age	Reported	Prevalence	Age change	Sex diff
Every night	6 mths	Stein et al., 2001	USA	472	4-12	Parent	1.9	↔[f]	NR
Many or every night	N/A	Paavonen et al., 2000	Finland	5813	8-9	Parent	0.8	NA	=
Frequently/always	6 mths	Agargun et al., 2004	Turkey	971	7-11	Parent	0.9	=	=
5-7 x/wk	1 week	Liu et al., 2005a	USA	394	~5-9	Parent	0.0	NR	NR
	1 week	Liu et al., 2005a	China	292	~5-9	Parent	1.0	NR	NR
	6 mths	Smedje et al., 1999a	Sweden	1844	5-7	Parent	0.1	NR	NR
	6 mths	Smedje et al., 2001a[a]	Sweden	635	6-8	Parent	0.0	NR	NR
Frequently	N/A	Carvalho Bos et al., 2009	Portugal	779	6-11	Parent	2.4	NR	NR
Several times a week	6 mths	Quine, 2001	UK	576	4-12	Parent	1.0	=	=
Often	N/A	Wiater et al., 2005	Germany	4531	8-11	Parent	1.0	NR	=
Usually	1 week	Gregory et al., 2006	UK	600	8	Parent	0.0	NA	NR
Sometimes/frequently	7 yrs [b]	Laberge et al., 2000	Canada	870	3-10	Parent	14.7		NR
	12 mths[c]				11^		3.8	↓	=
					12^		2.3		NR
					13^		1.2		NR
Sometimes	N/A	Wiater et al., 2005	Germany	4531	8-11	Parent	5.0		=
2-4 x/wk	1 week	Liu et al., 2005a	USA	394	~5-9	Parent	1.3	NR	NR
	1 week	Liu et al., 2005a	China	292	~5-9	Parent	6.2	NR	NR
Occasionally	1 week	Gregory et al., 2006	UK	600	8	Parent	10.0	NA	NR
	12 mths[d]	Petit et al., 2007	Canada	1043	5	Parent	11.8	↓[g]	NR
					6		11.3		=
	6 mths	Smedje et al., 1999a	Sweden	1844	5-7	Parent	7.3	NR	NR
	6 mths	Smedje et al., 2001a	Sweden	635	6-8	Parent	8.2	NR	NR
> 2 x /wk	6 mths	Blader et al., 1997	USA	987	5-12	Parent	0.5	NR	=
1-2 x /wk	6 mths	Blader et al., 1997	USA	987	5-12	Parent	0.8	NR	=
> Once/wk	6 mths	Stein et al., 2001	USA	472	4-12	Parent	3.8	↑[f]	NR
Once/wk	6 mths	Simonds & Parraga, 1982	USA	309	5-18	Parent	1.3	↓	=
>7/year	N/A	Ipsiroglu et al., 2002	Austria	332	10-15	Self	1.8	NR	NR

Sleep Walking

Definition	Retrospective period	Author et al., Year	Location	N	Age	Reported	Prevalence	Age change	Sex diff
Every night	6 mths	Stein et al., 2001	USA	472	4-12	Parent	0.4	↑[f]	NR
	N/A	Neveus et al., 2001	Sweden	1413	6-10	Child	0.3	NR	=
Many or every night	N/A	Paavonen et al., 2000	Finland	5813	8-9	Parent	3.3	NA	=
Frequently/always	6 mths	Agargun et al., 2004	Turkey	971	7-11	Parent	1.2	=	=
5-7 x/wk	1 week	Liu et al., 2005a	USA	394	~5-9	Parent	0.5	NR	NR
	1 week	Liu et al., 2005a	China	292	~5-9	Parent	1.0	NR	NR
	6 mths	Smedje et al., 1999a	Sweden	1844	5-7	Parent	0.2	NR	NR
	6 mths	Smedje et al., 2001a[a]	Sweden	635	6-8	Parent	0.5	NR	NR
Frequently	N/A	Carvalho Bos et al., 2009	Portugal	779	6-11	Parent	1.3	NR	NR
Several times a week	6 mths	Quine, 2001	UK	576	4-12	Parent	1.0	=	=
Often	N/A	Wiater et al., 2005	Germany	4531	8-11	Parent	1.0	NR	=
Usually	1 week	Gregory et al., 2006	UK	600	8	Parent	0.0	NA	NR
> 3 x /wk	6 mths	Blader et al., 1997	USA	987	5-12	Parent	0.4	=	=
Sometimes/frequently	7 years [b]	Laberge et al., 2000	Canada	870	3-10	Parent	9.2		NR
	12 mths[c]				11		7.0	↓	=
					12		6.8		NR
					13		3.3		NR
Sometimes	N/A	Wiater et al., 2005	Germany	4531	8-11	Parent	7.0	NR	=
2-4 x/wk	1 week	Liu et al., 2005a	USA	394	~5-9	Parent	3.3	NR	NR
	1 week	Liu et al., 2005a	China	292	~5-9	Parent	5.8	NR	NR
Occasionally	1 week	Gregory et al., 2006	UK	600	8	Parent	8.0	NA	NR
	12 mths[d]	Petit et al., 2007	Canada	1035	5	Parent	4.8	=[g]	NR
					6		7.8		♂
	6 mths	Smedje et al., 1999a	Sweden	1844	5-7	Parent	7.6	NR	NR
	6 mths	Smedje et al., 2001a	Sweden	635	6-8	Parent	10.6	NR	NR
> Once/wk	6 mths	Stein et al., 2001	USA	472	4-12	Parent	2.1	↓[f]	NR
1-2 x /wk	6 mths	Blader et al., 1997	USA	987	5-12	Parent	0.6	=	=
Once/wk	6 mths	Simonds & Parraga, 1982	USA	309	5-18	Parent	2.3	↑ until 9 ↓	=

Sleep Walking (continued)

Definition	Retrospective period	Author et al., Year	Location	N	Age	Reported	Prevalence	Age change	Sex diff
Every week	N/A	Neveus et al., 2001	Sweden	1413	6-10	Child	0.7	NR	=
> once/mth	6 mths	Kahn et al., 1989b	Belgium	972	8-10	Parent	5.0	NR	NR
>7/year	N/A	Ipsiroglu et al., 2002	Austria	332	10-15	Self	0.9		NR
Yes/No	12 mths	Liu et al., 2005b	China	2001	3-5	Parent	0.2	↑	=
				2439	6-10		0.6		=
				904	11-12		0.9		=

Sleep Talking

Definition	Retrospective period	Author et al., Year	Location	N	Age	Reported	Prevalence	Age change	Sex diff
Every night	6 mths	Stein et al., 2001	USA	472	4-12	Parent	4.7	↑[f]	NR
	N/A	Neveus et al., 2001	Sweden	1413	6-10	Child	0.6	NR	=
Frequently/always	6 mths	Agargun et al., 2004	Turkey	971	7-11	Parent	3.9	=	=
5-7 x/wk	1 week	Liu et al., 2005a	USA	406	~5-9	Parent	1.5	NR	NR
	1 week	Liu et al., 2005a	China	292	~5-9	Parent	5.8	NR	NR
	6 mths	Smedje et al., 1999a	Sweden	1844	5-7	Parent	0.9	NR	NR
	6 mths	Smedje et al., 2001a[a]	Sweden	635	6-8	Parent	2.2	NR	NR
Frequently	N/A	Carvalho Bos et al., 2009	Portugal	779	6-11	Parent	10.9	NR	NR
Several times a week	6 mths	Quine, 2001	UK	576	4-12	Parent	13.0	=	=
Usually	1 week	Gregory et al., 2006	UK	600	8	Parent	3.0	NA	NR
Sometimes/frequently	7 years [b]	Laberge et al., 2000	Canada	870	3-10	Parent	37.1		NR
	12 mths[c]				11		32.5	=	♂
					12		30.1		NR
					13		29.2		NR
2-4 x/wk	1 week	Liu et al., 2005a	USA	406	~5-9	Parent	21.7	NR	NR
	1 week	Liu et al., 2005a	China	292	~5-9	Parent	14.7	NR	NR
Occasionally	1 week	Gregory et al., 2006	UK	600	8	Parent	32.0	NA	NR
	12 mths[d]	Petit et al., 2007	Canada	1041	5	Parent	60.9	↑ until 5 ↓[g]	NR
					6		58.1		=
	6 mths	Smedje et al., 1999a	Sweden	1844	5-7	Parent	54.5	NR	NR
	6 mths	Smedje et al., 2001a	Sweden	635	6-8	Parent	53.7	NR	NR
> Once/wk	6 mths	Stein et al., 2001	USA	472	4-12	Parent	15.0	↔[f]	NR
	6 mths	Kahn et al., 1989b	Belgium	972	8-10	Parent	7.0	NR	NR
Once/wk	6 mths	Simonds & Parraga, 1982	USA	309	5-18	Parent	12.7	NR	=
Every week	N/A	Neveus et al., 2001	Sweden	1413	6-10	Child	4.7	NR	=
Yes/No	12 mths	Liu et al., 2005b	China	2001	3-5	Parent	4.3		=
				2439	6-10		4.7	=	=
				904	11-12		5.5		=

Nocturnal leg movements

Definition	Retrospective period	Author et al., Year	Location	N	Age	Reported	Prevalence	Age change	Sex diff
5-7 x/wk	6 mths	Smedje et al., 2001a[a]	Sweden	635	6-8	Parent	0.3	NR	NR
Often	N/A	Wiater et al., 2005	Germany	4531	8-11	Parent	1.0	NR	=
						Child	2.0	NR	=
Sometimes/frequently	7 years [b]	Laberge et al., 2000	Canada	870	3-10	Parent	-		NR
	12 mths[c]				11		18.8	=	♀
					12		15.9		NR
					13		17.6		NR
Sometimes	N/A	Wiater et al., 2005	Germany	4531	8-11	Parent	4.0	NR	=
						Child	10.0	NR	=
Occasionally	6 mths	Smedje et al., 2001a	Sweden	635	6-8	Parent	30.2	NR	NR
Yes/No	12 mths	Liu et al., 2005b	China	2001	3-5	Parent	1.1	↑ until 6-10	=
				2439	6-10		2.4	=	=
				904	11-12		2.0		=

Restless Sleep

Definition	Retrospective period	Author et al., Year	Location	N	Age	Reported	Prevalence	Age change	Sex diff
Every night	N/A	Neveus et al., 2001	Sweden	1413	6-10	Child	1.4	NR	=
5-7 x/wk	1 week	Liu et al., 2005a	USA	400	~5-9	Parent	6.3	NR	NR
	1 week	Liu et al., 2005a	China	292	~5-9	Parent	16.8	NR	NR
	6 mths	Smedje et al., 1999a	Sweden	1844	5-7	Parent	2.6	NR	NR
	6 mths	Smedje et al., 2001a[a]	Sweden	635	6-8	Parent	4.9	NR	NR
Several times a week	6 mths	Quine, 2001	UK	576	4-12	Parent	26.0	=	=
Usually	1 week	Gregory et al., 2006	UK	600	8	Parent	13.0	NA	NR
2-4 x/wk	1 week	Liu et al., 2005a	USA	400	~5-9	Parent	28.8	NR	NR
	1 week	Liu et al., 2005a	China	292	~5-9	Parent	19.5	NR	NR
Occasionally	1 week	Gregory et al., 2006	UK	600	8	Parent	34.0	NA	NR
	6 mths	Smedje et al., 1999a	Sweden	1844	5-7	Parent	41.5	NR	NR
	6 mths	Smedje et al., 2001a	Sweden	635	6-8	Parent	41.8	NR	NR
Once/wk	6 mths	Simonds & Parraga, 1982	USA	309	5-18	Parent	7.5	NR	=
Every week	N/A	Neveus et al., 2001	Sweden	1413	6-10	Child	5.1	NR	=
Yes/No	12 mths	Liu et al., 2005b	China	2001	3-5	Parent	5.6		=
				2439	6-10		3.9	↓	=
				904	11-12		3.4		=

Bedtime Resistance

Definition	Retrospective period	Author et al., Year	Location	N	Age	Reported	Prevalence	Age change	Sex diff
Every night	6 mths	Stein et al., 2001	USA	472	4-12	Parent	4.9	↓[f]	NR
	6 mths	Blader et al., 1997	USA	987	5-12	Parent	10.5	=	=
5-7 x/wk	1 week	Liu et al., 2005a	USA	402	~5-9	Parent	2.7	NR	NR
	1 week	Liu et al., 2005a	China	292	~5-9	Parent	1.7	NR	NR
	6 mths	Smedje et al., 1999a	Sweden	1844	5-7	Parent	6.0	NR	NR
	6 mths	Smedje et al., 2001a[a]	Sweden	635	6-8	Parent	6.2	NR	NR
Frequently	N/A	Carvalho Bos et al., 2009	Portugal	779	6-11	Parent	13.0	NR	NR
Several times a week	6 mths	Quine, 2001	UK	576	4-12	Parent	27.0	↓	=
Usually	1 week	Gregory et al., 2006	UK	600	8	Parent	3.0	NA	NR
	1 week	Gregory et al., 2006	UK	600	8	Child	15.0	NA	NR
2-4 x/wk	1 week	Liu et al., 2005a	USA	402	~5-9	Parent	6.2	NR	NR
	1 week	Liu et al., 2005a	China	292	~5-9	Parent	5.1	NR	NR
Occasionally	1 week	Gregory et al., 2006	UK	600	8	Parent	14.0	NR	NR
	1 week	Gregory et al., 2006	UK	600	8	Child	32.0	NR	NR
	6 mths	Smedje et al., 1999a	Sweden	1844	5-7	Parent	51.6	NR	NR
	6 mths	Smedje et al., 2001a	Sweden	635	6-8	Parent	52.6	NR	NR
> Once/wk	6 mths	Stein et al., 2001	USA	472	4-12	Parent	9.7	↓[f]	NR
1-2 x /wk	6 mths	Blader et al., 1997	USA	987	5-12	Parent	22.1	=	=
Once/wk	6 mths	Simonds & Parraga, 1982	USA	309	5-18	Parent	3.6	↓	=

Night Wakings

Definition	Retrospective period	Author et al., Year	Location	N	Age	Reported	Prevalence	Age change	Sex diff
Every night	6 mths	Blader et al., 1997	USA	987	5-12	Parent	2.3	↓	=
	N/A	Neveus et al., 2001	Sweden	1413	6-10	Child	4.6	NR	=
Many or every night	N/A	Paavonen et al., 2000	Finland	5813	8-9	Parent	7.1	NA	=
5-7 x/wk	1 week	Liu et al., 2005a	USA	402	~5-9	Parent	4.5	NR	NR
	1 week	Liu et al., 2005a	China	292	~5-9	Parent	19.2	NR	NR
	6 mths	Smedje et al., 1999a	Sweden	1844	5-7	Parent	8.7	NR	=
	6 mths	Smedje et al., 2001a[a]	Sweden	635	6-8	Parent	10.6	NR	NR
Several times a week	6 mths	Quine, 2001	UK	576	4-12	Parent	13.0	↓	=
Often	N/A	Wiater et al., 2005	Germany	4531	8-11	Parent	3.0	NR	=
Usually	1 week	Gregory et al., 2006	UK	600	8	Parent	6.0	NA	NR
Sometimes	N/A	Wiater et al., 2005	Germany	4531	8-11	Parent	29.0	NR	=
2-4 x/wk	1 week	Liu et al., 2005a	USA	402	~5-9	Parent	20.6	NR	NR
	1 week	Liu et al., 2005a	China	292	~5-9	Parent	15.8	NR	NR
Occasionally	1 week	Gregory et al., 2006	UK	600	8	Parent	21.0	NA	NR
	12 mths[d]	Petit et al., 2007	Canada	988	5	Parent	17.0	↓[g]	NR
					6		13.2		=
	6 mths	Smedje et al., 1999a	Sweden	1844	5-7	Parent	51.5	NR	=
	6 mths	Smedje et al., 2001a	Sweden	635	6-8	Parent	46.9	NR	NR
1-2 x /wk	6 mths	Blader et al., 1997	USA	987	5-12	Parent	6.0	↓	=
Every week	N/A	Neveus et al., 2001	Sweden	1413	6-10	Child	8.7	NR	=
>7/year	N/A	Ipsiroglu et al., 2002	Austria	332	10.5-15.9	Parent	7.2	NR	NR

Sleep Onset Problems

Definition	Retrospective period	Author et al., Year	Location	N	Age	Reported	Prevalence	Age change	Sex diff
Every night	6 mths	Blader et al., 1997	USA	987	5-12	Parent	3.2	=	=
	6 mths	Stein et al., 2001	USA	472	4-12	Parent	8.3	=[f]	NR
	N/A	Neveus et al., 2001	Sweden	1413	6-10	Child	2.5	NR	=
Many or every night	N/A	Paavonen et al., 2000	Finland	5813	8-9	Parent	11.1	NA	=
5-7 x/wk	1 week	Liu et al., 2005a	USA	415	~5-9	Parent	5.1	NR	NR
	1 week	Liu et al., 2005a	China	292	~5-9	Parent	7.9	NR	NR
	6 mths	Smedje et al., 1999a	Sweden	1844	5-7	Parent	2.2	NR	=
	6 mths	Smedje et al., 2001a[a]	Sweden	635	6-8	Parent	3.8	NR	NR
Usually	1 week	Gregory et al., 2006	UK	600	8	Parent	17.0	NA	NR
	1 week	Gregory et al., 2006	UK	600	8	Child	45.0	NA	NR
Often	N/A	Wiater et al., 2005	Germany	4531	8-11	Parent	6.0	NR	=
						Child	10.0	NR	=
Sometimes	N/A	Wiater et al., 2005	Germany	4531	8-11	Parent	22.0	NR	=
						Child	35.0	NR	=
2-4 x/wk	1 week	Liu et al., 2005a	USA	415	~5-9	Parent	15.9	NR	NR
	1 week	Liu et al., 2005a	China	292	~5-9	Parent	12.3	NR	NR
Occasionally	1 week	Gregory et al., 2006	UK	600	8	Parent	32.0	NA	NR
	1 week	Gregory et al., 2006	UK	600	8	Child	31.0	NA	NR
	12 mths[d]	Petit et al., 2007	Canada	1045	5	Parent	10.0	↓[g]	NR
					6		7.4		=
	6 mths	Smedje et al., 1999a	Sweden	1844	5-7	Parent	58.3	NR	=
	6 mths	Smedje et al., 2001a	Sweden	635	6-8	Parent	59.1	NR	NR
1-2 x /wk	6 mths	Blader et al., 1997	USA	987	5-12	Parent	12.9	=	=
> Once/wk	6 mths	Stein et al., 2001	USA	472	4-12	Parent	15.0	↔[f]	NR
Every week	N/A	Neveus et al., 2001	Sweden	1413	6-10	Child	11.4	NR	=

Daytime Sleepiness

Definition	Retrospective period	Author et al., Year	Location	N	Age	Reported	Prevalence	Age change	Sex diff
Every night	6 mths	Stein et al., 2001	USA	472	4-12	Parent	4.0	↑[f]	NR
	N/A	Neveus et al., 2001	Sweden	1413	6-10	Child	0.4	NR	=
Several times a week	6 mths	Quine (2001)	UK	576	4-12	Parent	3.0	↓ until 6-8 =	♂
5-7 x/wk	1 week	Liu et al., 2005a	USA	403	~5-9	Parent	0.2	NR	NR
	1 week	Liu et al., 2005a	China	292	~5-9	Parent	4.5	NR	NR
	6 mths	Smedje et al., 1999a	Sweden	1844	5-7	Parent	0.4	NR	NR
	6 mths	Smedje et al., 2001a[a]	Sweden	635	6-8	Parent	0.3	NR	NR
Frequently	N/A	Carvalho Bos et al., 2009	Portugal	779	6-11	Parent	2.6	NR	NR
Often	6 mths	Liu et al., 2000a	China	2004	6-12	Teacher	0.5	=	=
	N/A	Wiater et al., 2005	Germany	4531	8-11	Parent	1.0	NR	♀
						Child	3.0	NR	=
Usually	1 week	Gregory et al., 2006	UK	600	8	Parent	2.0	NA	NR
	1 week	Gregory et al., 2006	UK	600	8	Child	20.0	NA	NR
Sometimes	6 mths	Liu et al., 2000a	China	2004	6-12	Teacher	8.9	=	=
	N/A	Wiater et al., 2005	Germany	4531	8-11	Parent	18.0	NR	♀
						Child	22.0	NR	=
2-4 x/wk	1 week	Liu et al., 2005a	USA	403	~5-9	Parent	23.8	NR	NR
	1 week	Liu et al., 2005a	China	292	~5-9	Parent	16.4	NR	NR
Occasionally	1 week	Gregory et al., 2006	UK	600	8	Parent	41.0	NR	NR
	1 week	Gregory et al., 2006	UK	600	8	Child	43.0	NR	NR
	6 mths	Smedje et al., 1999a	Sweden	1844	5-7	Parent	47.8	NR	NR
	6 mths	Smedje et al., 2001a	Sweden	635	6-8	Parent	57.9	NR	NR
> Once/wk	6 mths	Stein et al., 2001	USA	472	4-12	Parent	17.0	↓[f]	NR
Once/wk	6 mths	Simonds & Parraga, 1982	USA	309	5-18	Parent	4.9	NR	=
Every week	N/A	Neveus et al., 2001	Sweden	1413	6-10	Child	3.6	NR	=
>7 x/year	N/A	Ipsiroglu et al., 2002	Austria	332	10-15	Child	11.1	NR	NR
Yes / no	6 mths	Blader et al., 1997	USA	987	5-12	Parent	17.8	=	=

1.6.1 Prevalence of sleep problems in school-aged children

The above table demonstrates that prevalence rates of sleep problems vary substantially around the world. Direct comparisons of prevalence rates are impossible due to the differing methodologies but in general the dyssomnia type problems appear to be more prevalent in school-aged children than the parasomnias. That is, overall problems such as bedtime resistance and sleep onset problems were more commonly reported than nightmares or sleep walking.

Unquestionably the largest influence on the reported prevalence of any sleep problem is how it is defined. Aside from the symptomology of the sleep problem, classification comprises of main two components: frequency and duration (American Sleep Disorders Association, 1990). The operational difficulty with omnibus studies however is that not all sleep problems occur at the same frequency or over the same period of time. For example, sleep walking is considered chronic but moderate if it has occurred more than once per month for the previous 3 months while sleep talking is considered chronic but moderate if it has occurred more than once per week over the previous year (ASDA, 1990). In addition, what constitutes normal and problematic sleep for parents is highly subjective and is often dependent on the amount of disruption caused to the parents (Owens, 2007). As a result the definition of when a particular sleep behaviour becomes a problem is often arbitrarily based. For example, Blader et al. (1997) defined bedtime resistance, sleep onset difficulty and night waking a problem if it occurred 3 or more times per week in the last 6 months. Enuresis was considered a problem if it occurred more than once per week. Other studies, such as that by Petit et al. (2007), used more subjective language in their definition. In that study, the presence of a sleep problem was recorded if it occurred "occasionally" over the previous 12 months. These differences in definition have a great impact on the reported results.

Without exception, the highest prevalence rates are yielded by those studies which use subjective language and long retrospective periods in their classification method (see Table 1.3). Definitions which incorporated specific frequencies (e.g. 5-7 times per week) over shorter time frames (e.g. in the past week) yielded lower, but not necessarily the lowest, prevalence rates. The lack of consistency in definition is concerning, particularly considering that the research may be used to inform health professionals as to the pervasiveness of a sleep problem in the community. If, by definition, a sleep problem yields a low prevalence, it may not be considered an important health consideration and ignored. If, on the other hand, a particular definition yields a high prevalence, it may be oversubscribed and consequently misdiagnosed as the cause of health or behavioural concerns without alternate considerations. While current validated questionnaires have many merits (see below), development of a universal tool which provides standard definitions and allows for direct cross-cultural comparisons is well overdue.

1.6.2 Developmental changes in prevalence of sleep problems

Establishing a pattern of developmental change from the cross-sectional literature is difficult as the majority of studies group the ages and report data together (Carvalho Bos et al., 2009; Ipsiroglu et al., 2002; Kahn et al., 1989a; Smedje et al., 1999a, 2001b; Wiater et al., 2005). Other studies have reported prevalence rates across age groups but did not statistically examine differences (Stein et al., 2001) or controlled for age in the comparative analysis (Liu et al., 2005a). The cross-sectional studies that do report age-related changes in the prevalence of sleep problems predominantly report no change or a decrease in prevalence with age (Blader et al., 1997; Liu et al., 2000b; Quine, 2001; Simonds & Parraga, 1982). However, there are some inconsistencies depending on the particular sleep problem and how it is defined.

A better understanding of the developmental course of sleep problems comes from the examination of the longitudinal studies, limited as they may be. To date, there have been two studies, both conducted in Canada, which have taken an omnibus approach to the examination of sleep problems. Petit et al. (2007) conducted a longitudinal study of the prevalence and natural history of dyssomnias and parasomnias in 1,997 children from 29 months of age to 6 years (final N = 1,492). That study reported a decrease in the prevalence of enuresis, night terrors, night awakenings and sleep onset problems with increasing age. The prevalence of bruxism increased, while sleep walking showed no change. The prevalence of sleep talking increased until age 5 and then decreased (see Table 1.3). Laberge et al. (2000) examined parasomnias and dyssomnias in children (N=1,353) retrospectively at age 10, and then longitudinally each year until age 13. Consistent with Petit et al. that study found the prevalence of enuresis and night terrors decreased with increasing age. Contrary to Petit et al., Laberge et al. reported a decrease in the prevalence of bruxism and sleep walking with advancing age. The prevalence of sleep talking and nocturnal leg movements did not change with age (see Table 1.3).

Taken together these results suggest the developmental course of some sleep problems, such as bruxism or sleep walking, may peak in mid-childhood. This has been supported by other studies such as that of Agargun et al. (2004) who reported the prevalence of bruxism to peak at 9 years and then decline rapidly between 10 and 11 years (N=971). Simonds and Parraga (1982) reported sleep walking to peak at 9 years. Other sleep problems, such as enuresis or nightmares, appear to have a linear developmental course, suggesting that occurrence may coincide with physical, cognitive and emotional development in children.

Firm conclusions on the developmental course of the prevalence of sleep problems cannot be made due to the limited studies and differing definitions, however overall it appears that as children age, the prevalence of sleep problems reduce. It must be acknowledged that a decrease in prevalence could also be due to psychosocial factors. That is, as children age they may be more likely to self-sooth and establish independent sleeping routines (Mindell & Meltzer, 2008) resulting in less interaction with parents during the night. Accurate knowledge of age-related changes in prevalence rates is vital in determining whether a particular sleep problem is a concern or simply a developmental consequence. As such, development of standard definitions and further longitudinal studies are required.

1.6.3 Sex differences in the prevalence of sleep problems

Similar to developmental trends, the examination of sex differences in epidemiological studies of sleep problems in school-aged children is rare. When sex differences are examined, most sleep problems show equivalent prevalence rates in boys and girls. The two exceptions are enuresis and nightmares (see Table 1.3).

The most common and consistent sex difference seen in Table 1.3 is in nocturnal enuresis where higher prevalence rates are reported in boys. The predominance of bedwetting in boys is also well demonstrated in the enuresis literature (for review see Hjalmas, 1998). Interestingly, the studies of Neveus et al. (2001) and Wiater et al. (2005) found no sex difference in nocturnal enuresis when reported by the children themselves. One can only speculate why this may be the case. Perhaps the boys were too embarrassed to report the frequency of their bedwetting. Indeed, in Wiater et al.‟s study parent-reported prevalence of bedwetting was twice that of child-reported bedwetting.

Reports on sex differences in nightmares are not as clear. While the majority of studies in Table 1.3 show no difference, two report higher prevalence of nightmares in boys (Liu et al., 2000b; Paavonen et al., 2000), and two report higher prevalence in girls (Simonds & Parraga, 1982; Smedje et al., 1999a). Examination of these studies provides no clear answer for the inconsistent results. All four studies were cross-sectional, parent-report questionnaire studies. Although the frequency of occurrence was different, similar language was used to describe a nightmare, limiting the confounder of perception. Therefore, it may be that these findings are due to particulars of each specific cohort and not a sex effect of nightmares.

Overall there appears to be very little difference in the prevalence of sleep problems between school-aged boys and girls, except perhaps in enuresis and sleep disordered breathing (SDB) which has been described in Lumeng and Chervin (2008). The impact of these sex differences, or lack of, on the daytime consequences of sleep problems is unknown. As behavioural expression manifests differently in boys and girls (i.e. hyperactivity is more common in boys; Biederman & Faraone, 2005) this is an important consideration for future research.

1.6.4 Cultural difference in the prevalence of sleep problems

Once again, due to the difference in reporting methodology, it is impossible to reach conclusions regarding whether culture influences prevalence rates of sleep problems. To date only one study has compared the prevalence of sleep problems across two countries. Liu et al. (2005a) conducted a study that compared parent-reported sleep problems as defined on the Child Sleep Habits Questionnaire (CSHQ) in an American (N=391) and Chinese (N=292) cohort of school-aged children from grades 1-4. For the most part, a higher prevalence of nocturnal sleep problems was reported for the Chinese cohort (see Table 1.3). The American cohort, however, reported a higher prevalence of daytime sleepiness indicators. As with developmental changes, this difference may be mediated parental awareness. In China, it is common practice for the child to co-sleep or room share with siblings or parents (Li et al., 2008; Liu et al., 2003) whereas this is not the case in most American households (Latz et al., 1999; Lozoff et al., 1996). Therefore, Chinese parents may be more aware of nocturnal problems than their American counterparts. As daytime sleepiness is regarded as a symptom of nocturnal disturbance (Fallone et al., 2002), it may be that the prevalence of sleep problems in the American cohort were under-reported. Indeed, studies examining cultural differences in sleep practices in multi-cultural societies have reported a higher prevalence of sleep problems in children who co-sleep or room share due to cultural preference or economic constraints (Lozoff et al., 1996).

The cultural aspect of sleep problems in children is an area of research greatly neglected. This is an important oversight as a sleep problem that is considered pathologic in one culture may be considered normal or even advantageous in another (Owens, 2005). For example, in China it has been reported that boys who snore are strong and masculine (Owens, 2005). These cultural beliefs would limit parents seeking health advice and may place the child at risk.

Sleep problems in children have been associated with concerning daytime sequelae such as behavioural (Gregory & O'Connor, 2002) and academic (Curcio et al., 2006) deficits, and physical health concerns such as obesity (Cappuccio et al., 2008) and cardiovascular disease (Gozal et al., 2008). In addition, Meltzer and Mindell (2007) reported a relationship between sleep disturbance in children and maternal mood. In that study, child sleep appeared a significant mediating factor between maternal sleep disruption, mood, stress and fatigue.

Consequently, accurate knowledge of the prevalence and biopsychosocial influences of sleep problems in the community is vital, not only for the health management of children, but also for the potential influence on family functioning.

1.7 ASSOCIATIONS BETWEEN SLEEP AND BEHAVIOUR IN SCHOOL-AGED CHILDREN

Overall, very little is known about the developmental and cultural aspects of sleep problems in school-aged children. One reason for the limited attention may be that, for the most part, sleep problems appear to resolve naturally over time as shown by a decreasing prevalence with age (see Table 1.3). Indeed, Clarkson and colleagues (1986) have questioned whether sleep problems in school-aged children are worthy of concern. They reported that sleep problems in middle childhood are "infrequent, do not persist, are inconsistently reported by parent and child and do not identify a psychologically disturbed group of children" (p35). They went on to suggest that sleep problems are "for the most part, benign and should be regarded as such by parents and family physicians alike" (p35). This statement may be warranted in the context of their longitudinal study in which only 0.3% of children (5-9 years) were reported to have a persistent sleep problem and less than 14% reported a sleep problem at any particular point in time. However, such a statement is misleading considering that sleep problems in this study were defined by one question either to the parents – "Does the child have a sleep problem?" – or to the child when tested at 9 years – "My sleep is pretty good". A positive answer in the former, or negative answer in the latter, constituted having an overall sleep problem (Clarkson et al., 1986). More rigorous research has since shown a substantial proportion of children experience frequent sleep problems which do persist (Laberge et al., 2001; Petit et al., 2007) and considering them benign may be placing a child at risk of, at the very least, behavioural problems. This in turn could have a considerable impact on academic performance (Curcio et al., 2006) and family functioning (El-Sheikh et al., 2006; Benoit et al., 1992; Keller et al., 2008; Meltzer & Mindell, 2007).

1.7.1 Sleep Duration and Behaviour

There is an extensive body of research in the adult literature to suggest that short sleep duration impairs cognitive and behavioural functioning (for review see Pilcher & Huffcutt, 1996). Dahl (1996a) suggested that there is a neurobiological mechanism that controls the association between sleep and behaviour. This model postulates that the pre-frontal cortex, which is involved in both modulating appropriate behavioural responses and regulation of sleep, is the mechanism in which sleep and behaviour are linked. Indeed, Horne (1993) has reported that sleep deprivation in adults impairs pre-frontal cortex functioning which results in a reduction in executive control. The association between sleep duration and behaviour in paediatric studies however, is inconclusive with studies reporting inconsistent behavioural manifestations of both short and long sleep durations.

Nixon et al. (2008) reported an association between short sleep duration (<9hrs, actigraphy measured) and emotional lability, as measured on the Connor‟s Rating Scale, in a large study of 7-year-old children in New Zealand (N=591). However, compared to other correlates of short sleep duration such as obesity (B=3.86, p=0.0004), the relationship between emotional lability and short sleep duration was not strong (*B*=0.18, *p*=0.03). No other associations between short sleep duration and behavior or daytime sleepiness were found. Notably, sleep duration in that study was measured through 24 hours actigraphy monitoring. An actigraph is a device, usually worn on the wrist that measures light and movement. It has been well validated as an effective measure of sleep and wake in children (Acebo et al., 2005; Sadeh et al., 1995; Sung et al., 2009). Whilst this provided a „snapshot‟ of sleep in the sample, longer monitoring to determine a regular sleep pattern is required before these findings can be confirmed.

Longer actigraphy monitoring was employed in Aronen et al. (2000) study and failed to find a relationship between short sleep duration and emotional lability (or internalising behaviours as defined in the Child Behavior Checklist: CBCL). That study measured sleep patterns in a sample of 49 school-aged children with 72-hour actigraphy monitoring and found that children with short sleep duration (<9hrs) had more teacher reported externalising behaviours (aggression and delinquent behaviours) as measured on the Child Behaviour Checklist (CBCL) than children with a sleep duration greater than 9 hours. No association was found between short sleep duration and parent-reported CBCL measures. The small sample however demands that the results are interpreted with caution, especially considering a greater proportion of children slept less than 9 hours (67%).

In a more controlled study, Fallone et al. (2005) experimentally manipulated sleep duration over a 3 week period and did not find an association between short sleep duration and teacher-reported externalising behaviours. In that study, 74 children participated in a 3-week counter-balanced experimental study during which self-selected sleep duration was restricted (8hrs TIB for grade 1&2; 6.5hrs TIB ≥ grade 3) and then optimized (≥10hrs TIB) for one-week each. Teachers, blinded to the experimental condition, were asked to rate the children‟s academic performance and classroom behaviour. Teachers reported an increase in inattentive behaviours during the restriction period, but no change in hyperactive or impulsive behaviours. This lead the authors to suggest that insufficient sleep may not be a causal link in hyperactive and impulsive behaviour as previously supposed.

Conversely, long sleep duration has also been associated with behavioural problems in children. Gau (2006) reported that children with a T-score greater than 60 on the teacher reported ADHD-index of the Connors Teachers Rating scales slept significantly longer on school-days than children without abnormal ADHD scores (N=2584; age= 6-15 years). The same trend was reported in the parent-reported ADHD scores, however did not reach significance. Carvalho Bos et al. (2009) also recently reported children with teacher-reported hyperactive behaviours on the Rutter B2 scale slept significantly longer than children without these behaviours (N=779, age=7-11 years).

Carvalho Bos et al. (2009) speculated that the longer sleep periods in children with hyperactivity/conduct problems could be due to a hypoarousal state. That is, the intrinsic sleepiness caused by energy expenditure in these children result in a need for longer sleep to allow for recovery. Psychophysiology research has reported that children with diagnosed conduct disorders display autonomic hypoarousal (Herpertz et al., 2007), however very little research has been conducted into the effects of long sleep duration. In adults, long sleep duration has been associated more with a variety of internalising psychological variables such as social introversion, decreased adaptability (Hartmann et al., 1971), depression (Patel et al., 2006) and anxiety (Ohayon et al., 2004). It may be possible that the results of Gau (2006) and Carvalho Bos et al. (2009) are indicative of some hypoarousal state which leads to extended sleep periods, however it is more likely that these children are simply spending more time in bed due to poor sleep consolidation caused by increased fragmentation, night awakenings and extended sleep latency (for review see Grandner & Drummond, 2007; Ivanenko et al., 2006). The fragmentation, night awakenings and extended sleep latency may not necessarily be observed by parents and thus mistakenly recorded as sleep time.

Nonetheless, these results imply that a U-shaped relationship may exist, with both short and long sleep periods affecting daytime behavioural outcomes. The U-shaped effects of sleep duration have been observed in adults in other areas of health and well-being such as risk of diabetes (Yaggi et al., 2006) and obesity (Bjorvatn et al., 2007). For example, Yaggi et al. (2006) observed a cohort of men (N=1139; aged 40-70 years) without diabetes at baseline over a period of 15-17 years and revealed that when compared with 7 hours per night, those with a nocturnal sleep duration of less than 5 or greater than 8 hours were twice and three times more likely to develop diabetes, respectively. This relationship remained even after controlling for other related factors such as weight and smoking status.

The methodological concerns, limited research and mixed results suggest that any relationship between sleep duration and behaviour in children is a tentative one. However, the U-shaped relationship is an area worth further examination. Akin to other areas of health and well-being such as food consumption, moderation rather than deprivation or abundance may be most advantageous when it comes to sleep duration.

1.7.2 Sleep Problems and Behaviour

Associations between sleep problems, such as sleep disordered breathing, and behavioural deficits are fairly well established. A comprehensive review by Beebe

(2006a) revealed that the common behavioural associates with SDB are externalising behaviours such as hyperactivity, rebelliousness and aggression. Inattention has also been implicated as a behavioural manifestation of SDB, however findings are not as consistent. There appears to be little or no association between SDB and internalising behaviours, such as emotional regulation and mood (Beebe, 2006a). Behavioural manifestations of sleep problems other than SDB have not been as well or extensively studied yet a trend has emerged from the limited research. It appears that dyssomnias are more likely to be associated with externalising behaviours and parasomnias with internalising behaviours.

An examination of the relationship between sleep problems and behaviour in children was conducted by Gau (2006). In this study, parents of 2584 children aged 6-15 years completed an author devised Sleep Habits Questionnaire and Connors" Parent Rating scale. Teachers also completed the Connors" Teachers Rating Scales for all subjects. Sleep problem items were factor analysed and regression analysis was conducted to determine the predictive relationships between the sleep problem factors and problem behaviours (T-scores >60) on each of the Connors" sub-scales. Results found that children with dyssomnias – insomnia, circadian rhythm dysfunction and PLMS – were up to 3 times more likely to score in the abnormal range of parent-reported inattention, hyperactivity-impulsivity, oppositional behaviour and ADHD-index. The magnitude of this relationship was greater in boys. Reports of parasomnias – nightmares, enuresis, sleep talking, bruxism, sleep walking, and sleep terrors – also increased the risk of scoring highly on these sub-scales, however not to the same extent (Odds Ratio <2). No sex effect was found in the relationship between parasomnias and behaviour.

Stein et al. (2001) reported strong associations between parasomnias – night terrors, nightmares, sleep walking, and head banging – and high scores on the anxious/depressed, thought and social problem sub-scales on the CBCL (17, 21 and 22% of the variance explained, respectively). In this study, insomnia-related behaviours – long sleep latency, too much energy to sleep, and frequent waking – revealed a lesser association with anxious/depressed, attention and somatic problem sub-scales on the CBCL (15, 18 and 19% of the variance explained, respectively).

Petit et al. (2007) compared children who reported persistent sleep problems up to the age of 6 years with children who had never reported experiencing sleep problems on three behavioural outcomes: separation anxiety, hyperactivity-inattention, and aggressive behaviour. Proportionately more children with persistent night waking, sleep walking, sleep terrors, sleep talking and bruxism than without were reported to score above the 90th percentile of separation anxiety. Hyperactivity-inattentive scores above the 90th percentile were more common in children with persistent sleep walking. No difference between groups was found in reports of aggressive behaviour.

Wiater et al. (2005) reported significant associations between sleep problems and all sub-scales on the Strengths and Difficulties Questionnaire (SDQ) as reported by parents and children in a large German cohort study (N=4531, age 8-11 years). According to those results, sleep onset delay and problems sleeping through the night were most likely to result in emotional problems. The relative risk of hyperactivity or conduct problems were lower than emotional problems, however were still over twice as likely with these sleep problems than without. Examination of just two sleep problems, especially so poorly defined, does not provide a full understanding of the relationship between sleep and behaviour however. Using the same behavioural measure, Smedje et al. (2001a) also reported night terrors and difficulty falling asleep significantly increased the risk of emotional lability [Odds Ratio (OR) = 3.3 and 2.7 respectively]. In that study, children who tossed and turned during the night, sleep walked and had bedtime resistance were more than twice as likely to exhibit signs of hyperactivity. This relationship was more apparent in boys than girls. Tossing and turning and bedtime resistance were also associated with conduct problems (OR = 2.1 and 2.6 respectively); unsurprising considering the high correlation between hyperactivity and conduct problems. When hyperactivity was controlled, only bedtime resistance showed to be a significant predictor of conduct problems (OR = 2.3).

Thus, although limited, there is emerging evidence that a relationship between sleep problems and behaviour exists. Due to the nature of the epidemiological study designs however there is some controversy surrounding the cause and effect relationship. Indeed, it must be noted that while proportionately more children with persistent sleep problems in Petit et al."s study reported scores in the 90th percentile of problem behaviours, a substantial proportion of children without sleep problems also reported problem behaviours. In that study 16.5% of children without sleep walking, 14.8% without sleep terrors and 10.8% without sleep talking reported high separation anxiety scores. This suggests that rather than being causal, sleep problems may simply exacerbate or be a symptom of an existing problem. For example, it is not surprising that children with conduct problems show bedtime resistance. Bedtime schedules are usually enforced as „rules". Children who exhibit conduct problems are classed as disobedient and defiant and are unlikely to submit easily to „rules". Similarly, it is understandable that a child would have difficulty falling asleep, perhaps due to being scared of the dark or experiencing nightmares, if they were naturally anxious or worrisome.

Mindell and Barrett (2002) reported children (N=60) aged 5 to 11 years experienced nightmares three or more times per week had significantly higher trait anxiety scores than those experiencing nightmares either monthly or annually.

Nonetheless, the emerging intervention and treatment research in community samples, particularly in pre-school children (Hiscock et al., 2008; Minde et al., 1994), suggest that an improvement in sleep will also result in a concomitant improvement in behaviour. Intervention and treatment studies in school-aged children with sleep problems other than sleep disordered breathing are scarce, yet would be beneficial in determining the true relationship and ultimate importance of sleep problems on daytime behaviour. This in turn may have a substantial impact on reducing the subscription of psychotropic medication for behavioural problems in children.

1.8 METHODLOGICAL PROBLEMS OF STUDYING SLEEP IN A LARGE POPULATION: SLEEP QUESTIONNAIRES

Undoubtedly the most effective way to examine sleep/wake behaviours and sleep problems in children is objectively with measures such as actigraphy or polysomnography (PSG). These methods, however, are costly, time consuming and not always logistically viable for large populations. Thus, irrespective of the accuracy and reporter-bias issues involved with parent- or self-report retrospective questionnaires, survey study designs are still the only cost effective way to gather sleep information from large populations. Unfortunately, although several paediatric sleep questionnaires have been developed and utilised over the past 25 years, methodological limitations continue to restrict knowledge.

One method of gathering information on sleep problems in large community samples of children has been to use sleep questions which are embedded into an existing validated, but not sleep specific, questionnaire. For example, Gregory and

O'Connor (2002) used the 5 sleep questions embedded in the Child Behavior Checklist to examine if sleep problems at age 4 years were predictive of behavioural concerns during adolescence. Similarly, Paavonen et al. (2000) utilised the sleep questions within the Rutter A1 to determine the frequency of sleep problems in their sample. While this method ensures validity of the questions, it does not provide for an extensive examination of sleep problems as questions are usually limited and generic.

More often sleep questionnaires are devised by the author‟s based on past experience and/or literature reviews (Bruni et al., 1996; Carvalho Bos et al., 2009; Kahn et al., 1989b; Smedje et al., 2001a; Stein et al., 2001; Wiater et al., 2005). This method does allow for a more in-depth examination of sleep problems yet the quality of the questions vary from vague, generalised statements based on symptomology (eg: Do you snore? Neveus et al., 2001) to sets of specific, well defined questions based on diagnostic criteria (eg: 1. The child has difficulty breathing during the night. 2. The child gasps for breath and is unable to breath during sleep. 3. The child snores. Bruni et al., 1996).

Authors have also utilised clinical diagnostic criteria to develop their sleep questions. For example, Gau (2006) utilised the DSM-IV to develop a set of questions for their Sleep Habits Questionnaire. Similarly, Simonds and Parraga (1982) based the majority of their questions on the four groups of arousal and sleep disorders recognised by the DSM-III (American Psychiatric Association, 1980). They recognised that the DSM-III did not cover all sleep concerns and also included sleep-related problems which had been clinically observed. Owens et al., 2000a) devised a set of parent-report sleep behaviour questions based on the common clinical symptoms of sleep disorders presented in the *International Classification of Sleep Disorders* (ASDA, 1990). These questions formed the Child

Sleep Habits Questionnaire (CSHQ) which has become the most widely used sleep problems questionnaire in paediatric sleep research. The CSHQ has also been adapted into a child self-report questionnaire (Owens et al., 2000b).

Regardless of the method used to devise the questions, very few of the omnibus questionnaires examining sleep problems in school-aged children have undergone a reliability and/or validation process. Some authors have attempted factor analysis to identify underlying constructs within their questionnaires, with varying degrees of success. Neveus et al. (2001) performed a factor analysis on their 18 questionnaire items and reported a two-factor solution: one factor pertaining to nocturnal arousals and the other to psychosocial factors of sleep. Unfortunately, as the process and results of the factor analysis are poorly described and interpreted, the validity of this solution must be questioned. It appears the solution was forced, although this is not specifically stated. As the name suggests, a forced solution forces items to be grouped together in a „best fit" model but that may not otherwise load together. As very few items load substantially on to the factors (loadings >0.4 explaining more than 20% of the variance) and no item loaded more than 0.6, it can be suggested that this is a poor factor model (Henson, 2001). Therefore, while the items in Nevéus et al."s questionnaire may be meaningful individually, they do not necessarily group together to measure an underlying construct.

Stein et al. (2001) and Carvalho Bos et al. (2009) also conducted a factor analysis on a series of sleep questions, providing more stable solutions. Stein et al. utilised a principle factors approach on 25 sleep items and obtained a 5-factor solution explaining 59% of the variance. Carvalho Bos et al. used a principle components analysis on 27 sleep items and revealed six factors explaining 63% of the variance. Both indicated moderate to strong solutions with loadings between

0.4 and 0.9. However, reliability analysis or validation of the factor structures were not reported so it is impossible to determine if these factor structures were the most appropriate measures of the underlying constructs. Two factors in Carvalho Bos et al.‟s solution (Factor 4 & 5) each contain two items with almost identical loadings, suggesting the items may be redundant. The structure matrix of Stein et al.‟s solution suggests a number of possible solutions with item loadings >0.4 on more than one factor. Without a reliability analysis, it is difficult to determine which combination of items most effectively measure the construct in question. Thus, while these two studies provide an adequate data reduction solution, reliability analysis and/or validation is required to ensure the effectiveness of the measure.

The CSHQ and the Sleep Disturbance Scale for Children (SDSC; Bruni et al., 1996) are two questionnaires which have undergone a rigorous validation and reliability process. The CSHQ consists of 45 items conceptually grouped into 8 subscales: bedtime resistance, sleep onset delay, sleep duration, sleep anxiety, night wakings, parasomnias, sleep disordered breathing, and daytime sleepiness. Validity of the CSHQ was conducted by comparing questionnaire results between two samples: a community group (N=469; mean age = 7.6±1.5yrs) and a clinical group (N=154; mean age = 6.8±1.7yrs). Sixty parents of the community sample agreed to complete the questionnaire twice over a two-week period for test-retest reliability analysis (Owens et al., 2000a). Internal consistency was assessed using Cronbach‟s alpha and revealed a mild to strong internal consistency for the subscales ($0.36 \leq \alpha \leq 0.83$). Test-retest reliability analysis revealed acceptable correlations for individual items ($r>0.6$) (Owens et al., 2000a). Comparisons between the two groups found the clinical sample to score significantly higher than the community sample on all sub-scales. Comparisons of scores between specific clinical sub-groups found children diagnosed with parasomnias to score higher on the parasomnia sub-scale, behavioural sleep problems to score higher in these corresponding sub-scales, and sleep disordered breathers to score higher in the SDB sub-scale. These results confirmed the ability of the CSHQ sub-scales to measure appropriate target areas. Initially developed for school-aged children, the CSHQ has also recently been validated against actigraphy in children as young as 2-years of age (Goodlin-Jones et al., 2008).

While the CSHQ is well accepted as a measure of behavioural sleep problems in children and has been used in a number of different cohorts around the world (e.g. Bloom et al., 2002; Cortesi et al., 2008; Li et al., 2007a; Liu et al., 2005a), it is not without its limitations. The low response rate of the original community sample (42%) and the differences in age and SES of the community and clinical groups may have confounded the results of the validation process. As such the CSHQ may not be effective for all sectors of the population.

More methodologically concerning however is that the items were conceptually grouped into sub-scales rather than factor analysed. The purpose of a factor analysis is to identify a group of variables that commonly share a significant portion of the variance of one underlying construct (Ford et al., 1986; Henson, 2001). The mild reliability of the majority of sub-scales of the CSHQ (eg: parasomnias α=0.36 & 0.56 in the community and clinical sample, respectively) suggests that, together, the items are not measuring the same construct. This becomes an issue when the sub-scales are used for predictive analysis as they may provide misleading information. That is, one item within the scale, rather than the combination of items, may be the underlying determinant of any predictive relationship. To date only one study has conducted a factor analysis to determine the appropriateness of the items within each sub-scales (Li et al., 2007b). In that study a three factor solution representing bedtime behavior problems, sleep disturbance and sleep duration/daytime sleepiness was found. It is noteworthy that the CSHQ was translated to Chinese for that study and as such a factor analysis on the original questionnaire is yet to be conducted. Nonetheless, the CSHQ was not developed as a diagnostic tool (Owens et al., 2000b), is highly effective as a screening tool and remains the most extensively used questionnaire to date for the examination of behavioural sleep problems in school-aged children.

The Sleep Disturbance Scale for Children (SDSC) was developed by Oliviero Bruni and colleagues (1996) as a diagnostic tool and consists of 26 items pertaining to typical symptoms of the major sleep disorders. The SDSC requires parents to comment on their child"s sleep over the last 6 months. A factor analysis was performed and revealed a six-factor solution: disorders of initiating and maintaining sleep; sleep breathing disorders; disorders of arousal/nightmares; sleep wake transition disorders; disorders of excessive somnolence; sleep hyperhydrosis. A reliability analysis was conducted on all items of the SDSC and showed acceptable internal consistency ($\alpha = 0.79$ control group) and test-retest reliability (Rho = 0.71). No reliability analysis was reported on the factor structure, however Receiver Operator Characteristic (ROC) analysis revealed sufficient sensitivity and specificity for diagnostic accuracy (AUC = 0.91). The SDSC has been used to examine sleep problems in general (e.g. Bruni et al., 2006) and clinical populations (e.g. Hartshorne et al., 2009) and has been cross-culturally validated (Ferreira et al., 2009). Aside from some minor statistical indiscretions within the final factor structure (i.e. inclusion of a trivial item and factor), there are few limitations with the SDSC. However, as it was developed as a clinical tool, it lends itself to be more sensitive to clinical populations. That is, the 6-month retrospective period and the focus on physical sleep disorders such as sleep disordered breathing, leg movements and hyperhydrosis are more likely to capture those with severe or pathological problems.

Therefore, while the past decade has seen the development of several sleep questionnaires, no questionnaire to date has suitably addressed all potential sleep problems of school-aged children within the general population.

1.9 SUMMARY AND CURRENT STUDY

In summary, although there has been an increasing interest into the study of sleep/wake behaviours and sleep problems in children, the questions posed 100 years ago asking how much sleep a child needs for optimal functioning remain largely unanswered. Whilst it is well acknowledged that sleep duration decreases as a child ages, changing sleep practices are determined not only by biological processes, but also by cultural and social influences. Few studies to date have adequately addressed these influences. It is also well acknowledged that sleep problems in childhood are common, yet methodological limitations preclude any informed commentary on the pervasiveness of these problems. Accurate knowledge of poor sleep/wake habits and prevalence of sleep problems may be vital to ensuring the behavioural well-being of many children.

Sadly, limited studies and methodological concerns also plague current research of behavioural associates of poor sleep/wake patterns and sleep problems. Development of better tools to measure sleep and sleep problems in school-aged children is the first step in adequately addressing these important research questions.

Therefore, the initial aim of this study was to:

a. develop an encompassing, statistically reliable, omnibus questionnaire to examine sleep/wake patterns and sleep problems in school-aged children.

Additionally, as there is a paucity of comprehensive research examining sleep and associated behaviours in school-aged children in Australia, three additional aims were to:

b. provide normative data on sleep/wake patterns in an Australian cohort of school-aged children
c. determine the prevalence and biopsychosocial determinants of sleep problems in this cohort, and
d. examine the relationship between poor sleep/wake behaviours, sleep problems and behaviour in this cohort.

The subsequent thesis describes how these aims were met in the following manner.

Chapter two details the development and distribution of the South Australian Paediatric Sleep Survey (SAPSS), a large, parent-report, cross-sectional survey conducted between February and November, 2007. The SAPSS was designed to gather data on sleep/wake patterns, sleep problems, behaviour, activity levels and health in children aged 5-10 years. This chapter also discusses the methodology used to develop the SAPSS questionnaire as a statistically reliable measure of sleep problems in a community cohort.

Chapter three examines the sleep/wake patterns of the SAPSS cohort across school days, weekends and holidays by sex, age, ethnicity and socio-economic status (SES). The aim of this chapter is to provide normative data for bedtimes, risetimes, sleep duration and changes in sleep/wake patterns across the week and year in an Australian population of school-aged children.

Chapter four examines the prevalence and biopsychosocial associates of sleep problems in the SAPSS cohort. This chapter aims to provide health professionals with current and geographically relevant information on parent-reported sleep problems, as well as determine biopsychosocial influences that could be future targets for parental education or intervention programs to aid in promoting healthy sleep in children.

Chapter five examines the relationship between poor sleep/wake behaviours, sleep complaints and behaviour. The aim of this chapter is to extend the current knowledge regarding the predictive nature of sleep disruption on daytime behavioural functioning.

Chapter six examines the influence of media both in and out of the bedroom on poor sleep/wake behaviours and sleep problems. With the ever increasing intrusion of technology into the bedroom, this chapter aims to add to the debate regarding the potential effects this has on sleep, detrimental or otherwise.

Chapter seven summaries the main findings of the SAPSS, comments on the limitations of the study, provides a general discussion and speculates as to the implications of these results for future research, education and promotion of healthy sleep habits in school-aged children.

CHAPTER 2: GENERAL METHODOLOGY

In 2007, an epidemiological study was undertaken to determine the sleep/wake patterns, sleep problems and behavioural associates in a large cohort of Australian children aged 5 to 10 years. This study was labelled the South Australian Paediatric Sleep Survey (SAPSS). The following chapter describes the methods, procedures and protocols used to conduct the SAPSS. It also discusses the methodology used to develop the SAPSS questionnaire (SAPSS-Q) as a statistically reliable measure of sleep problems in a community cohort. The data obtained from the SAPSS were used in all subsequent chapters of this thesis.

2.1 QUESTIONNAIRE DEVELOPMENT

The SAPSS-Q (Appendix A) is a retrospective parent-report questionnaire consisting of 111 items within 5 sections: demographic information, sleep habits, activity, behaviour and general medical history. Below is a description of the final item inclusions within each section. Items were refined through a pilot study process described in Section 2.3.

2.1.1 Demographic

The demographic information was designed to gather information regarding the child, as well as information that could potentially influence sleeping and behavioural patterns. Parents were asked to provide date of questionnaire completion, child‟s date of birth, sex, gestational age and birth weight.

Gestational age and birth weight were included as previous research has shown that pre-term and low birth weight children are at higher risk of sleep problems, in particular sleep disordered breathing (Emancipator et al., 2006; Rosen et al., 2003).

Parents were also asked to measure and report on the child"s current height and weight to provide information for future body mass index (BMI) calculations. The literature concerning the association between sleep and obesity in children has increased exponentially since the first article by Locard et al. (1992), with the majority of studies showing clear and consistent associations between short sleep duration and overweight/obesity (for review see Cappuccio et al., 2008; Patel & Hu, 2008; for contrary view see Horne, 2008; Marshall et al., 2008).

Respondents were required to indicate their relationship to the child, how many children were in the family, and the birth order of the child as family size has been associated with sleep/wake patterns in children 5-12 years (Adam et al., 2007).

Postcode was recorded as a measure of individual socio-economic status. Postcode is used by the Australian Bureau of Statistics (ABS) to allocate Socio-economic Indexes for Areas (SEIFA). SEIFA contains four indexes which summarises different aspects of socio-economic conditions, created using National Census information, in a particular area. The four indexes are: Index of Relative Socio-economic Disadvantage; Index of Relative Socio-economic Advantage and Disadvantage; Index of Economic Resources; and, Index of Education and Occupation. For each index, geographical regions are given a score, rank, decile and percentile figure. The SEIFA score is devised from number of key variables including household income, education, occupation and ethnicity and is standardised with a National mean of 1000 and standard deviation of 100 (range = 650-1200). The score is an average of people and households in the area and thus reflects the relative disadvantage of all living in that area, not individuals within the area. The lower the score, the greater the disadvantage for the area. The score is then ranked from highest to lowest to give a rank for each region. For the decile figure, the distribution of SEIFA scores are divided into 10 equal groups with the lowest 10% receiving a decile number of 1 and the highest 10% a 10. Percentiles divide the distribution into 100 equal groups and number accordingly (Australian Bureau of Statistics, 2006b). For the purposes of this thesis, the Index of Relative Socio-Economic Disadvantage was used as the measure of socio-economic status (SES).

Ethnicity in the current questionnaire was indicated through a forced choice scale of Caucasian, Indigenous, African, Asian, Polynesian, Caribbean and Other, with a space for further elucidation on Other. These choices reflect the majority racial demographic breakdown of the region (ABS, 2006a).

2.1.2 Sleep Habits

The sleep habits section was broken into two parts: A. sleep problems, and B. sleep/wake patterns. The development of the sleep habits section was as follows:

a) Rewording of items from the Children‟s Sleep Habits Questionnaire (CSHQ) (Owens et al., 2000a) to past tense
b) Addition of items from Sleep Disturbances Scale for Children (SDSC) (Bruni et al., 1996), as well sleep hygiene and snoring items
c) Addition of sleep/wake pattern questions for school days, weekends, and holidays

All items used and their origins are detailed in Table 2.1.

Table 2.1: *List of sleep habits questionnaire items and their origin.*

Item	Origin
1. Your child went to bed the same time every night	CSHQ
2. Your child fell asleep within 20 minutes	CSHQ
3. Your child shared a bedroom	Author devised
4. Your child fell asleep in own bed	CSHQ
5. Your child fell asleep in parent"s or sibling"s bed	CSHQ
6. Your child needed a parent in the room to fall asleep	CSHQ
7. After going to bed, your child spent time watching TV/DVD/Video in their bedroom	Author devised
8. After going to bed, your child spent time listening to music in their bedroom	Author devised
9. After going to bed, your child spent time talking to friends on the phone	Author devised
10. After going to bed, your child spent time playing electronic games (Xbox/Playstation/PC games/Gameboy)	Author devised
11. Your child struggled at bedtime (cried, refused to stay in bed, etc)	CSHQ
12. Your child was afraid of sleeping in the dark	CSHQ
13. Your child was afraid of sleeping alone	CSHQ
14. Your child"s bedroom was noisy (could hear road or outside noise, TV etc)	Author devised
15. You felt your child slept too little	CSHQ
16. You felt your child slept the right amount	CSHQ
17. Your child slept about the same amount each day	CSHQ
18. Your child wet the bed	CSHQ
19. Your child twitched or jerked when falling asleep	SDSC
20. Your child twitch or jerked violently when asleep	SDSC
21. Your child talked during sleep	CSHQ
22. Your child was restless and moved lots during sleep (changed positions, threw covers off)	CSHQ
23. Your child sleepwalked during the night	CSHQ
24. Your child moved to someone else"s bed during the night (parent, sibling)	CSHQ
25. Your child ground their teeth during the night (your dentist may have told you this)	CSHQ

Item	Origin
26. Your child breathed heavily during the night (but did not snore)	Author devised
27. Your child currently snores	Author devised
28. Your child currently snores loudly	CSHQ
29. Your child seemed to stop breathing during the night	CSHQ
30. You watched your child while they slept at night afraid that they would stop breathing	Author devised
31. Your child snorted and/or gasped during sleep	CSHQ
32. Your child had trouble sleeping away from home (visiting relatives, vacation)	CSHQ
33. Your child woke during the night screaming, sweating or was inconsolable	CSHQ
34. Your child woke alarmed by a frightening dream	CSHQ
35. Your child sweated excessively when falling asleep	SDSC
36. Your child sweated excessively after falling asleep	SDSC
37. Your child woke during the night	CSHQ
a) In total, how long did your child usually stay awake during the night (no awakenings = 0 minutes)	Author devised
38. Your child woke up by him/herself	CSHQ
a) If your child usually woke up by themselves, did this happen on (please circle): weekdays / weekends / both	Author devised
39. Parent (or sibling) woke your child up in the morning	CSHQ
40. An alarm clock woke your child up in the morning	Author devised
41. Your child usually woke up in a negative mood	CSHQ
42. Your child had difficulty getting out of bed in the morning	CSHQ
43. Your child took a long time to become alert in the morning	CSHQ
44. Your child seemed tired all the time	CSHQ

Item	Origin
45. Please indicate your child‟s level of sleepiness during each of the following activities:	
a) Watching TV	CSHQ
b) Riding in the car on a short trip	CSHQ
c) At school	Author devised
d) Reading a book	Author devised

The Children‟s Sleep Habits Questionnaire (CSHQ) was specifically designed for screening of sleep problems in children aged 4-10 years and is based on the common clinical symptoms of sleep disorders presented in the *International Classification of Sleep Disorders* (ASDA, 1990). The CSHQ is well accepted as a measure of behavioural sleep complaints in children and has been used in a number of different cohorts around the world (Cortesi et al., 2004; Goodlin-Jones et al., 2008; Liu et al., 2005a, see Chapter 1 for details). The CSHQ has the additional advantage of evaluating parental perceptions of sleep problems. Respondents are asked to indicate whether they think the particular sleep behavior is a problem on a 3-point scale of "yes", "no", and "not applicable (N/A)".

Whilst comprehensive for behavioural sleep problems, the CSHQ does not address the more physical sleep problems such as hyperhydrosis, which may be related to sleep disordered breathing (Brouillette et al., 1984), and excessive movement, which may be indicative of periodic limb movement or restless leg syndrome (Picchietti & Picchietti, 2008). As a result, four items from the Sleep Disturbances Scale for Children (SDSC) (Bruni et al., 1996) were added into the questionnaire. These items were: A. twitching and jerking, and B. sweating excessively while falling asleep and during sleep. Two additional questions regarding sleep disordered breathing were also added: “your child currently snores”, and “you watched your child while they slept during the night, afraid they would stop breathing”.

It has been reported that children with television in their bedrooms report later bedtimes and less time in bed than those without (Olds et al., 2006; Van den Bulck, 2004). The same effect has been found in children who play computer games before bed (Fuligni & Hardway, 2006; Van den Bulck, 2004) and there is a suggestion that any type of screen use before sleep may affect sleep quality (Cajochen et al., 2000; Higuchi et al., 2005). As a result, several questions were added regarding bedroom activities such as watching television, using computers, using a telephone, listening to music or playing electronic games after going to bed. Questions regarding shared bedrooms and level of bedroom noise were also included as aspects of sleep hygiene (Gellis & Lichstein, 2009; Li et al., 2008).

In the current questionnaire, parents were asked to recall their child‟s sleep behaviours over the last typical school week. If the last week was unusual for any reason, eg illness or a holiday period, parents were asked to think of the most recent typical school week. Items were rated on a 4-point Likert scale of “Never”, “Rarely - once per week”, “Sometimes - 2-4 times per week”, and “Usually - 5-7 times per week”. Six items (1, 2, 4, 16, 17, and 38) were reversed to eliminate response bias. Parents were also asked to rate whether they considered the sleep behaviour a problem on a 4-point Likert scale of “N/A”, “No”, “Somewhat”, and “Yes”. Data pertaining to these perceptual responses are not reported in this thesis.

To assess daytime sleepiness parents were asked to rate their child‟s level of sleepiness watching T.V., riding in the car on a short trip, at school, and reading a book on a scale of “Not sleepy”, “Slightly sleepy”, “Very sleepy”, and “Falls asleep”.

To assess sleep/wake behaviours, parents were asked to consider the most recent school nights, weekend and holiday period, and estimate to the nearest 5 minutes usual bedtime, usual lights out, usual time of sleep onset, earliest bedtime, latest bedtime, usual waketime, earliest waketime and latest waketime. Parents were also asked to report any napping activity by indicating the time their child usually napped and how long the nap was on school days, weekends and holidays. Space was provided at the end of this section to allow for qualitative comments regarding the children‟s sleep. Qualitative comments are not presented in this thesis.

2.1.3 Activity

The activity section was developed in consultation with the School of Health Sciences, University of Adelaide and was based on questions from the Australian Schools Health and Fitness Survey conducted by the Australian Council for Health, Physical Education and Recreation Inc. (ACHPER) (Pyke, 1987). This national survey was conducted in 1985 and contained a range of measures, both questionnaire and objective, of health, lifestyle, physical fitness and performance. The ACHPER survey was completed by 6586 children and has been extensively published (e.g. Biggs & Dollman, 2007; Dollman et al., 2007; Eisenmann et al., 2006; Lewis et al., 2007; Martin et al., 2005). The questionnaire used in the ACHPER study contains 40 items (Pyke, 1987), however only three were used here as the intention was to determine how much physical activity, both through organized sports and unorganized “play”, the child does per week. These data are not reported in this thesis.

Screen- and homework time questions were added as both the amount of television viewing and homework have been linked to reduced total sleep time and sleep concerns (Adam et al., 2007; Owens et al., 1999; Van den Bulck, 2000).

2.1.4 Behaviour

The Strengths and Difficulties questionnaire (SDQ) was used to measure behavioural problems. Based on the Rutter questionnaire (Elander & Rutter, 1996), the SDQ was specifically designed to fit on one side of paper, have applicability for both children and adolescents, be completed by both parents and teachers, and have equal number of items for each behavioural dimension (Goodman, 1997). The SDQ consists of 25 items which were originally divided into 5 distinct scales: emotional symptoms; conduct problems; hyperactivity; peer problems; and pro-social. Respondents are asked to rate the child"s behaviour over the previous three months on a 3-point Likert scale of “Not True”, “Somewhat True”, and “Untrue”. Examples of questions within each scale are as follows:

a) Emotional symptoms – your child has “many worries, often seems worried”
b) Conduct problems – your child “often fights with other children or bullies them”
c) Hyperactivity – your child is “restless, overactive, cannot stay still for long”
d) Peer problems – your child is “rather solitary, tends to play alone”
e) Pro-social – your child is “considerate of other people"s feelings”

Five items are reversed scored to eliminate reporter bias. A Total Difficulties Score is obtained by summing all but the pro-social sub-scale. According to Goodman (1997), the pro-social scale is not incorporated as the absence of pro-social behaviour does not necessarily indicate the presence of psychological difficulties.

The SDQ sub-scales as proposed by Goodman have been validated against the Rutter Behavioural Scale and Achenbach‟s Child Behavior Checklist (Goodman, 1997; Goodman & Scott, 1999; Smedje et al., 1999b). Moderate to strong reliabilities for these subscale have been found in large Australian (N=1359; Hawes & Dadds, 2004), Swedish (N=900; Smedje et al., 1999b) and Danish (N=562; Muris et al., 2003) cohorts of children and adolescents. Hawes and Dadds (2004) also showed the SDQ sub-scales to have adequate external validity against DSM-IV diagnosis of internalising behaviours, conduct disorders and ADHD. The SDQ has been used previously in sleep related research (Nixon et al., 2008; Smedje et al., 2001a; Wiater et al., 2005), however methodological limitations in the development and subsequent validation of this measure suggest further examination of the sub-scales is necessary to provide more accurate indicator of behavioural correlates to sleep. A full discussion of these limitations and a further factor analysis is given below in Section 2.8.

Previous research has shown that children with sleep problems, in particular sleep disordered breathing, report a poor quality of life (for review see Mitchell & Kelly, 2006) thus five additional items targeting quality of life were added to the behaviour section as follows: Over the last 3-months, your child has been:

1. Having problems doing anything that is physically demanding
2. Happy doing chores around the house when asked
3. Often missing school due to illness
4. Having trouble paying attention at school
5. Seeming to enjoy life

Four of the items were loosely derived from two of the Pediatric Quality of Life Inventory (PedsQL 4.0) subscales (Varni et al., 2003). The PedsQL 4.0 is a 23-

item questionnaire with 4 core scales relating to physical, emotional, social and school functioning. For the purposes of this questionnaire, two items (26 & 27) were chosen to represent physical functioning and two (28 & 29) to represent school functioning. Emotional and social functioning were deemed to be adequately measured in the SDQ. Item 30 was included to give an overall indication of quality of life. These data however do not relate specifically to the aims of this thesis and thus are not reported.

2.1.5 General Medical History

Questions for the general medical history section were derived in consultation with Respiratory Physician‟s at the Adelaide Women‟s & Children‟s Hospital. The questions in this section were designed to gather information regarding any physical or psychological complaints experienced by the child that could affect sleep and/or behaviour. In particular, questions concerning diagnosed and treated sleep disordered breathing, family history of sleep disordered breathing, craniofacial abnormalities, neurological or muscular disorders, intellectual or developmental delay, and behavioural disorders were included. Questions on past respiratory complaints, such as asthma, and current medications, were also included. As passive smoking has been associated with sleep problems in children (Ali et al., 1993; Anuntaseree et al., 2001; Ersu et al., 2004; Kuehni et al., 2008), a question on the amount of cigarettes smoked by members of the household was included here.

2.1.6 Further participation

At the end of the questionnaire, a tear-off section was included for participants to register their interest in further studies. To ensure confidentiality, this information was removed from the questionnaire data and entered into a separate database.

2.2 ETHICS APPROVAL

Ethics approval was sought from Children, Youth & Women‟s Health Service (CYWHS) and University of Adelaide Human Research Ethics Committees (HREC) in the first instance. Conditional approval was given pending approval from the relevant educational boards of public (Government funded) and private (fee-based) schools. Before ethics approval was sought from the educational boards, meetings were held with key stakeholders in these organizations to determine the suitability of the project to current educational and developmental priorities. A research partnership was developed with public schools educational department while an educational partnership was developed with the private schools educational board to assist in providing sleep education materials. Ethics approval was granted from both the public and private educational boards with the understanding that individual schools had right of refusal.

2.3 PILOT STUDY

In July and August 2006, a pilot study was conducted to trial the SAPSS-Q. Four schools were approached to participate, two agreed. Two versions – one short and one long – of the SAPSS-Q were distributed randomly in both schools. The sleep and activity sections were consistent across both versions. The SDQ was omitted from the short version and this version contained only 7 items in the general health section whereas the long version contained 23. The two versions were used to determine whether the additional information, extending the length of the questionnaire, impeded the response rate. The primary aim of this research was to determine sleep/wake behaviours and prevalence of sleep complaints in a large cohort of South Australian children and as such any behavioural information was deemed secondary and would be discarded if response rate was affected.

Questionnaires were distributed to every child (N=628) in grades 1-5. Table 2.2 shows distribution figures and response rates for both versions across the two pilot schools. As response rate was equal across the two versions, the longer version was maintained for the study proper. After analysis of the pilot study data, some alterations were made prior to the study proper to improve the effectiveness of the questionnaire.

Table 2.2: *Pilot study distribution and response rates for two versions of the SAPSS-Q*

	Questionnaire Version						
	Short			Long			
	Distributed	Returned	Resp Rate	Distributed	Returned	Resp Rate	Total RR
School 1	169	88	52%	168	95	57%	54%
School 2	146	73	50%	145	77	53%	51%
Total	315	161	52%	313	157	55%	53%

The alterations made were as follows:

1. **Demographics:**
   - questions regarding gestational age, number of children in the family and birth order were added
   - specific instructions were given to measure current height and weight of the child to increase the accuracy of the results.
   - results from the pilot study showed no advantage of including the respondent‟s ethnicity, therefore this question was dropped.

- ethnic categories were changed to better represent major demographic categories in South Australia as identified on the Australian Bureau of Statistics (ABS) (ABS, 2006a).

2. **General Medical History:**
   - although response rates were similar, a large amount of missing data was found in general medical history (GMH) section of the longer version that was not seen in the short version. As a result, the shorter version of GMH was used for the study proper.
   - three questions considered vital for screening purposes were added. These questions concerned snoring history of child and family members, and whether the child was currently taking any prescriptive medication with a request for a description of the medication.
   - all questions, except age of first observed snoring, description of medication and number of cigarettes smoked, were re-designed to be answered on a 3 point Likert scale – unsure, no, yes – with order of categories reversed to reduce potential response error.
3. **Sleep Habits:**
   - additional questions regarding specific sleep/wake behaviours, such as time of lights out, time of actual sleep, earliest and latest bed/risetime, and napping activity were added as the pilot questionnaire provided limited and poor quality responses in this area. Similarly, more specific instructions were included to improve response quality. For example, parents were requested to estimate sleep/wake pattern times to the nearest 5 minutes and to indicate a specific time rather than a range.
   - questions regarding sleep hygiene and in particular bedtime activities were also added.

- the original 3-point Likert scale used by Owens was transformed into a 4-point scale, with the addition of a “Never” category. It was felt that the “Rarely” category, defined as a behaviour occurring 0-1 times per week, was misleading as it did not allow for the distinction between a child who never experiences a particular sleep behaviour to those who experience the sleep behaviour occasionally. It can be reasonably assumed that characteristics between these groups may be different. An additional “somewhat” category was also added to the parental perception scale as it was deemed that a binary response was too limiting.
- due to the number of parents writing comments in the margins of the pilot questionnaire, a space for qualitative comments was added.

4. **Activity:**
    - all questions pertaining to physical activity were redesigned to be answered on a 4-point Likert scale of “never”, “sometimes”, “usually” and “often”.
    - questions regarding the homework habits were added
    - instructions were reworded to elicit more accurate accounts of screen and homework time with parents asked to estimate times to the nearest 5 minutes.
5. **Behaviour**
    - the quality of life question in the pilot questionnaire yielded poor results with all responses marked at either 9 or 10 of the 10-point Likert scale. Thus, it was decided to expand the quality of life questions. Four questions adapted from the Pediatric Quality of Life Inventory (Varni et al., 2003) and an overall life satisfaction question were included at the end of the SDQ with responses on the same 3-point Likert scale.

Finally, the design of the questionnaire was altered as a result of feedback given by parents as to the cramped and sometimes confusing nature of the questionnaire layout. The wording of various questions throughout was also changed to improve readability, however meaning was left unchanged. The final version of the questionnaire used for the study proper can be found in Appendix A.

Data from the pilot study were not included in any analysis described within this thesis.

2.4 PARTICIPANTS & PROCEDURE

A population-based, cross-sectional design was used for this study. Negotiations with the two educational boards lead to separate sampling methods for each jurisdiction. Public (Government funded) school requirements precipitated a multi-stage stratified, random sampling design. In the first step, all 220 regular public primary schools in the Adelaide metropolitan area were grouped into strata of Index of Educational Disadvantage. The Adelaide metropolitan area consists of 8 districts covering 870 square kilometres and with a population of approximately 1.1 million inhabitants (ABS, 2006a) (Figure 2.1). The Index of Educational Disadvantage has been used since 2001 to allocate resources addressing the educational needs of students from low socio-economic backgrounds. The Index of Educational Disadvantage is a measure of parental income, education and occupation, Aboriginality, and student mobility, with each component contributing relatively equally to the overall disadvantage score. Schools are ranked into seven distinct categories, with category 1 schools serving the most disadvantaged families and category 7 the least disadvantaged families. According to the Strategic Planning and Information Directorate, 5.5% of schools are ranked at category 1, 14% as category 2, 10.8% as category 3, 14.5% as category 4, 20% as category 5, and 35.2% as category 6/7 (Department of Education and

Children's Services, 2001). Forty-two schools, 6 from each category, were initially chosen at random and invited to participate in this study. Due to the lower than expected response rate across all schools, a further 21 (3 in each category) schools were chosen at random and invited to participate.

Eligible subjects within private (fee-based) schools were identified using a multi-stage, clustered, random sampling design. In the first step, all private primary schools classified either as denominational or non-denominational with student enrolments of over 100 in the Adelaide metropolitan area were identified. Of the 43 schools identified, 3 were excluded due to concurrent research activities with these schools. Twenty schools (50%) were then chosen at random and invited to participate in the study.

Initial contact with principals was made through surface mail or email, which consisted of sending a package with an introduction letter outlining the purpose and proposed outcomes of the study, details of what and how much was involved from schools, teachers and parents, copies of ethics approval letters, copy of questionnaire, and information on what to do if interested in participating (Appendix B). Initial contact was followed up with a telephone call approximately 7 days later. During this time, principals were given the opportunity to ask questions and the school was subsequently recruited if they were interested in participating. A meeting was then set up where a formal presentation of the proposed project was given. On a number of occasions, principals invited teaching staff and/or members of parental groups to attend. At the completion of the meeting, verbal consent was given by the principal to send questionnaire to parents with stipulations of anonymity and right of refusal for the school, parents and children. Articles were placed in the school newsletters to inform parents of the study 1-2 weeks prior to questionnaire distribution (Appendix D). All children in grades 1-5 in these schools were defined as eligible for this study. As children‟s age and grade level are not absolute, some subjects were later excluded for being outside the age-range specified for this study (<5 or ≥11 years). Eligible subjects were finally recruited out of 7186 students from grades 1-5 in 23 public and 9 private schools.

Each child was given a small package to take home to parents that contained an introduction letter, information sheet, consent form (Appendix C), questionnaire and reply-paid envelope. Parents were instructed to read the information sheet, sign the consent form, complete the questionnaire, and return the consent form and questionnaire to the researcher in the reply-paid envelope. Methods of distribution of the questionnaire package varied between schools. Some schools elected for the teachers to distribute at the completion of the day. Other schools requested that the researcher attend each classroom, discuss sleep with the children, and then distribute the questionnaire. No difference in response rate was found between distribution methods. Reminder articles were placed in school newsletters at 2 and 4 weeks following initial distribution (Appendix D). Six weeks post-distribution, principals were contacted and informed of the response rate from their school. At this time they were asked if they would agree to a second distribution. Two schools declined further participation. Within the remaining 30 schools, distribution remained as outlined above, however collection methods were altered. In addition to the reply-paid envelope, brightly coloured boxes were placed in each classroom. Children were encouraged to place their completed questionnaire in the box and in return were rewarded with a sticker. For the second distribution, parents were given a deadline of 2 weeks to complete the questionnaire. At the completion of the two weeks, the boxes were collected from the classrooms. Response rates for each school district are shown in Figure 2.1.

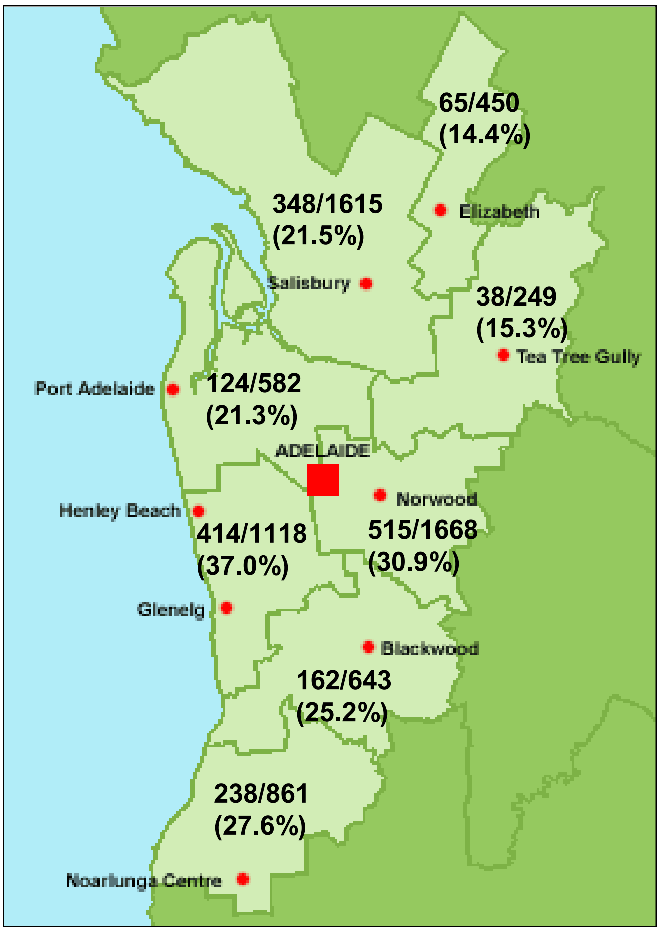

Figure 2.1. *Questionnaire response rates by school district. Dots indicate the major suburbs within each area and are not names of schools involved.*

Table 2.3 shows response rates for public schools by Index of Disadvantage (public schools only). Table 2.4 shows response rates for private schools by SEIFA deciles. Overall response rate for both public and private schools was 26.5% (1904/7186).

Table 2.3. *Questionnaire response rates by DECS Index of Disadvantage (public schools only N=23)*

Index of Disadvantage	No of Schools	Response	%
1/2 Most Disadvantaged	5	105/717	14.6
3/4	5	167/975	17.2
5	6	423/1611	26.3
6/7 Least Disadvantaged	7	481/1611	29.9
Total	23	1176/4914	23.9

Table 2.4. *Questionnaire response rates by SEIFA Index of Disadvantage deciles (private schools only N=9)*

Deciles	No of Schools	Response	%
1-3 Most Disadvantaged	2	170/560	30.4
4-6	5	324/1060	30.6
7-10 Least Disadvantaged	2	234/652	35.9
Total	9	728/2272	32.0

No differences were found between public and private schools in regards to sex, ethnicity or family structure. Small but significant differences were found in age – private: mean age 7.8±1.7yrs; public: mean age 7.6±1.6yrs (p<0.05) – and SEIFA index of disadvantage, the measure used for individual SES scores – private: 988.7±66.4; public: 981.1±70.5 (p<0.05). However, these differences were deemed inconsequential as a mean age difference of 2.4 months over a range of 6 years and 7.6 points in a scale with a standard deviation of 100 is unlikely to affect outcomes.

All schools were sent a thank-you letter and certificate of appreciation. A report of the final results was sent to each school at the completion of analysis.

Of the 1904 returned questionnaires, 41 were outside the age range, 7 provided no date of birth, 6 had more than 20% missing data, and 5 were excluded due to chronic medical conditions known to effect sleep such as cerebal palsy. Therefore, 1845 (97%) of all questionnaires returned were included in the analysis.

2.5 STATISTICAL ANALYSIS

All data was entered into a database. All entries were checked for entry error (eg „12" entered in cell instead of „1") using frequency analysis. Questionnaires were double entered at random to check for data integrity. All statistical analyses were conducted using SPSS version 15 for Windows (Chicago, IL, USA).

In accordance with recommendations by Gorsuch (1997), an exploratory factor analytic procedure using principle factor analysis, also known as principle axis factoring, was initially conducted to determine the factor structure of 42 of the 48 sleep complaint items. As it is likely that sleep problem items are interrelated and nonorthogonal, oblique rotation (Promax) was chosen to enhance interpretability (Ford et al., 1986; Gorsuch, 1970; Henson & Roberts, 2006). Reversed items were rescored prior to analysis (Cortina, 1993). Six items (3, 7-10, & 14) were excluded in the exploratory factor analysis as they pertained specifically to bedroom activity rather than sleep behaviour. Initial factor extraction was based on the Kaiser test of eigen values over 1. As Gorsuch (1997) explains large sample sizes can lead to an oversubscribed factor structure when based on eigen values alone. Therefore, subsequent analyses were conducted with factor extraction based on examination of low loadings, salient and trivial factors and the scree test (Cattell, 1966; Gorsuch, 1997; Nasser et al., 2002). Reliability analysis on all sleep problem factors was assessed through internal consistency using Cronbach‟s α-coefficient and precision measurement (Cortina, 1993). Item and factor stability were assessed using test-retest analysis. A similar factor analytic procedure was applied to the 25 items of the SDQ. The procedure is described in full in Section 2.6 below.

Detailed descriptions for specific statistical analysis for each chapter are outlined in the method section of the proceeding chapters.

2.6 FACTOR ANALYSIS OF SLEEP ITEMS

There are two main types of factor analysis: exploratory (EFA) and confirmatory (CFA). The difference between the two is explained parsimoniously by Gorsuch (1983):

> "… the former (exploratory factor analysis) simply finds those factors that best reproduce the variables under the maximum likelihood conditions, the later (confirmatory factor analysis) tests specific hypothesis regarding the nature of the factors" (p129).

Thus, as the name implies, EFA is used to explore and generate a theory from a set of variables whereas CFA is used to confirm a theory from a-priori selected set of variables (Henson & Roberts, 2006). For the purposes of this research, it may be presumed that CFA is more appropriate considering the items used in the questionnaire were derived from previous research. However, the CSHQ has not been previously factor analysed in a Western population. Additionally, the tense of the original items was changed from present to past, the response scale was altered and additional items added, thus previous relationships between items could no longer be assumed (Gorsuch, 1997).

Therefore, exploratory factor analysis was used to determine the factor structure of the SAPSS questionnaire. Factor analysis requires complete datasets for accurate results. Missing data was identified in 339 (18%) cases and removed, leaving a sample of 1506 for analysis.

An exploratory factor analysis can be conducted in a number of ways. The two most common are a principle components analysis (PCA) or common factor analysis using principle axis factoring (PAF) (Gorsuch, 1997). There is much debate over the most appropriate methods to use with some authors claiming it makes little difference (Velicer et al., 1982) and others claiming PCA is inappropriate on most occasions (Gorsuch, 1997). PCA assumes that the items can be reproduced into a single component, are perfectly reliable and are highly correlated with at least one other item (Ford et al., 1986; Gorsuch, 1997). In this sense, PCA is a data reduction technique which summarises the items into separate components. PAF, on the other hand, assumes that each item can be broken down into both common and unique components which include random error and systematic variance specific to the item (Ford et al., 1986; Gorsuch, 1990, 1997). By introducing an error variance, PAF uses reliabilities to determine unique factor structures (Fabrigar et al., 1999) and avoids overinflated loadings (Gorsuch, 1997). It can be assumed that the items with the SAPSS-Q will share common variance and contain random error as the questionnaire contains both objective or prescriptive (eg your child currently snores) and subjective or consequential (eg your child took a long time to become alert) items. Therefore, PAF was chosen as the most appropriate EFA technique to be used in this analysis.

Just as there are multiple methods of EFA, there are multiple methods for determining the number of factors to extract. Some, such as the scree test (Cattell, 1966), are easily performed, whereas others, such as parallel analysis (Horn, 1965), require complex mathematical analysis. The most commonly used is the eigenvalue over 1 rule (EV>1) (Fabrigar et al., 1999; Thompson & Daniel, 1996). When items are factored, the number of factors produced – representing a summed total of 100% of the variance – are not all meaningful. Many factors will not contribute significantly to the overall solution or will be the result of noise (Henson & Roberts, 2006). Eigenvalues provide information about the variance accounted for by the factor before rotation and an EV>1 indicates that the factor explains more of the variance than the individual items within the factor

(Thompson & Daniel, 1996; Zwick & Velicer, 1986). However, as Zwick and Velicer (1986) showed, EV>1 have a tendency to overestimate the number of meaningful factors and as such the scree test is also popular for factor extraction.

In the scree test, all eigenvalues are plotted and examined for obvious inflections or breaks in the plotted line. These inflections or breaks indicate the separation between meaningful or salient factors and trivial ones (Cattell, 1966). The scree test has been reported to be more accurate than the EV>1 rule (Zwick & Velicer, 1986) and is easy to perform, however does contain some inherent biases, the least being the subjective nature of visual discrimination. As the number of factors extracted will impact the outcome of the EFA and any further analysis, Henson and Roberts (2006) recommends using a number of methods interspersed with "reasoned reflection" (p399) to determine the number of factors retained. Therefore, for the purposes of this analysis, examination of EV>1, the scree plot, and factor reliabilities (Cronbach‟s alpha and precision measurements detailed below) were used to determine the number of factors extracted.

In the first instance, EV>1 was applied. A PAF containing 42 items of the SAPSS-Q was conducted resulting in a 12 factor solution accounting for 57.9% of the variance. It was mentioned earlier that the EV>1 rule is based on unrotated factors and as such there is a tendency to overestimate meaningful factors (Thompson & Daniel, 1996). Rotation of factors enables greater reliability, reproducibility and interpretation of the factor structure (Ford et al., 1986). In simplistic terms, rotation searches for linear combinations of variables so that the variance of the loadings on a specific factor is maximised and minimised on all other factors (Gorsuch, 1970). There are two types of rotation: orthogonal, which produces uncorrelated factors; and oblique, which allows for factor correlation. In exploratory analysis, without a priori theory, it is impossible to know if factors will be correlated and Gorsuch (1997) recommends conducting an oblique rotation in the first instance, examining the factor correlation matrix and then determining if another rotation method is needed. In the present research however, it is likely that the extracted factors will be correlated as previous research had shown comorbidity between sleep complaints (e.g. Ipsiroglu et al., 2002; Spruyt et al., 2005). Therefore, an oblique rotation was conducted from the outset.

In a comparison of rotation procedures, Gorsuch (1970) found the Promax method to be the most efficient of the oblique rotations so was chosen as the method used in the present analysis. The Promax rotation forces a solution by raising the power by maximising the high loadings and minimising the low loadings and then computing a least square fit to the target matrix. A *k*-value of 4 – ie: raising the power of the rotation by 4 to force the solution – was set on the Promax rotation based on Tataryn et al. (1999) recommendations. Examination of the factor correlation matrix revealed correlated factors thus it was deemed the oblique (Promax) rotation was appropriate for this analysis.

The structure matrix was then examined for any item which did not attain a factor loading above 0.4 (Henson & Roberts, 2006). A cutoff of 0.4 ensures that the variable is a fair measure of the factor measuring approximately 20% of the variance (Tabachnick & Fidell, 2001). As a result of this examination, item 18 (wet the bed), item 23 (sleepwalked), item 25 (ground teeth during night), item 32 (had trouble sleeping away from home), and item 40 (alarm clock woke the child) were removed from subsequent analysis.

A second PAF revealed a 10-factor solution with EV>1 explaining 58.5% of the variance. As mathematical examinations of PAF have determined that a minimum of three variables are required for a true factor to be identified (Zwick & Velicer, 1986), a second examination of the structure matrix was conducted to identify salient and trivial factors. Gorsuch (1997) defines a salient factor as one that contains three or more items with loadings over 0.4 and a trivial factor as one with few items that have higher loadings elsewhere. Two trivial factors were found in the examination of the structure matrix: Factor‟s VIII and IX. Factor VIII, although with high loadings, consisted of only two items: sweated excessively when falling asleep (item 35) and during sleep (item 36). Factor IX contained 3 items with one having a higher loading elsewhere (item 42: had difficulty getting out of bed in the morning). It was thus considered a trivial factor as only two items with maximum loading remained: item 38 (child woke by themselves); and item 39 (parent or sibling woke the child). Item‟s 35, 36, 38 and 39 were removed from subsequent analysis.

A third PAF was conducted with the remaining items resulting in an 8-factor solution with EV>1 explaining 55.4% of the variance. Examination of the scree plot showed a major inflection at Factor IV and a minor one at Factor IX, which was in agreement with the EV>1 rule (Figure 2.2). Thus, exploratory factor analysis revealed an 8-factor structure, consisting of 34 items and explaining 55.4% of the total variance. After rotation, the initial 8-factors extracted explained 42.4% of the variance. Factor I accounted for the greatest amount of variance at 18.31%. Factor‟s 2 to 8 explained 6.42, 5.87, 3.15, 2.80, 2.14, 1.93, and 1.76 of the variance respectively.

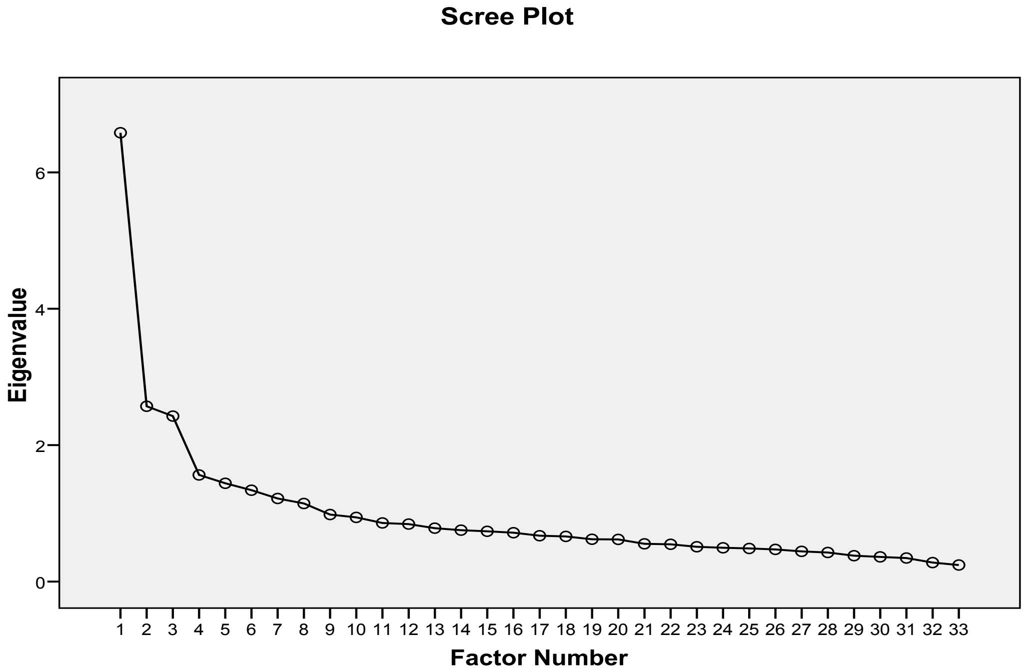

Figure 2.2: *Scree plot of 3rd run PAF showing one major inflection at Factor 4 and a minor inflection at Factor 9*

Table 2.5: *Factor pattern matrix of sleep items rotated to Promax criterion. Items ordered according to loading size.*

	Factor							
Item	I	II	III	IV	V	VI	VII	VIII
16. Slept the right amount	**.866**	-.011	-.072	.008	-.005	.019	-.008	.007
17. Slept about the same amount each night	**.811**	-.016	-.101	-.093	.001	-.008	.004	.046
2. Fell asleep within 20 minutes	**.574**	-.028	.077	.007	.020	-.001	-.047	-.101
15. Slept too little	**.560**	-.077	.131	.131	-.020	.029	-.012	-.028
1. Went to bed the same time every night	**.508**	.138	.019	-.147	-.022	-.024	.042	.038
11. Struggled at bedtime	.326	.060	.029	.298	.031	.007	-.013	-.056
4. Fell asleep in own bed	.067	**.757**	-.026	-.157	.004	.073	.008	-.002
6. Needed a parent in room to fall asleep	-.053	**.709**	.007	.065	-.007	.023	-.019	.025
5. Fell asleep in others bed	-.004	**.688**	.037	-.060	-.017	.052	.015	.058
13. Afraid of sleeping alone	.009	**.574**	.073	.340	.033	-.088	-.013	-.065
42. Had difficulty getting out of bed	-.019	.064	**.852**	-.105	-.004	-.015	-.006	-.069
43. Took a long time to become alert	-.039	.006	**.835**	-.072	.010	.002	-.011	.001
41. Woke in a negative mood	.037	-.012	**.626**	.027	-.031	.044	.005	.007
44. Seemed tired all the time	.116	-.085	**.438**	.171	-.018	-.093	.102	.215
34. Woke alarmed by a frightening dream	-.079	-.122	-.038	**.703**	.000	.075	.001	.011
37. Woke during the night	-.033	-.033	-.055	**.664**	-.019	.077	-.017	.030
24. Moved to someone else‟s bed	.010	.207	-.128	**.517**	-.051	-.076	.073	.070
12. Afraid of sleeping in the dark	.035	.118	.028	**.440**	.020	-.121	.000	-.072

	Factor							
Item	I	II	III	IV	V	VI	VII	VIII
33. Woke screaming, sweating and inconsolable	-.047	-.050	-.007	**.437**	-.003	.154	.039	-.031
27. Currently snores	.009	.017	-.026	-.034	**1.066**[1]	-.057	-.095	.017
28. Currently snores loudly	-.013	-.020	-.015	.001	**.669**	-.021	.148	.018
26. Breathed heavily during the night	-.015	-.018	.035	.032	**.413**	.149	.034	-.047
20. Twitched/jerked during the night	.029	.028	-.029	-.032	-.062	**.664**	.021	-.009
19. Twitched/jerked falling asleep	.005	.076	-.049	-.014	-.009	**.602**	.028	.044
21. Talked during sleep	-.057	.022	.055	.139	.047	**.426**	-.054	-.018
22. Restless during sleep	.031	-.018	.098	.182	.091	.389	-.075	-.028
29. Seemed to stop breathing during night	-.019	-.047	.007	.016	.017	-.027	**.775**	-.008
30. Watched, afraid would stop breathing	-.020	.038	.001	.051	-.038	-.049	**.519**	-.068
31. Snorted/gasped during night	.045	.026	.008	-.044	.110	.151	**.512**	.023
45a. Sleepiness watching T.V	-.013	.021	-.093	-.019	-.025	-.049	.020	**.522**
45d. Sleepiness reading a book	-.037	.047	.087	-.110	.012	.039	-.047	**.473**
45c. Sleepiness at school	.057	-.066	.043	.062	.019	.042	-.092	**.447**
45b. Sleepiness riding in a car	-.040	.069	-.038	.118	.027	.006	-.019	.378

[1] Loading > 1suggests the impossibility that the items accounts for more that 100% of the factor variance, indicating that the model may be over-factored (Velicer & Jackson, 1990). van Driel, 1978(1978) explains that, although a concern, these cases are not always problematic and simply indicate little common error. As the rotated commonality and loading on the structure matrix was within parameters, this item was retained in the factor structure.

Table 2.6: *Factor structure matrix of sleep items rotated to Promax criterion. Items ordered according to loading size.*

	Factor								
Item	I	II	III	IV	V	VI	VII	VIII	Communalities
16. Slept the right amount	**.833**	.182	**.412**	**.424**	.172	.273	.180	.288	.698
17. Slept about the same amount each night	**.719**	.118	.316	.286	.130	.190	.145	.255	.534
15. Slept too little	**.677**	.128	**.483**	**.448**	.167	.286	.161	.271	.490
2. Fell asleep within 20 minutes	**.572**	.106	.346	.281	.108	.162	.070	.127	.340
11. Struggled at bedtime	**.495**	.265	.340	.495	.195	.267	.171	.192	.330
1. Went to bed the same time every night	**.485**	.196	.259	.191	.074	.113	.116	.181	.258
6. Needed a parent in room to fall asleep	.157	**.728**	.127	.357	.083	.137	.096	.087	.535
13. Afraid of sleeping alone	.308	**.717**	.271	**.564**	.158	.178	.147	.109	.606
4. Fell asleep in own bed	.170	**.712**	.075	.230	.070	.118	.095	.040	.522
5. Fell asleep in others bed	.179	**.679**	.149	.296	.084	.148	.118	.120	.469
43. Took a long time to become alert	.384	.090	**.782**	.302	.156	.230	.086	.313	.618
42. Had difficulty getting out of bed	.378	.132	**.767**	.275	.118	.187	.061	.242	.605
41. Woke in a negative mood	**.402**	.105	**.668**	.348	.145	.264	.118	.300	.450
44. Seemed tired all the time	**.491**	.094	**.640**	**.459**	.218	.273	.252	**.487**	.510
37. Woke during the night	.299	.245	.263	**.644**	.218	.370	.215	.250	.423
34. Woke alarmed by a frightening dream	.263	.168	.258	**.633**	.237	.375	.229	.239	.425
24. Moved to someone else‟s bed	.259	**.411**	.154	**.545**	.138	.204	.219	.202	.357
33. Woke screaming, sweating and inconsolable	.210	.150	.207	**.467**	.208	.358	.220	.170	.243
12. Afraid of sleeping in the dark	.244	.298	.204	**.442**	.118	.119	.111	.082	.226

Item	Factor								Communalities
	I	II	III	IV	V	VI	VII	VIII	
27. Currently snores	.174	.086	.171	.272	**.986**	.371	.377	.249	.987
28. Currently snores loudly	.149	.058	.143	.250	**.726**	.338	**.452**	.228	.544
26. Breathed heavily during the night	.143	.059	.163	.241	**.496**	.353	.287	.151	.270
20. Twitched/jerked during the night	.204	.105	.181	.295	.237	**.629**	.258	.205	.400
19. Twitched/jerked falling asleep	.201	.154	.177	.321	.282	**.614**	.284	.246	.385
22. Restless during sleep	.293	.134	.323	.427	.312	**.520**	.200	.232	.326
21. Talked during sleep	.178	.133	.226	.348	.258	**.490**	.183	.186	.261
29. Seemed to stop breathing during night	.145	.053	.103	.236	.366	.296	**.766**	.207	.590
31. Snorted/gasped during night	.225	.118	.174	.284	**.425**	**.419**	**.633**	.259	.442
30. Watched, afraid would stop breathing	.082	.107	.043	.168	.182	.149	**.479**	.066	.241
45c. Sleepiness at school	.254	.010	.286	.242	.156	.227	.093	**.497**	.267
45d. Sleepiness reading a book	.137	.040	.230	.111	.118	.162	.083	**.464**	.228
45a. Sleepiness watching T.V	.100	.029	.095	.103	.082	.093	.117	**.454**	.222
45b. Sleepiness riding in a car	.154	.135	.170	.253	.157	.189	.137	**.401**	.181

The rotated factor pattern and structure matrices are shown in Tables 2.5 and 2.6 respectively. The pattern matrix provides the correlations between variables and a specific factor (ie orthogonal solution), whereas the structure matrix provides the correlations between variables and all other latent factors (oblique solution). While the pattern matrix allows for easy interpretation, it can eliminate important items which are essential to the relationship between factors (Graham et al., 2003). As recommended by Graham et al. (2003) and Gorsuch (1997), the structure matrix was used to identify items within factors. Post-rotation communalities are also provided in Table 2.6 to show the variance of each item accounted for by the factors.

Table 2.6 shows many items with correlations of over 0.4 on more than one factor. Therefore, a reliability analysis measuring internal consistency (Cronbach‟s alpha & precision estimates) and factor stability (test-retest) was conducted to determine the combination of items which produce the strongest measure of the factor construct. Cronbach‟s alpha is a measure of internal consistency and uses a split-half technique to determine interrelatedness of items (Cronbach, 1951). The alpha coefficient is the square of the correlation between the true score (average score a person would obtained if measured an infinite number of times) and the observed score (Cronbach, 1951; Cronbach & Shavelson, 2004). The higher the alpha coefficient, the more consistent or reliable the observed score is. However, alpha relies on the assumption of independence (ie response to one item will not affect responses on later items) and with items that include psychological aspects this assumption is unlikely to be met (Cronbach & Shavelson, 2004; Green et al., 1977). This is of particular concern in the SAPSS-Q as it contains prescriptive and consequential items. For example, parental perceptions could lead to responses such as: “My child struggles at bedtime” therefore “Seemed tired all the time”, creating interrelated but multidimensional factors (Factor I Table 2.6).

Cortina (1993) argues that, in addition to alpha coefficients, precision estimates are required to determine the dimensionality of the factors. As defined by Cortina (1993):

> “Precision (of alpha) is measured in terms of the standard error of item intercorrelations, which, in turn, is a function of the variance of the item intercorrelations. (and) … reflects the range of correlations regardless of the source or sources of the range eg measurement error or multidimensionality” (p. 100).

Precision estimates are calculated by the following formula:

$$\frac{SD_r}{\sqrt{[(½ \times k \times [k - 1]) - 1]}}$$

> “where SD_r is the standard deviation of item intercorrelations and k is the number of items” (p100).

The closer to zero the precision estimate, the more unidimensional, or measure of one construct, the factor. Inter-item correlations, precision estimates, Cronbach‟s alpha and resulting alpha if item is removed for each factor is shown in Table 2.7.

Table 2.7: *Internal consistency analysis of sleep item factor structures*

Item	Inter-item correlations A	B	C	D	E	F	G	H	Precision estimate	α	α if removed
Factor I									.022	.808	
A. Went to bed same time every night	-										.803
B. Fell asleep within 20 minutes	.287	-									.791
C. Slept the right amount	.357	.419	-								.762
D. Slept too little	.287	.371	.636	-							.770
E. Slept about the same amount each night	.410	.409	.625	.422	-						.780
F. Struggled at bedtime	.218	.382	.370	.351	.290	-					.794
G. Woke in a negative mood	.189	.222	.317	.354	.237	.282	-				.800
H. Seemed tired all the time	.169	.247	.402	.438	.308	.284	.473	-			.789
Factor II									.038	.789	
A. Needed a parent in the room to fall asleep	-										.725
B. Afraid of sleeping alone	.558	-									.726
C. Fell asleep in own bed	.527	.457	-								.746
D. Fell asleep in others bed	.469	.473	.530	-							.738
E. Moved to someone else‟s bed during night	.316	.378	.208	.320	-						.800

Item	Inter-item correlations									Precision estimate	α	α if removed
	A	B	C	D	E	F	G	H	I			
Factor III										.031	.814	
A. Slept the right amount	-											.798
B. Slept too little	.638	-										.792
C. Took a long time to become alert	.294	.338	-									.773
D. Had difficulty getting out of bed	.259	.316	.628	-								.783
E. Woke in a negative mood	.311	.348	.505	.516	-							.782
F. Seemed tired all the time	.404	.440	.488	.422	.466	-						.779
Factor IV										.018	.758	
A. Slept too little	-											.728
B. Slept the right amount	.637	-										.729
C. Afraid of sleep alone	.228	.255	-									.727
D. Seemed tired all the time	.436	.403	.212	-								.736
E. Woke during the night	.280	.243	.291	.266	-							.724
F. Woke alarmed by a frightening dream	.215	.216	.263	.264	.427	-						.735
G. Moved to someone else‟s bed during night	.219	.222	.377	.190	.466	.270	-					.734
H. Woke screaming, sweating and inconsolable	.194	.204	.204	.210	.265	.448	.187	-				.751
I. Afraid of sleeping in dark	.186	.182	.432	.175	.246	.249	.227	.139	-			.758

Item	Inter-item correlations A	B	C	D	E	Precision estimate	α	α if removed
Factor V						.069	.731	
A. Currently snores	-							.554
B. Currently snores loudly	.717	-						.629
C. Snorted/gasped during night	.351	.355	-					.737
D. Breathed heavily during night	.478	.328	.318	-				.723
Factor VI						.026	.644	
A. Twitched/jerked when falling asleep	-							.571
B. Twitched/jerked during the night	.442	-						.572
C. Restless during sleep	.286	.286	-					.591
D. Talked during sleep	.244	.289	.380	-				.579
E. Snorted/gasped during night	.279	.285	.190	.182	-			.632
Factor VII						.043	.624	
A. Currently snores loudly	-							.630
B. Seemed to stop breathing during night	.366	-						.513
C. Snorted/gasped during night	.348	.480	-					.492
D. Watched, afraid would stop breathing	.187	.382	.298	-				.599

Item	Inter-item correlations A	B	C	D	E	Precision estimate	α	α if removed
Factor VIII						0.021	.539	
A. Sleepiness watching T.V	-							.485
B. Sleepiness riding in a car	.253	-						.495
C. Sleepiness at school	.178	.152	-					.470
D. Sleepiness reading a book	.200	.167	.282	-				.482
F. Seemed tired all the time	.155	.169	.345	.203	-			.492

Inter-item correlations and alpha coefficients if item removed were examined to determine the best fit for each factor. „Woke in a negative mood" and „Seemed tired all the time" showed greater impact – higher inter-item correlations and greater effect on alpha – on Factor III than Factor I or Factor IV. „Slept the right amount" and „Slept too little" had the greatest impact in Factor I so were removed from Factor III and IV. Analysis showed alpha to improve if „Moved to someone else"s bed" was removed from Factor II, but would decrease if removed from Factor IV. Thus this item was deemed to have a better fit in Factor IV. Although removing "Snorted/gasped during the night" would improve alpha slightly, the new precision estimate of Factor IV without this item increased to 0.143, suggesting a multidimentional factor with the two snoring items responsible for the higher alpha. Therefore, it was decided to keep this item within Factor IV for further analysis. As a result, Factor VII was excluded from further analysis as it now only contained two independent items. Factor VIII was also removed due to the high number of low inter-item correlations (<0.2) and low alpha (<0.55), suggesting a poor internal consistency.

Research convention states that an alpha > 0.7 is an acceptable cut-off, however alpha is a function of the number of items in the scale, the size of the inter-correlations, and the dimentionality of the items (Cortina, 1993) and as such, a blanket rejection of any factors which do not reach the 0.7 cut-off may be limiting. As Cronbach (1951) himself stated:

> "A high α is therefore to be desired, but a test need not approach a perfect scale to be interpretable. Items with quite low intercorrelations can yield an interpretable scale." (p332).

Thus, Factors IV and VI were retained with an alpha coefficient of less than 0.7 as inter-item correlations were moderate (>0.2) and precision estimates were acceptable (Cortina, 1993).

Table 2.8 shows the Factor labels, items, precision estimates and final alpha coefficients of the final Factors. Factor I was labelled “Sleep Routine” as it pertained to items concerned with consistency of bedtime and sleep patterns. Factor II was labelled “Bedtime Anxiety” as it contained items concerned with anxiousness about going to sleep. The items within Factor III pertained to difficulty getting up and becoming alert in the morning and was subsequently labelled “Morning Tiredness”. Factor IV was labelled “Night Arousals” as items pertained to waking, either spontaneously or due to nightmares, during the night. Factor V was labelled “Sleep Disordered Breathing” although it is acknowledged that technically, this label is incorrect as there is no confirmatory polysomnography. However, a possibly more appropriate label of “Snoring” was not considered encompassing and may lead to incorrect assumptions as two of the items contain the word „snoring‟ (Henson & Roberts, 2006). Factor VI was labelled “Restless Sleep” as three out of the four items pertained to movement either when falling asleep or during the night. The fourth item “Talked during sleep” could also be considered to contribute to restlessness so was not thought to be misallocated.

Table 2.8. *Factor labels and internal consistency estimates of final SAPSS-Q subscales*.

Factors	Internal consistency		
	Precision estimate	α	N
Factor I: Sleep Routine	0.031	0.789	1780
Went to bed the same time every night			
Fell asleep within 20 mins			
Slept too little			
Slept the right amount			
Slept about the same amount each night			
Struggled at bedtime			
Factor II. Bedtime Anxiety	0.019	0.798	1794
Fell asleep in own bed			
Fell asleep in others bed			
Needed parent in room to fall asleep			
Afraid of sleeping alone			
Factor III. Morning Tiredness	0.031	0.802	1808
Woke in a negative mood			
Had difficulty getting out of bed			
Took a long time to become alert			
Seemed tired all the time			
Factor IV. Night Arousals	0.053	0.661	1800
Woke during the night			
Moved to someone else"s bed			
Woke alarmed by a frightening dream			
Woke screaming, sweating and inconsolable			

Factors	Internal consistency		
	Precision estimate	α	N
Factor V. Sleep Disordered Breathing	0.069	0.731	1776
Breathed heavily during night			
Currently snores			
Currently snores loudly			
Snorted/gasped during night			
Factor VI. Restless Sleep	0.033	0.632	1731
Twitched/jerked when falling asleep			
Twitched/jerked during sleep			
Restless during sleep			
Talked during sleep			

2.7 TEST/RETEST ANALYSIS

Test-retest reliability was assessed in 109 randomly selected volunteer subjects participating in further research at the Sleep Laboratory at the Women‟s & Children‟s Hospital, North Adelaide. The time frame between the initial and subsequent completion of the questionnaire ranged between 2.2 months to 18.1 months. Spearman‟s Rho correlational analysis was conducted on three test-retest time intervals: 0 – 5.9 months; 6.0 – 11.9 months; and 12.0 – 18.1 months. Mean (SD) time intervals between testing and demographic differences between groups are shown in Table 2.9. Spearman‟s Rho rank order correlations for sub-scales and items are shown in Table 2.10.

Table 2.9: *Mean (SD) test-retest interval, age, SES and sex differences between three SAPSS-Q test-retest time interval groups.*

		Test-Retest Interval			
		0-5.9mths	6-11.9mths	12-18.1mths	
Sex	Male N(%)	9 (22.5)	19 (47.5)	12 (30.0)	χ^2 =0.89, *p*=0.64
	Female N(%)	10 (15.9)	30 (47.6)	23 (36.5)	
Age	Mean (SD)	7.26 (1.3)	7.37 (1.6)	7.51 (1.7)	F= 0.15, *p*=0.85
SES	Mean (SD)	976.9 (60.8)	982.0 (80.7)	993.6 (76.5)	F= 0.37, *p*=0.69

Table 2.10: *Spearman's Rho coefficients for Factor scores and individual sleep items at short, medium and long term intervals.*

	Test-Retest					
Factors	0-5.9 mths		6-11.9 mths		12-18.1 mths	
	r_s	N	r_s	N	r_s	N
I. Sleep Routine	**0.62****	**19**	**0.52*****	**52**	**0.61*****	**36**
Went to bed the same time every night	0.84***	19	0.36**	55	0.48***	36
Fell asleep within 20 mins	0.76***	19	0.42**	55	0.56***	36
Slept too little	0.35	19	0.37**	55	0.71***	36
Slept the right amount	0.31	19	0.42**	54	0.60***	36
Slept about the same amount each night	0.47*	19	0.35**	54	0.41*	36
Struggled at bedtime	0.75***	19	0.46**	54	0.41*	36
III. Bedtime Anxiety	**0.84*****	**19**	**0.66*****	**52**	**0.36***	**35**
Fell asleep in own bed	0.72**	19	0.52***	54	0.50**	36
Fell asleep in others bed	0.98***	19	0.60***	55	0.37*	36
Needed parent in room to fall asleep	0.65**	19	0.56***	55	0.50**	36
Afraid of sleeping alone	0.78***	19	0.27*	53	0.11	35
II. Morning Tiredness	**0.82*****	**19**	**0.63*****	**53**	**0.75*****	**36**
Woke in a negative mood	0.71**	19	0.41**	53	0.51**	36
Had difficulty getting out of bed	0.77**	19	0.69***	55	0.70***	36
Took a long time to become alert	0.55*	19	0.29*	55	0.64***	36
Seemed tired all the time	0.50*	19	0.51***	55	0.65***	36

Factors	Test-Retest					
	0-5.9 mths		6-11.9 mths		12-18.1 mths	
	r_s	N	r_s	N	r_s	N
IV. Night Arousals	**0.55**	**19**	**0.41****	**54**	**0.79*****	**36**
Woke during the night	0.67**	19	0.30*	55	0.64***	36
Moved to someone else‟s bed	0.56*	19	0.61***	54	0.84***	36
Woke alarmed by a frightening dream	0.42	19	0.24	55	0.32	36
Woke screaming, sweating and inconsolable	-	19	0.66***	55	0.59***	36
V. Sleep Disordered Breathing	**0.90*****	**19**	**0.55*****	**53**	**0.59*****	**32**
Breathed heavily during the night	0.48*	19	0.45**	55	0.51**	34
Currently snores	0.95***	19	0.73***	54	0.60***	35
Currently snores loudly	0.82***	19	0.49***	54	0.32	36
Snorted/gasped during the night	0.61**	19	0.26	54	0.67***	35
VI. Restless Sleep	**0.75*****	**19**	**0.60*****	**50**	**0.47****	**32**
Twitched/jerked when falling asleep	0.90***	19	0.44**	51	0.48**	34
Twitched/jerked during sleep	-0.08	19	0.31*	50	0.42*	34
Restless during sleep	0.59**	19	0.53***	55	0.48**	35
Talked during sleep	0.64**	19	0.48***	54	0.38*	33

**p*<0.05; ***p*<0.01; ****p*<0.0001

Test-retest coefficients for subscales at 0-5.9 months are moderate to strong (r_s= 0.55-0.90) indicating that the subscales are stable over a short time period. As expected, subscale stability decreases from 6-11.9 months. Moderate coefficients (r_s > 0.5) are shown in all but one of the sub-scales. At 12-18.1 months, test-retest coefficients again improve in 4 of the 6 sub-scales, suggesting a long-term stability of these items. This is an unexpected result as it is well known that children‟s sleep behaviours change with age. It may be that sleep behaviours are more influenced by seasonal fluctuations then previously accounted for. Individual item stability fluctuates both within sub-scales and over time. Overall, however, reliability analysis conducted through internal consistency and scale stability measures indicates that the 6 sub-scales identified from the EFA are salient and stable.

To allow for future comparisons, means, standard deviations, medians range of scores and t-score cut-offs for each sub-scale by age and sex are presented in Appendix E.

2.8 FACTOR ANALYSIS OF STRENGTHS AND DIFFICULTIES QUESTIONNAIRE

Goodman (1994) developed the Strengths and Difficulties questionnaire as an alternative to the Rutter questionnaires based on anecdotal evidence that "parents and teachers found the focus of the Rutter items disconcerting" (p1483). According to informal feedback given to Goodman, respondents wanted to highlight their children"s strengths and not just their undesirable traits as required in the Rutter. Goodman, therefore, designed a questionnaire which combined the Rutter items with the desirable trait items of the Prosocial Behaviour Questionnaire developed by Weir and Duveen (1981). The modified questionnaire was trialled in a sample of 320 parents of children diagnosed with hemiplegia, with responses from 250 subjects entered into a principle components factor analysis. The factor analysis of the 46 items revealed 15 factors with EV>1. The scree plot did not reveal any obvious inflections thus six rotated factors were chosen for the final solution based on interpretability and clinical relevance. Goodman (1994) does not report how much of the variance explained by the individual factors or final solution and only reliabilities for the newly developed pro-social domain are reported. Thus it is impossible to determine the efficacy of the chosen factors. The limited sample size, large number of factors and the lack of inflections in the scree plot in the initial solution, suggest that this was not a well defined model. Further examination of the factor structure and additional analysis may have been required to improve construct validity of the factors.

Due to the increased time required to complete the modified questionnaire, caused by the additional items, Goodman (1997) redesigned the questionnaire according to the following quidelines:

> “it should fit easily on one side of paper; it should be applicable to children and young people ranging from 4 to 16 years; the same version should be completed by parents and teachers; a similar version should be available for self-report; both strengths and difficulties should be well represented; and there should be equal numbers of items on each of five relevant dimensions, namely conduct problems, emotional symptoms, hyperactivity, peer relationships, and pro-social behaviour.” (p581)

Based on the factor loadings and frequency distributions of the aforementioned analysis, Goodman chose five items for each of the five designated sub-scales. Together, these 25 items and 5 sub-scales became known as the Strengths and Difficulties Questionnaire (SDQ).

The SDQ was initially validated against the Rutter questionnaire in a sample of 403 children attending either a psychiatric or dental clinic. The high correlations between the measures as well as the equivalent predictive ability as reported by ROC curves led Goodman (1997) to conclude that the SDQ was a valid measure of behavioural problems in children. This conclusion however may have been premature. It is not surprising that the two measures were comparable considering the SDQ was developed using questions from the Rutter questionnaire. Later, Goodman and Scott (1999) conducted a study to validate the SDQ against the Child Behaviour Checklist (CBCL; Achenbach & Rescorla, 2001). In this study, mothers of 71 children aged 4-11 years, completed the SDQ and CBCL in the waiting room of a London dental clinic. Mothers of 61 children (4-11 years) attending a psychiatric clinic also completed both questionnaires.

Correlations between the comparable sub-scales of the two questionnaires were moderate to strong (0.59-0.87). Analysis of ROC curves revealed an equivalent sensitivity in distinguishing the psychiatric sample. When compared with interview scores, the SDQ was better at predicting hyperactivity/inattention in the psychiatric sample than the CBCL. Due to the comparability between the two questionnaires and the reported preference in the low-risk sample for the SDQ, Goodman (1999) proposed that the SDQ may be a satisfactory screening tool for large community samples where response rates and bias are a concern.

Smedje et al. (1999b) was the first, other than Goodman, to examine the factor structure of the SDQ albeit in a Swedish version. As part of their study on sleep and behaviour in school-aged children (N=844), Smedje and colleagues conducted a principle components analysis (PCA) on the SDQ which revealed six factors with EV>1 explaining 48.5% of the variance. Instead of examining this further however, a second PCA was performed, forcing a five-factor solution. This five factor solution explained 44.5% of the variance and confirmed the original sub-scales. Chronbach"s alpha reliability analysis revealed moderate internal consistency (α=0.51-0.75) for sub-scales. Deletion of items were reported to improve alpha on some scales yet it appears this was not done. A third and forth forced PAC was conducted for boys and girls separately. Examination of the loadings indicate that some items may be misallocated (<0.4), however this is inconsistent across the sexes. Taken together, this suggests that the five-factor forced solution, although confirmatory to the original sub-scales, may not have been the most appropriate measure of the underlying constructs.

More recently, Hawes and Dadds (2004) examined the psychometric properties of the SDQ in an Australian sample of boys (N=706) and girls (N=653) aged 4 to 9 years. In this study, two PCA"s with a five factor forced solution were conducted separately for boys and girls. Again the original sub-scales structure was confirmed, however one item from the conduct problems sub-scale (generally obedient) had higher loadings on the pro-social sub-scale. Different loading patterns were observed for boys and girls. A particular strength of this study was the validation of the SDQ sub-scales against a corresponding DSM-IV diagnosis. Using the 90^{th} centile cut-off proposed by Goodman, Hawes and Dadds reported strong predictive relationships between DSM-IV diagnosis and high scores on 3 of the 5 sub-scales: emotional symptoms; conduct problems; and hyperactivity. This suggests that whilst there may be some question as to the appropriateness of all items in each sub-scale, at least three of the sub-scales are sensitive to identifying behavioural problems. The weaker relationships observed in the remaining two sub-scales – peer problems and pro-social behaviour – may be the result of a lack of similar diagnosis in the DSM-IV or limited construct validity due to the forced factor solution. Mathai et al. (2002) also found that in Australian children and adolescents, the SDQ was adequate for detecting hyperactivity and conduct problems, but weaker for the other behavioural domains.

Due to the relatively arbitrary nature of the original sub-scale structure and subsequent confirmatory factor analyses using forced solutions, a Principle Axis Factor analysis with Promax rotation was conducted on the 25 items of the Strengths and Difficulties Questionnaire (Goodman, 1997) as per the procedure outlined in Section 2.6 (N=1738). A Promax rotation was used based on the high correlations observed between sub-scales in previous research (Hawes & Dadds, 2004; Smedje et al., 1999b).

According to Goodman"s scoring instructions, 5 items within the SDQ require recoding due to reverse scoring. However, due to the exploratory nature of this analysis, all items were entered in their original state. The initial solution revealed a 5-factor solution with EV>1 explaining 49.5% of the variance. Examination of the structure matrix identified 3 items with loadings less than 0.4 (item 6: rather solitary; item 22: stealing; item 23: gets along better with adults). These items were removed and remaining items reanalysed. The second PAF again revealed a 5-factor solution with EV>1 explaining 53.5% of the variance. No further trivial items or factors were identified, however many items cross-loaded on two or more factors (i.e. loadings >0.4 on more than one factor).

An initial reliability analysis was conducted on each of the five factors with all cross-loaded items included. Factor 5 contained four items and produced a Cronbach‟s alpha of 0.14. Only one item loaded independently on to Factor 5 (item 11: good friends with at least one person). After removal of this item, a third PAF revealed a 4-factor solution explaining 49.9% of the variance. All factors contained cross-loadings. In particular, two items (item 5: often loses temper; item 12: often fighting with other children) loaded similarly across three factors (range = 0.40 – 0.55). This is problematic as it indicates that the items are ambiguous and not measuring a specific construct. Removal of these items resulted in a 3-factor solution explaining 46.3% of the variance with two cross-loaded factors (Factor‟s 1 & 2) and one independent factor (Factor 3).

Reliability analysis found little difference in alpha coefficients of Factors 1 (α=0.81) and 2 (α=0.80) when both independent and cross-loaded items were included. Removal of all cross-loaded factors reduced the alpha coefficients to 0.76 (Factor 1) and 0.73 (Factor 2). This analysis revealed one item as impacting negatively on Factor 2 (item 18: often lying or cheating). Its removal improved the reliability rating to 0.77. After removal of this item, a fourth, and final, PAF was conducted. The final solution contained three factors with EV>1, explaining 47.6% of the variance. Examination of the structure matrix revealed little difference to the previous analysis with three cross-loaded items on Factor‟s 1 and 2. Reliability analysis was conducted with systematic removal and addition of these items to determine the factor structures with the greatest internal consistency. Item loadings, communalities, and reliability estimates for the final 3 factors are described in Table 2.12.

Table 2.11: *Structure matrix, communalities and reliability analysis for final 3 factors of SDQ.*

	Factors				Reliability	
Item	1	2	3	Communality	α	precision
Considerate of others feelings	**0.68**	-0.36	-0.17	0.47		
Helpful if someone is hurt	**0.61**	-0.23	-0.09	0.39		
Shares readily with other children	**0.61**	-0.30	-0.15	0.38		
Generally obedient	**0.61**	-0.46	-0.25	0.40		
Often volunteers to help others	**0.58**	-0.27	-0.08	0.34		
Thinks things out before acting	**0.58**	-0.49	-0.18	0.39		
Kind to younger children	**0.54**	-0.16	-0.11	0.31		
Generally liked by other children	**0.50**	-0.30	-0.33	0.29	0.81	0.01
Easily distracted	-0.34	**0.73**	0.32	0.53		
Restless, overactive	-0.31	**0.71**	0.29	0.51		
Constantly fidgeting	-0.30	**0.70**	0.35	0.50		
Has good attention span (reversed)	-0.44	**0.64**	-0.28	0.42	0.79	0.05
Has many worries	-0.08	0.21	**0.65**	0.43		
Often unhappy	-0.24	0.29	**0.60**	0.37		
Easily scared	-0.13	0.23	**0.60**	0.35		
Nervous and clingy in new situations	-0.18	0.28	**0.51**	0.27		
Picked on or bullied	-0.23	0.35	**0.44**	0.23		
Often complains of headaches	-0.06	0.18	**0.44**	0.19	0.70	0.02

Factor 1 contained 8 items related to interpersonal or pro-social behaviours. When items were summed to obtain an overall score, the outcome was a positive scale (i.e. the higher the score, the better the behaviour) as opposed to the other two factors which both had negative scales (i.e. the higher the score, the worse the behaviour). To remain consistent, scoring on Factor 1 was reversed and labelled Anti-social Behaviour. Factor 2 contained 4 items related to hyperactive/inattentive behaviours and was labelled Hyperactive Behaviour. Factor 3 contained 6 items relating to emotional behaviours and somatic complaints and was labelled Internalising Behaviour.

By way of comparison, a forced five-factor solution using PAC with varimax rotation was conducted as per previous analysis (Hawes & Dadds, 2004; Smedje et al., 1999b) and revealed a solution which explained 49.5% of the variance. The rotated component matrix reported similar, although not the same, factor structure as the SDQ developed by Goodman (1997). Factor 1, most consistent with Goodman‟s pro-social scale, contained two extra items (item 7: generally obedient; item 21 thinks things out before acting). Factor 4, contained only 4 items of Goodman‟s conduct problems scale as a result of item 7 loading on Factor 1. This is consistent with Hawes and Dadds (2004). Cross-loadings were found on one item (item 21: thinks things out before acting). Factors 2, 3 and 5 resembled Goodman‟s hyperactivity scale, emotional symptoms scale and peer-problems scale, respectively.

Reliability analysis on the original sub-scales suggested reduced internal consistency to the 3-factor solution, however differences were not substantial. Chronbach‟s alpha for pro-social behaviour, hyperactivity, emotional symptoms, conduct problems and peer-problems were 0.74, 0.78, 0.69, 0.67 and 0.60, respectively. Precision measures were also slightly worse in the original SDQ sub-scales (range 0.02-0.04), with one exception (Factor 3 = 0.05). This suggests that overall, the current factor structure has improved construct validity on the original sub-scales proposed by Goodman (1997). Thus, these factors were used for the predictive analysis conducted in Chapter 5.

CHAPTER 3: SLEEP/WAKE PATTERNS IN AUSTRALIAN CHILDREN AGED 5-10 YEARS: RESULTS FROM THE SOUTH AUSTRALIAN PAEDIATRIC SLEEP SURVEY (SAPSS)

3.1 INTRODUCTION

Due to the emerging belief that healthy sleep in children is essential for optimal daytime functioning, many researchers worldwide have undertaken studies to determine what constitutes healthy sleep (See chapter 1 for review). Within Australia, a number of studies have examined the impact of sleep disorders in specifically targeted samples of Australian children (e.g. Blunden et al., 2000; Blunden & Chervin, 2008; Bower et al., 1996; Hiscock et al., 2007; Kohler et al., 2009), yet few have examined sleep/wake patterns in community samples with the view of providing normative and culturally appropriate information on sleep habits. This research is particularly lacking in school-aged children.

Compared with other ages during childhood, sleep/wake patterns in adolescents have received the most research attention in Australia in recent years. In an incidental, archival study, Dollman et al. (2007) reported on the secular trends of average school night sleep duration over a 20 year period in children aged 10 to 15 years. Data for this study was drawn from the Australian Schools Health and Fitness Survey (ASHFS) conducted in 1985 (N=390) and the South Australian Physical Activities Survey conducted in 2004 (N=510), both designed to assess a variety of physical health related behaviours and attitudes. Sleep was assessed via two self-report questions: „What time did you go to bed and turn the lights out last night?" and „What time did you wake up in the morning?" All data was obtained during the school week. Compared with 1985, children and adolescents in 2004 were reported to go to bed on average 25 minutes later and sleep 30 minutes less. The difference in bedtime and sleep duration between the two time points was more pronounced in lower socio-economic groups. Not surprisingly, as school start times have not changed, rise-times remained consistent over the 20 year period. Although the scope of this study was limited in regards to sleep patterns, the trends in bedtime and sleep duration were consistent with those previously reported elsewhere (Iglowstein et al., 2003).

Warner et al. (2008) recently described the nocturnal sleep/wake patterns of Australian adolescents over school and holiday periods. In this study, 310 adolescents aged 15 to 18 years retrospectively recorded sleep logs and various sleep quality and daytime functioning scales for a previous two week period at two time points: during the school term and during holidays. The results of this study revealed that sleep/wake patterns in Australian adolescents were comparable to other Western countries. That is, the subjects slept longer on weekends than weekdays during the school term and had an evening-type circadian phase profile. On average, total sleep time was over one hour longer per night during holiday periods than school term (9 hours 6 mins vs 8 hours 11mins) as a result of later bedtimes and substantially later rise times (increase of 2.5 hours). Interestingly, during holiday periods, adolescents reported less sleep on weekends than weekdays.

Patterns of napping in Australian adolescents have been reported by Gradisar et al. (2008). A study of 231 older adolescents (mean age 17.7 ±0.4 years) revealed 32% of the sample regularly napped. Nappers went to bed later, got up later and had less nocturnal sleep than non-nappers on school nights. No difference was found between groups in nocturnal sleep on weekends. Nocturnal sleep patterns were consistent with Werner et al. (2008) with longer sleep duration on weekend than school nights, irrespective of napping.

Earlier studies have reported sleep/wake patterns in infants and toddlers. Eaton-Evans and Dugdale (1988) reported on the sleep patterns of Australian infants during the first year of life. In this study, 117 mothers, recruited from a routine visit to a child health clinic in Queensland, reported on their child‟s nocturnal sleeping patterns every month for 12 months. Results from this study are limited as only frequency of night awakenings are reported, however in that, night awakenings were reported to decrease until 6 months of age, and then increase again between 6 and 9 months. Armstrong et al. (1994) later conducted a more detailed cross-sectional study on sleep behaviours in 3269 Australian infants and toddlers up to 3 years old. Similar to the findings in adolescents, results from this study were comparable to others worldwide. In particular, circadian entrainment was established at approximately 4 months old, length and frequency of napping reduced with age, night awakenings reduced with age, and parental involvement at bedtime increased from approximately 18 months.

As can be seen, relatively little epidemiological research on sleep/wake patterns in children has been conducted in Australia. Most concerning is that to date, no study has examined sleep/wake patterns in a large community sample of school-aged children. As such, current recommendations for optimal sleep patterns for children in Australia are based on international research. Sleep/wake patterns are not only dictated by biological need, but also by environmental, cultural and social expectations, thus these recommendations may not be the most appropriate for Australian children. Therefore, the aim of this study was to examine the sleep characteristics of a large cohort of Australian children between the ages of 5 to 10 years with the view to provide normative data for health professionals and educators.

3.2 METHODS

Please refer to Chapter 2 for a detailed description of methodology.

3.2.1 Sleep/Wake Patterns

Sleep/wake patterns were assessed through 11 items within 3 sections: bedtime, napping and waketime. Parents were asked to report their child‟s sleep behaviour over the previous week on school days (Sun-Thurs) and weekends (Fri-Sat).

Sleep variables recorded were usual bedtime, earliest bedtime, latest bedtime, reported sleep onset, usual risetime, earliest risetime, latest risetime, the time of day their child napped (if at all), and the length of the nap. Parents also provided this information for the most recent school holiday/vacation period (labelled holidays hereafter). In Australia, the school year runs from the end of January to mid-December with three holiday periods interspersed at regular intervals (April, July, October). Each holiday period is two-weeks.

Nocturnal time in bed (TIB) was calculated as the difference between usual bedtime and risetime. Nocturnal total sleep time (TST) was determined as the difference between reported sleep onset and usual risetime less wake after sleep onset (WASO). WASO was recorded within the sleep problems items of the questionnaire.

A bedtime latency figure was calculated as the difference between usual bedtime and reported sleep onset. In previous epidemiological research, this variable is labelled “sleep onset latency” (e.g.Spruyt et al., 2005). Technically, sleep onset latency is the time between attempting sleep (eyes closed, quiescent) and falling asleep (Stage 1) (Rechtschaffen & Kales, 1968) which can only be accurately measured on polysomnography. Thus, to avoid confusion and more accurately describe the construct being measured, the label „bedtime latency" was chosen.

To assess consistency of sleep routines over the time period, bedtime and risetime variability, and bedtime and risetime shift variables were calculated. Bedtime variability was calculated as the difference between the earliest and latest time the child went to bed for the time period. Bedtime shift was calculated as the difference usual bedtime on schooldays and weekends. These was calculations were repeated for risetime to determine risetime variability and risetime shift.

3.2.2 Statistical Analysis

All data was checked for normality. Outliers were identified and removed (<2% of all entries). Reported sleep onset contained a large amount of missing data (41.6%), thus analysis of TST and bedtime latency variables were conducted using only part of the sample (N=1077). No differences in sex, age, ethnicity or SES were found between those with and those without recorded sleep onset. Usual bedtime, risetime, TIB, TST and nap length showed normal distribution after removal of outliers. Bed- and risetime variability, and bed- and risetime shift showed severe positive skew which were corrected with logarithmic transformations (Tabachnick & Fidell, 2001). Bedtime latency was corrected with Box-Cox transformation at λ=-0.15. In this transformation, the observation y is raised to the power of λ through the following equation: $y^{(\lambda)} = y^{(\lambda)}-1 / \lambda$ when $\lambda \neq 0$, and $y^{(\lambda)} = \log y$ when $\lambda = 0$. A series of ANOVA tests are then conducted on λ values – in this case λ = -0.2. -0.15, - 0.10, -0.05, 0, 0.05, 0.10, 0.15, 0.2 – until the lowest error sum of squares is observed (Box & Cox, 1964). All comparative analysis was conducted on transformed data. Means ($\pm$SD) are reported on untransformed data.

To improve interpretability of analysis, age was dichotomised into younger (5-7 years) and older (8-10 years). Ethnicity was dichotomised into Caucasian and Non-Caucasian. Socio-economic status was categorised into three groups based on the SEIFA index of deciles (Table 3.1) (ABS, 2006b). A univariate analysis of variance (ANOVA) was conducted to examine sleep variables by sex, age, ethnicity and SES. Post-hoc analysis was conducted on SES where appropriate ($p<0.05$). Significant two-way interactions were tested with paired comparisons. Three- and four-way interactions were not tested further due to limited cell sizes.

All statistically significant results are tabulated, regardless of effect size, however in the attempt to avoid over-interpretation and accepting inconsequential results, only effect sizes reaching a minimum of what is characterised as mild (d=0.2; ω^2=0.01) in univariate analysis are discussed.

Season was categorised by questionnaire completion date and defined by months (March – May = Autumn, June – August = Winter, and September – November = Spring). A one-way ANOVA was conducted to determine the effect of season on sleep variables.

3.3 RESULTS

3.3.1 Demographic Characteristics

Of the 1845 questionnaires included in the analysis, 957 (51.9%) were female. Proportionately more responses were for the younger than the older age groups (5-7yrs = 58.3%; 8-10yrs = 41.7%). 1505 (81.6%) of respondents identifying themselves as Caucasian. Of the remaining 29.3%, one percent identified as Indigenous, 8.8% as Asian, 1.6% as African and 7.1% as Other. According to the 2006 Census data, 4% of the population within metropolitan Adelaide classify their ancestry as Asian, 0.5% as African, and 1% as Indigenous (ABS, 2006a).

Therefore, in this sample, both Asian and African respondents are over-represented.

The majority of questionnaires were completed for the eldest child (39.6%) followed by the youngest (31.7%), middle (14.7%), only (12.6%) and twin (1.4%). Forty-eight percent of the questionnaires were completed in the winter months, 35.3% in Autumn and 16.5% in Spring.

Mean SES score was 983.87 (±69.09), with a range of 755.88 to 1127.74. This is lower than the national mean of 1000 (±100), yet distribution was equivalent over the deciles.

Table 3.1*: SEIFA groups and scores.*

	Decile Range	SEIFA Score	N (%)
Most Disadvantaged (Low)	1-3	≤960.33	703 (38.1)
Mid-range (Middle)	4-7	964.31 - ≤1028.56	527 (28.6)
Most Advantaged (High)	8-10	≥1032.81	615 (33.3)

3.3.2 Napping

A total of 102 (5.6%) children were reported to nap. Chi-square analysis revealed proportionately more Non-Caucasian children were reported to nap than Caucasian children (12.3% vs 4.8%; χ^2=22.0, *p*<0.0001). Proportionately less children in the high SES group (3.1%) were reported to nap than children in the mid (7.5%) or low SES (7.1%) group (χ^2=12.8, *p*=0.002). No sex or age differences were found in the proportion of napping children.

The average length of naps on school days was 55.2 (±36) minutes, on weekends 72.8 (±35.7) minutes, and on holidays 65 (±35) minutes. The average time the nap was taken on school days was 15:00h. The average time of napping on weekends was 14:06h and holiday"s 14:00h. A quarter of all nappers (25.5%) napped on both weekends and holidays, with 22.5% napping on all days. The same amount (22.5%) napped on school days only, while 14.7% napped only on weekends, 9.8% only on holidays and 3.9% on both school days and weekends.

Univariate analysis revealed no differences in sex, age, ethnicity or SES in napping length on school days or weekends. A significant main effect was found for sex in napping during holidays ($F_{(19,58)}$=4.41, p<0.05), with girls (M±SD = 14.4±1.3 minutes) napping longer than boys (M±SD = 13.8±1.5 minutes). Effect sizes were moderate (d=0.41).

A one-way ANOVA revealed nappers to have later bedtimes on holidays (+16.9 minutes), shorter TIB on weekend (-11.7 minutes) and holidays (-12.2 minutes), greater bedtime variability on school nights (+24.9 minutes) and weekends (+19.4 minutes), and greater risetime variability on school days (+31.6 minutes). No other differences were found between nappers and non-nappers. Significant ANOVA results are presented in Table 3.2.

Table 3.2: *One-way ANOVA results for significant differences in various sleep variables between nappers and non-nappers.*

	Nappers	Non-Nappers	ANOVA results		
Sleep Variable	M(±SD)	M(±SD)	F	*p*	*d*
$BT_{(hol)\ (dec\ 24h\ time)}$	21.2 (1.1)	20.9 (0.9)	8.4	0.004	0.28
$TIB_{(weekend)\ (dec\ hours)}$	10.4 (0.9)	10.6 (0.8)	4.9	0.027	0.23
$TIB_{(hol)\ (dec\ hours)}$	10.5 (0.9)	10.7 (0.8)	4.7	0.031	0.23
$BTV_{(school)\ (mins)}$	97.3 (61)	72.4 (49)	19.3	<0.001	0.43
$BTV_{(weekend)\ (mins)}$	119.7 (82)	100.3 (62)	4.3	0.039	0.20
$RTV_{(school)\ (mins)}$	91.0 (63)	59.4 (39)	29.6	<0.001	0.58

$BT_{(hol)}$ = bedtime holidays, $TIB_{(weekend)}$ = time in bed weekends, $TIB_{(hol)}$ = time in bed holidays, $BTV_{(school)}$ = bedtime variability school nights, $BTV_{(weekend)}$ = bedtime variability weekends, $RTV_{(school)}$ = risetime variability school days.

3.3.3 Nocturnal Sleep/Wake Patterns

Figure 3.1 shows mean bedtimes, risetimes, TIB and TST for school nights, weekends and holidays across age groups. Descriptive statistics for the complete cohort revealed that overall bedtimes were later on weekends than school nights (+46.8 mins). Risetimes were also later on weekends than school days (+26.4 mins). Holiday periods showed an additional increase in bedtimes (+2.4 min) and risetimes (+9.6 mins) as compared to weekends (Table 3.3).

Time in bed and total sleep time on weekends were shorter than on school days (TIB = -19.8min; TST = -18.0min). An increase in TIB and TST was seen during holidays compared to weekends (TIB = +7.2min; TST = +7.2min), however holiday sleep duration was still less than school nights (Table 3.5). Due to the large sample size, all paired comparisons were significant ($p<0.001$), even if actual differences were small (eg: mean difference between bedtime on weekends and holidays is 2.4 minutes yet $p<0.001$). Thus to provide for more informed discussion, univariate analysis was conducted on all sleep/wake pattern variables with sex, age, ethnicity and SES as independent variables.

Across the complete cohort, 0.9% (N=10/1077) of children were reported to have a TST of <9hrs per night on school days. This increased to 5.1% (N=52) on weekends and 4.4% (N=43) on holidays. 1.5% (N=16) of children were reported to have a TST of over 12 hours on school days, while 1.6% (N=16) and 3.4% (N=33) had TST of over 12 hours on weekends and holidays, respectively.

Figure 3.1: *Means (±SD) for bedtime, risetime, TIB and TST by age for school nights (black bars), weekends (grey bars) and holidays (white bars).*

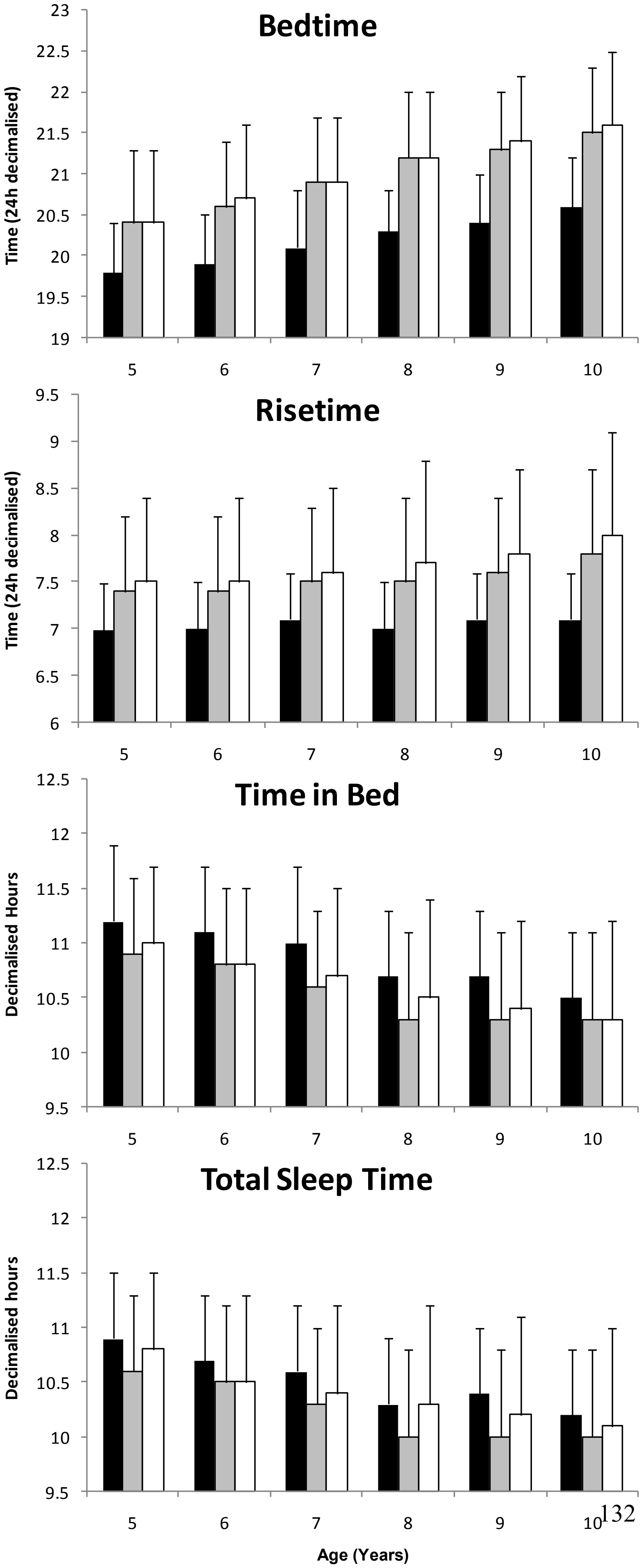

Table 3.3: *Mean (±SD) for reported bedtime, risetime and bedtime latency by sex, age, ethnicity and SES on school days, weekends and holidays*

	Demographics																								
Sex	Male												Female												Total
Age	Younger (5-7yrs)						Older (8-10yrs)						Younger (5-7yrs)						Older (8-10yrs)						
Ethn	Caucasian			Non-Caucasian			Caucasian			Non-Caucasian			Caucasian			Non-Caucasian			Caucasian			Non-Caucasian			
SES	Low	Mid	High	Low	Mid	High	Low	Mid	High	Low	Mid	High	Low	Mid	High	Low	Mid	High	Low	Mid	High	Low	Mid	High	
	N=148	N=115	N=141	N=34	N=23	N=9	N=106	N=94	N=118	N=19	N=17	N=7	N=169	N=118	N=159	N=42	N=23	N=17	N=105	N=83	N=127	N=29	N=17	N=10	N=1745
BT$_{(school)}$	19.8 (0.6)	19.9 (0.7)	19.8 (0.6)	20.6 (0.7)	20.4 (0.9)	19.9 (1.0)	20.3 (0.6)	20.4 (0.4)	20.4 (0.6)	20.9 (0.7)	20.9 (0.8)	21.0 (1.1)	19.9 (0.6)	19.8 (0.5)	19.8 (0.6)	20.5 (0.7)	20.6 (0.6)	20.4 (0.6)	20.4 (0.6)	20.2 (0.5)	20.4 (0.6)	20.6 (0.6)	20.8 (0.7)	20.8 (0.8)	20.1 (0.7)
BT$_{(weekend)}$	20.6 (0.8)	20.6 (0.8)	20.4 (0.7)	21.3 (1.0)	21.3 (0.9)	20.8 (0.8)	21.3 (0.9)	21.3 (0.6)	21.2 (0.8)	21.8 (0.9)	21.9 (0.6)	21.5 (1.3)	20.6 (0.9)	20.6 (0.7)	20.4 (0.8)	21.5 (0.7)	21.2 (0.8)	21.0 (0.9)	21.4 (0.8)	21.1 (0.8)	21.2 (0.8)	21.7 (0.7)	21.4 (0.7)	21.6 (0.6)	20.9 (0.9)
BT$_{(hol)}$	20.6 (0.8)	20.6 (0.8)	20.4 (0.8)	21.5 (1.2)	21.4 (1.0)	20.8 (1.0)	21.3 (0.9)	21.2 (0.6)	21.3 (0.8)	21.8 (0.9)	22.2 (0.7)	21.6 (1.1)	20.6 (0.8)	20.6 (0.8)	20.4 (0.8)	21.6 (0.8)	21.2 (0.8)	21.1 (1.0)	21.4 (0.9)	21.1 (0.7)	21.2 (0.8)	21.9 (0.8)	21.8 (1.0)	22.1 (0.6)	20.9 (0.9)
RT$_{(school)}$	6.9 (0.6)	7.0 (0.5)	6.9 (0.5)	7.2 (0.6)	7.0 (0.7)	7.0 (0.7)	7.0 (0.6)	7.0 (0.4)	7.1 (0.5)	7.1 (0.6)	7.4 (0.5)	7.0 (0.8)	7.0 (0.5)	7.1 (0.4)	7.0 (0.5)	7.3 (0.5)	7.3 (0.5)	7.2 (0.5)	7.1 (0.5)	7.1 (0.4)	7.1 (0.5)	7.1 (0.6)	7.3 (0.7)	7.4 (0.3)	7.0 (0.5)
RT$_{(weekend)}$	7.3 (0.9)	7.2 (0.7)	7.1 (0.7)	7.9 (1.1)	7.7 (1.2)	7.3 (0.7)	7.3 (0.8)	7.6 (0.9)	7.3 (0.7)	7.4 (1.0)	8.3 (1.2)	7.4 (1.4)	7.4 (0.8)	7.5 (0.8)	7.4 (0.7)	8.0 (0.9)	7.7 (0.8)	7.7 (0.8)	7.7 (0.9)	7.5 (0.9)	7.8 (0.9)	8.1 (1.1)	8.1 (1.4)	7.7 (0.6)	7.5 (0.7)
RT$_{(hol)}$	7.4 (0.9)	7.3 (0.7)	7.2 (0.8)	8.1 (1.0)	7.8 (1.4)	7.4 (0.9)	7.5 (0.9)	7.7 (0.9)	7.5 (0.8)	8.0 (1.1)	8.3 (1.4)	8.1 (1.5)	7.5 (0.9)	7.7 (0.9)	7.5 (0.8)	8.3 (1.0)	8.0 (0.9)	8.0 (1.0)	7.9 (1.1)	7.7 (1.0)	8.0 (1.0)	8.2 (1.4)	8.7 (1.7)	8.1 (0.6)	7.6 (1.0)
	N=73	N=68	N=92	N=25	N=15	N=7	N=53	N=49	N=84	N=15	N=13	N=5	N=104	N=84	N=90	N=35	N=20	N=14	N=62	N=52	N=86	N=16	N=11	N=7	N=897
BTL$_{(school)}$	18.8 (23)	23.3 (29)	24.7 (24)	14.4 (20)	15.7 (13)	16.4 (21)	24.3 (19)	18.5 (15)	26.7 (20)	11.0 (13)	28.5 (22)	10.0 (4)	25.6 (26)	19.8 (14)	19.9 (20)	22.0 (31)	10.0 (12)	11.8 (11)	25.1 (26)	22.4 (20)	24.0 (21)	20.0 (17)	27.7 (23)	22.1 (21)	22.9 (22)
BTL$_{(weekend)}$	14.6 (17)	17.8 (26)	21.9 (25)	14.2 (21)	12.0 (9)	15.7 (23)	21.1 (21)	14.8 (16)	19.7 (17)	6.3 (9)	22.9 (17)	10.0 (5)	19.3 (20)	18.7 (13)	17.0 (19)	23.0 (37)	14.2 (27)	8.2 (9)	18.9 (19)	14.6 (14)	18.7 (17)	15.7 (19)	13.8 (12)	14.3 (14)	18.3 (19)
BTL$_{(hol)}$	21.7 (37)	18.0 (22)	22.7 (25)	14.6 (21)	13.6 (9.9)	15.7 (23)	20.1 (21)	17.2 (16)	19.9 (17)	7.1 (14)	23.7 (13)	10.0 (5)	22.8 (19)	17.9 (14)	17.4 (19)	24.0 (37)	14.7 (28)	6.4 (9)	22.4 (21)	15.1 (18)	20.7 (20)	15.0 (17)	18.1 (13)	17.1 (16)	19.9 (22)

BT$_{(school)}$ = bedtime school nights; BT$_{(weekend)}$ = bedtime weekends, BT$_{(hol)}$ = bedtime holidays, RT$_{(school)}$ = risetime school days, RT$_{(weekend)}$ = risetime weekends, RT$_{(hol)}$ = risetime holidays, BTL$_{(school)}$ = bedtime latency school nights, BTL$_{(weekend)}$ = bedtime latency weekends, BTL$_{(hol)}$ = bedtime latency holidays

Table 3.4: *Univariate ANOVA results for bedtime, risetime and bedtime latency*

	Bedtime									Risetimes									Bedtime Latency								
	School nights			Weekends			Holidays			School days			Weekends			Holidays			School			Weekends			Holidays		
Demographics	F	*p*	d/ω^2	F	*p*	d/ω^2	F	*p*	d/ω^2	F	*p*	d/ω^2	F	*p*	d/ω^2	F	*p*	d/ω^2	F	*p*	d/ω^2	F	*p*	d/ω^2	F	*p*	d/ω^2
Sex[a]	0.03			0.17			0.02			8.93	0.003	0.20	12.6	<0.001	0.27	13.6	<0.001	0.30	0.59			0.04			0.32		
Age[a]	106.1	<0.001	0.76	94.8	<0.001	0.83	106.9	<0.001	0.80	2.10			6.24	0.013	0.21	13.8	<0.001	0.26	7.95	0.005	0.21	1.79			3.29		
Ethnicity[a]	138.5	<0.001	0.83	68.7	<0.001	0.68	114.6	<0.001	0.82	18.5	<0.001	0.35	22.6	<0.001	0.43	41.4	<0.001	0.52	11.7	0.001	0.34	13.4	<0.001	0.39	10.17	0.001	0.39
SES[b]	1.87			6.59	0.001	0.07	4.36	0.013	0.04	0.61			3.85	0.021	0.04	1.13			1.06			0.83			0.35		
Sex*Age	2.00			1.74			0.10			0.51			0.12			0.05			0.04			0.05			0.40		
Sex*Ethnicity	0.32			0.01			0.08			0.22			0.01			0.03			0.46			0.32			0.75		
Age*Ethnicity	0.48			3.75			0.45			0.00			0.35			0.00			1.18			0.93			3.39		
Sex*SES	0.43			1.72			2.11			0.45			2.79			0.10			1.51			2.08			1.94		
Age*SES[b]	4.66	0.010	0.05[b]	0.63			2.08			2.98			2.92			3.03	0.048	0.03	1.06			0.16			0.80		
Ethnicity*SES	1.69			0.43			0.72			0.45			1.85			1.00			1.93			1.68			2.90		
Sex*Age*Ethnicity[b]	5.22	0.022	0.05[b]	1.30			0.03			0.16			0.03			0.52			3.36			1.29			2.01		
Sex*Age*SES[b]	0.92			0.20			0.23			0.93			4.12	0.016	0.04	0.43			0.59			0.68			0.83		
Sex*Ethnicity*SES	2.72			0.76			1.90			0.81			0.45			0.16			1.76			2.36			0.33		
Age*Ethnicity*SES[b]	1.74			0.14			1.86			3.16	0.043	0.03	2.75			2.79			3.48	0.031	0.05	3.13	0.044	0.05	2.01		
Sex*Age*Ethnicity*SES	0.87			0.18			0.13			0.94			0.53			1.87			0.27			0.49			0.00		

[a] Cohen‟s *d*, 0.2 mild effect: 0.5 moderate effect: 0.8 strong effect. [b]Hays ω^2 for multi-sample cases, 0.01 mild effect: 0.059 moderate effect: 0.138 large effect.

Table 3.3 shows mean (±SD) values for bedtime, risetime and bedtime latency for school nights, weekends and holidays across all groups. Bedtime and risetime are reported in decimalised hours. Bedtime latency is reported in minutes. Table 3.3.4 reports univariate analysis for bedtime, risetime, and bedtime latency by sex, age, ethnicity and SES.

Univariate analysis found a significant main effect of sex in risetimes only. Girls were reported to rise significantly later than boys on school days (+6.2min), weekends (+13.8min) and holidays (+17.1min). Effects were mild.

A significant main effect for age was found in bedtime over all time measures. Differences were found in risetimes on weekends and holidays. Significant age differences were found in bedtime latency on school nights only. On school nights, older children went to bed on average 28.7 minutes later than younger children. This extended to 40.8 minutes on weekends and 41.5 minutes during holidays. Older children rose 10.7 minutes later on weekends and 33.0 minutes later during holidays than younger children. Bedtime latency on school nights differed by an average of 2.3 minutes. Effect sizes for differences in bedtimes were strong, but mild for risetimes and bedtime latency.

A significant main effect for ethnicity was found across all variables. Usual bedtime was on average 34.7, 35.5 and 45.4 minutes later for Non-Caucasian than Caucasian children on school nights, weekends and holidays, respectively. Risetime was also later in Non-Caucasian children on school days (+11.4min), weekends (+24.0min) and holidays (+33.0min). Bedtime latency, however, was longer in Caucasian children with an increase of 5.4 minutes on school nights, 3.1 minutes on weekends, and 3.8 minutes on holidays. Effect sizes for ethnicity were moderate to strong.

SES differences were found in bedtimes on weekends and holidays and risetimes on weekends. Post-hoc analysis revealed children from the low SES went to bed significantly later than those from mid- (+7.3min) or high SES (+16.1min) groups on weekends. Bedtimes on weekends were also significantly later in the mid-SES group compared to the high SES group (+8.8min). Bedtimes on holidays differed only for the low SES group at 7.9 minutes later than mid-SES and 7.1 minutes later than high SES groups. The high SES group was found to rise significantly earlier than mid-SES (-8.0min) or low SES groups (-7.5min). Effect sizes were moderate.

Significant age by SES interactions were found for bedtimes on school nights and risetimes during holidays. Paired comparisons revealed that young children in the high SES group went to bed earlier on school nights and got up earlier during holidays than any other group.

Three-way interactions were found in a small number of sleep/wake variables, however low cell numbers prevented further post-hoc analysis.

Table 3.5: *Mean (±SD) reported TIB and TST by sex, age, ethnicity and SES on school days, weekends and holidays*

	Demographics																								
Sex	Male												Female												Total
Age	Younger (5-7yrs)						Older (8-10yrs)						Younger (5-7yrs)						Older (8-10yrs)						
Ethn	Caucasian			Non-Caucasian			Caucasian			Non-Caucasian			Caucasian			Non-Caucasian			Caucasian			Non-Caucasian			
SES	Low	Mid	High	Low	Mid	High	Low	Mid	High	Low	Mid	High	Low	Mid	High	Low	Mid	High	Low	Mid	High	Low	Mid	High	
	N=140	N=109	N=137	N=34	N=23	N=8	N=103	N=91	N=117	N=20	N=16	N=7	N=162	N=127	N=155	N=41	N=23	N=16	N=95	N=82	N=124	N=27	N=17	N=10	N=1684
$TIB_{(school)}$	11.1 (0.6)	11.0 (0.6)	11.1 (0.6)	10.6 (0.7)	10.7 (0.9)	11.2 (0.6)	10.6 (0.7)	10.6 (0.6)	10.6 (0.6)	10.2 (0.7)	10.5 (0.7)	10.0 (0.8)	11.1 (0.6)	11.3 (0.6)	11.3 (0.6)	10.7 (0.6)	10.7 (0.8)	10.8 (0.5)	10.7 (0.6)	10.9 (0.6)	10.8 (0.6)	10.3 (0.7)	10.5 (0.7)	10.6 (0.7)	10.9 (0.7)
$TIB_{(weekend)}$	10.7 (0.7)	10.7 (0.7)	10.7 (0.7)	10.6 (0.9)	10.4 (0.8)	10.5 (0.8)	10.0 (0.8)	10.3 (0.8)	10.1 (0.7)	9.6 (1.1)	10.4 (1.0)	9.9 (0.9)	10.8 (0.8)	11.0 (0.7)	11.0 (0.7)	10.4 (0.7)	10.5 (0.7)	10.7 (0.6)	10.4 (0.8)	10.4 (0.7)	10.6 (0.7)	10.3 (0.9)	10.8 (1.2)	10.2 (0.7)	10.6 (0.8)
$TIB_{(hol)}$	10.8 (0.8)	10.7 (0.7)	10.8 (0.7)	10.5 (0.9)	10.4 (0.9)	10.5 (0.5)	10.2 (0.9)	10.5 (0.9)	10.3 (0.7)	10.0 (1.2)	10.1 (1.4)	10.5 (0.9)	10.9 (0.7)	11.1 (0.7)	11.1 (0.8)	10.6 (0.6)	10.7 (0.9)	10.9 (0.6)	10.6 (0.8)	10.6 (0.8)	10.8 (0.8)	10.2 (1.2)	10.7 (0.9)	10.2 (0.6)	10.7 (0.8)
	N=68	N=64	N=88	N=24	N=16	N=6	N=53	N=47	N=83	N=15	N=12	N=5	N=100	N=79	N=87	N=35	N=20	N=14	N=56	N=52	N=83	N=15	N=11	N=7	N=1040
$TST_{(school)}$	10.7 (0.6)	10.8 (0.7)	10.7 (0.6)	10.6 (0.6)	10.5 (0.8)	10.9 (0.5)	10.2 (0.6)	10.3 (0.6)	10.2 (0.6)	10.0 (0.7)	10.2 (0.5)	10.0 (0.8)	10.7 (0.6)	10.9 (0.5)	11.0 (0.6)	10.3 (0.6)	10.4 (0.7)	10.5 (0.4)	10.3 (0.6)	10.5 (0.6)	10.4 (0.6)	10.0 (0.8)	10.0 (0.5)	10.3 (0.6)	10.6 (0.7)
$TST_{(weekend)}$	10.4 (0.7)	10.4 (0.7)	10.4 (0.7)	10.4 (0.7)	10.2 (0.9)	10.2 (1.1)	9.7 (0.8)	10.1 (0.9)	9.8 (0.6)	9.3 (1.0)	10.0 (1.1)	9.7 (0.9)	10.5 (0.8)	10.7 (0.7)	10.8 (0.7)	10.0 (0.9)	10.3 (0.8)	10.5 (0.6)	10.1 (0.8)	10.1 (0.7)	10.3 (0.7)	10.2 (1.0)	10.3 (1.1)	9.9 (0.9)	10.3 (0.8)
$TST_{(hol)}$	10.4 (0.9)	10.5 (0.7)	10.5 (0.7)	10.4 (0.9)	10.2 (0.9)	10.3 (0.9)	9.9 (0.9)	10.2 (0.9)	10.0 (0.7)	9.8 (1.4)	9.9 (1.2)	10.4 (0.5)	10.5 (0.6)	10.9 (0.8)	10.9 (0.7)	10.4 (0.9)	10.5 (0.8)	10.8 (0.5)	10.3 (0.8)	10.4 (1.0)	10.5 (0.8)	9.9 (1.7)	10.6 (1.0)	9.7 (0.6)	10.4 (0.9)

$TIB_{(school)}$ = time in bed school nights; $TIB_{(weekend)}$ = time in bed weekends; $TIB_{(hol)}$ = time in bed holidays; $TST_{(school)}$ = total sleep time school nights; $TST_{(weekend)}$ = total sleep time weekends, $TST_{(hol)}$ = total sleep time holidays

Table 3.6: *Univariate ANOVA results for TIB and TST*

	TIB									TST								
	School nights			Weekends			Holidays			School days			Weekends			Holidays		
Demographics	F	*p*	*d*/ω^2	F	*p*	*d*/ω^2	F	*p*	*d*/ω^2	F	*p*	*d*/ω^2	F	*p*	*d*/ω^2	F	*p*	*d*/ω^2
Sex[a]	4.56	0.33	0.19	17.2	<0.0001	0.33	17.5	<0.0001	0.37	0.19			11.2	0.001	0.34	9.66	0.002	0.40
Age[a]	77.6	<0.0001	0.66	46.1	<0.0001	0.62	29.0	<0.0001	0.49	73.0	<0.0001	0.74	37.4	<0.0001	0.68	23.6	<0.0001	0.47
Ethnicity[a]	55.0	<0.0001	0.56	11.7	0.001	0.27	11.6	0.001	0.28	22.5	<0.0001	0.42	6.94	0.009	0.23	4.23	0.040	0.18
SES[b]	1.88			4.82	0.008	0.05	3.71	0.025	0.04	2.76			2.74			2.96		
Sex*Age	3.70			3.74			0.12			1.66			2.56			0.08		
Sex*Ethnicity	0.37			0.00			0.15			3.65			0.13			1.57		
Age*Ethnicity	0.02			2.49			0.72			0.01			0.83			0.01		
Sex*SES	0.09			0.16			1.49			0.43			0.52			1.25		
Age*SES[b]	3.70			4.88	0.008	0.05	1.57			0.54			1.82			0.75		
Ethnicity*SES	0.85			0.98			0.66			0.64			0.23			0.05		
Sex*Age*Ethnicity	3.14			2.76			0.08			1.46			1.29			1.18		
Sex*Age*SES[b]	2.12			2.35			0.70			0.05			4.86	0.008	0.08	1.96		
Sex*Ethnicity*SES	0.88			0.16			2.42			0.08			0.21			1.71		
Age*Ethnicity*SES[b]	1.16			3.56	0.029	0.04	1.23			0.05			0.54			0.64		
Sex*Age*Ethnicity*SES[b]	3.14	0.044	0.03	0.73			3.14	0.043	0.03	0.86			1.47			2.50		

[a] Cohen"s *d*, 0.2 mild effect: 0.5 moderate effect: 0.8 strong effect. [b]Hays ω^2 for multi-sample cases, 0.01 mild effect: 0.059 moderate effect: 0.138 large effect.

Mean (±SD) values for TIB and TST are presented in Table 3.5. Table 3.6 shows the univariate ANOVA results.

Significant sex differences were found in TIB for all time periods, however no differences were found in TST on school nights. Girls spent longer in bed than boys on school nights (+7.8min), weekends (+16.0min) and holidays (+18.5min). The mean difference in TST on weekends was 16.1 minutes and on holidays 20.3 minutes.

Significant main effects were found for age and ethnicity on all TIB and TST variables. Younger children spent longer in bed than older children on school nights (+25.6min), weekends (+29.2min) and holidays (+24.4min). Total sleep time was also longer in younger children (+33min school nights; +28.3min weekends; +23.9min holidays).

Caucasian children spent longer in bed than Non-Caucasian children on school nights (+23.4min), weekends (+13.5min) and holidays (+15.3min). The difference in TST was 16.5, 11.9, and 10.0 minutes on school nights, weekends, and holidays, respectively.

Differences in TIB across SES groups were found on weekends and holidays only. Children from the low SES group spent less time in bed than those from the mid (-7.5min) or high (-8.1min) SES groups. TIB was 8.0 minutes longer in the low SES group than high SES group on holidays. Post-hocs revealed no other significant differences after Bonferroni corrections were applied. No differences were found in TST in any measurement period.

A significant age by sex interaction for TIB on weekends revealed that older children from the low SES group spent significantly less time in bed than any other group. Young children from the low SES group spent significantly more time in bed than older children from any SES group, yet significantly less than younger children from the high SES group.

Table 3.7: *Mean (±SD) for reported bedtime variability, risetime variability, bedtime shift and risetime shift by sex, age, ethnicity and SES on school days and weekends*

	Demographics																								
Sex	Male												Female												Total
Age	Younger (5-7yrs)						Older (8-10yrs)						Younger (5-7yrs)						Older (8-10yrs)						
Ethn	Caucasian			Non-Caucasian			Caucasian			Non-Caucasian			Caucasian			Non-Caucasian			Caucasian			Non-Caucasian			
SES	Low	Mid	High	Low	Mid	High	Low	Mid	High	Low	Mid	High	Low	Mid	High	Low	Mid	High	Low	Mid	High	Low	Mid	High	
	N=146	N=114	N=140	N=34	N=23	N=8	N=103	N=92	N=116	N=20	N=16	N=7	N=165	N=129	N=159	N=40	N=22	N=17	N=103	N=82	N=125	N=27	N=15	N=10	N=1474
BTV$_{(school)}$	80.8	72.5	62.3	91.6	81.5	56.3	82.6	72.1	65.0	76.5	90.9	70.0	73.4	68.8	63.3	83.1	92.3	77.9	74.7	77.7	68.2	81.3	107.7	72.0	73.1
	(53)	(54)	(42)	(62)	(51)	(50)	(52)	(53)	(42)	(61)	(46)	(44)	(55)	(44)	(39)	(40)	(52)	(39)	(47)	(51)	(49)	(54)	(73)	(57)	(49)
BTV$_{(weekend)}$	103.1	90.8	87.9	90.9	92.4	77.1	112.0	112.4	103.8	101.0	140.6	102.9	102.6	102.4	89.5	94.8	96.4	96.2	115.2	107.4	110.3	99.4	99.3	94.5	101.5
	(65)	(58)	(52)	(60)	(49)	(64)	(65)	(72)	(60)	(99)	(86)	(64)	(68)	(64)	(58)	(49)	(44)	(55)	(74)	(57)	(63)	(68)	(64)	(62)	(63)
BTV$_{(hol)}$	104.1	96.5	97.7	107.1	96.8	72.9	119.4	115.9	111.1	97.2	129.4	105.0	109.9	112.3	93.3	91.0	105.5	100.9	119.3	124.1	120.6	110.2	113.1	104.4	108.2
	(61)	(57)	(57)	(72)	(45)	(57)	(68)	(67)	(71)	(73)	(79)	(78)	(94)	(67)	(55)	(45)	(64)	(55)	(66)	(78)	(67)	(56)	(54)	(67)	(65)
RTV$_{(school)}$	68.2	64.4	64.8	61.3	66.5	58.8	65.1	66.2	52.0	70.6	59.1	39.3	62.3	54.6	58.9	59.6	52.2	63.8	58.5	59.1	56.7	61.8	64.7	68.5	61.0
	(39)	(38)	(31)	(49)	(47)	(23)	(45)	(50)	(31)	(58)	(31)	(41)	(44)	(30)	(36)	(40)	(38)	(34)	(40)	(62)	(46)	(64)	(39)	(47)	(41)
RTV$_{(weekend)}$	85.2	71.5	80.3	81.7	77.4	67.1	87.2	93.6	75.6	70.3	88.0	72.9	87.9	78.0	74.8	74.9	61.7	75.0	97.4	76.4	90.3	83.1	78.2	93.9	82.1
	(50)	(42)	(45)	(51)	(56)	(35)	(56)	(54)	(47)	(59)	(36)	(60)	(51)	(46)	(43)	(44)	(40)	(25)	(61)	(55)	(55)	(58)	(48)	(55)	(50)
RTV$_{(hol)}$	87.0	81.8	85.4	82.0	80.5	65.0	96.4	94.1	88.0	92.1	97.7	81.4	89.6	82.3	81.1	94.7	79.8	68.4	99.1	81.2	102.1	93.8	110.8	93.3	87.5
	(50)	(44)	(49)	(76)	(54)	(29)	(60)	(76)	(48)	(65)	(47)	(83)	(53)	(47)	(41)	(71)	(64)	(32)	(62)	(51)	(67)	(40)	(35)	(39)	(55)
BTSHFT	49.6	39.7	36.3	34.4	55.4	41.3	58.1	55.7	46.7	53.5	63.4	30.0	42.9	44.7	35.5	52.7	32.7	37.9	63.5	54.6	48.0	59.4	45.0	48.0	46.8
	(35)	(34)	(32)	(33)	(42)	(40)	(39)	(33)	(36)	(40)	(44)	(35)	(38)	(35)	(28)	(34)	(32)	(39)	(42)	(37)	(38)	(45)	(31)	(43)	(36)
RTSHFT	23.9	16.9	13.7	39.3	41.3	6.4	22.5	36.4	16.4	14.7	56.0	24.3	25.2	27.5	20.3	34.6	30.2	35.0	34.0	26.3	36.6	59.0	49.3	20.0	26.6
	(35)	(25)	(28)	(44)	(43)	(12)	(34)	(48)	(32)	(50)	(81)	(40)	(33)	(34)	(31)	(43)	(41)	(26)	(50)	(40.8)	(43)	(57)	(63)	(36)	(39)

BTV$_{(school)}$ = bedtime variability school nights, BTV$_{(weekend)}$ = bedtime variability weekends, BTV$_{(hol)}$ = bedtime variability holidays, RTV$_{(school)}$ = risetime variability school days, RTV$_{(weekend)}$ = risetime variability weekends, RTV$_{(hol)}$ = risetime variabililty holidays, BTSHFT = bedtime shift, RTSHFT = risetime shift

Table 3.8: *Univariate ANOVA results for bed-, risetime variability and bed-, risetime shift*

	Bedtime Variability									Risetime Variability									Bedtime Shift			Risetime Shift		
	School nights			Weekends			Holidays			School days			Weekends			Holidays								
Demographics	F	*p*	d/ω^2	F	*p*	d/ω^2	F	*p*	d/ω^2	F	*p*	d/ω^2	F	*p*	d/ω^2	F	*p*	d/ω^2	F	*p*	d/ω^2	F	*p*	d/ω^2
Sex[a]	1.17			0.18			1.59			0.19			0.44			10.3			0.02			6.32	0.012	0.10
Age[a]	0.05			5.79	0.016	0.45	7.82	0.005	0.23	2.64			2.45			9.95	0.002	0.16	12.3	<0.0001	0.34	4.39	0.036	0.20
Ethnicity[a]	4.47	0.035	0.23	1.01			2.34			0.07			1.11			1.00			1.00			8.64	0.003	0.34
SES[b]	3.40	0.033	0.03	1.14			1.31			0.17			1.00			1.09			5.76	0.003	0.06	7.10	0.001	0.08
Sex*Age	0.66			1.30			0.05			2.82			0.82			0.30			0.20			0.00		
Sex*Ethnicity	2.15			0.00			0.36			2.91			0.07			1.94			0.00			0.02		
Age*Ethnicity	0.35			0.17			0.00			0.26			0.36			3.21			1.36			0.80		
Sex*SES	0.48			0.26			0.10			1.67			2.69			0.61			2.74			2.50		
Age*SES	1.05			0.60			0.40			1.17			0.70			0.56			0.60			0.26		
Ethnicity*SES	2.06			1.15			1.37			0.61			0.08			1.20			0.38			1.52		
Sex*Age*Ethnicity	1.58			1.16			0.02			0.72			0.91			1.78			0.01			0.10		
Sex*Age*SES[b]	0.64			0.51			0.78			1.14			1.65			0.38			0.54			3.68	0.025	0.04
Sex*Ethnicity*SES[b]	0.35			0.75			0.55			0.83			0.93			0.10			4.03	0.018	0.04	0.11		
Age*Ethnicity*SES	1.06			0.22			0.24			0.38			0.06			0.27			0.28			0.22		
Sex*Age*Ethnicity*SES[b]	0.90			0.26			1.09			0.89			0.22			0.62			1.99			3.26	0.039	0.03

[a] Cohen"s *d*, 0.2 mild effect: 0.5 moderate effect: 0.8 strong effect. [b]Hays ω^2 for multi-sample cases, 0.01 mild effect: 0.059 moderate effect: 0.138 large effect.

3.3.4 Sleep Schedules

The difference between the latest and earliest time a child went to bed (bedtime variability), and the latest and earliest time a child rose (risetime variability) was calculated as a measure of sleep schedules.

Table 3.7 shows reported mean (±SD) variability and shift times in minutes. Univariate results are presented in Table 3.8.

A significant main effect for sex was found in risetime shift, with girls reporting a greater difference between school day and weekend risetime. No other sex differences were found.

Significant main effects were found for age in bedtime variability on weekends and holidays, risetime variability on holidays, and both shift measures. Older children showed a greater variability than younger children by 13.9 minutes on weekends and 15.5 minutes on holidays. Risetime variability on holidays was 10.1 minutes greater in older children. The difference between bedtimes on school nights and weekend (bedtime shift) was 12.2 minutes longer in older children. Risetime shift was 7.2 minutes longer in older children.

Significant differences were found between Caucasians and Non-Caucasians in two variability measures: bedtime variability on school nights; and risetime shift. Non-Caucasian children were reported with greater bedtime variability (+12.9min) and risetime shift (+12.5min).

SES differences were also found in bedtime variability on school nights and risetime shift as well as bedtime shift. Both low (+13.8min) and mid-SES (+10.3min) groups reported greater bedtime variability than the high SES group. Low and mid-SES groups also reported greater risetime (low=+7.5min;

mid=+7.4min) and bedtime (low=+10.6min; mid=+6.9min) shift than the high SES group.

Two 3-way interactions were found, however limited cell size prevented further analysis. Effect sizes for all differences on sleep schedule variables were mild except for SES differences in risetime shift which were moderate.

3.3.4 Seasonal Effects

Significant seasonal effects were found in a number of nocturnal sleep characteristics. Bedtime on weekends was later in Spring than Autumn (+9.1min) or Winter (11.4min; $F_{(2, 1769)}$=4.4, p=0.012). Usual bedtime (+10.2min; $F_{(2, 1729)}$=3.3, p=0.038) and risetime (+11.1min; $F_{(2, 1635)}$=4.64, p=0.010) during holidays was later in Spring than Autumn. $TIB_{(weekend)}$ was significantly longer in Winter than Spring (+9.5min; $F_{(2, 1653)}$=4.0, p=0.018). Bedtime variability on school days (+7.2min; $F_{(2, 1741)}$=3.5, p=0.029) and holidays (+13.4min; $F_{(2, 1650)}$=7.4, p=0.001) was greater in Spring than Autumn. Risetime shift was also greater in Spring than Autumn (+5.8min; $F_{(2, 1644)}$=3.1, p=0.044). All effect sizes were mild ($\omega^2 \leq 0.01$).

3.4 DISCUSSION

This study is the first to examine sleep/wake patterns in a large cohort of school-aged children in Australia. In this study, 5.6% of children were reported to nap. There was no difference in the proportion of younger children napping compared with older children, however both ethnicity and SES appeared to influence the rate of napping. Some differences were found in nocturnal sleep/wake patterns between nappers and non-nappers.

Nocturnal sleep/wake patterns differed according to sex, age, ethnicity and SES. Girls spent longer in bed than boys as a result of later risetimes. No differences were found in the amount of sleep obtained between the sexes however. Older children went to bed later, got up later, had less time in bed and total sleep time, and greater variability in routines than younger children. This pattern was similar to differences seen between Caucasian and Non-Caucasian children, with the latter reporting later bedtimes, risetimes and less sleep opportunity (TIB and TST). Bedtime variability on school nights and risetime shift also differed between ethnic groups. Differences across SES groups were only seen on weekends and holidays, except for bedtime variability on school nights where children from the high SES group reported significantly less variability than the mid- or low SES groups. In general, this pattern was observed for all differences: the high SES group reported earlier bedtimes and risetimes, and greater sleep opportunity than either the mid- or low SES groups. Sleep/wake patterns were similar between the mid- and low SES groups.

3.4.1 Napping

The overall prevalence of napping in the current study was low, yet consistent with other Western countries. Thorleifsdottir et al. (2002) reported the prevalence of napping in children in Iceland to be 6.5% at 5-6 years and less than 4% at 7-9 years. In a review of sleep in children and adolescents in Italy, Giannotti et al. (2005) reported the average prevalence of napping in 4-6 year-olds to be 13%, 6-8 year-olds 2% and 8-10 year-olds 3.4%. Crosby et al. (2005) reported similar prevalence rates in a sample of Caucasian-American children at 7 and 8 years (<10%), but higher rates in 5 year-olds (~60%) and 6 year-olds (~40%).

In most studies, napping has been reported to reduce with age. This was not supported here. In Saudi Arabia, BaHammam et al. (2006) reports the prevalence of napping to increase from 5 to 10 years, with 29% of children napping at 5 and 40% napping at 10. It may be however that the rate of napping is directly related to reduced nocturnal sleep time. Thorleifsdottir et al. (2002) found that the percent of children napping reduced from 3- to 10-years (21.8% - 4%), yet increased again during adolescence – 40% of adolescents aged 15-20 years were reported to nap – when nocturnal sleep reduced. In BaHammam et al‟s study, children reported less than 9 hours nocturnal sleep during school days, but within the 24 hour period, the average total sleep time was approximately 9½ hours. Thus, the high rate of naps may be a compensation for the shorter nocturnal sleep. The fact that no napping is reported on weekends in that study when nocturnal sleep increased by 1½ hours – the same amount of the average nap during school days – supports this. In the current study, there is a decrease in nocturnal sleep time with age, yet no change in napping. This suggests that the practice of napping is due to other influences and not sleep need.

In the current study proportionately more children from the low and mid SES groups napped than those from the high SES group. Children from the lower SES group also reported less time in bed than those in higher SES groups on both weekends and holidays however, there was no difference in nocturnal total sleep time. Thus, the increase in the proportion of children in the low SES groups napping may be due to a greater number of Non-Caucasian children in these groups.

Whilst there was no ethnic differences reported in the length of napping, proportionately more Non-Caucasian than Caucasian children were reported to nap. This is consistent with Crosby et al. (2005). In a study examining racial differences in napping and nocturnal sleep between Caucasian- and African-American children aged 2-8 years (N=1043), Crosby et al. reported that proportionately more African-American children napped at every age except 2-

years-old. The African-American children were also reported to have an increased bedtime, less nocturnal sleep, and a greater variability between school night and weekend sleep than their Caucasian counterparts. Similarly, the current study found nappers to obtain less nocturnal time in bed and a greater variability in sleep schedules than non-nappers on both school nights and weekends, with the greatest effects found in the bed- and risetime variability measures. The impact of inconsistent sleep schedules is unknown and may have ramifications for daytime functioning. Chapter 5 explores this in more detail.

Other studies have found that nappers have significantly shorter nocturnal sleep than non-nappers but equivalent sleep over a 24 hour period (BaHammam et al., 2006; Thorleifsdottir et al., 2002), however the current study found no difference in nocturnal sleep time between nappers and non-nappers. This suggests that the nappers are obtaining more sleep within a 24 hour period than the non-nappers. Unfortunately the current study did not indicate how often the children napped, thus it is unknown as to whether the napping occurred every day or only occasionally (e.g. one day during the school week) within the specified period. Further study using sleep diaries or actigraphy would be beneficial in obtaining a more accurate understanding of the differences in and subsequent consequences of sleep/wake patterns between nappers and non-nappers.

The current results demonstrate that the practice of napping is predominately embedded in cultural ideals; however, compared with other cross-cultural napping research (e.g. Crosby et al., 2005; Durrence & Lichstein, 2006), the proportion of Non-Caucasian children napping was still low. It may be that as the current cohort obtain an average of over 10 hours sleep per night, napping is not be biologically necessary. It may also be that the traditional cultural practices are not widely observed as Non-Caucasians adapt to Australian lifestyles. Thus, whilst napping may be an important consideration in the sleep/wake patterns of children in other countries, it does not appear to be an influential factor in Australian school-aged children.

3.4.2 Nocturnal sleep/wake patterns across school days, weekends and holidays.

The nocturnal sleep/wake patterns across school days and weekends are rarely reported as consistent at any age. In school-aged children however, there is discrepancy as to whether sleep duration is less (Gulliford et al., 1990; Laberge et al., 2000; Nixon et al., 2008; Thorleifsdottir et al., 2002) or more (Adam et al., 2007; BaHammam et al., 2006; Russo et al., 2007; Shinkoda et al., 2000) on weekends. The current cohort of school-aged children were reported to sleep significant less on weekend nights than school nights. This reduced sleep duration was a result of a greater shift to later bedtimes as compared to risetimes.

It is proposed that extended sleep on weekends is the result of recovery from sleep debt accrued during the week (Dahl & Lewin, 2002). Indeed, it appears that children who have relatively shorter sleep periods during the week are also the ones who have relatively longer sleep on weekends (see Chapter 1). For example, Shinkoda et al. (2000) reported children less than 10 years old in Japan obtain approximately 60 minutes more sleep on weekends than school nights. In Japan, homework loads and early school start times may force children to sleep less than biologically needed on school nights, requiring recovery sleep on weekends when time permits. Indeed, Liu et al. (2005a) suggests that school night sleep duration in Chinese children is restricted as they are expected to do between 1-3 hours homework a night and then be at school for 7:30am classes. In Australia, school start times are approximately 8:30am and children receive very little homework until high school years which may allow ample sleep opportunity during the week to meet sleep need, negating the necessity to recover on weekends.

Nixon et al. (2008) suggests that the differences in weekly trends of sleep duration across ages may demonstrate a pubertal effect of sleep behaviour as children move from childhood through to adolescence. This is a plausible explanation as it is well accepted that as children move through puberty, sleep/wake cycles change (Carskadon et al., 2004; Roenneberg et al., 2004; Tonetti et al. (2008). However, the fact that previous sleep duration findings are inconsistent suggests that this phenomenon may be socially or culturally bound. Adolescents of the Warner et al. (2008) study showed longer sleep duration on weekends compared to weekdays during the school term, but not during the holiday period. In fact, during the holiday period, average weekend sleep duration was less than weekday sleep albeit with shifted bed and risetimes. In a longitudinal study examining annual and weekly variations in sleep/wake cycles of children aged 10 and 14 years (N=64), Szymczak et al. (1993) reported similar findings with differences in weekday/weekend sleep time eliminated during the holiday periods. This suggests that when children are able to sleep adlib, weekday and weekend sleep is consistent, supporting the notion that longer sleep duration on weekends is a function of accrued sleep debt and not necessarily a biological consequence (Carskadon et al., 1998; Dahl & Lewin, 2002).

Sleep/wake patterns during holidays periods were similar to weekends in the current cohort. That is, bedtimes were later, risetimes were later but to a lesser extent, resulting in reduced sleep duration compared to school nights. This is contrary to Szymczak et al. (1993) who reported sleep duration to be longer during the holiday period than during the school year. Warner et al."s (2008) also report longer weekday sleep duration during holidays compared with school days, however the weekend sleep of this adolescent study again showed similar trends to the SAPSS cohort. That is, weekend bed and risetimes were shifted during holidays compared to the school term weekend, however there was no difference in total sleep time. Although statistically significant, the mean difference between holiday and weekend sleep in the current study was less than 8 minutes. Risetimes were almost 10 minutes later on holidays than weekends. It may be that sporting or other weekend commitments resulted in earlier risetimes than would otherwise occur if children were able to rise on their own volition and if this was not a factor, weekend sleep would be equivalent to holiday sleep.

This study was limited to a cross-sectional cohort of children aged 5 to 10-years-old. Longitudinal research examining sleep/wake patterns from childhood through to adolescence, would provide further understanding of the developmental patterns of sleep in Australia. Further examination of the point at which the shift to accrued sleep debt occurs, resulting in longer weekend sleep duration, would be beneficial for intervention.

3.4.3 Sex related differences in sleep/wake patterns

Although limited, previous research has more consistently found girls to sleep longer than boys (see Chapter 1) which is supported by the findings of the current study. That is, girls were found to sleep longer than boys on weekends and holidays as a result of later risetimes. This is consistent with Spruyt et al. (2005) who reported girls go to bed earlier and get up later than boys on weekends at all ages from 6-13 years. The current results and the more usual finding of longer sleep duration in girls initiates speculation as to whether girls have a greater sleep need than boys

Tonetti et al. (2008) recently postulated that sleep need was greater in females as a result of biological factors related to reproductive hormones. In a study of 8,972 participants aged 10-87 years, Tonetti and colleagues examined ideal bedtime, risetime and sleep duration via a Morning-Eveningness Questionnaire. The results found that females at all ages except over 55 year-olds, indicate a preference for longer sleep duration than men. Contrary to the current study, this difference was the result of a preference for earlier bedtimes and not later risetimes. Actual sleep/wake patterns were not measured in the Tonetti et al. study, however the age-related timing of earlier bedtimes in females corresponds to a previous study by Ronnenberg and colleagues (2004), which reported sex differences in circadian phase preference from puberty to the age of menopause. Objective studies of sleep in community samples of adults have also reported longer sleep durations in women than men (Jean-Louis et al., 2000). Thus, it is plausible that the reproductive hormone activity in females results in a biological need for more sleep than men.

This does not explain the sex effect in the current study however. As the current sample can be assumed to be predominately pre-pubertal, the sex difference in sleep duration in pre-pubertal children may be a social phenomenon. For example, the earlier risetime in boys may be due to them being more active than girls. Olds et al. (2009) demonstrated that boys in Australia engage in more structured physical activity than girls. Retrospective analysis of the current cohort revealed that 13.5% of boys were reported to often play organised sport outside of school compared to 6.1% of girls (results not reported above). Thus, boys may be required to get up earlier to attend to sporting commitments. The Olds et al. study also reports boys engage in more screentime activity than girls. Again, boys may be getting up earlier to watch television before school or on weekends. In the current sample, boys reported longer mean screentimes than girls, with differences reaching statistical significance on weekends corresponding to the difference in TST. However as specific information regarding timing (i.e. morning, afternoon or evening) of sporting activities or television was not obtained in the current study, these explanations are speculative.

Whilst sex-effects have been found, caution must be taken when interpreting these results as effect sizes were small. Additionally, although mean differences were larger than have been observed in previous studies (Gulliford et al., 1990; Liu et al., 2005a; Ng et al., 2005), questions remain as to whether a 20 minute difference in habitual sleep time has any meaningful consequence. If, however, there is a difference in sleep need between boys and girls, this information would have importance consequences for sleep educators and physicians, especially considering the current „one size fits all" recommendations to sleep length. Further studies with more objective sleep measures are required to determine if sex differences in sleep/wake patterns are inherent or sociological, and what the consequences of these differences may be.

3.4.4 Age related differences in sleep/wake patterns

The most robust and widely accepted finding in epidemiological sleep research is that sleep duration reduces with age as a result of later bedtimes. Results from the current study do not contradict previous findings. That is, time in bed and total sleep time showed an age related decline predominantly as a result of later bedtimes. Risetime also increased with age on weekends and holidays but to a lesser extent. One novel finding of the current study is that sleep schedules were more inconsistent in the older age group, depicted by the significant increase in bedtime variability and bedtime shift.

Whilst the increasing bedtimes and decreasing sleep opportunity may be indicative of maturational change and not of concern, the increasing inconsistency of sleep schedules may be worthy of further examination. Wittmann et al. (2006) coined the term „social jetlag" to describe the shift in sleep time between weekdays and weekends, likening it to the change in sleep schedules when crossing time-zones. In a study of adolescents and adults (N=501; age = 14-94 years), Wittmann et al. found that social jetlag was associated with unhealthy behaviours such as smoking, increased alcohol intake and increased consumption of caffeinated beverages. It is unlikely that the current cohort would be partaking in these behaviours, however the "social jetlag" impact of increasingly inconsistent sleep schedules may manifest in other ways such as excessive sleepiness or mood changes. Again, the impact of inconsistent sleep schedules is relatively unknown, however ensuring consistency in routine as a child ages may ameliorate deficits to well-being. Chapter 5 explores the impact of inconsistent routines on behavioural functioning, however further research, in particular intervention designs, is needed to understand the impact of inconsistent schedules.

3.4.5 Ethnic differences in sleep/wake patterns

It has been suggested that sleep/wake patterns are determined as much by cultural practices as biological need (Jenni & O'Connor, 2005). Aside from age, the greatest differences with the largest effects in sleep/wake patterns in the current study were seen between Caucasians and Non-Caucasians, supporting the notion that cultural variations are a vital consideration in determining healthy sleep behaviour in children.

The later bed- and risetime and shorter sleep duration in Non-Caucasian children are consistent with previous studies examining ethnic difference in sleep/wake patterns in children (Gulliford et al., 1990; Liu et al., 2005a; Spilsbury et al., 2004). Interestingly, Non-Caucasian children also reported less bedtime latency than Caucasian children, resulting in a reduced difference in total sleep time. This suggests that there may be a difference between the groups in bedroom activities. Analysis of bedroom activities did not show any difference in the proportion of Caucasian and Non-Caucasian children watching television or listening to music after going to bed although proportionately more Non-Caucasian children played computer games (See Chapter 6). However, the current study did not ask parents to indicate how long the children were engaged in a particular activity. It may be that Caucasian children spend more time watching TV or playing on computers after going to bed than Non-Caucasian children. Alternatively, the later bedtimes of Non-Caucasian children may be more consistent with their biological need for sleep (i.e. Process S) and they are able to fall asleep quicker than their Caucasian counterparts.

A sleep onset latency – time taken to actually fall asleep – greater than 20 minutes is considered to indicate a pathological sleep problem and be detrimental (Ivanenko et al., 2006), however studies examining the effects of a long bedtime latency – time between going to the bedroom and being asleep – are rare. It may be that a late bedtime, currently understood as detrimental to well-being, is healthier for children than an early bedtime but lengthy bedtime latency. Further study examining effects of a lengthy bedtime latency and the activities children are engaged in before falling asleep on sleep quality, quantity and subsequent daytime functioning would be beneficial, particularly considering the increasing intrusion of technology into the bedroom (Christakis et al., 2004). Chapter 6 explores this further.

Sleep schedules were also reported to be more inconsistent in Non-Caucasian children, with greater bedtime variability on weekends and a greater difference between risetimes on school nights and weekends. Previous research has indicated that the importance of a sleep or bedtime routine appears to reside predominately in cultural ideals. For example, in Italy children are encouraged to participate in family activities in the evenings, falling asleep later than their counterparts in other countries (Ottaviano et al., 1996). In the United States, set bedtimes are recommended by child-rearing experts and often enforced by parents, regardless of whether the child is actually tired (Milan et al., 2007). In some Asian countries, completing homework is favoured over a consistent sleep routine (Steger, 2006; Yang et al., 2005). Indeed, in the current study, Non-Caucasian children spent almost twice as long as Caucasian children doing homework on both school nights (Mean±SD = 40.6±30 vs 26.6±20 mins, p<0.0001) and weekends (Mean±SD = 42.8±40 vs 22.2±20 mins, p<0.0001) (results not reported above).

Thus, whilst it is clear that there are cultural differences in sleep/wake patterns in children, it is unknown as to whether these differences can be considered unhealthy. It has been suggested that short sleep duration and late bedtimes are problematic for daytime functioning (Aronen et al., 2000; Fallone et al., 2005; Nixon et al., 2008) and as such age appropriate recommendations (National Sleep Foundation: www.sleepfoundation.org/article/sleep-topics/children-and-sleep) have been made to help parents ensure that children receive ample amounts of sleep. These recommendations however have been based on Western population norms without consideration for cultural variations in sleep habits. With the great variability in sleep patterns both within individuals and across cultures (Jenni & Carskadon, 2007), it may be that there is no optimal sleep amount or pattern for the entire population. Chapter 5 explores the behavioural implications of these different sleep behaviours and further comments on the appropriateness of promoting an optimal sleep amount.

3.4.6 Socio-economic differences in sleep/wake patterns

SES has an impact on a number of aspects of well-being in children including diet, access to health services, educational opportunities (Carter-Pokras & Baquet, 2002) and sleep (Rona et al., 1998). Consistent with previous studies (Crosby et al., 2005; Lozoff et al., 1996; McLaughlin Crabtree et al., 2005; Rona et al., 1998), children from lower SES areas in the current study reported later bedtimes and less time in bed than those from higher SES areas. However, this effect was only seen on weekends and holidays, with no differences in sleep/wake patterns found across SES bands on school days. This suggests that during the school week, bed and sleep routines are well monitored by all parents, while on weekends, those from lower SES areas maintain looser controls (Lozoff et al., 1996). The greater difference in bed- and risetime shift between the lower and higher SES groups in the current study also seems to support this. In addition, although time in bed was shorter, total sleep time was consistent across SES groups. This is heartening as it may be indicative of an understanding of the importance of sleep for academic and behavioural functioning, even if it is anecdotal.

The greater bedtime variability in the low and mid SES groups compared to the high SES group during the school week does warrant further investigation however. Attar et al. (1994) report that children in low-income areas are exposed to more stressful events, such as family conflict and adverse situations (e.g. alcoholism) which has a detrimental effect on school adjustment. Evans and English (2002) reported that children from low-income areas are more likely to report psychological distress and have greater difficulty in regulating their behaviour. Whilst these psychosocial factors may result in a greater variability in bedtime over the week, it may also be that bedtime variability can exacerbate any detrimental effects associated with low SES. Further investigation as to the cause of the increased variability and any detrimental effects is needed.

3.5 SUMMARY

In summary, many of sleep/wake patterns in South Australian children are consistent with those published elsewhere in the world. In particular, total sleep duration declines with age as a result of later bedtimes, with girls sleeping longer than boys. Encouragingly, very few children sleep less than currently recommended, suggesting that Australian families regard sleep as an important aspect of healthy development. Cultural variations are observed with Non-Caucasian children going to bed later and sleeping less than Caucasian children and some social differences are apparent with weekend sleep duration less than school night.

As the first study of its kind in Australia, this study leads to a number of future research directions. Of particular import is the finding that sleep schedules are more inconsistent in older children, Non-Caucasian children and children from low SES areas. Given that greater inconsistency of sleep schedules are observed in groups of children previously identified at risk of unhealthy sleep behaviours, closer examination of the consequences of poor sleep schedules is needed. Additionally, the current results suggest that girls may have a greater sleep need than boys. Further examination of this would better inform health educators and professionals on appropriate sleep practices.

Although not without its limits (discussed in Chapter 7), results from this study provide the first indication of normative sleep/wake patterns in a representative sample of school-aged children in Australia. To date, information regarding normative sleep in children has been modelled from other Western research, specifically American data. As can be seen from the above results, some sleep/wake patterns are culturally and socially bound and thus recommendations based on foreign data may be misleading. This current and geographically relevant information will provide a better understanding of sleep/wake patterns in Australia for future researchers, educators and health professionals.

CHAPTER 4: PREVALENCE OF SLEEP COMPLAINTS IN CHILDREN AGED 5-10 YEARS: RESULTS FROM THE SOUTH AUSTRALIAN PAEDIATRIC SLEEP SURVEY (SAPSS)

4.1 INTRODUCTION

Sleep problems are common in childhood with up to 40% of children reported to suffer from some type of sleep complaint (Mindell & Meltzer, 2008). Knowledge of the prevalence of sleep complaints is vital for promoting the health and well-being of children as sleep problems have been associated with behavioural (O'Brien & Gozal, 2002) and academic (Curcio et al., 2006; Meijer, 2008) deficits as well as physical health concerns such as obesity (Cappuccio et al., 2008) and cardiovascular disease (Gozal & Kheirandish-Gozal, 2008). Childhood sleep problems also have a substantive effect on family functioning with sleep disruption increasing the risk of maternal depression (Lam et al., 2003), family conflict (El-Sheikh et al., 2006) and strained parent/child relations (Kerr & Jowett, 1994).

Just as sleep/wake patterns change as a function of age (Iglowstein et al., 2003; Thorleifsdottir et al., 2002), sleep problems also appear to have a developmental component. In infancy, behavioural sleep problems are most commonly manifested as problems of initiating sleep, developing a sleep routine or circadian rhythmicity. During the pre-school years (3-5), bedtime resistance, sleep anxiety (such as fear of the dark), nightmares and night awakenings become the most prevailing sleep problems. These problems do continue through childhood (6-12 years), however tend to become less prevalent over time. Childhood is a time where parasomnias, such as enuresis, sleep talking, and sleep walking become more frequent, even if only briefly. This is also becoming recognised as the period in which Restless Leg Syndrome (RLS) or Periodic Limb Movement disorder (PLMD) manifests, reportedly often mistaken for „growing pains" (Moore et al., 2006; Stores, 2007). The most common sleep problem to affect adolescents is Delayed Sleep Phase Syndrome, resulting in chronic sleep deprivation and extreme daytime sleepiness (Carskadon, 2004). Insomnia is also more prevalent in adolescence than at any other age during childhood, however this may be partly the result of an increase in caffeine or other stimulant use (Moore et al., 2006).

In contrast to the marked developmental change observed in most behavioural sleep problems, the prevalence of sleep disordered breathing (SDB) or habitual snoring appears to remain relatively consistent throughout childhood. The range of prevalence rates for SDB varies greatly around the world depending on definitions used and data collection methodology, however a comprehensive review of the epidemiological SDB literature reports a median prevalence of approximately 15% for pre-school children, 12% for primary school children, and 10% for adolescents (Lumeng & Chervin, 2008). This slight reduction over time may be the result of children being treated for obstructive sleep apnoea by adenotonsillectomy (Ali et al., 1996; Wei et al., 2007), spontaneous recovery (Ali et al., 1994; Anuntaseree et al., 2005; Urschitz et al., 2004) or reflect a reduction of parental monitoring.

Sex, ethnicity and social factors in addition to age, may also be important considerations when examining sleep problems during childhood. It is fairly well documented that sleep disordered breathing and enuresis show a predominance in males (e.g. Devlin, 1991; Yeung et al., 2006). Research on sex differences on many other sleep problems in children however is limited and inconsistent (see Chapter 1).

Asian cultures have reported higher rates of sleep problems in children than European or American cultures (eg Liu et al., 2005a), however what is considered a sleep problem is often determined by social or cultural norms (Jenni & O'Connor, 2005; Lozoff et al., 1996). Many Western societies are becoming increasingly multi-cultural, yet current knowledge of sleep problems in children are predominately based on Caucasian samples. Cross-cultural research is imperative to gain a true understanding of sleep problems and their consequence for children.

Socio-economic status has also been implicated in impacting on the prevalence of sleep disorders in children. Current debate exists, however, as to whether the influence of SES is mediated by other health related factors such as body mass index (Chervin et al., 2003a), household smoking or overcrowding (Rona et al., 1998).

Previous research examining the prevalence of sleep problems in populations of children and potential biopsychosocial aspects that precipitate the problem are limited and fraught with methodological concerns. Australia, in particular, has a paucity of research in this area. Informed knowledge of this is important for health professionals and educators in determining what aspects of sleep problems in children may or may not be amenable to intervention. Therefore, the purpose of this study was to provide a comprehensive overview of sleep complaints and biopsychosocial associates in a community sample of otherwise healthy Australian children aged 5-10 years.

4.2 METHODS

Please refer to Chapter 2 for a detailed description of methodology.

4.2.1 Statistical Analysis

Frequency analysis was conducted on responses to the 48 sleep problem items within SAPSS-Q to determine prevalence rates. Exploratory factor analysis, using

Principle Axis Factoring (PAF), was conducted on 42 of the 48 items of the CSHBQ revealing a 6-factor solution. See Chapter 2 for detailed results of this analysis. When factor items were summed, a higher score on each factor indicated a more severe sleep problem. A Total Sleep Problems score was obtained by summing all sub-scales. A Box-Cox correction was used to transform sleep problem sub-scales to meet assumptions of parametric testing (Box & Cox, 1964). In the present analysis, the lowest error sum of squares was observed at λ = -0.05. All means (±SD) are presented on untransformed data. All univariate and multivariate analysis were conducted with transformed data.

Descriptive statistics were calculated for the complete cohort by sex, age, ethnicity and socio-economic status (SES). Due to small cell numbers impeding interpretability, age was dichotomised into younger (5-7yrs) and older (8-10yrs) and ethnicity into Caucasian and Non-Caucasian for analysis. SES categories were based on SEIFA deciles (ABS, 2006b) and were categorised as low, middle and high.

Separate univariate analysis of variance (ANOVA) were conducted to determine sex, age, ethnicity and SES differences on each sleep problem sub-scale. Post-hoc testing was conducted on significant main effects of SES and two-way interactions (p<0.05). Three- and four-way interactions were not tested due to limited cell size. Effect sizes were determined using Cohen‟s *d* for binary comparisons and Hay‟s ω^2 for multiple comparisons (Kirk, 1996).

Biopsychosocial predictors of sleep problems were examined through regression analysis. Known biopsychosocial associates of sleep problems – history of respiratory complaint (HRC), BMI, family size, birthorder, and household smoking – were entered into a step-wise hierarchical multiple regression analysis with sex, age, race and SES in the first step. BMI, family size and household smoking were entered as continuous variables. HRC, determined by a reported incidence of asthma, hayfever or rhinitis in the previous 12 months, was dichotomised into yes/no. Birthorder was categorised into three dummy variables: youngest (yes/no), oldest (yes/no), and only (yes/no).

Individual sleep items relating to dyssomnias and parasomnias not included in the factor analysis solution were dichotomised according to published clinical criteria (ASDA, 1990). Daytime sleepiness items were dichotomised into mild (not or slightly sleepy) and severe (very sleepy or falls asleep). Pearson"s χ^2 tests were used to determine demographic differences in dichotomised sleep and sleepiness variables. Bonferroni adjustment was used to control for possible inflated Type I error associated with multiple tests (Grove & Andreasen, 1982; Larzelere & Mulaik, 1977). As Larzelere and Mulaik (1977) note, the possibility of accepting that a true difference exists between groups when one does not (Type I error) increases with the size of the sample and number of tests performed. In these cases, a Bonferroni procedure is conducted which controls for the number of tests by adjusting the significance level accordingly. This procedure involves dividing the nominated significance level (in this instance 0.05) by the number of tests to be performed. Comparisons with individual sleep problem items consisted of 32 separate χ^2 tests (8 sleep variables x 4 demographic variables), thus, significance level was set at $p \leq 0.002$ (0.05/32 = 0.0016). Significance level for comparisons within daytime sleepiness was set at $p \leq 0.003$ (0.05/16). Only results which meet corrected significance are discussed.

4.3 RESULTS

4.3.1 Frequencies of Sleep Items

Table 4.1 shows frequencies for each sleep item within the SAPSS-Q. The most commonly reported problem was fear of the dark with 17.8% of children reported to be afraid of falling asleep in the dark ≥ 5 nights/week.

Table 4.1: *Prevalence of specific sleep problems in total cohort as reported on the SAPSS-Q*

		Percentage of Sample			
Item	N	Never	Rarely Once/wk	Sometimes 2-4 times/wk	Usually 5-7 times/wk
1. Went to bed same time every night	1834	2.1	3.1	19.5	75.4
2. Fell asleep within 20 minutes	1829	3.8	8.5	21.4	66.3
3. Shared a bedroom	1811	58.6	7.2	4.9	29.3
4. Fell asleep in own bed	1818	5.1	3.6	6.7	84.7
5. Fell asleep in others bed	1823	73.9	13.7	6.4	5.9
6. Needed parent in room to fall asleep	1819	78.9	8.5	5.3	7.3
7. Watched TV after going to bed	1826	83.9	7.4	5.0	3.7
8. Listened to music after going to bed	1828	76.1	10.7	5.5	7.6
9. Spent time talking on the phone after bed	1825	99.6	0.2	0.1	0.1
10. Spent time playing electronic games after bed	1827	92.3	5.7	1.5	0.5
11. Struggled at bedtime	1829	74.5	16.3	7.1	2.1
12. Afraid of sleeping in the dark	1827	55.8	14.3	12.0	17.8
13. Afraid of sleeping alone	1824	73.2	13.1	6.9	6.8
14. Bedroom was noisy	1822	60.4	19.2	10.4	10.0
15. Slept too little	1822	38.1	38.4	18.6	5.0
16. Slept the right amount	1806	75.5	15.3	7.0	2.2
17. Slept about same amount each night	1810	2.2	3.1	15.6	79.1

Item	N	Percentage of Sample Never	Rarely Once/wk	Sometimes 2-4 times/wk	Usually 5-7 times/wk
18. Wet the bed	1815	83.9	7.5	4.0	4.6
19. Twitched/jerked when falling asleep	1759	74.3	15.1	7.6	3.1
20. Twitched/jerked during sleep	1770	88.2	6.7	3.3	1.7
21. Talked during sleep	1808	44.5	35.6	16.6	3.3
22. Restless during sleep	1811	27.8	28.5	28.3	15.4
23. Sleepwalked	1814	89.5	8.0	2.2	0.3
24. Moved to someone else"s bed	1827	72.8	16.4	7.6	3.2
25. Ground teeth during night	1797	75.2	10.2	10.4	4.2
26. Breathed heavily during night	1804	58.9	20.3	16.2	4.5
27. Currently snores	1814	66.5	18.6	10.1	4.8
28. Currently snores loudly	1812	85.8	8.4	3.3	2.5
29. Seemed to stop breathing during night	1796	96.5	2.3	0.9	0.2
30. Watched, afraid would stop breathing	1818	94.9	3.1	1.4	0.6
31. Snorted/gasped during night	1800	91.2	5.9	2.1	0.8
32. Had trouble sleeping away from home	1789	82.9	11.3	4.0	2.1
33. Woke screaming, sweating and inconsolable	1815	90.2	7.4	2.0	0.3
34. Woke alarmed by a frightening dream	1820	64.2	29.7	5.6	0.5
35. Sweated excessively when falling asleep	1813	83.9	10.8	3.8	1.5
36. Sweated excessively during sleep	1811	74.2	14.7	8.6	2.4
37. Woke during the night	1820	40.6	37.3	16.5	5.6
38. Woke by themselves	1786	48.8	26.8	18.4	6.0
39. Parent/sibling woke child in morning	1820	26.9	25.9	26.4	20.9
40. Alarm clock woke child	1821	86.5	6.0	4.2	3.2
41. Woke in a negative mood	1820	42.5	37.8	16.8	3.0

Item	N	Percentage of Sample			
		Never	Rarely Once/wk	Sometimes 2-4 times/wk	Usually 5-7 times/wk
42. Had difficulty getting out of bed	1824	45.1	30.9	18.1	5.9
43. Took a long time to become alert	1821	57.4	28.7	10.4	3.4
44. Seemed tired all the time	1822	57.3	33.1	7.6	2.0

Item	N	Percentage of Sample			
		Not sleepy	Slightly Sleepy	Very sleepy	Falls asleep
45. Watching T.V	1829	72.4	24.9	1.3	1.4
46. Riding in the car on a short trip	1834	72.4	23.6	2.3	1.8
47. At school	1813	90.2	9.0	0.6	0.2
48. Reading a book	1834	81.9	16.6	1.3	0.2

Following this was restless sleep at 15.4%. Of the traditional parasomnias, sleep talking was the most common with over half of the cohort talking in their sleep at least once per week. Nightmares (item 34: 35.8%), night terrors (item 33: 9.7%), enuresis (item 18: 16.1%), and sleep walking (item 25: 10.5%) were less common. Prevalence of behaviours related to sleep disordered breathing (items 27-31) occurring more than twice per week ranged from 1.1% at the most severe (stopped breathing during the night) to 20.7% at the mildest (breathed heavily during night). Almost ⅓ of children usually shared a bedroom, however less than 6% fell asleep in a bed other than their own. Listening to music after going to bed on ≥ 5 nights/week was more common than watching T.V (7.6% versus 3.7% respectively). Behaviours related to daytime sleepiness (items 45-48) were the least common with less than 5% of children showing moderate (slightly sleepy) to severe (falls asleep) symptoms.

4.3.2 Demographic differences in Sleep Problem Sub-scales

Descriptive statistics for Sleep Problem sub-scales are detailed in Table 4.2. Univariate analysis revealed significant main effects for age, sex, ethnicity and SES on some, but not all sub-scales. Some interaction effects were also found. Table 4.3 provides the F-values, significance and effect sizes for the univariate analysis. Post-hoc testing was conducted on the main effect of SES and the two-way interactions to determine where the differences lay.

Sex differences were found in Bedtime Anxiety (Mean±SD; 1.7±2.8 girls vs 1.5±2.6 boys) and Morning Tiredness (2.9±2.7 girls vs 2.6±2.5 boys) sub-scales, with girls scoring higher than boys on both sub-scales. Age differences were found on the Sleep Routine, Bedtime Anxiety and Night Arousals sub-scales. Older children (2.9±3.2) had a poorer Sleep Routine than younger children (2.6±3.0), whereas younger children had more Bedtime Anxiety (1.8±2.9 vs 1.2±2.3) and Night Arousals (2.1±2.1 vs 1.4±1.6). A significant difference was found between Caucasians and Non-Caucasians on the Bedtime Anxiety sub-scale. The mean score for Non-Caucasians in this sub-scale was over twice that of Caucasians (3.6±3.7 vs 1.2±2.3). There was also a significant ethnic difference in the Total Problems sub-scale with Non-Caucasians again reporting a higher mean score (16.4±10.0 vs 12.7±9.4).

Significant SES differences were found in Sleep Routine, Bedtime Anxiety, SDB and Total Problems sub-scales. Post-hoc analysis showed that children in the low SES group had poorer Sleep Routine (3.0±3.3 low vs 2.5±2.9 mid & 2.5±2.8 high), more Bedtime Anxiety (2.0±3.0 low vs 1.4±2.5 mid & 1.2±2.3 high), SDB (1.7±2.4 low vs 1.5±2.1 mid & 1.3±2.0 high) and Total Problems (14.8±10.2 low vs 12.6±8.9 mid & 11.9±8.6 high) than the middle or high groups. No difference between the middle and high SES groups.

Table 4.2: *Mean (±SD) sleep problem subscale scores by individual group categories.*

	Demographics																								
Sex	Male												Female												Total
Age	Younger (5-7yrs)						Older (8-10yrs)						Younger (5-7yrs)						Older (8-10yrs)						
Ethn	Caucasian			Non-Caucasian			Caucasian			Non-Caucasian			Caucasian			Non-Caucasian			Caucasian			Non-Caucasian			
SES	Low	Mid	High	Low	Mid	High	Low	Mid	High	Low	Mid	High	Low	Mid	High	Low	Mid	High	Low	Mid	High	Low	Mid	High	
	N=137	N=101	N=127	N=36	N=20	N=10	N=96	N=85	N=104	N=19	N=16	N=8	N=155	N=118	N=151	N=40	N=20	N=16	N=96	N=76	N=117	N=25	N=12	N=8	N=1808
SR	3.0	2.2	2.6	2.0	2.5	0.9	3.0	2.4	2.7	4.4	4.8	2.1	2.6	2.1	2.3	3.3	2.5	2.5	3.3	2.7	2.5	2.2	2.3	2.4	2.7
	(3.5)	(2.8)	(3.2)	(2.4)	(3.2)	(1.3)	(3.3)	(3.2)	(2.7)	(4.6)	(5.0)	(2.9)	(2.8)	(2.5)	(2.5)	(3.2)	(3.2)	(3.2)	(3.9)	(2.8)	(2.7)	(2.2)	(2.3)	(2.4)	(3.0)
BA	1.5	1.2	1.3	5.4	2.8	1.8	1.0	0.9	0.7	2.1	1.5	3.5	1.6	1.3	1.2	5.3	3.6	4.3	1.1	1.1	1.0	3.5	2.8	2.8	1.6
	(2.4)	(2.2)	(2.2)	(4.6)	(3.3)	(2.7)	(2.1)	(1.9)	(1.7)	(3.2)	(2.2)	(4.0)	(2.5)	(2.6)	(2.4)	(3.8)	(3.3)	(4.4)	(1.9)	(2.1)	(2.1)	(3.5)	(2.3)	(3.0)	(2.7)
MT	2.7	1.9	1.9	2.4	2.9	0.9	3.2	3.0	3.0	2.2	3.7	1.9	2.8	2.8	2.3	3.3	3.8	3.3	3.2	2.9	3.1	3.2	1.8	3.9	2.8
	(2.7)	(2.0)	(1.9)	(2.2)	(3.1)	(1.3)	(3.1)	(2.5)	(2.6)	(2.1)	(2.7)	(1.6)	(2.7)	(2.5)	(2.2)	(3.2)	(3.2)	(2.3)	(2.9)	(2.6)	(3.1)	(2.7)	(2.3)	(3.0)	(2.6)
NA	2.2	2.0	2.0	1.6	2.1	2.4	1.7	1.6	1.4	1.9	1.2	1.6	2.4	1.7	1.8	2.1	1.8	2.2	1.4	1.2	1.3	1.4	1.3	2.1	1.8
	(2.1)	(1.8)	(2.1)	(1.9)	(1.8)	(1.6)	(2.0)	(1.8)	(1.5)	(1.6)	(1.2)	(1.8)	(2.3)	(1.8)	(1.9)	(2.1)	(1.8)	(2.3)	(1.6)	(1.5)	(1.4)	(1.2)	(2.0)	(2.0)	(1.9)
SDB	1.7	1.3	1.5	2.1	2.4	0.0	2.2	1.8	1.4	2.6	1.6	1.0	1.5	1.1	1.3	1.7	1.6	1.9	1.5	1.5	1.0	0.7	1.5	1.3	1.5
	(2.5)	(2.0)	(2.2)	(2.5)	(2.5)	(0.4)	(2.6)	(2.4)	(2.1)	(2.8)	(1.9)	(1.2)	(2.4)	(1.5)	(1.9)	(2.2)	(2.4)	(2.2)	(2.4)	(2.2)	(1.8)	(0.9)	(2.4)	(1.8)	(2.2)
RS	3.3	2.9	2.5	2.5	3.1	2.5	3.3	3.5	2.9	3.1	3.4	1.8	3.4	2.8	2.9	3.6	2.3	2.9	3.2	3.2	2.4	2.9	2.9	3.9	3.1
	(2.8)	(2.3)	(2.5)	(2.3)	(2.4)	(2.1)	(2.7)	(2.5)	(2.3)	(2.3)	(2.5)	(1.8)	(2.8)	(2.5)	(2.5)	(2.6)	(1.6)	(2.7)	(2.6)	(2.4)	(2.3)	(1.9)	(2.6)	(2.5)	(2.5)
TOT	14.5	11.5	11.7	16.1	15.6	8.7	14.5	13.3	12.1	16.4	16.1	11.9	14.4	11.7	11.8	19.3	15.6	17.1	13.6	12.7	11.4	13.9	12.7	16.3	13.2
	(11.1)	(8.4)	(8.6)	(7.2)	(11.2)	(6.0)	(10.6)	(9.7)	(8.3)	(10.3)	(10.8)	(8.1)	(9.7)	(8.4)	(8.9)	(11.5)	(9.3)	(10.6)	(10.2)	(7.8)	(8.4)	(7.7)	(10.3)	(9.3)	(9.4)

SR=Sleep Routine, BA=Bedtime Anxiety, MT=Morning Tiredness, NA=Night Arousals, SDB=Sleep Disordered Breathing, RS=Restless Sleep, TOT=total sleep problem score

.

Table 4.3: *Univariate results of sex, age, ethnicity and SES differences on Sleep Problem Sub-scales*

	Sleep Problems Sub-scale																				
	Sleep Routine			Bedtime Anxiety			Morning Tiredness			Night Arousals			SDB			Restless Sleep			Total Problems		
Demographics	F	*p*	*d*/ω^2	F	*p*	*d*/ω^2	F	*p*	*d*/ω^2	F	*p*	*d*/ω^2	F	*p*	*d*/ω^2	F	*p*	*d*/ω^2	F	*p*	*d*/ω^2
Sex[a]	0.02			5.62	0.018	0.09	8.17	0.004	0.12	1.12			1.29			0.82			0.67		
Age[a]	6.98	0.008	0.11	10.5	0.001	0.24	3.51			11.38	0.001	0.32	0.21			1.51			0.00		
Ethnicity[a]	0.05			113.3	<0.0001	0.85	0.05			1.40			1.01			0.23			6.28	0.012	0.31
SES[b]	3.74	0.024	0.04	4.91	0.007	0.05	1.58			0.83			3.59	0.028	0.03	2.82			6.32	0.002	0.07
Sex*Age[b]	2.00			0.03			6.10	0.014	0.06	0.06			2.28			0.05			1.34		
Sex*Ethnicity[b]	0.05			4.08	0.044	0.04	2.28			0.17			0.89			1.55			0.99		
Age*Ethnicity	2.09			0.83			1.06			0.61			0.01			0.15			0.53		
Sex*SES[b]	0.67			0.03			2.22			0.03			3.43	0.033	0.03	2.75			2.65		
Age*SES[b]	0.18			3.16	0.043	0.03	1.02			0.21			0.08			0.12			1.32		
Ethnicity*SES	2.57			1.40			0.42			1.39			0.64			0.21			0.55		
Sex*Age*Ethnicity	2.28			0.29			1.00			0.27			0.23			1.23			0.32		
Sex*Age*SES[b]	0.32			1.27			2.81			3.03	0.049	0.03	2.85			1.16			0.02		
Sex*Ethnicity*SES[b]	1.67			0.06			4.14	0.016	0.04	0.09			2.47			1.41			3.30	0.037	0.03
Age*Ethnicity*SES	0.09			2.08			0.46			0.93			1.32			0.14			0.20		
Sex*Age*Ethnicity*SES	0.30			1.78			0.64			1.20			1.53			2.86			0.01		

[a]Cohen"s *d*, 0.2 mild effect: 0.5 medium effect: 0.8 strong effect. [b]Hays ω^2 for multi-sample cases, 0.01 mild effect: 0.059 medium effect: 0.138 large effect.

A sex by age interaction was found in Morning Tiredness. Post-hoc analysis revealed young males reported lower scores on Morning Tiredness than any other group. No difference was found between young females, older females or older males.

Interaction effects were found between sex and ethnicity on Bedtime Anxiety. Both male and female non-Caucasian children scored significantly higher than male and female Caucasian children. No difference was found between the sexes within each ethnic category.

Post-hoc analysis of the sex by age interaction on the SDB sub-scale revealed males from low SES scored significantly higher than males from high SES and females from mid or high SES groups. No other differences were found.

The age by SES interaction on Bedtime Anxiety revealed that young children from low SES had significantly higher bedtime anxiety than any other group. Post-hoc analysis on three-way interactions were not conducted due to limited sample sizes in each group (see table 4.3).

Overall, effect sizes for significant results were weak to moderate, except for the main effect of ethnicity on Bedtime Anxiety (d=0.85).

4.3.3 Psychosocial associates with sleep problem sub-scales

A stepwise multiple regression controlling for sex, age, ethnicity and SES revealed a history of respiratory complaint was significantly predictive of Sleep Routine (B = 0.13; p<0.0001; Δr^2=0.02), Morning Tiredness (B = 0.17; p<0.0001; Δr^2=0.03), Night Arousals (B = 0.15; p<0.0001; Δr^2=0.02), SDB (B = 0.18; p<0.0001; Δr^2=0.03), and Restless Sleep (B = 0.17; p<0.0001; Δr^2=0.03). Family size was significantly associated with Sleep Routine (B = 0.07; p = 0.024; Δr^2=0.01). Household smoking was predictive of Restless Rleep (B = 0.10; p = 0.001;

Δr^2=0.01). Being the youngest child was predictive of Bedtime Anxiety (B = 0.07; p = 0.026; Δr^2<0.01). Body mass index did not predict scores on any of the sleep problem sub-scales.

4.3.4 Demographic differences in individual sleep problem items and daytime sleepiness.

Individual sleep items were dichotomised into mild and moderate/severe based on severity criteria outlined the *International Classification of Sleep Disorders* (ASDA, 1990). As there was no criteria for Item 12 – afraid of sleeping in the dark – this item was dichotomised into ≤ once per week (no) and ≥ twice per week (yes) as increased frequency is less likely to be caused by situational factors (e.g. watching a scary movie).

According to ICSD criteria, moderate enuresis is defined as the involuntary voiding of urine during sleep at least twice per week. Severe enuresis occurs nightly. Therefore, enuresis was dichotomised into ≤ once per week (mild) and ≥ twice per week (moderate/severe) for analysis.

In general, sleepwalking occurs infrequently with mild sleepwalking classified as occurring less than once per month and moderate as more than once per month but not nightly. As parents in the current study were requested to provide information on their child"s sleep behaviour over the previous week, only weekly sleepwalking was reported. Therefore, mild sleepwalking was classified by a response of „never" and moderate/severe sleepwalking was any response ≥ once per week.

Bruxism was dichotomised into ≤ 4 times per week (mild) and ≥ 5 times per week (moderate/severe) in accordance with the ICSD classifications.

Hyperhydrosis was identified through two items: sweated excessively while falling asleep (item 35) and during sleep (item 36). Severity criterion in the ICSD is not based on frequency but on whether bathing was needed or clothing and/or bedclothes required changing. As this information was not obtained in the SAPSS-Q, mild hyperhydrosis was defined as excessive sweating ≤ once per week, and moderate/severe as ≥ twice per week due to the fact that increased frequency is less likely to be the result of acute environmental factors.

Observed apnoeas (items 29 & 30) were dichotomised into „no" and „yes". Apnoeic episodes, symptoms of obstructive sleep apnoea, are characterised by a cessation of breathing during sleep usually followed by a snort or loud gasp (ICSD) and objective classification can only be done by polysomnography (PSG). Parental observations of respiratory events have been reported, although somewhat inconsistently, to be correlated PSG defined sleep disordered breathing (Montgomery-Downs et al., 2004). It is proposed that apnoeic events may be the mechanism by which SDB affects child"s development (O'Brien & Gozal, 2002), therefore any report of the child stopping breathing or fear they would stop breathing at least once per week was classified as yes.

Demographic comparisons of individual items relating to sleep problems not included in the factor analysis solution were tested using χ^2 tests (Table 4.4). Item 32 – had trouble sleeping away from home – was not included in the analysis because as an individual item it would be difficult to distinguish this from general anxiety symptoms. Item 12 – afraid of sleeping in the dark – reported a difference in age only with proportionately more younger children reported as being afraid of the dark than older children (35 vs 23%; χ^2=32.0, p<0.0001). This item was not explored further. Items relating to activities in the bedroom after going to bed are reported in Chapter 6.

Significant sex differences were found in enuresis and hyperhydrosis (sweating falling asleep and during sleep) with these sleep problems occurring more often in males than females. Bedwetting was more common in younger children than older children. SES differences were found in sweating while going to sleep and parental monitoring of nocturnal breathing, however significance did not reach Bonferroni adjustment criteria. No differences were found in any individual sleep problem item between Caucasians and Non-Caucasians.

Ethnic differences were found in two daytime sleepiness items (Table 4.3.5). Proportionately more Non-Caucasians than Caucasians were reported as being very sleepy or falling asleep while watching T.V or riding in the car on a short trip. Children from the low SES group were also more likely to show severe signs of sleepiness when watching T.V. Some age differences were seen however these did not reach adjusted significance levels. No sex differences were reported.

Table 4.4: *Sex, age, ethnic and SES differences in individual items relating to sleep problems*

Demographics		Enuresis			Sleep Walking			Bruxism			Hyperhydrosis: Sweating going to sleep			Hyperhydrosis: Sweating during sleep			Observed Apnoeas: Seemed to stop breathing			Observed Apnoeas: Watched afraid would stop breathing		
		≤1/wk% (N)	≥2/wk% (N)	χ^2	Never% (N)	≥1/wk % (N)	χ^2	≤4/wk% (N)	≥5/wk% (N)	χ^2	≤1/wk% (N)	≥2/wk% (N)	χ^2	≤1/wk% (N)	≥2/wk% (N)	χ^2	No% (N)	Yes % (N)	χ^2	No% (N)	Yes % (N)	χ^2
Sex	Male	88.9 (775)	11.1 (97)		88.7 (773)	11.3 (98)		95.6 (821)	4.4 (38)		92.5 (802)	7.5 (65)		85.7 (744)	14.3 (124)		96.2 (826)	3.8 (33)		95.2 (831)	4.8 (42)	
	Female	93.7 (884)	6.3 (59)	13.66**	90.1 (850)	9.9 (93)	0.93	95.9 (900)	4.1 (38)	0.15	96.7 (915)	3.3 (31)	16.07**	91.9 (867)	8.1 (76)	17.84**	96.8 (907)	3.2 (30)	0.54	94.7 (895)	5.3 (50)	0.22
Age	5-7 yrs	89.4 (949)	10.6 (112)		91.0 (964)	9.0 (95)		94.6 (1002)	5.4 (57)		94.2 (1002)	5.8 (62)		88.5 (942)	11.5 (123)		96.6 (1020)	3.4 (36)		94.4 (1005)	5.6 (60)	
	8-10 yrs	94.2 (710)	5.8 (44)	12.50**	87.3 (659)	12.7 (96)	6.56[a]	97.4 (719)	2.6 (19)	8.47[b]	95.5 (715)	4.5 (34)	1.45	89.7 (669)	10.3 (77)	0.67	96.4 (713)	3.6 (27)	0.07	95.8 (721)	4.2 (32)	1.76
Ethn	Caucasian	91.6 (1363)	8.4 (125)		89.3 (1328)	10.7 (159)		95.9 (1415)	4.1 (60)		95.2 (1419)	4.8 (71)		89.2 (1327)	10.8 (161)		96.5 (1419)	3.5 (52)		95.4 (1423)	4.6 (69)	
	Non-Caucasian	89.8 (237)	10.2 (27)	0.94	90.1 (237)	9.9 (26)	0.15	95.4 (248)	4.6 (12)	0.17	92.7 (241)	7.3 (19)	2.93	88.1 (229)	11.9 (31)	0.28	96.2 (252)	3.8 (10)	0.05	92.8 (244)	7.2 (19)	3.17
SES	Low	91.1 (625)	8.9 (61)		89.6 (613)	10.4 (71)		94.9 (648)	5.1 (35)		93.0 (639)	7.0 (48)		88.0 (601)	12.0 (82)		95.6 (649)	4.4 (30)		92.9 (640)	7.1 (49)	
	Middle	92.0 (482)	8.0 (42)		89.8 (469)	10.2 (53)		96.5 (498)	3.5 (18)		96.1 (497)	3.9 (20)		89.6 (464)	10.4 (54)		97.3 (502)	2.7 (14)		95.6 (497)	4.4 (23)	
	High	91.2 (552)	8.8 (53)	0.32	89.0 (541)	11.0 (67)	0.25	96.2 (575)	3.8 (23)	2.26	95.4 (581)	4.6 (28)	6.61[c]	89.5 (546)	10.5 (64)	1.04	96.8 (582)	3.2 (19)	2.84	96.7 (589)	3.3 (20)	10.47[d]

**$p<0.0001$, *$p<0.001$, [[a]$p=0.01$,[b]$p=0.004$, [c]$p=0.04$, [d]$p=0.005$, does not meet Bonferroni adjustment significance criteria (0.0015)]

Table 4.5: *Sex, age, race and SES differences in individual items relating to daytime sleepiness*

Demographics		Sleepiness watching T.V Not/slightly% (N)	Sleepiness watching T.V Very/falls asleep% (N)	χ^2	Sleepiness riding in car Not/slightly% (N)	Sleepiness riding in car Very/falls asleep% (N)	χ^2	Sleepiness at school Not/slightly% (N)	Sleepiness at school Very/falls asleep% (N)	χ^2	Sleepiness reading a book Not/slightly% (N)	Sleepiness reading a book Very/falls asleep% (N)	χ^2
Sex	Male	97.3 (858)	2.7 (24)		96.8 (855)	3.2 (28)		98.9 (863)	1.1 (10)		98.4 (869)	1.6 (14)	
	Female	97.4 (922)	2.6 (25)	0.01	95.1 (904)	4.9 (47)	3.66	99.6 (936)	0.4 (4)	3.06	938 (98.6)	1.4 (13)	0.15
Age	5-7 yrs	97.9 (1039)	2.1 (22)		94.9 (1012)	5.1 (54)		99.5 (1045)	0.5 (5)		97.7 (750)	2.3 (18)	
	8-10 yrs	96.5 (741)	3.5 (27)	3.55	97.3 (747)	2.7 (21)	6.19[a]	98.8 (754)	1.2 (9)	2.85	99.2 (1057)	0.8 (9)	6.92[b]
Ethn	Caucasian	97.9 (1465)	2.1 (32)		96.8 (1452)	3.2 (48)		99.3 (1476)	0.7 (11)		98.7 (1479)	1.3 (20)	
	Non-Caucasian	94.4 (251)	5.6 (15)	10.67*	90.7 (243)	9.3 (25)	21.57**	98.8 (256)	1.2 (3)	0.49	97.8 (262)	2.2 (6)	1.28
SES	Low	95.5 (660)	4.5 (31)		94.4 (655)	5.6 (39)		99.1 (678)	0.9 (6)		98.1 (681)	1.9 (13)	
	Middle	97.7 (513)	2.3 (12)		95.8 (504)	4.2 (22)		99.2 (515)	0.8 (4)		99.0 (521)	1.0 (5)	
	High	99.0 (607)	1.0 (6)	15.76**	97.7 (600)	2.3 (14)	9.28[c]	99.3 (606)	0.7 (4)	0.21	98.5 (605)	1.5 (9)	1.76

Individual items relating to daytime sleepiness

**p<0.0001, *p<0.003 [[a]p=0.013, [b]p=0.009, [c]p=0.01, does not meet Bonferroni adjustment significance criteria (0.0031)]

4.4 DISCUSSION

Consistent with previous claims to the pervasiveness of sleep complaints in children (Mindell & Meltzer, 2008; Stores, 2007), parent-reported sleep problems in South Australian school-aged children are common with the prevalence of a single sleep concern occurring at least once in the previous week, ranging between 3.4% and 72.2%. In this cohort of otherwise health children, age and SES factors appear to have the greatest impact on the reporting of sleep problems, however cultural factors are also evident. Whilst further validation is required, this study provides the first culturally relevant information regarding sleep problems in Australian children.

4.4.1 Prevalence of Dyssomnias and Parasomnias in South Australian School-aged Children

Of the dyssomnia type sleep problems, night awakenings (item 37) were the most common with over half (59.4%) of the cohort waking at least once per week. Observed apnoeas (item 29) were the least common at 3.4%. One in three children were reported to snore (item 27) or have sleep onset problems (item 2) at least once per week. One quarter (25.5%) of children were resistant at bedtime (item 11).

Parasomnias were also common with over half (55.5%) of the children talking in their sleep (item 21), one third (35.8%) experiencing nightmares (item 34), and one quarter (24.8%) grinding their teeth at least once per week. Night terrors (item 33), sleepwalking (item 23) and enuresis (item 18) were less prevalent at 9.7, 10.5 and 16.1% respectively. The majority of sleep problems showed a negative dose response relationship with frequency. That is, the more frequent the occurrence, the less prevalent the problem.

Two exceptions were enuresis and bruxism. There was no difference in the percentage of children who experienced enuresis between 2 and 4 times in the last week and those who wet the bed 5 or more times. This is consistent with Butler and Heron (2008) observation that for the most part children will wet the bed less than once per month, however a small proportion will consistently wet almost every night. It may be that as we only required parents to comment on the previous week, we only captured that small proportion of children.

The prevalence rate for children who experienced bruxism between one and 4 times per night was consistent at 10%, then halved for 5 or more times per week. This is also consistent with previous studies. For example Liu et al. (2005a) reported a dramatic drop between occasional and frequent bruxism in both the US and Chinese cohorts (see Table 4.6).

Making direct comparisons of prevalence rates with previous studies is difficult due to the disparity in question structure and response options, differences in age range and sociocultural factors. In 2005 however, Liu and colleagues published a cross-cultural comparison study similar in design to the SAPSS. Recruitment for Liu et al."s study was also conducted through schools and parents were asked to complete the Child Sleep Habits Questionnaire (CSHQ) with the aim of determining sleep patterns and prevalence rates for sleep complaints in American (N=494) and Chinese (N=292) children in grades 1-4. As questions from the CSHQ were used in the SAPSS-Q, some direct comparisons are possible here and are reported in Table 4.6.

Table 4.6: *Comparisons of prevalence rates for individual sleep items between the South Australian, American and Chinese cohorts*

	SAPSS (N=1845)		US (N=494)		China (N=292)	
	5-10 years		Grades 1-4			
Sleep Item	2-4/wk	≥5/wk	2-4/wk	≥5/wk	2-4/wk	≥5/wk
Fell asleep in others bed	6.4	5.9	6.3	6.3	6.2	16.8
Needed a parent in room	5.3	7.3	7.8	3.5	11.3	14.0
Struggled at bedtime	7.1	2.1	6.2	2.7	5.1	1.7
Afraid of sleeping in dark	12.0	17.8	13.8	12.1	13.0	16.1
Afraid of sleeping alone	6.9	6.8	9.8	4.0	14.4	15.1
Moved to someone else"s bed	7.6	3.2	11.7	2.5	11.3	2.1
Felt child slept too little	18.6	5.0	19.5	0.7	24.3	17.1
Snored loudly	3.3	2.5	18.3	1.5	9.9	3.4
Stopped breathing during night	0.9	0.2	1.0	0.3	5.8	1.4
Snorted or gasped during night	2.1	0.8	4.3	0.8	8.6	4.8
Wet the bed	4.0	4.6	4.3	3.3	7.5	1.4
Talked during sleep	16.6	3.3	21.7	1.5	14.7	5.8
Restless during sleep	28.3	15.4	28.8	6.3	19.5	16.8
Sleepwalked	2.2	0.3	3.3	0.5	5.8	1.0
Ground teeth during night	10.4	4.2	15.9	4.8	15.1	6.5
Woke, screaming and sweating	2.0	0.3	1.3	0.0	6.2	1.0
Woke alarmed by frightening dream	5.6	0.5	9.8	0.0	8.2	1.7
Woken by others in morning	26.4	20.9	36.3	31.7	20.2	38.0
Woke in a negative mood	16.8	3.0	32.6	1.5	19.9	6.2
Had difficulty getting out of bed	18.1	5.9	29.9	8.8	23.3	20.2
Took a long time to become alert	10.4	3.4	20.3	3.2	15.8	6.8

Comparisons of prevalence rates reported by Liu et al (2005) showed SAPSS cohort to have the greatest similarity to the US cohort. Obvious differences from both cohorts (US & China), however were found in loud snoring and the items relating to morning tiredness. Both the US and Chinese cohorts reported much higher prevalence rates of occasional loud snoring (2-4 times/wk) than the SAPSS cohort. There is no simple explanation for this discrepancy. Firstly, it may be that the higher rate of room or bed-sharing with children in China (Liu et al., 2003) results in parents being more aware of their child"s snoring. However this explanation does not apply to the American cohort where room and bed-sharing are rare amongst Caucasian-Americans (Lozoff et al., 1996; Milan et al., 2007). Secondly, it may be that there are anthropometric differences between the US and South Australian cohorts resulting in greater rates of loud snoring (Verhulst et al., 2007). Although the gap is closing, childhood obesity rates are greater in the US than Australia (Catford & Caterson, 2003). However, as BMI estimates were not taken for the US cohort it is impossible to determine if this was a factor. Additionally, BMI in the current cohort was not related to sleep disordered breathing (see below). Thirdly, it may reflect parental perception of what is considered „loud". Finally, it may reflect a true result. That is, less children in South Australia snore on an occasional basis compared to the United States or China. As snoring has been associated with academic (e.g. Gozal, 1998) and behavioural (e.g. Mulvaney et al., 2006) deficits, determining the reason for such a large discrepancy is worth further investigation.

The SAPSS cohort also reported a much lower rate of daytime sleepiness or morning tiredness problems than either the US or Chinese cohorts. On average, the current cohort went to bed earlier (8:09pm vs 8:27 & 9:01pm), got up later (7:03am vs 6:54 & 6:27am) and thus had more sleep opportunity (TIB: 10.54h vs 10.09 & 9.15h) than the US and Chinese cohorts, respectively. As sleep duration has been associated with daytime sleepiness (Anders et al., 1978; Carskadon et al., 1998; Gau et al., 2004; Saarenpaa-Heikkila et al., 2000; Shin et al., 2003), this is a likely explanation for the reduced prevalence of this problem in this study. This is encouraging as it suggests that Australian children are meeting their sleep need.

Whilst prevalence rates provide a snapshot as to the pervasiveness of certain sleep problems, it is the functional sequelae that is important, in particular to physicians and sleep educators. Of interest are the potential biopsychosocial aspects that precipitate the problem that may or may not be amenable to intervention.

4.4.2 Biopsychosocial Associates of Sleep Problem Sub-scales

4.4.2.1 Sleep Routine

Sleep Routine was defined by items pertaining to consistency of bedtimes, sleep duration, sleep onset latency and bedtime resistance. Similar to the bedtime and sleep variability measures reported in Chapter 3, Sleep Routine was reported to be poorer in older children and children from lower SES areas.

One explanation for the age difference may be an increase in extra-curricular activities. As children age, they may be more likely to engage in activities after school such as sport, music or other leisure pursuits. This could result in going to bed late and getting less sleep on one or two nights per week resulting in a higher sleep routine score. The age differences observed in Sleep Routine scores may also be due to poorer limit setting. With increasing age, parents become less involved in regulating their child‟s sleep (Carskadon, 1990). This reduction of parental control may lead to increased variability in bedtimes and sleep durations, as well as a perception by parents that the children are not obtaining enough sleep.

This may also hold for the poorer sleep routine observed in the low SES group. Spilsbury et al. (2005) examined the relationship between home environment and sleep in children (N=907; 8-11 years) using child-report 7-day sleep diaries and parent-interview Middle Childhood Home Observation for Measurement of the Environment (MC-HOME) scale and found parental involvement to be associated with reduced night-to-night variability in bedtime. This relationship was strongest in subjects from more disadvantaged environments. Recent research by Adam and colleagues (2007) also reported that family economic strain is an independent predictor of sleep patterns in children aged 5-11 years. Adam et al. conducted a large study (N=1718 families) examining the associations between SES, race and family functioning on sleep using time diaries and the HOME scale. Consistent with Spilsbury et al., this study also found parental involvement (i.e. parental warmth and rule setting) to be predictors of sleep patterns.

The aetiology of a poor sleep routine is unknown in the current study. If, as suggested by previous research, it is related to limit setting, this is encouraging for treatment strategies, particularly if the Sleep Routine sub-scale is associated with daytime functioning. The association between poor sleep routine and daytime behaviour is explored in Chapter 5.

4.4.2.2 Bedtime Anxiety

Bedtime Anxiety was defined by items relating to where the child fell asleep, whether they needed a parent‟s presence to fall asleep and whether they were anxious about sleeping on their own. Statistically, the greatest effect was found in the difference in Bedtime Anxiety between Caucasians and Non-Caucasians. There is a suggestion in the adult anxiety literature that being a member of a minority group may increase feelings of anxiety, especially social anxiety (Hsu & Alden, 2007; Lau et al., 2009). It may be that the child who is anxious about „fitting in‟ at school or with peers, seeks out comfort and support from family members which translates into needing a parent at bedtime, falling asleep in another‟s bed or being afraid (perhaps hesitant) to go to sleep alone. The ethnic differences found in this subscale, however, may also be more of an indication of cultural preference than psychological consequence.

As the majority of Non-Caucasian"s identified themselves as Asian, the current result compares with Liu and colleagues (2005) who reported Chinese children were three times more likely to be frightened of sleeping alone and to need a parent in the room to fall asleep than their American counterparts. The authors suggest that, due to the one-child policy of China, Chinese children may have possessed characteristics that lead to these problems, such as over-dependency. While this may be a factor in China, this explanation does not hold true for Australia. A more likely explanation for this finding is provided by Wu et al. (2002) who report Chinese parents are more protective than their Western counterparts and often encourage their children to stay physically close to them. In this sense they foster dependence and ensure a safe environment. In addition, Wu et al. notes that it is expected in Chinese culture that mothers will be "immensely involved and devoted to their children, especially in the early years" (p483). Taken together, these cultural values, which extend beyond the Chinese population to other Asian cultures, may result in a reliance on the mother at bedtime and a sense of responsibility of the mother to be with the child as they fall asleep. Indeed, Japanese mothers typically report lying down with their child until they fall asleep (Latz et al., 1999).

Moreover, co-sleeping is a common practice amongst non-Western cultures (Bharti et al., 2006; Jiang et al., 2007; Latz et al., 1999; Yang & Hahn, 2002), reflecting the values of individualist and collectivist cultures (Jenni & O'Connor, 2005). In Western countries such as Australia, where high value is placed on individual independence, children sleep in separate beds and often in separate rooms to parents or siblings. However, in collectivist cultures, high value is placed on familial interdependence and room- or bed-sharing is the norm (Jenni & O'Connor, 2005). Although co-sleeping was not measured, proportionately more

Non-Caucasians in the SAPSS cohort reported sharing a room (48% vs 26% - not reported in results) which could have contributed to the higher bedtime anxiety score. Indeed, retrospective regression analysis revealed that sharing a bedroom was predictive of Bedtime Anxiety, independently explaining 10% of the variance, even after controlling for sex, age, ethnicity and SES (B= -0.317; p<0.0001; Δr^2=0.10; results not reported above).

Similarly, the SES differences in Bedtime Anxiety in the SAPSS cohort may be due to the greater room sharing or proportion of non-Caucasians in this group. It may also be that children in low SES areas experience a greater exposure to stressful events which lead to feelings of insecurity at bedtime. Previous research has indicated that children living in low SES areas experience more family turmoil and adverse circumstances than those in more affluent areas (Attar et al., 1994; Brooks-Gunn et al., 1995). El-Sheikh et al. (2006) reports that family turmoil impacts on significantly sleep behaviour. In a study using actigraphy measured sleep, El-Sheik et al. found marital conflict to be a strong predictor of both quantity and quality of sleep in 8-9 year old children (N=54). The author suggests that the child"s feelings of anxiety, insecurity or fear for safety may have mediated the relationship between the marital conflict and sleep problems.

Younger children had greater Bedtime Anxiety than older children. Given that Bedtime Anxiety is correlated with Night Arousals (see Chapter 2) which contain items pertaining to nightmares and night terrors, this difference may indicate a developmental phenomenon. It is a fairly robust finding that younger children experience more nightmares than older children (Muris et al., 2000; Schredl et al., 2009b). It can be assumed that children who experience nightmares may be hesitant to go to sleep and require soothing from parents. Moreover, research has reported that children who experience nightmares also exhibit higher levels of trait anxiety than those who do not (Laberge et al., 2000; Mindell & Barrett, 2002). Presumably, children with trait anxiety would be likely to seek comfort in others at bedtime as well as throughout the rest of the day. In the current study, however, retrospective analysis controlling for nightmares and night terrors did not alter the results, suggesting the age difference in Bedtime Anxiety is independent of other sleep factors.

Thus, this result may again be indicative of social or cultural determinants rather than psychological. Findings from the 2004 National Sleep Foundation *Sleep in America Poll* reported 45.7% of pre-schoolers and 30% of school-aged children had a parent present at bedtime (Mindell et al., 2009a). As children age they are more likely to develop independent bedtime routines, such as reading to themselves rather than being read to, resulting in a natural reduction in parental presence. Similarly, older children may be less likely to resist going to bed or to fall asleep in someone else‟s bed, resulting in an overall lower bedtime anxiety score as measured on the current sub-scale.

Further validation research is needed to determine the covariates of Bedtime Anxiety. If, as suggested by the relationship with sharing a bedroom, this sub-scale is measuring environmental factors rather than actual sleep concerns, the items may need further development. If, however, this sub-scale is indicative of feelings of insecurity and anxiety in children, then it is an important factor for determining and designing treatment plans for particular sleep problems.

4.4.2.3 Morning Tiredness and Daytime Sleepiness

In the current study, the factor analysis of sleep problem items identified morning tiredness and daytime sleepiness as two separate constructs. The Morning Tiredness factor pertains to behaviours exhibited immediately after waking such as having difficulty getting out of bed and struggling to become alert whereas daytime sleepiness pertained to falling asleep in inappropriate places.

Univariate analysis revealed that girls reported a higher mean score on the Morning Tiredness sub-scale than boys. Spruyt et al. (2005) also reported that the girls of their cohort had significantly increased odds of being tired when waking in the morning. Interestingly, in the SAPSS cohort, girls also rose later than boys but did not report any differences in other sleep parameters that may have lead to increased morning tiredness such as later bedtimes or greater bedtime variability (see Chapter 3). Retrospective analysis revealed that girls were also more likely to be woken by parents or siblings (χ^2=31.2, p<0.0001) and less likely to wake by themselves (χ^2=11.5, p=0.009) than boys (not reported in results). As discussed in Chapter 3, these findings may be indicative of a greater sleep need in girls.

The suggestion put forth by Tonetti et al. (2008) that the increased sleep need is related to hormonal maturation is supported in this study by the sex by age interaction. That is, young males scored significantly less on the Morning Tiredness sub-scale than older males or females at any age. In a study of 458 children aged 11-12 years, Carskadon et al. (1993) reported that pubertal development was directly related to sleep behaviours: the more advanced the pubertal development, the greater the tendency for evening preferences. In Carskadon‟s study the relationship was only significant in girls who were reported to be more developmentally advanced than boys. Given that girls generally physically mature earlier than boys, the current result could be an early indication of phase delay and an increase in sleep need. Girls may be going to bed the same time as boys due to parental controls, yet an evening preference and increased sleep need is perhaps manifested through extended sleep in the morning and Morning Tiredness behaviours. Unfortunately, pubertal maturation was not examined in this study so it is impossible to confirm if this was influential. Nonetheless, the current results suggest that this is an area worthy of further investigation.

No ethnic differences were found in Morning Tiredness scores, however proportionately more Non-Caucasian children were reported to have moderate to severe sleepiness as measured on the daytime sleepiness items. Given that Non-Caucasian children reported later bedtimes and shorter sleep durations (Chapter 3), it follows that they would also exhibit more signs of sleepiness than their Caucasian counterparts. Liu et al. (2005a) also reported a greater frequency of Chinese children reporting severe sleepiness than American children. In that study, daytime sleepiness was related to sleep duration in Chinese children only, who obtained an average of 60 minutes less sleep than the American cohort.

This may also be the case for SES, however the higher proportion of children from low SES areas exhibiting signs of excessive sleepiness whilst watching television is more likely to be due to when and where these children watch television, not an indication of sleepiness per se. The current study shows that children from low SES areas were more likely than other SES groups to watch T.V in the bedroom (see Chapter 6). The chances of falling asleep in front of the television in bed are assumed higher than when watching television in a common area. The current study did not specify watching T.V. at a particular time so it may be that this result captures those children who fall asleep watching T.V. in their bedrooms at night and is not indicative of sleepiness caused by sleep/wake patterns or sleep problems. The lack of difference in total sleep time and the null-findings for all other sleep problems support this suggestion.

The fact that the daytime sleepiness items were not included in the factor structure warrants further comment. Daytime sleepiness is reported as a serious sleep related concern, especially in adolescents (Wolfson & Carskadon, 1998) and is often assumed to be the one of the first signs of a sleep problem. Indeed in adults, daytime sleepiness resultant from sleep deprivation is easily observable through physical signs such as yawning, drooping eyelids and spontaneous sleep attacks (micro-sleeps) (Van Dongen et al., 2003). These specific symptoms have been associated with concentration problems, mood changes (Dinges et al., 1997), and increases the risk of injury or accident (Dobbie, 2002; Horne & Reyner, 1999). In children however, this association may not be so clear and there are two possible explanations for why daytime sleepiness was not present in the factor structure.

Firstly, parental monitoring of sleep/wake patterns is usual in this age group and it may be that prevalence of sleep deprivation in children aged 5-10 years is so limited that very few exhibit signs of excessive sleepiness. Indeed, less than 1% of children on school nights and 5% on weekends slept less than the commonly recommended 9 hours (see Chapter 3). Secondly, research has shown that in younger children, sleepiness is more likely to be associated with hyperactive or oppositional behaviours (Fallone et al., 2001) than the traditional signs of tiredness. Together this suggests that eliciting information regarding traditional signs of sleepiness such as falling asleep in inappropriate places may not provide an accurate indication of daytime sleepiness in pre-pubertal children.

Further validation is needed, however, the current Morning Tiredness sub-scale may be a more appropriate indication of nocturnal sleep problems than parent-reported daytime sleepiness.

4.4.2.4 Night Arousals

Night Arousals are defined by items pertaining to waking during the night, either spontaneously or as the result of nightmare/night terrors. The only demographic difference on the sub-scale was that of age: younger children score significantly higher on Night Arousals than older children. This result suggests that this factor may be measuring a developmental aspect of sleep in that older children experience less nightmares and night awakenings. It may also be indicative of an older child"s ability to self-sooth.

Examination of the research on nightmares suggest that they peak in children during the early school-aged years somewhere between 6 and 10 years and then decline as the child moves towards puberty (Muris et al., 2000; Schredl et al., 2009b). Based on these findings, it may be expected to see no difference in the incidence of Night Arousals between younger and older children. Indeed the majority of epidemiological studies reporting frequency of nightmares show no difference in this age group (see Chapter 1). However older children may still be experiencing nightmares and waking during the night, yet are going back to sleep without arousing parents. Schredl et al. (2009a) reports agreement between child and parent-reported nightmares is poor in school-aged children (8-11 years). In a study examining the relationship between nightmares and behaviour (N=8599), Schredl et al. asked both parents and children to report on the frequency of nightmares experienced by the children. Parents reported 29.2% of the children experienced nightmares sometime or often, whereas 43.5% of children reported that they had nightmares at this frequency. Schredl et al. surmised that for the most part, children of this age do not report their nightmares to their parents and simply go back to sleep.

Similarly, older children may be more able to go back to sleep after spontaneously waking during the night than younger children. Night wakings are common in infants and toddlers who are usually coaxed back to sleep with parental intervention (i.e. given a bottle, pacifier or being held). As children age this can become a problem as they are not able to fall asleep after a night arousal without these sleep association conditions (Moore et al., 2008), causing substantial disruption to the parent. The age-effect of Night Arousals may indicate that ages 5-7 years is the transition period in which children are learning to self-sooth.

Irrespective of the potential explanations for this result, Night Arousals indicate a true sleep problem. Previous research indicates that arousals during the night, either spontaneous or due to nightmares, are detrimental to daytime functioning in children (for review see Blunden & Beebe, 2006), thus understanding the developmental nature of Night Arousals is vital.

4.4.2.5 Sleep Disordered Breathing

In this study, sleep disordered breathing was defined by items related to observed snoring. Whilst it is acknowledged that this does not adequately measure obstructive events, these items are consistent with previous subjective definitions of sleep disordered breathing (Brouillette et al., 1984; Chervin et al., 2007; Montgomery-Downs et al., 2004).

The lack of a sex difference SDB scores in the current cohort is unexpected and inconsistent with much of the international research. There is a consensus in the literature of a greater prevalence and severity of SDB in boys as compared to girls. A recent review by Lumeng & Chervin, 2008) reports a male predominance in SDB in 60% (15/25) of the studies they examined. Nine studies reported no difference and only one reported a higher prevalence of snoring in females. Lumeng and Chervin (2008) speculate that the null results may be due to lack of power as the majority of studies reporting null findings contain samples of less than 1000 subjects. Although the current study was greater than 1000 subjects, the lack of power may explain the current finding, as overall effect sizes are small.

The current results do report that males in the low SES group reported the highest mean scores on SDB. It may be that the added risk of SES provided enough power for the sex effect to be observed. However, it may also be that maturational development leads to a greater propensity for boys to exhibit signs of SDB, independent of SES. Indeed, the studies reviewed by Lumeng and Chervin reveal a greater proportion of adolescent studies reporting sex differences than those in school-aged children.

The question of race as a risk factor for SDB is a complex and yet unanswered one. There is some suggestion that craniofacial differences place some racial groups at higher risk of SDB (Cakirer et al., 2001; Ong & Clerk, 1998), however a comparison of worldwide epidemiological prevalence rates does not suggest any clear differences (Lumeng & Chervin, 2008). The current study supports the latter. Some studies, such as that by Rosen et al. (2003), report African American children are at higher risk of SDB than Caucasian children. In that study, parents of 850 children aged 8-11 years completed a SDB questionnaire and 243 of these same children underwent home oximetry monitoring. Questionnaire results reported a higher prevalence of snoring in African American children than Caucasian children (24% and 13% respectively). Analysis of the oximetry data revealed that African American children were 4-6 times more likely to have SDB (Rosen et al., 2003). While the oximetry results are compelling, SES factors such as overcrowding and smoking, and health factors such as respiratory ailments were not controlled. Indeed whilst the current study did not find any difference in SDB between Caucasian and non-Caucasian children, it did find a significant difference in SDB scores between SES groups.

Specifically, children from the low SES group reported higher SDB scores than those from the high SES group. As with Bedtime Anxiety, the current result may be due to the higher proportion of room sharing in the low SES group (34.2% low vs 25.4% high – not reported in results). Snoring or other nocturnal respiratory noises during sleep can only be reported if someone else observes them. Therefore, it stands to reason that reports of snoring will be higher, and possibly more accurate, amongst children who co-share with a sibling or parent. After adding room sharing as a co-variate in retrospective analysis, the significance level of the mean difference dropped from p=0.028 to p=0.05 (not reported in results).

However, children in lower SES environments may also be at higher risk of SDB due to substantial health disparity (Carter-Pokras & Baquet, 2002). Within the context of public health, health disparity refers to:

> "… a chain of events signified by a difference in: (1) environment, (2) access to, utilization of, and quality of care, (3) health status, or (4) a particular health outcome that deserves scrutiny." (Carter-Pokras & Baquet, 2002: p427)

Children in low SES areas encounter environments of overcrowding and increased household smoking (Evans & English, 2002; Rona et al., 1998); may be less likely to see a doctor regarding sleep problems (Blunden et al., 2004); have poorer diets and overall health (Carter-Pokras & Baquet, 2002); and may be more susceptible to allergies and respiratory infections from household pollutants (Zhang et al., 2004). All of these factors have been reported as risk factors for SDB. For example, Corbo et al. (1989) reported that habitual snorers where almost twice as likely as non-snorers to live in a household of heavy smokers (≥20 cigarettes per day). In that same study (N=1907; 6-11 years), habitual snorers were over twice as likely as non-snorers to have a history of respiratory infection.

Additionally, there is some evidence that SES is an independent risk factor for SDB. For example, Urschitz et al. (2004) reported SES, defined by maternal education, to be an independent predictor of habitual snoring in boys after adjusting for household smoking. Chervin et al. (2003a) reported low SES, defined through qualification for school lunch assistance which was objectively based on family income and number of dependents, to be a risk factor for SDB after controlling for history of respiratory disease. However, this association disappeared after the removal of BMI. In the current study household smoking was greater (39 vs 14 cigarettes per week) and proportionately more children were obese (17.7% vs 9.2% with BMI percentile > 95%) in the low SES group than the high SES group. BMI and household smoking were not independent predictors of SDB, however they may be moderating factors.

Whilst it is acknowledged that the SDB factor of the SAPSS-Q cannot diagnose obstructive apnoea, the current results indicate that it may be an appropriate tool for identifying children at risk. Further validation studies are required for this to be confirmed.

4.4.2.6 Enuresis

Enuresis in the current study was defined as nocturnal enuresis (i.e. wetting the bed at night) and did not discriminate between primary and secondary enuresis. Although this may be limiting for clinical assessment, the results are consistent with previous epidemiological research.

In the present cohort, proportionately more boys and younger children reported enuresis. The predominance of enuresis in boys is well demonstrated (Devlin, 1991; Laberge et al., 2000; Petit et al., 2007). For example, in a large epidemiological study of 16,512 children aged 5-19 years, Yeung et al. (2006) reports a higher prevalence of nocturnal enuresis in boys at all ages, except mid-teens (14 &15 years). The reduction of bedwetting with age is also a robust finding in epidemiological studies and appears to be independent of culture with both longitudinal (Butler & Heron, 2008; Fergusson et al., 1986) and cross-sectional (Kanaheswari, 2003; Yeung et al., 2006) research worldwide consistently reporting this finding. Consequently, the aetiology of enuresis is understood to be predominately developmental, with bladder control relating to maturation of neural pathways (Jarvelin et al., 1991).

Persistence of enuresis into adolescence and adulthood may be indicative of a pathological concern (Fergusson & Horwood, 1994) and indeed, Yeung et al. (2006) reported that severity of symptoms in enuretic children progressively increased with advancing age. Fergusson & Horwood, 1994) conducted a 15-year longitudinal study of a birth cohort examining the relationship between nocturnal enuresis and behavioural problems. In that study, enuretic children over the age of 10 were more likely to exhibit conduct problems, attention deficit and anxiety/withdrawal behaviours as measured on the CBCL even after confounding factors were controlled. However, the relationships were weak and the authors suggest that there is little evidence that enuresis, even during adolescence, increases the risk of psychological problems.

Nonetheless, persistent enuresis in older children can cause embarrassment and perhaps social withdrawal. As such it is vital that enuresis continue to be examined in sleep research but considered in context.

4.4.2.7 Hyperhydrosis

Hyperhydrosis in the current study is defined as excessive sweating either going to and/or during sleep. Proportionately more boys than girls were reported to sweat excessively while falling asleep and during sleep. With the exception of studies utilising the Sleep Disturbance Scale for Children (Blunden & Chervin, 2008; Bruni et al., 2006; Ferreira et al., 2009) which specifically measures hyperhydrosis, very little attention has been paid to this phenomenon in the sleep literature. This may be because on its own, aside from sheet changes, it is not overly disruptive or concerning for parents and thus largely ignored.

The association between nocturnal sweating and sleep disordered breathing was first observed by Brouilette and colleagues (1984). That study compared 23 children diagnosed with obstructive sleep apnoea (OSA) with 45 controls on the frequency of symptoms related to OSA. Fifty percent of the OSA group reported nocturnal sweating compared with 16% of the control group. Spruyt et al. (2006) also reported hyperhydrosis as an indicator of SDB, however it was secondary to other sleep problems such as disorders of initiating and maintaining sleep. Retrospective analysis of the current study revealed that children who reported excessive sweating both while going to ($F_{1,1765)}$=31.3, p<0.0001) and during sleep ($F_{1,1763)}$=41.0, p<0.0001) also scored higher on the SDB sub-scale. However, this result was significant for both boys and girls and there was no statistically significant difference in overall SDB scores between boys and girls. Thus, whilst hyperhydrosis may be associated with SDB, SDB does not explain the sex effect.

It may be that boys just sleep hotter than girls. Sex differences in core body temperatures during sleep in children has not been explored and is worthy of further investigation, especially considering hyperhydrosis may be related to thermoregulation and perhaps cortical arousal (Krauchi, 2007). Research examining circadian rhythms and core body temperature in adults has indicated that both the propensity to fall asleep and length of sleep is inextricably linked to the thermoregulatory system (Krauchi, 2007). If boys do sleep hotter, sex-specific adjustments to bedroom environments may need to be made to improve sleep consolidation which would be vital information for sleep education programs.

Whether associated with SDB or thermoregulation, excessive sweating prior to and during sleep may be an indication of nocturnal arousal. Further information regarding incidence and potential causes of hyperhydrosis may be vital in determining appropriate treatment or intervention programs daytime functioning deficits associated with nocturnal arousals.

4.4.3 Other psychosocial correlates of sleep problems

The psychosocial correlates – history of respiratory complaint, family size, birthorder and household smoking – of the Sleep Problem sub-scales in the current study are, for the most part, consistent with previous research. One exception however was the association found between household smoking and Restless Sleep, and the null association between household smoking and SDB.

It is hardly surprising that a history of respiratory complaint was associated with SDB. Respiratory illness is well recognised as a risk factor for SDB and has been observed in many studies previously (e.g. Chng et al., 2004; Kaditis et al., 2004; Kuehni et al., 2008; Lu et al., 2003; Redline et al., 1999; Urschitz et al., 2004). Intuitively, it is also not surprising that children with a history of respiratory complaint also experience greater Restless Sleep and Night Arousals. Difficulty breathing during the night would precipitate increased arousals and movement. Although not studied specifically, there is some previous evidence that respiratory illness is a risk factor for sleep routine. For example, Camhi et al. (2000) examined the associates of sleep disturbance in 452 children aged 3-14 years and reported wheezing to be a significant predictor of disorders of initiating and maintaining sleep (DIMS). Camhi et al. defined DIMS as “trouble falling asleep”, “trouble staying asleep", and "waking too early and not being able to get back to sleep" (p122). In the current study, history of respiratory complaint was defined as an incidence of asthma, hayfever and rhinitis over the previous 12 months. Although often chronic conditions, when effectively managed, symptoms of asthma, hayfever and rhinitis are acute. Thus it stands to reason that a child experiencing an episode of asthma, hayfever or rhinitis would go to bed later, have more difficulty falling asleep and get overall less sleep than they normally would, resulting in a higher Sleep Routine score. Thus, it is evident from the above results that illness, in this case respiratory illness, is a significant risk factor for all sleep problems, not just SDB, and needs to be considered when determining the aetiology of sleep complaints.

The current result of an association between family size and Sleep Routing is also not surprising as this relationship has been noted previously. For example, Rona et al. (1998) reports a large family to be one of the predictor of poor sleep in their cohort of 14,372 children aged 5-11 years. Macgregor and Balding (1988) reported that increased family size was associated with later bedtime and shorter sleep duration in young adolescents. Intuitively, the larger the family the less likely the parents are to maintain strict routines, the more likely there will be extra-curricular activities during the week, and reduced limit-setting for older children may equally pertain to younger children regardless of whether it is age appropriate. Similarly, the greater likelihood of the youngest child reporting Bedtime Anxiety in the current study is most likely related to family dynamics. Whilst family size and birth order may not be a concern for sleep problems per se, it may be an important consideration for treatment strategies.

Previous research has indicated a strong association between household smoking and SDB (Corbo et al., 1989; Ekici et al., 2008; Kuehni et al., 2008;

Zhang et al., 2004), however this was not found in the current study. Household smoking was associated with Restless Sleep. There is no obvious explanation for this result and it may just be an artefact of the sample. Further examination of the impact of household smoking on sleep problems other than SDB is required.

The current results demonstrate that psychosocial factors such as illness, family dynamics and household smoking all influence reports of sleep problems in children, albeit to a limited degree (less than 3% of the variance). This confirms that these factors need to be considered in examination and treatment of sleep problems.

4.5 SUMMARY

This study provides the first geographically relevant information on the prevalence of sleep problems and biopsychosocial associations in school-aged children in Australia. According to these results, sleep problems are common in South Australian children and are influenced by a number of biopsychosocial factors. The most salient are age and SES, however sex and ethnic differences are also observed. Other factors associated with sleep problems in this cohort include history of respiratory complaint, family dynamics and passive smoking. The limitations of this study, in particular the small effect sizes and variance explained are discussed in Chapter 7. However, based on these results, future validation studies can now target socially and culturally appropriate areas to improve healthy sleep in Australian children.

CHAPTER 5: SLEEP/WAKE BEHAVIOURS, SLEEP PROBLEMS AND DAYTIME BEHAVIOURAL FUNCTIONING IN CHILDREN AGED 5-10 YEARS.

5.1 INTRODUCTION

Sleep problems are often overlooked by parents and medical professionals during health evaluations (Blunden et al., 2004; Chervin et al., 2001). This has noteworthy consequences as research, especially over the last 15 years, has shown associations between sleep disturbance and problem behaviour (Ali et al., 1994; Aronen et al., 2000; Carskadon et al., 2004; Chervin et al., 2003b; Giannotti et al., 2002; Lam et al., 2003; Mulvaney et al., 2006; Sadeh et al., 2002; Smedje et al., 2001a; Stein et al., 2001; Wiater et al., 2005)

Nocturnal sleep can be disturbed in three main ways: restriction of what is considered optimal sleep length; a specific problem that causes disruption to consolidation of sleep during the night; or a combination of both. The factors influencing sleep disturbance can be physiological, behavioural, and/or socio-cultural (Adair & Bauchner, 1993). Regardless of whether sleep is disturbed through restriction or disorder, daytime functioning appears to be affected. For example, Nixon et al. (2008) recently reported children with a sleep duration of less than 9 hours per night were more likely to be emotionally labile than those with over 9 hours sleep. Experimentally restricting sleep in otherwise healthy children results in decreased attention at school as reported by teachers (Fallone et al., 2005) and impairment in neurobehavioural functioning (Sadeh et al., 2003). Studies examining disruption to sleep consolidation have shown that everything from a loosely defined sleep problem (e.g. “your child has a sleep problem – yes/no”) to specifically defined sleep disorders such as obstructive sleep apnoea, diagnosed by polysomnography (PSG), are related to problem behaviours such as emotional lability (Clarkson et al., 1986; Smedje et al., 2001a; Wiater et al., 2005; Zuckerman et al., 1987), hyperactivity or attention deficit hyperactivity disorder (ADHD) (Ali et al., 1993; Carvalho Bos et al., 2009; Chervin et al., 2002; Hiscock et al., 2007), conduct problems (Carvalho Bos et al., 2009; Chervin et al., 2003b; Sadeh et al., 2002; Smedje et al., 2001a; Vignau et al., 1997; Wiater et al., 2005), aggression (Bruni et al., 2000; Stein et al., 2001), and depression (Bruni et al., 2000; Stein et al., 2001; Wolfson & Carskadon, 1998).

Some sleep problems, such as obstructive sleep apnoea, require complex treatments, however many of the more common sleep problems, such as extended bedtime latencies, are amenable to simple behavioural changes (Mindell et al., 2009b). In order to maximise the potential health and well-being of children, it is vital that parents and health professionals are aware of the impact of sleep disruption on daytime behaviour and potential areas for targeted treatment strategies. To date, large population based studies examining sleep and daytime behaviour in Australian children are limited. Therefore, the aims of this study were to examine the effect sleep/wake patterns, sleep problems and daytime behaviour in a large cohort of children in Australia to determine the specific associations between sleep problems and behavioural deficits.

5.2 METHODS

Please refer to Chapter 2 for a detailed description of methodology.

5.2.1 Statistical Analysis

A factor analysis, using principle axis factoring (PAF) with oblique rotation (Promax), of the 25 Strengths and Difficulties Questionnaire (SDQ) items revealed a three-factor solution: Anti-social Behaviour, Internalising Behaviour, and Hyperactive Behaviour (see Chapter 2 for details). A score for each sub-scale was obtained by summing the items. A Total Problem Behaviour Scale was derived from the sum of all the sub-scale scores. SDQ sub-scales were checked for normality and revealed a severe positive skew. This was corrected with logarithmic transformations (Tabachnick & Fidell, 2001). All univariate and multivariate analysis were conducted on transformed data. Descriptives are presented on untransformed data.

Univariate analysis of variance (ANOVA) was conducted to determine sex, age, ethnic and SES differences in SDQ sub-scales. Post-hoc analysis was conducted on SES where appropriate ($p<0.05$). Pearson‟s correlational analysis was conducted to determine associations between SDQ sub-scales and sleep/wake patterns. Bonferroni adjustment was used to control for Type 1 error. Hierarchical linear regression modelling, using the significant correlations observed in correlational analysis as independent variables and controlling for demographics, was conducted to determine the predictive relationships between sleep/wake patterns and SDQ sub-scales.

Sleep/wake patterns were further categorised and multinomial logistic regression modelling was conducted to determine the dose response relationship between sleep/wake patterns and problem scores on the SDQ. SDQ sub-scales were dichotomised into 0 (no problem) and 1 (problem) based on cut-offs of mean score plus 2 standard deviations (95^{th} centile).

Correlational and hierarchical linear regression analysis, with Bonferroni adjustment, was repeated for sleep problems sub-scales to determine the relationship between behaviour as reported on the SDQ and sleep problems as reported on the SAPSS-Q. Untransformed sleep problem sub-scale scores were dichotomised according to T-score cut-offs (>70) by age and gender (see Chapter 2). Enuresis, hyperhydrosis, sleep walking and bruxism were dichotomised as per Chapter 4. Forward hierarchical logistic modelling was used to determine the odds of high sleep problem sub-scale scores and moderate to severe individual sleep problem items on problem behaviour scores (>95th centile), controlling for sex, age, race and SES.

All statistically significant results are tabulated, regardless of effect size, however in the attempt to avoid over-interpretation and accepting inconsequential results, only effect sizes reaching a minimum of what is characterised as mild (d=0.2; ω^2=0.01) in univariate analysis are discussed.

5.3 RESULTS

5.3.1 Demographic Differences on Strengths and Difficulties Questionnaire Factor Sub-scales

Mean(±SD) scores by sex, age, ethnicity and SES are displayed in Table 5.1. Results from univariate analysis are displayed in Table 5.2. Univariate analysis revealed three significant main effects for sex meeting effect size criteria. Males scored significantly higher than females on Anti-social (5.0±2.8 vs 3.9±2.4), Hyperactive (3.3±2.3 vs 2.3±2.0) and Total Behaviour Problems (10.3±5.3 vs 8.3±4.7) sub-scales. A main effect for age was found on the Hyperactive behaviour sub-scale, however Cohen‟s criteria for effect size was not reached. Significant differences were found across SES groups in all sub-scales with medium to large effects. Post-hoc analysis revealed that children from the low SES group scored significantly higher on Anti-Social (4.7±2.7 vs 4.2±2.6 & 4.3±2.5), Internalising (2.3±2.1 vs 1.9±1.9 & 1.8±2.0), Hyperactive (3.1±2.3 vs 2.9±2.2 & 2.6±2.2), and Total Problem Behaviour (10.1±5.3 vs 9.0±5.0 & 8.6±4.8) than either middle or high SES groups. No difference was found between middle and high SES groups.

A significant sex by ethnicity interaction was found on Internalising and Total Problem behaviour sub-scales. Post-hoc analysis revealed Non-Caucasian females scored significantly higher in Internalising behaviour than Non-Caucasian males (2.2±2.0 vs 1.5±1.6). No other differences were found between groups for Internalising Behaviour. Caucasian males scored significantly higher in Total Problem behaviour than Non-Caucasian (10.4±5.4 vs 8.8±4.2) and Caucasian (10.4±5.4 vs 8.3±4.7) females. Non-Caucasian males scored significantly higher on this sub-scale than Caucasian females (9.7±4.7 vs 8.3±4.7).

A significant ethnicity by SES interaction was found for Anti-social and Total Problem behaviour. Post-hoc analysis revealed that children from the low SES group, both Caucasian (4.8±2.8) and Non-Caucasian (4.7±2.5) scored higher on the Anti-social Behaviour sub-scale than Caucasian children from the mid-SES group (4.1±2.6). Caucasian (10.1±5.4) and Non-Caucasian (10.0±4.6) children from the low SES group scored significantly higher on the Total Problem behaviour sub-scale than Non-Caucasian children from the high SES group (7.1±3.9) and Caucasian children from the mid- (8.9±5.1) and high SES group (8.7±4.9).

One three-way interaction was found, however due to limited cell numbers post-hoc analysis was not performed.

Table 5.1: *Raw mean (±SD) SDQ subscale scores by individual group categories*.

	Demographics																								
Sex	Male												Female												Total
Age	Younger (5-7yrs)						Older (8-10yrs)						Younger (5-7yrs)						Older (8-10yrs)						
Ethn	Caucasian			Non-Caucasian			Caucasian			Non-Caucasian			Caucasian			Non-Caucasian			Caucasian			Non-Caucasian			
SES	Low	Mid	High	Low	Mid	High	Low	Mid	High	Low	Mid	High	Low	Mid	High	Low	Mid	High	Low	Mid	High	Low	Mid	High	
	N=147	N=114	N=142	N=37	N=22	N=10	N=106	N=95	N=118	N=21	N=17	N=8	N=169	N=131	N=159	N=36	N=22	N=17	N=103	N=83	N=126	N=27	N=16	N=10	N=1819
AS	5.2 (3.1)	4.9 (2.7)	4.8 (2.3)	5.6 (2.9)	5.3 (2.6)	3.4 (2.2)	5.7 (2.8)	4.2 (2.8)	4.9 (2.7)	5.1 (2.4)	5.6 (3.0)	3.6 (2.5)	4.1 (2.4)	3.6 (2.4)	3.7 (2.4)	4.2 (2.1)	4.0 (1.9)	3.8 (2.3)	4.0 (2.5)	3.8 (2.2)	4.0 (2.6)	3.8 (2.0)	4.6 (2.3)	4.1 (1.9)	4.4 (2.6)
IB	2.2 (2.1)	2.0 (1.9)	1.8 (1.9)	1.3 (1.5)	1.4 (1.2)	0.3 (0.5)	2.3 (2.1)	1.9 (2.1)	2.1 (2.2)	2.5 (2.3)	1.6 (1.4)	1.0 (1.1)	2.4 (2.2)	1.9 (1.8)	1.8 (1.8)	3.0 (2.2)	1.7 (1.7)	1.5 (1.5)	2.2 (2.1)	2.1 (2.2)	1.9 (2.2)	2.3 (2.1)	1.7 (1.8)	2.2 (1.6)	2.0 (2.0)
HYP	3.7 (2.5)	3.5 (2.3)	3.2 (2.3)	2.7 (1.9)	3.7 (1.6)	2.6 (2.1)	3.7 (2.2)	3.2 (2.4)	3.1 (2.2)	3.3 (2.2)	2.5 (1.8)	2.0 (2.7)	2.8 (2.2)	2.3 (2.0)	2.1 (1.9)	2.9 (2.1)	2.9 (1.5)	2.0 (1.8)	2.2 (2.2)	2.6 (2.1)	2.0 (2.0)	2.9 (2.2)	1.5 (1.6)	1.7 (1.2)	2.8 (2.2)
TOT	11.2 (5.9)	10.3 (4.9)	9.8 (4.9)	9.8 (4.9)	10.6 (4.1)	6.3 (3.3)	11.5 (5.2)	9.3 (5.8)	10.0 (5.5)	11.1 (4.9)	9.8 (3.9)	6.6 (5.0)	9.4 (4.9)	7.8 (4.8)	7.5 (4.1)	10.3 (4.7)	8.5 (3.7)	7.3 (4.1)	8.4 (5.0)	8.5 (4.9)	7.9 (4.7)	8.9 (3.7)	7.8 (4.3)	8.0 (3.7)	9.3 (5.1)

AS = Anti-social behaviour, IB = Internalising behaviour, HYP= Hyperactive behaviour, TOT = Total problem behaviour

Table 5.2: *Univariate results of sex, age, ethnicity and SES differences on SDQ sub-scales.*

	SDQ sub-scales											
	Anti-Social Behaviour			Internalising Behaviour			Hyperactive Behaviour			Total Problem		
Demographics	F	*p*	d/ω^2	F	*p*	d/ω^2	F	*p*	d/ω^2	F	*p*	d/ω^2
Sex[a]	14.7	<0.0001	0.41	5.53	0.019	0.08	19.6	<0.0001	0.43	10.0	0.002	0.38
Age[a]	0.09			2.48			5.02	0.025	0.08	0.20		
Ethnicity	0.06			2.74			1.07			0.57		
SES[b]	4.32	0.013	0.04	8.62	<0.0001	0.09	5.84	0.003	0.07	11.5	<0.0001	0.12
Sex*Age	0.68			3.12			0.13			0.02		
Sex*Ethnicity[b]	3.16			5.90	0.015	0.06	2.77			5.47	0.019	0.06
Age*Ethnicity	0.06			1.93			1.86			0.01		
Sex*SES	2.42			1.30			0.19			1.68		
Age*SES	0.18			0.72			2.15			0.37		
Ethnicity*SES[b]	4.08	0.017	0.04	1.54			1.05			3.67	0.026	0.03
Sex*Age*Ethnicity	0.07			1.55			0.00			0.02		
Sex*Age*SES	1.52			1.53			1.04			2.25		
Sex*Ethnicity*SES	2.39			1.71			1.51			2.22		
Age*Ethnicity*SES[b]	0.77			0.53			4.17	0.015	0.04	0.21		
Sex*Age*Ethnicity*SES	0.37			0.92			1.38			0.53		

[a] Cohen"s *d*, 0.2 weak effect: 0.5 medium effect: 0.8 strong effect. [b]Hays ω^2 for multi-sample cases, 0.01 weak effect: 0.059 medium effect: 0.138 large effect.

5.3.2 Sleep/wake patterns and SDQ Factor Sub-scales

Sleep/wake patterns used in this analysis were time spent napping, nocturnal time in bed (TIB), total sleep time (TST), bedtime latency (difference between usual bedtime and usual sleep time; BTL), bed and rise time variability (difference between latest and earliest time went to bed and rose; BTV & RTV), on school nights $_{(school)}$ and weekends $_{(weekend)}$. Holiday sleep/wake patterns were not included due to their similarity to weekend sleep/wake patterns. Bed and rise time shift were calculated as the difference between usual bed/rise time on school nights and weekends (BTSFT & RTSFT).

Correlational analysis was conducted to determine associations between SDQ sub-scales and sleep/wake behaviours (Table 5.3). $BTV_{(school)}$ was significantly correlated with all SDQ sub-scales. $BTV_{(weekend)}$, $RTV_{(school)}$ and $RTV_{(weekend)}$ were significantly correlated with Internalising, Hyperactive and Total Problem behaviour. BTSFT was also correlated with Hyperactive behaviours. Correlations were found with some TIB and TST measures, however these did not reach Bonferroni adjustment criteria.

Table 5.3: *Correlations between SDQ sub-scales and sleep/wake behaviours for total cohort*

	Sleep/Wake Behaviours																	
	Napping		Bedtime		Risetime		TIB		TST		BTL		BTV		RTV		BTSFT	RTSFT
SDQ	Sch	Wend	Sch	Wend	Sch	Wend	Sch	Wend	Sch	Wend	Sch	Wend	Sch	Wend	Sch	Wend		
N	49	65	1740	1705	1660	1593	1675	1594	1028	966	1056	1032	1680	1637	1632	1561	1735	1587
Anti-social	0.18	0.17	0.01	0.02	-0.02	-0.03	-0.03	-0.05	-0.03	-0.04	0.03	0.03	**0.09***	0.04	0.05[a]	0.02	0.02	-0.03
Internalising	0.01	-0.04	0.01	0.01	-0.04	-0.02	-0.03	-0.02	-0.07[a]	-0.06	**0.11***	**0.12***	**0.14***	**0.12***	**0.14***	**0.10***	0.02	0.00
Hyperactivity	-0.14	-0.14	-0.03	0.04	-0.06[a]	-0.01	-0.03	-0.05[a]	-0.04	-0.08[a]	0.09[a]	0.08[a]	**0.15***	**0.10***	**0.11***	**0.11***	**0.10***	0.03
Total	-0.01	0.04	-0.00	0.03	-0.05[a]	0.03	-0.04	-0.05[a]	-0.05	-0.08[a]	0.09[a]	0.09[a]	**0.17***	**0.11***	**0.14***	**0.10***	0.05[a]	-0.01

* *p*<0.0001 ([a]*p*<0.05, [b]*p*<0.01 does not meet Bonferroni adjustment criteria of *p*<0.0005). NB: figures reported for N are minimum entries used in analysis. TIB = Time in Bed, TST = Total Sleep Time, BTL = Bedtime latency, BTV = Bedtime variability, RTV = Risetime variability, BTSFT = Bedtime shift, RTSFT = Risetime shift

Linear regression modelling was conducted to determine which of the associated sleep/wake patterns were predictive of SDQ sub-scales. Results of this analysis are presented in Table 5.4. As can be seen from this table, $BTV_{(school)}$ was the strongest predictor of all SDQ sub-scales after controlling for sex, age, ethnicity and SES. $RTV_{(school)}$ predicted Internalising and Total Problem behaviour. $BTL_{(school)}$ was a predictor of Internalising, Hyperactive and Total Problem behaviour. BTSFT was a predictive of Hyperactive behaviour.

Table 5.4: *Step-wise linear regression of SDQ Factor Sub-scales from sleep/wake behaviours after controlling for sex, age, ethnicity and SES*

	Regression Analysis															
	Step 1		Step 2												Total Model	
	Demographics		Bedtime Variability School			Risetime Variability School			Bedtime Latency School			Bedtime Shift				
SDQ	F	R^2	*B*	FΔ	$R^2\Delta$	*B*	FΔ	$R^2\Delta$	*B*	FΔ	$R^2\Delta$	*B*	FΔ	$R^2\Delta$	F	R^2
Anti-social	11.1***	0.04	0.14	4.7*	0.01										9.9***	0.05
Internalising	2.47*	0.01	0.26	15.4***	0.02	0.22	8.1*	0.01	0.13	7.4*	0.01				5.9***	0.04
Hyperactive	12.8***	0.05	0.29	19.3***	0.02				0.12	6.5*	0.01	0.14	4.4*	<0.01	11.8***	0.08
Total Prob	11.2***	0.04	0.25	22.4***	0.02	0.13	4.8*	0.01	0.10	6.3*	0.01				11.5***	0.08

* $p<0.01$, *** $p<0.0001$

Although significance was moderate to strong ($p<0.01$), individual sleep/wake pattern predictors explained less than 3% of the variance and did not add substantially to, in some cases weakened, the final model. Thus, further analysis was conducted to determine whether these measures had any practical implication for problem behaviour.

All SDQ sub-scales were dichotomised into „no problem" and „problem" categories based on cut-offs of the mean score plus 2 standard deviations (95th percentile). $BTV_{(school)}$ and $RTV_{(school)}$ were categorised into ≤30, 31-60, 61-90, 91-120, and >120 minutes. $BTL_{(school)}$ was categorised into ≤15, 16-30, 31-45, 46-60, and >60 minutes. Multinomial logistic regression modelling was used to determine the effect of each increment on the likelihood of scoring within the problem range (95^{th} centile) on the SDQ sub-scales.

A dose response relationship was found between $BTV_{(school)}$ and scores above the 95^{th} centile on the Anti-social and Hyperactive sub-scales (Table 5.5). Children with a $BTV_{(school)}$ between 91 and 120 minutes were over 1.8 times, and those with a $BTV_{(school)}$ of greater than 2 hours were more than twice as likely to report scores in the 95^{th} percentile of Anti-social behaviour. The risk of reporting a problem score on the Hyperactivity sub-scale increased from twice at $BTV_{(school)}$ of 30-60 minutes to over 4 times at a $BTV_{(school)}$ greater than 2 hours. A $BTV_{(school)}$ greater than 2 hours resulted in a two-fold risk of reporting a high score in Internalising behaviours and Total problems. The risk of reporting a high score in Internalising behaviour or Total problems was not affected by $BTV_{(weekend)}$, however a $BTV_{(weekend)}$ greater than 2 hours posed a significantly increased risk of scores in the 95^{th} percentile on the Anti-social and Hyperactivity sub-scales. A $RTV_{(school)}$ greater than 2 hours also significantly increased the likelihood of scoring in the 95^{th} percentile of Internalising behaviours by over 4 times. A large $RTV_{(weekend)}$ was not associated with behaviour scores on any of the SDQ sub-scales.

Children with a $BTL_{(school)}$ between 46 and 60 minutes were over twice as likely to report a score in the 95^{th} percentile of Internalising behaviour [B=1.05, p<0.014, Odds Ratio (OR)=2.9, 95%CI 1.2 – 6.6]. Children with a $BTL_{(school)}$ over 60 minutes were over three times more likely to report a score in the 95^{th} percentile of Hyperactive behaviour (B=1.24, p<0.015, OR=3.4, 95%CI 1.3 – 9.3) and four times more likely to report a problem score on Total Problem behaviour (B=1.40, p<0.023, OR=4.1, 95%CI 1.2 – 13.7).

Table 5.5: *Results from the multinomial logistic regression between bed and rise time variability categories and symptomatic scores on SDQ sub-scales*

	Bedtime Variability – School nights															
	30-60 minutes				61-90 minutes				91-120 minutes				>120 minutes			
	Beta (S.E)	*p*	Exp(B)	95% CI	Beta (S.E)	*p*	Exp(B)	95% CI	Beta (S.E)	*p*	Exp(B)	95% CI	Beta (S.E)	*p*	Exp(B)	95% CI
Anti-social	0.19 (0.3)	NS	1.21	0.73 – 2.03	0.38 (0.3)	NS	1.46	0.85 – 2.51	**0.61 (0.3)**	**0.049**	**1.84**	**1.00 – 3.38**	**0.72 (0.3)**	**0.022**	**2.06**	**1.09 – 3.83**
Internalising	0.18 (0.3)	NS	1.20	0.70 – 2.08	0.48 (0.3)	NS	1.61	0.92 – 2.83	0.61 (0.3)	NS	1.83	0.97 – 3.47	**0.94 (0.3)**	**0.003**	**2.57**	**1.38 – 4.78**
Hyperactive	**0.66 (0.3)**	**0.015**	**1.93**	**0.14 – 3.28**	**0.64(0.3)**	**0.027**	**1.99**	**1.08 – 3.35**	0.38 (0.4)	NS	1.45	0.72 – 2.99	**1.43 (0.3)**	**<0.0001**	**4.16**	**2.30 – 7.53**
Total Prob	0.16 (0.3)	NS	1.17	0.67 – 2.06	-0.14 (0.3)	NS	0.87	0.45 – 1.68	0.26 (0.3)	NS	1.30	0.63 – 2.67	**0.93 (0.3)**	**0.004**	**2.54**	**1.34 – 4.83**
	Bedtime Variability – Weekend															
	30-60 minutes				61-90 minutes				91-120 minutes				>120 minutes			
	Beta (S.E)	*p*	Exp(B)	95% CI	Beta (S.E)	*p*	Exp(B)	95% CI	Beta (S.E)	*p*	Exp(B)	95% CI	Beta (S.E)	*p*	Exp(B)	95% CI
Anti-social	0.36 (0.4)	NS	1.43	0.71 – 2.90	0.60 (0.4)	NS	1.83	0.92 – 3.63	0.49 (0.4)	NS	1.63	0.78 – 3.40	**0.83 (0.3)**	**0.014**	**2.28**	**1.18 – 4.42**
Internalising	-0.21 (0.3)	NS	0.81	0.43 – 1.55	-0.24 (0.3)	NS	0.79	0.41 – 1.51	0.15 (0.3)	NS	1.16	0.61 – 2.22	0.22 (0.3)	NS	1.24	0.69 – 2.24
Hyperactive	0.61 (0.4)	NS	1.83	0.90 – 3.74	**0.87 (0.4)**	**0.014**	**2.39**	**1.19 – 4.78**	0.47 (0.4)	NS	1.60	0.74 – 3.45	**0.92 (0.3)**	**0.008**	**2.52**	**1.27 – 4.97**
Total Prob	-0.19 (0.4)	NS	0.83	0.38 – 1.79	0.15 (0.4)	NS	1.16	0.56 – 2.42	0.33 (0.4)	NS	1.39	0.65 – 2.98	0.55 (0.3)	NS	1.72	0.87 – 3.41
	Risetime Variability – School Days															
	30-60 minutes				61-90 minutes				91-120 minutes				>120 minutes			
	Beta (S.E)	*p*	Exp(B)	95% CI	Beta (S.E)	*p*	Exp(B)	95% CI	Beta (S.E)	*p*	Exp(B)	95% CI	Beta (S.E)	*p*	Exp(B)	95% CI
Internalising	0.31 (0.3)	NS	1.36	0.81 – 2.26	0.47 (0.3)	NS	1.60	0.89 – 2.88	0.59 (0.4)	NS	1.81	0.88 – 3.72	**1.46 (0.3)**	**<0.0001**	**4.32**	**2.19 – 8.53**
Total Prob	0.34 (0.3)	NS	1.40	0.82 – 2.39	0.17 (0.3)	NS	1.19	0.61 – 2.29	0.11 (0.4)	NS	1.12	0.47 – 2.68	0.63 (0.5)	NS	1.88	0.78 – 4.55

Reference category is: < 95th percentile

5.3.3 Sleep problem Sub-scales and behaviour

Pearson‟s correlational analysis was conducted between sleep problem sub-scales and the SDQ sub-scales. Significant correlations were found between all sleep problem and SDQ sub-scales, however correlations between Anti-social behaviour and Bedtime Anxiety and SDB did not reach Bonferroni adjustment criteria (p<0.002) (Table 5.6).

Table 5.6: *Pearson's correlations between Sleep Problem sub-scales and SDQ factors*.

	Sleep Problem Factors						
	Sleep Routine	Bedtime Anxiety	Morning Tiredness	Night Arousals	SDB	Restless Sleep	Total Sleep Problems
Anti-social	0.22**	0.04[a]	0.23**	0.13**	0.07[b]	0.08*	0.20**
Internalising	0.31**	0.17**	0.33**	0.30**	0.15**	0.25**	0.37**
Hyperactivity	0.27**	0.10**	0.26**	0.24**	0.19**	0.23**	0.32**
Total	0.35**	0.13**	0.35**	0.27**	0.18**	0.24**	0.39**

* p<0.001, ** p<0.0001 ([a]p<0.05, [b]p<0.01 does not meet Bonferroni adjustment criteria of p<0.002)

Stepwise hierarchical linear regression modelling was conducted to determine the predictive relationships between the Sleep problem and SDQ factors after controlling for demographic covariates. Sex, age, ethnicity and SES were entered in Step 1. Morning Tiredness was entered independently in Step 2 as: A. this factor measures a different construct to the others i.e. it is secondary behaviour perhaps caused by a nocturnal problem, rather than a primary behaviour; and B. parents may have been more aware of the secondary behaviour than the primary and therefore Morning Tiredness may be a proxy for another nocturnal event.

As can be seen in Table 5.7, Morning Tiredness is the strongest predictor of all SDQ sub-scales, explaining up to 13% of the variance on each sub-scale. The first sleep problem variable to be entered into Step 3 for Anti-social and Total Problem behaviour was Sleep Routine. For Internalising behaviours the first sleep problem variable entered in Step 3 was Night Arousals and for Hyperactive behaviour it was Restless Sleep. Sleep Routine, however, was also predictive of Internalising and Hyperactive behaviours. SDB was included in the final predictive model for Hyperactive behaviours, however it did not add substantially to the strength of the model, explaining less than 1% of the variance. Bedtime Anxiety was not predictive of any SDQ sub-scale.

Table 5.7: *Stepwise linear regression of SDQ Factor Sub-scales from Sleep problem factors after controlling for sex, age, ethnicity, SES and Morning Tiredness*

	Regression Analysis																		
	Step 1		Step 2			Step 3												Total Model	
	Demographics		Morning Tiredness			Sleep Routine			Night Arousals			Restless Sleep			SDB				
SDQ	F	R^2	*B*	FΔ	$R^2\Delta$	*B*	FΔ	$R^2\Delta$	*B*	FΔ	$R^2\Delta$	*B*	FΔ	$R^2\Delta$	*B*	FΔ	$R^2\Delta$	F	R^2
Anti-social	19.4**	0.04	2.0	106.2**	0.06	1.0	25.1**	0.01										36.1**	0.11
Internalising	4.3*	0.01	2.7	206.1**	0.11	1.3	38.7**	0.02	2.0	87.8**	0.04	0.8	13.2**	0.01				48.3**	0.19
Hyperactivity	22.4**	0.05	2.4	150.1**	0.08	1.2	36.4**	0.02	0.9	14.2**	0.01	1.4	46.1**	0.02	0.5	7.1*	<0.01	40.9**	0.18
Total Prob	19.7**	0.04	2.5	272.1**	0.13	1.5	86.9**	0.04	1.0	32.1**	0.02	0.6	11.2*	0.01				65.4**	0.24

* p<0.05, ** p<0.0001

Sleep problem scores were dichotomised according to a T-score cut-off of 70 for age and gender (see Chapter 2, Appendix E). A binary logistic regression was conducted to determine the odds ratios of high sleep problems score (T-score >70) predicting a problem score in the SDQ. Table 5.8 details the results of the logistic regression.

Children with a T-score >70 on Sleep Routine and Morning Tiredness were up to 4 times more likely to report a problem score on the SDQ sub-scales. A high score on Restless Sleep resulted in a three-fold risk of problem scores in Internalising and Hyperactive behaviours. A high score on Bedtime Anxiety doubled the risk of scoring in the 95th centile of Internalising behaviour. Subjects with a high score on Night Arousals were over twice as likely to score in the 95th centile of Hyperactive behaviour.

Table 5.8: *Results of logistical regression of sleep problem T-scores > 70 and SDQ scores in the 95th centile controlling for sex, age, ethnicity and SES.*

SDQ Sub-scale	Sleep Problem	Beta (S.E)	*p*	Exp(B)	95% CI
Anti-Social Behaviour					
	Sleep Routine	1.02 (0.33)	0.002	2.77	1.45 – 5.26
	Morning Tiredness	0.82 (0.35)	0.020	2.27	1.14 – 4.55
Internalising Behaviour					
	Sleep Routine	1.33 (0.29)	<0.0001	3.78	1.13 – 6.70
	Bedtime Anxiety	0.89 (0.35)	0.010	2.45	1.24 – 4.83
	Morning Tiredness	1.42 (0.31)	<0.0001	4.12	2.27 – 7.49
	Restless Sleep	1.19 (0.36)	0.001	3.30	1.62 – 6.72
Hyperactive Behaviour					
	Sleep Routine	1.42 (0.29)	<0.0001	4.13	2.35 – 7.24
	Morning Tiredness	0.78 (0.33)	0.019	2.19	1.14 – 4.20
	Night Arousals	0.83 (0.37)	0.026	2.29	1.11 – 4.75
	Restless Sleep	1.31 (0.36)	<0.0001	3.71	1.82 – 7.55
Total Problem Behaviour					
	Sleep Routine	1.80 (0.31)	<0.0001	6.02	3.27 – 11.11
	Morning Tiredness	1.67 (0.33)	<0.0001	5.27	2.74 – 10.14

5.3.4: Individual sleep problem items and behaviour

Items pertaining to enuresis, hyperhydrosis, sleepwalking and bruxism were dichotomised based on the *ISDC* criteria (see Chapter 4). A binary logistic regression was conducted to determine the predictive relationship between moderate to severe symptoms on these individual sleep problems and problem scores on the SDQ sub-scales. Results are detailed in Table 5.9.

Table 5.9: *Results of logistical regression of enuresis, hyperhydrosis, sleepwalking and bruxism and SDQ scores in the 95th centile controlling for sex, age, ethnicity and SES.*

SDQ Sub-scale	*Sleep Problem*	*Beta (S.E)*	*p*	*Exp(B)*	*95% CI*
Anti-Social Behaviour					
	Excessive sweating during sleep	0.66 (0.20)	0.001	1.93	1.31 – 2.84
Internalising Behaviour					
	Excessive sweating falling asleep	1.42 (0.21)	<0.0001	4.13	2.72 – 6.28
	Sleepwalking	0.61 (0.26)	0.020	1.84	1.10 – 3.09
Hyperactive Behaviour					
	Excessive sweating during sleep	0.55 (0.19)	0.004	1.74	1.19 – 2.53
	Bruxism	0.48 (0.20)	0.016	1.61	1.09 – 2.37
	Sleepwalking	0.53 (0.25)	0.037	1.70	1.09 – 2.79
Total Problem Behaviour					
	Excessive sweating during sleep	1.08 (0.24)	<0.0001	2.96	1.86 – 4.71
	Excessive sweating falling asleep	0.66 (0.32)	0.036	1.94	1.05 – 3.59

Hyperhydrosis, either before or during sleep, was a significant predictor of all SDQ sub-scales. Children with moderate to severe sleepwalking were at almost twice the risk of scoring in the 95th centile of Internalising and Hyperactive behaviours. Moderate to severe bruxism was also predictive of Hyperactive Behaviours.

As Hyperhydrosis is known to be associated with SDB, further logistic regression was conducted controlling for SDB to determine the independent predictive relationship between Hyperhydrosis and problem behaviours. After controlling for SDB, excessive sweating remained a significant predictor of Internalising behaviours (B = 1.4, p<0.0001, OR 4.0, 95% CI 2.2-7.3), and bruxism remained a significant predictor of Hyperactive behaviours (B = 0.60, p=0.007, OR 1.9, 95% CI 1.2-2.8). No other relationships remained.

5.4 DISCUSSION

This study is the first of its kind to explore in detail the associations between sleep and behaviour in a large cohort of Australian children. The results from this study showed that both sleep/wake patterns and sleep problems were associated with daytime behavioural concerns. Importantly, these results revealed that not only were specific sleep concerns associated with specific behaviours, but that inconsistency of sleep routine appears to be an overarching concern for all behavioural deficits.

5.4.1 Sleep/wake Patterns and Behavioural Outcomes

Previous research concerning the relationship between sleep duration and behaviour is unclear with some studies reporting short sleep duration is predictive of problem behaviour (e.g. Aronen et al., 2000; Nixon et al., 2008) and others reporting long sleep duration effects behaviour (e.g. Carvalho Bos et al., 2009; Gau, 2006). In the current study, no relationship was found between traditional measures of sleep/wake patterns (i.e. napping, bedtime, risetime, TIB or TST) and behavioural outcomes as measured on the SDQ. Whilst the null findings of the current study may be due to methodological differences (see Chapter 1 for full details), it is more likely due to the fact that very few children were reported as having what was previous defined as poor sleep/wake patterns. That is, less than 5% of children were reported to sleep less than 9 hours on any night, and less than 10% were reported to have bedtimes later than 10pm. Even considering the social desirability bias of parental report, this result is encouraging as it suggests that overall, children in South Australia are meeting their sleep need.

A novel finding of this study is the dose response relationship between bedtime variability – difference between the earliest and latest bedtime over any one period – and problem behaviours. Compared with a variation in bedtime of 30 minutes across the school week, any variation over 90 minutes incrementally increases the risk of reporting problem scores in every SDQ domain. Similarly, Bates et al. (2002) reported that a regular sleep schedule was associated with better adjustment and overall behaviour in school in a cohort of preschool children (N=202; 4-5yrs) from low socioeconomic backgrounds. In particular, nocturnal sleep- and bedtime variability, calculated as the average squared deviation of the variable across a 4-week period, were negatively correlated with teacher reported preschool adjustment and daily positive behaviours, and positively correlated with problem behaviours. Consistent with the current study, traditional measures of poor sleep, such as late bedtimes and short sleep duration, were not associated with behavioural measures in that study.

It is not clear why a consistent routine, over an optimal sleep length, would provide for better behavioural outcomes. It may be that a better sleep routine results in a better quality of sleep. Mindell et al. (2009b) recently reported that implementing a consistent bedtime routine, described as regular activities performed ritually every night 30 minutes prior to bed, significantly improved sleep latencies, night arousals and total sleep time in a group of infants (N=206; age 7-

18 months) and toddlers (N=199; age 18-36 months) over a three week period. Although that study did not stipulate a consistent bedtime, it can be assumed that engaging in ritual routines every night would coincide with regular timing. Wiater et al. (2005) reports that children with regular bedtimes and who woke spontaneously were less likely to report sleep disturbance and daytime sleepiness. Indeed, structural equation modelling analysis in Bates et al. (2002) revealed that sleep and bedtime variability accounted for 92 and 80% of the variance of sleep disruption, respectively. Late bedtime accounted for only 40% of the variance. Constant variation of bedtimes may disrupt optimal circadian entrainment, an essential component of sleep consolidation (Borbély et al., 1989). As the circadian system is slow to adapt, children with highly variably sleep and bedtime may experience constant fatigue and mental confusion similar to jet lag, resulting in reduced daytime functioning. Indeed, a two hour difference in bedtime is akin to the shift in the timing of sleep that would be experienced if flying from Adelaide to Auckland, New Zealand.

Consistency of bedtimes is usually encompassed within the concept of sleep hygiene; the term used to describe the modifiable behaviours of parents and children that promote sleep quality, allow for ample sleep duration, and prevent or reduce daytime sleepiness (Mindell et al., 2009a). General sleep hygiene has been examined in relation to sleep quality in children and adolescents (LeBourgeois et al., 2005; Mindell et al., 2009a) however research specifically examining the association between sleep/wake schedules and daytime behavioural functioning in school-aged children is scarce. One possible reason for this research gap may be that as inadequate sleep hygiene is related to poor sleep quality (LeBourgeois et al., 2005), and poor sleep quality is well accepted in the research community as a predictor of behavioural deficits (for review see O'Brien

& Gozal, 2004), the need for targeted sleep hygiene research is seen as redundant. The findings of the current study argue strongly against such an assumption, at least from a parental perception perspective.

In the current study, up to 40% of children had a bedtime variability greater than 90 minutes across the week compared with 22% who were reported to sometime or usually wake during the night; a typical measure of sleep quality (e.g. Ali et al., 1993; Hayes et al., 2001; Meltzer & Mindell, 2007; Sadeh et al., 2000) (results not reported). Additionally, 6.1% of children were reported with Sleep Routine T-scores > 70, whereas 4.3% and 3.6% had T-scores > 70 for Night Arousals and Restless Sleep respectively (results not reported). This suggests that, in otherwise healthy children of this age, what happens prior to sleep is more salient to parents than what happens during sleep and may be a more appropriate target for education and intervention than sleep duration.

However in this study, bedtime variability was a crude measure, calculated as the difference between latest and earliest bedtimes and does not give an indication of the persistence of this problem. That is, it is impossible to determine if variation of bedtimes was a regular occurrence or the result of one unusual circumstance. Nonetheless, the mean and standard deviation of this measure (1.2±0.8hr) was only slightly higher than that previously reported for night-to-night variability in preschool children (1.0±0.8hr; Bates et al., 2002) and adolescents (0.9±0.5hr; Fuligni & Hardway, 2006) suggesting this is an important finding and one worthy of future targeted research. Behavioural intervention studies, using objective sleep and behaviour measures, are required to examine the influences and effects of night-to-night variability across the week as compared to „optimal" sleep length. The results of such studies may have serious implications not only for sleep education but also for the scheduling of after-school and evening activities.

Wake schedules in children have received little attention compared to nocturnal behaviours however the dose response relationship between rise-time variability and Internalising behaviours warrants further investigation. As school start times in Adelaide do not vary by more than 30 minutes (8:15-8:45am), children with a large variability in rise-times must, on average, get up earlier than those who have more consistent rise-times. Early morning waking is one of the specifying features of melancholia in the DSM-IV (APA, 2000) and in the adult literature, is common in patients with affective disorders such as major depressive disorder and bipolar disorder (for review see Armitage, 2007). It may be that variability of rise-time is an early indicator of the potential development of a mood disorder. As there is a lack of research in wake schedules, this is only speculation, however further research would be of benefit.

Bedtime latency on school nights was predictive of Internalising and Hyperactive behaviours as well as Total Problem behaviour. The relationship between bedtime latency and hyperactive behaviours is consistent with previous research. Ivanenko et al. (2006) compared sleep parameters as measured through parent report questionnaires between 174 children with diagnosed psychiatric disorders of ADHD, ADHD with comorbid affect disorders, affective disorder alone, and other psychiatric disorders such as adjustment disorder and 174 controls. In that study, it was reported that proportionately more children diagnosed with ADHD, or ADHD with comorbid affective disorders, than controls reported taking between 1-2 hours to fall asleep. In a small study (N=49; 7-12 years) using objectively measured sleep parameters with actigraphy, Aronen et al. (2000) reported that an extended sleep latency – the actual time to fall asleep – was associated with parent-reported aggressive/delinquent behaviour and attention problems. This is consistent with much of the research in the field which reports extended sleep onset latency is highly prevalent in children diagnosed with Attention Deficit/Hyperactivity Disorder (ADHD) (see Corkum et al., 1998 for review). ADHD is considered a clinical psychiatric disorder and is manifested in symptoms of extreme inattention, impulsivity and hyperactivity (Biederman & Faraone, 2005). The Hyperactive behaviours sub-scale within the SDQ does not imply that children with a symptomatic score in hyperactivity have ADHD, however comparisons with previous ADHD research are valid as the behavioural descriptors are similar, albeit of a lesser degree.

An association between difficulties going to sleep and Internalising behaviours has also been reported in previous research. For example, Smedje et al. (2001a) reported that children (N=635, 6-8yrs) with difficulties falling asleep were almost 3 times more likely to be in the symptomatic range of emotional symptoms. Wiater et al. (2005) reported sleep onset delay to be predictive of high scores on all sub-scales of the SDQ. In that study (N=4531; age 8-11 years), both parent and child report data revealed sleep onset delay as the greatest risk for emotional problems. However, it is unknown whether a distinction was made between sleep latency (time taken to fall asleep once have attempted to go to sleep) or bedtime latency (time between going to bed and observed sleep). This distinction is important, especially considering potentially different treatment requirements. Lengthy sleep latency may be indicative of a pathological sleep problem such as sleep onset insomnia (ASDA, 1990), whereas lengthy bedtime latency may be a socio-cultural issue. Treatment for delayed sleep latency may be difficult and costly requiring medication or psychological interventions such as cognitive behavioural therapy (Morin et al., 2009), whereas bedtime latency may simply require improving sleep hygiene knowledge (Hiscock et al., 2008; Mindell et al., 2009b) and removal of electronic devises from the bedroom (Olds et al., 2006; Van den Bulck, 2004).

The current results pertaining to the associations between sleep/wake patterns and behavioural functioning highlight the need for a focussed debate on the value of using bedtime and sleep duration as the measure of healthy sleep in children. In the current cohort substantially more children reported poor sleep schedules (i.e. variability of bed- and risetimes and long bedtime latencies) than traditional indicators of poor sleep habits (i.e. late bedtimes and short sleep duration). Considering the impact of poor sleep schedules on behavioural functioning as outlined above, limiting recommendations of healthy sleep to optimal bedtimes and sleep durations may have a detrimental impact on the well-being of a large number of children. Further research, using objective sleep measures and targeting intervention, is needed. The development of new recommendations, education and health messages regarding the benefits of consistent sleep schedules are well overdue.

5.4.2 Sleep Problem Sub-Scales and Behavioural Outcomes

There is evidence that nocturnal sleep disruption is associated with behavioural deficits in children (see Chapter 1) and indeed, the predictive relationships between the SAPSS-Q Sleep Problems Sub-scales and SDQ Sub-scales have been found as the strongest of all associations in this thesis to date. These results confirm that the more severe the sleep problem, the greater the chance of behavioural concerns.

5.4.2.1 Morning Tiredness

Without exception, Morning Tiredness was the strongest predictor of all behavioural sub-scales, explaining more of the variance than even demographic factors. A common theory is that daytime sleepiness is the mechanism linking sleep disruption and behavioural deficits (Dahl, 1996a) however subjectively, daytime sleepiness is difficult to define, especially in children (Fallone et al., 2002). Traditional signals of daytime sleepiness, such as yawning, heavy eyelids, falling asleep at inappropriate times, and lethargy, are often not observed in young children (Anders et al., 1978; Fallone et al., 2002). Additionally, signs of sleepiness in children can be suppressed by competing biopsychosocial factors such as hunger, motivation, and high sensory input from the immediate environment (eg: being up late at a party) (Fallone et al., 2002). The factor that was named Morning Tiredness in the current study was comprised of items relating specifically to difficulties getting up and becoming alert in the morning, yet did not include any of the traditional indicators of daytime sleepiness. Thus questions remain as to the appropriateness of a subjective daytime sleepiness measure as a link between sleep problems and behavioural outcomes in children. Indeed the association between daytime sleepiness and behaviour in previous paediatric studies is tenuous. In a study examining the association between sleep disorders, in particular SDB, PLMS and RLS, and conduct disorders in children aged 2-14 years (N=872), Chervin et al. (2003b) reported that daytime sleepiness was higher in children with conduct problems but was not a mediator between sleep disorders and conduct problems. Smedje et al. (2001a) reported differences in the prevalence of daytime sleepiness between children with reported emotional lability and peer-problems compared to those without, however when entered into regression analysis, daytime sleepiness was not a significant predictor of any behavioural outcome.

It may be that Morning Tiredness, as measured in the current study, is a more appropriate subjective measure of nocturnal sleep problems and ensuing behavioural concerns than daytime sleepiness. Firstly, it is a composite of overt behaviours occurring when there is high interaction between parent and child and therefore is more likely to be noticed. Secondly, signs of morning tiredness will occur before the child is fully interacting with the environment and before competing biopsychosocial factors have the opportunity to mask sleepiness. The value of objective measures of sleepiness through the multiple sleep latency test (MSLT) (Carskadon, 1993) cannot be dismissed, however these tests are expensive, time consuming and inappropriate for large epidemiological studies. Future research would do well to compare the efficacy of a daytime sleepiness versus a morning tiredness measure in relation to daytime functioning and carefully consider the use of tradition daytime sleepiness measures in young children.

5.4.2.2 Sleep Routine

Corresponding with the results concerning bedtime variability, Sleep Routine was predictive of all behavioural sub-scales. As mentioned above, the paucity of research examining consistency of sleep/wake schedules is concerning. In the current study, the associations between the traditional markers of healthy sleep such as sleep duration and appropriate bedtimes are non-existent, however associations between sleep routine measures and behavioural outcomes are strong. Fuligni and Hardway (2006) reported similar results in adolescents (N=761, 14-15yrs). In that two week sleep diary study, multiple regression analysis revealed a stronger predictive relationship between sleep variability, anxiety and depression than sleep duration and the mood measures. This brings to the fore the argument of quality versus quantity in regards to sleep and daytime functioning, especially considering that poor sleep routine appears to disrupt the quality of sleep yet quantity remains intact (Fuligni & Hardway, 2006; Wiater et al., 2005).

There are a variety of recommended sleep lengths for children (e.g. NSF: www.sleepfoundation.org/article/sleep-topics/children-and-sleep; Loughborough University: www.lboro.ac.uk/departments/ssehs/research/centres-institutes/sleep/pop_articles/children_sleep) which are predominately based on averages from population studies. Considering the great inter-individual differences in sleep duration, especially in children (Iglowstein et al., 2003), providing optimal sleep lengths, even if the range is large, may not be appropriate. Indeed, in a longitudinal study examining sleep patterns in children between 2.5 and 6 years, Touchette et al. (2007) found no difference in daytime effects between children who were chronic short sleepers (<9hrs from 2.5-6yrs) and those who were persistent 11-hour sleepers. That is not to say, however, that extreme sleep restriction does not impact on behavioural functioning and caution must be taken when generalising from the current results as very few children were reported to sleep less than 9 hours per night.

Nonetheless, providing examples of potential daytime behaviour problems resultant from ineffective sleep may be more informative for parents when trying to decide if their child is sleeping enough. Additionally, education regarding consistency of routine may be more effective in alleviating sleep related behavioural deficits than prescribing a sleep duration amount.

5.4.2.3 Bedtime Anxiety

The current analysis revealed that children with a T-score > 70 on Bedtime Anxiety were over twice as likely to report symptomatic scores on Internalising Behaviour. The Internalising Behaviour sub-scale on the SDQ is comprised of questions relating to both anxiety (e.g. has many worries) and depression (e.g. often unhappy). Gregory et al. (2006) recently reported similar associations between sleep problems, as measured on the Child Sleep Habits Questionnaire (CSHQ), anxiety and depression in mono- and dizygotic twins aged 8 years (N=576). In particular, that study found self-reported anxiety was greater in children with parent reported bedtime resistance. Self-reported depression scores were also significantly higher in children with bedtime resistance. The bedtime resistance sub-scale of the CSHQ contains all four items of the Bedtime Anxiety sub-scale of the current study and thus is likely to measure similar constructs, lending support to the current findings. This result is not surprising as it can be supposed that children who are anxious or unhappy will seek the comfort of others, especially at bedtime when there is a high likelihood that they will be on their own.

5.4.2.4 Night Arousals

Consistent with previous research on nightmares, Night Arousals, the factor containing items relating to nightmares and night terrors, was associated with Internalising behaviour. Smedje et al. (2001a) reported children with night terrors were over three times more likely to report emotional lability. Schredl et al. (2009b) reported emotional symptoms as defined on the SDQ were predictive of nightmare occurrence in a 2-year longitudinal study of 808 children aged 8-11 years. Mindell and Barrett (2002) reported a dose response relationship between nightmare frequency and trait-anxiety based on child report. In that study, children (N=60) aged 5 to 11 years reported on the frequency and level of distress caused by their nightmares as well as completing the State/Trait Inventory for Children. Post-hoc analysis in that study revealed that children who experienced nightmares three or more times per week had significantly higher trait anxiety scores than those experiencing nightmares either monthly or annually. In turn, monthly nightmare sufferers reported higher anxiety scores than annual nightmare sufferers. The level of distress caused by the nightmares was similarly associated with trait anxiety (Mindell & Barrett, 2002).

However, having a T-score >70 on Night Arousals was not predictive of a problem score on Internalising behaviour when examined with logistic analysis. It is not clear why the current study did not find a predictive relationship between high scores on Night Arousals and Internalising behaviour. Mindell and Barrett (2002) found a discrepancy between parent and child report in that child reported frequency of nightmares was significantly associated with trait anxiety but parent report was not. Perhaps, as the current study was parent report, too few children were reported with high scores on Night Arousals and thus a relationship was not observed due to a lack of statistical power. However, as a T-score >70 on Night Arousals was predictive of Hyperactive behaviour, the lack of statistical power is unlikely. It may simply be that whilst the two variables are related, the manifestation of extreme Internalising behaviour is more strongly associated with other sleep problems.

5.4.2.5 Restless Sleep

The association between Hyperactive behaviours and Restless Sleep reported in the current study are also consistent with previous findings. Smedje et al. (2001) reported tossing and turning during the night and sleepwalking as independent predictors of hyperactivity after controlling for comorbid conduct problems. In addition, excessive nocturnal movement appears to be a consistent observation in children with ADHD (see Corkum et al., 1998 for review). Ivanenko et al. (2006) found a higher prevalence of nocturnal leg movements in children with diagnosed ADHD both with and without comorbid affective disorders. Konofal et al. (2001) conducted an overnight polysomnography study, using video monitoring for movements, and found that children with diagnosed ADHD (N=30) had significantly greater number of movements and longer movement duration during sleep than controls (N=19; 5-10 years).

Walters et al. (2000) hypothesised that ADHD and periodic limb movements (PLMS), defined as repetitive movements of feet, legs and arms during sleep that are 0.5 to 5 seconds long and occurring at 5-90 seconds intervals (Picchietti & Walters, 1999), may be inextricably linked as both have been associated with a deficit in the production of dopamine. To test this theory, Walters et al. enrolled seven children with diagnosed ADHD and PLMS and/or restless leg syndrome (RLS) into a treatment study where dopaminergic therapy was given four times per day for 6 months. Treatment improved subjective ratings of RLS and improved objective measures of PLMS in all subjects. All children also reported improved scores on the inattention/overactivity and oppositional-defiant behaviour scale on the Connors Parent Rating scale and well as an overall improved score on the Child Behaviour Checklist. While this suggests the possibility of a doperminergic link between ADHD and nocturnal movements, it must be noted that only 3 of the seven children no longer met the DSM-IV criteria for ADHD. Additionally, this small study was neither randomised nor blinded and therefore must be interpreted with extreme caution. Larger randomised and blinded studies are needed before any conclusions can be made. However, the large number of studies reporting associations between hyperactive behaviour and excessive nocturnal movements (see Pockett & Kirk, 2006 for review) implies that a biological association cannot be dismissed.

5.4.2.6 Sleep Disordered Breathing

Contrary to expectations, whilst regression analysis revealed the SDB sub-scale added significantly to the predictive model of Hyperactive Behaviours, the amount of variance explained was less than 1%. This suggests that the result, although statistically significant, is not meaningful. Indeed, further logistic regression analysis revealed no relationship between a T-score > 70 on the SDB sub-scale and a problem score on Hyperactive Behaviour. A comprehensive review of disordered breathing and behaviour by Beebe (2006b) found that over 80% (26/32) of the studies reviewed reported a positive association between SDB and behavioural deficits such as hyperactivity, aggression or rebelliousness. A small number of studies reported a positive association between SDB and internalising behaviours, however the findings were mixed with a greater proportion reporting null findings.

One possible explanation for the contrary findings of the current study is that the majority of the previous SDB studies have used clinical samples to examine the relationship between behaviour and SDB. In those samples, the severity of SDB has been high with comparisons between children with moderate to severe apnoea and controls (see Beebe, 2006b for review). It may be that the current SDB factor did not include those children with moderate/severe apnoea as items such as “stopped breathing during the night” were not retained in the factor model. Thus, the current measure of SDB may only be capturing mild cases which do not have the associations with behavioural deficits seen in the clinical studies.

Calhoun et al. (2009) recently conducted a polysomnographic study with 571 children (6-12yrs) selected from the general population and reported no difference in neurocognitive functioning between children with mild SDB (1<apnoea/hypopnea index<5) and children with no sign of SDB. It may be that the behavioural consequences of SDB are similar in that the association is only observed in more severe cases.

However, with the disproportionate number of studies reporting a positive finding between snoring and behavioural outcomes in community samples as compared to null findings (see Beebe, 2006b for review), alternate explanations must be examined. Indeed, items within the current questionnaire may be limiting as they only ask about nocturnal respiration over the last week. When examined in isolation, it is impossible to determine if children score highly on the SDB sub-scale due to an acute illness such as cold or hayfever. Additionally, there is no determination of the history or persistence of snoring. It is unknown if the current non-snorers were once snorers but recently stopped, or if the current snorers had recently started snoring. Either of these circumstances could influence behavioural ratings (Ali et al., 1994). Consequently, these methodological concerns necessitate that the null findings are interpreted with caution, and in no way suggest, as stated by Calhoun et al., that future research ignore mild snoring and concentrate primarily on the effects of moderate to severe SDB on daytime functioning. Further longitudinal research, examining the natural history of snoring and behavioural consequence, using more objective measures such as polysomnography and trained behavioural assessment, is required before conclusions can be made.

5.4.2.7 Enuresis, Hyperhydrosis, Sleepwalking, and Bruxism

For the most part, the predictive relationships between the individual sleep items and problem behaviours on the SDQ sub-scales are consistent with previous research. An interesting finding here however is the prolific association between hyperhydrosis and behavioural outcomes, especially considering the lack of previous research in this area.

Hyperhydrosis as an independent sleep problem is not well studied. As mentioned in Chapter 4, it is most often associated with SDB (e.g. Brouillette et al., 1984; Spruyt et al., 2006). In the current study, excessive sweating during sleep was associated with Anti-social, Hyperactive and Total Problem behaviour: behaviours also typically associated with SDB (Beebe, 2006b). As such, retrospective logistic regression analysis, controlling for SDB, was conducted to determine the independent relationship between hyperhydrosis and behavioural outcomes. The results confirm the suggestion that hyperhydrosis may be a symptom of SDB as no significant relationships remained between excessive sweating during the night and problem behaviours. This is an important finding as it suggests that hyperhydrosis might be a more accurate indicator of mild SDB than snoring when reported by parents. Previous research is mixed on the ability of parents to accurately report their child"s snoring, with the suggestion that mild snoring is under-reported (Montgomery-Downs et al., 2004). Hyperhydrosis, however, may be more noticeable to parents it has tangible consequences of changing sheets or pyjamas. Further objective validation of this is required, however this result does provide the potential for new parent-report questionnaire screening criteria for mild SDB for health professionals.

Interestingly, sweating whilst falling asleep remained a significant predictor of Internalising behaviours after controlling for SDB. As Bedtime Anxiety was also associated with Internalising behaviours, it may be suggested that feelings of anxiousness or worry in these children result in a physiological reaction.

Consistent with previous epidemiological studies such as that by Petit et al. (2007) and Stein et al. (2001), initial analysis revealed sleepwalking was predictive of internalising and hyperactive behaviours. Sleepwalking is a state of partial arousal, usually occurring during the slow wave sleep (Stores, 2009) however, according to Guilleminault et al. (2003) may be triggered by SDB or restless leg episodes. After controlling for SDB, sleepwalking also did not show a relationship with Internalising or Hyperactive behaviours, supporting Guilleminault et al.‟s findings. Research regarding sleep disordered breathing usually excludes comorbid sleep disorders, however the current results suggest that this may be limiting, especially considering that not all SDB is obstructive (Gozal, 2004). That is, understanding the relationship between SDB and comorbid parasomnias such as sleepwalking may assist in treatment strategies for parasomnias.

The relationship between bruxism and hyperactive behaviour remained after controlling for SDB and supports previous findings from both experimental (e.g. Herrera et al., 2006) and epidemiological (e.g. Stein et al., 2001) research. The experimental study conducted by Herrera et al. is limited due to a small sample (N=10) and lack of control group, however provides an explanation as to the potential link between bruxism and hyperactive behaviour. In that study, analogous to sleep fragmentation in sleep disordered breathers (Beebe, 2006b for review), the number of polysomnographic recorded arousals revealed a significant correlation with attention, somatic and behaviour problems. The relationship between bruxism and behavioural functioning in children has received substantially more attention from dental researchers and practitioners (e.g. Antonio et al., 2006; Serra-Negra et al., 2009) than sleep researchers, however further objective study using polysomnography examining the relationship between bruxism related arousals and daytime functioning in children may be of benefit.

The lack of an association between enuresis and behavioural outcomes supports the claim that bedwetting is predominantly a developmental phenomenon in children under 10 years (Fergusson & Horwood, 1994) and not necessarily a pathological concern. This does not suggest however that bedwetting does not cause concern for the child and their family, nor does it claim that all bedwetting is part of normal development. In a national study of 10,960 children in the United States, Byrd et al. (1996) reported enuretic children as young as 5 years to have higher scores on a Behavioural Problem Index modelled from the Child Behaviour Checklist. Thus, it is advisable that enuresis remains a consideration in the overall assessment and treatment of sleep problems, however context should also be carefully assessed.

5.5 SUMMARY

These results confirm the postulation that sleep and behaviour are inextricably linked. Bedtime anxiety, restless sleep, night arousals, bruxism, hyperhydrosis and sleepwalking were all associated with behavioural deficits, either independently or comorbidly. The current study however adds considerably to the current state of knowledge by revealing a regular sleep routine, in otherwise healthy children, has the strongest effect on daytime functioning. In particular, the greater the inconsistency of bedtimes and risetimes across the week and the poorer the sleep routine, the more likely the child was to experience behavioural concerns. This suggests that new strategies for sleep education and health information are needed. Additionally, as Morning Tiredness was the strongest indicator of behavioural outcomes, symptoms of morning tiredness rather than sleepiness throughout the day may be a better indicator of nocturnal sleep problems when measured through parent report. The debate on the appropriateness of daytime sleepiness for children is not new, yet in the absence of alternatives, continues to be used as the measure of sleep disruption. Validation of the Morning Tiredness sub-scale as an indicator of nocturnal sleep disruption would provide such an alternative.

Whilst providing new insight into the effects of sleep disruption in children, this study is not without limits. General limitations of the SAPSS are discussed in Chapter 7, however it is relevant to note here that, as with all large, cross-sectional, parent-report epidemiological studies, it is impossible to determine causality in the current study. It may be that the associated sleep problems reported above are a consequence of the behaviour, rather than vice versa. Research in treatment effects of sleep disorders have provided some support for the causal effects of sleep disruption. A recent review by Garetz (2008) has reported that adenotonsillectomy is effective in improving behavioural deficits such as hyperactivity and aggression in children and adolescents (0-18yrs) with diagnosed SDB. In addition, Minde et al. (1994) has found that behavioural treatment regimes for sleep disturbances in toddlers improved their behaviour and maternal interactions. In particular, treatment for sleep disturbance yielded improvements in attentional and social skills, infant dysregulation, irritability and negative behaviour (Minde et al., 1994). As there was no change in the mother‟s behaviour after treatment, it was suggested that these improvements were a direct result of better sleep habits. Nonetheless, future research implementing intervention strategies to improve sleep/wake patterns and sleep problems, in particular sleep routine and bedtime variability, is needed to determine directionality.

This study provides the first evidence of the effects of sleep/wake patterns and sleep problems in a large community sample of school-aged children in Australia. As the nature of sleep is embedded in social and cultural expectations as well as biological mechanisms, this study will aid future studies in targeting socially and culturally appropriate research and intervention strategies to improve the health and well-being of children in Australia.

CHAPTER 6: THE EFFECT OF MEDIA USE ON SLEEP/WAKE PATTERNS AND SLEEP PROBLEMS IN CHILDREN AGED 5-10 YEARS.

6.1 INTRODUCTION

In the modern era, television, internet, electronic games, and mobile phones are a constant in most aspects of a child‟s life (Christakis & Zimmerman, 2006) and have increasingly made their way into the bedroom. According to the *Sleep in America Poll* of 2004, 17.3% of toddlers, 30% of preschoolers and 43% of school-aged children had a television in their bedroom (Mindell et al., 2009a). Van den Bulck (2003, 2004) conducted a study of 2546 adolescents in the first and fourth year of high school (mean age 13.2 and 16.4 years, respectively), and reported that between 23 and 44% of adolescents played computer games in their rooms. Up to 21% of these children were also woken during the night by incoming messages on their mobile phones. Research into the effects of digital media on sleep/wake patterns and sleep problems is in its infancy, however the early indications are that media, particularly in the bedroom, is detrimental to both the quantity and quality of sleep.

Initial research into television viewing reported no detrimental effect on sleep, with Weissbluth et al. (1981) reporting no association between television use and sleep duration in children aged 4 months to 16 years (N=2019, Weissbluth et al. (1981). However, viewing habits have changed over the last 25 years. Not only has the amount of programming increased, but the accessibility of television for children has also increased with the increase in the number of television sets within the household (Christakis & Zimmerman, 2006). More recently, Li et al. (2007a) reported watching television more than 2 hours per day was associated with later bedtime and reduced time in bed in a large cohort of Chinese children aged 5-11 years (N=19,299). Paavonen et al. (2006) reported that children aged 5-6 years (N=297) who reported a high frequency of television viewing at bedtime reported higher sleep problem severity than children with lower frequency of television watching. Owens et al. (1999) reported that watching more than 2 hours of television per day and having a television in the bedroom were powerful predictors of bedtime resistance and overall sleep disturbance in a cohort of 495 children aged 4-11 years.

To date, research on the effects of media on sleep have predominantly examined television use, however personal computer, electronic games and mobile phone use are quickly overtaking television in competition for the child"s time (Christakis et al., 2004; Schuz, 2005). In the aforementioned study by Li et al. (2007a), having a computer in the bedroom was reported to be associated with an increased risk of bedtime resistance, sleep duration problems, and sleep anxiety. In an Australian cohort of 10-13 year-olds (N=1039), Olds et al. (2006) reported that every hour of increased screentime – television, video games, computers or cinema – was associated with a 10 minute reduction in total sleep time. Van den Bulck (2004) reported that computer game and internet use, similar to television viewing, were associated with later bedtimes and reduced time in bed in adolescents. Van den Bulck (2007) also reported increased frequency and timing of phone usage after lights out was associated with increased long-term risk of self-reported tiredness. However, in that study, tiredness was measured a year after the children reported their telephone usage and other confounding factors were not controlled for. Thus, whilst this provides some evidence for the dangers of late night mobile phone use on daytime functioning, more controlled studies are required before any conclusions can be made.

Music is also commonplace in children and adolescent‟s bedrooms (Eggermont & Van den Bulck, 2006). Music has been reported to improve sleep onset in adults through the promotion of relaxation (for review de Niet et al., 2009), however the limited evidence in children is mixed. Field (1999) suggested that music improves sleep and reported shorter sleep latency during afternoon naps in toddlers and infants who were played classical guitar music compared to those who were not played music. In a group of fifth-grade children (N=86), Tan (2004) reported improvements in sleep duration and sleep efficiency, but not perceived sleep quality, after listening to 45 minutes of music prior sleep each night for three weeks. Conversely, Eggermont and Van den Bulck (2006) reported listening to music as a sleep aid resulted in poorer sleep habits in adolescents, resulting in increased bedtimes and decreased sleep duration.

Considering the increase in media use and prolific intrusion of technology in the bedroom, there is a great need for further research examining the effects of media on sleep/wake patterns and sleep problems, especially in school-aged children. If, as preliminary research is suggesting, digital media interrupts sleep quantity and/or quality, this may have serious consequences for daytime functioning in children. The aim of this study was to examine this relationship in a large cohort of Australian children aged 5-10 years.

6.2 METHODS

Please refer to Chapter 2 for detailed description of methodology.

6.2.1 Measures

Four questions within the SAPSS-Q pertained to media use in the bedroom. Parents were ask to report if their child spent time: A. watching T.V/DVD/Video in their bedroom; B. listening to music in their bedroom; C. talking to friends on the phone; and D. playing electronic games (Xbox/Playstation/PC games/Gameboy), after going to bed. Parents were asked to report whether that event occurred never, rarely (once/week), sometimes (2-4 times/week) or usually (5-7 times/week). In a separate section, parents were also asked to report on the amount of time the child spent in front of a screen per day on school days (Mon-Fri) and weekends (Sat/Sun). Screentime was defined as any time spent watching T.V, using the computer or playing video games. Examination of screentime data revealed some outliers (eg: one report of 900 minutes on weekend days) and it is likely that some parents may have reported weekly instead of daily screentime. As this was impossible to determine objectively, all screentime outliers were removed from the analysis [School days N=17(1%); Weekends N=24(2%)].

6.2.2 Statistical Analysis

Univariate analysis of variance (ANOVA) was conducted to determine the main and interaction effects of sex, age, ethinicity and SES on school day and weekend screentime. Frequency analysis was conducted to determine prevalence of media use after going to bed. As less than 1% of children were reported to talk on the phone at any time after going to bed, this variable was excluded from further analysis. The remaining media use after bedtime variables were dichotomised into (0) never/rarely and (1) sometimes/usually for further analysis. χ^2 tests, using Bonferroni corrections, were used to examine sex, age, race and SES differences in media use after going to bed. Stepwise hierarchical regression analysis was conducted to examine the predictive relationships between screentime and media use after going to bed on sleep/wake patterns and sleep problems, controlling for demographic factors.

6.3 RESULTS

6.3.1 Media Use

Average reported screentime for school days and weekends is reported in Table 6.1. Univariate ANOVA analysis revealed a significant main effect of age and SES on both school day and weekend screentime. Older children spent 12 minutes longer in front of the screen than younger children on school days ($F_{(23,1671)}$=9.80, *p*=0.002, *d*=0.19) and 21 minutes longer on weekends ($F_{(23,1619)}$=10.6, *p*=0.001, *d*=0.23). Post-hoc analysis revealed children from the high SES group spent less time in front of a screen throughout the week than either the mid or low SES groups. Children from the high SES group spent 10 and 15 minutes less in front of the screen on school days than children from the mid or low SES groups, respectively ($F_{(23,1671)}$=4.23, *p*=0.015, ω^2=0.04). On weekends, the difference in screen time between the high and low SES groups was 27 minutes and between the high and mid SES groups 21 minutes ($F_{(23,1619)}$=3.87, *p*=0.021, ω^2=0.04).

No main effects of sex or ethnicity were found. One 3-way interaction effect was found on school days: sex x age x ethnicity ($F_{(23,1671)}$=5.14, *p*=0.024, ω^2=0.05), but was not explored further due to limited cell size.

The prevalence of parent reported media use in the bedroom after going to bed is shown in Table 6.2. Listening to music was the most common with 13.1% of children engaging in this activity more than twice per week. 8.7% of children watched T.V after going to bed more than twice per week. Less than 2% of children played electronic games or talked on the phone regularly after going to bed.

Table 6.1: *Mean (±SD) reported screentime in minutes on school days and weekends by individual group categories.*

	Demographics																								
Sex	Male												Female												Total
Age	Younger (5-7yrs)						Older (8-10yrs)						Younger (5-7yrs)						Older (8-10yrs)						
Ethn	Caucasian			Non-Caucasian			Caucasian			Non-Caucasian			Caucasian			Non-Caucasian			Caucasian			Non-Caucasian			
SES	Low	Mid	High	Low	Mid	High	Low	Mid	High	Low	Mid	High	Low	Mid	High	Low	Mid	High	Low	Mid	High	Low	Mid	High	
	N=143	N=113	N=138	N=32	N=23	N=8	N=103	N=89	N=117	N=18	N=16	N=7	N=163	N=129	N=157	N=41	N=21	N=16	N=101	N=79	N=127	N=28	N=17	N=10	N=1776
SCSCH	104.8	102.5	91.6	106.6	93.3	64.4	121.9	113.4	92.1	130.6	131.6	115.7	100.4	96.4	91.0	91.7	103.1	89.7	121.0	106.2	103.6	101.1	92.9	87.0	106.3
	(63.4)	(61.3)	(54.7)	(60.0)	(53.3)	(42.2)	(60.7)	(67.2)	(54.4)	(75.6)	(90.5)	(68.0)	(60.3)	(57.8)	(61.2)	(51.8)	(54.2)	(43.8)	(66.4)	(64.0)	(67.4)	(57.4)	(67.1)	(84.2)	(77.2)
SCWE	192.5	169.6	159.1	182.6	185.2	137.5	212.0	199.6	171.8	201.0	210.0	205.7	167.4	178.0	146.2	174.0	190.9	144.0	201.9	184.0	177.7	192.7	183.8	177.0	183.8
	(99.2)	(96.4)	(83.0)	(105.3)	(108.0)	(70.1)	(98.4)	(104.9)	(84.0)	(88.5)	(119.5)	(103.1)	(93.4)	(96.7)	(77.6)	(90.6)	(107.4)	(71.8)	(94.8)	(89.4)	(87.2)	(99.4)	(111.1)	(117.0)	(109.6)

SCSCH = screentime on schooldays; SCWE = screentime on weekends

Table 6.2: *Parent reported media use after going to bed*

	Never	Rarely once /wk	Sometimes 2-4/wk	Usually 5-7/wk
	N(%)	N(%)	N(%)	N(%)
Watched T.V	1520(83.4)	143(7.8)	92(5.0)	67(3.7)
Listened to music	1392(76.1)	196(10.7)	101(5.5)	139(7.6)
Played electronic games	1686(92.3)	104(5.7)	28(1.5)	9(0.5)
Used the phone	1817(99.6)	4(0.2)	2(0.1)	2(0.1)

As can be seen in Table 6.3, proportionately more children from low SES areas are reported to watch T.V after going to bed more than twice per week. Proportionately more Non-Caucasian children are reported to play electronic games after going to bed more than twice per week. Proportionately more Caucasian children were reported to listen to music after going to bed, however this did not reach Bonferroni adjustment criteria. No sex or age differences were found in media use after going to bed.

Table 6.3: *Sex, age, ethnicity and SES differences in media use after going to bed.*

			Media Use After Going to Bed								
			Watching T.V			Listening to music			Playing electronic games		
Demographics		Total N(%)	Never/ 1x/wk	2-4x/wk / ≥5x/wk	χ^2	Never/ 1x/wk	2-4x/wk / ≥5x/wk	χ^2	Never/ 1x/wk	2-4x/wk / ≥5x/wk	χ^2
Sex	Male	888(48.1)	90.9	9.1		87.6	12.4		97.6	2.4	
	Female	957(51.9)	91.6	8.4	0.35	86.2	13.8	0.85	98.3	1.7	1.09
Age	5-7 yrs	1076(58.3)	91.2	8.8		87.4	12.6		98.5	1.5	
	8-10 yrs	769(41.7)	91.4	8.6	0.02	86.1	13.9	0.62	97.2	2.8	3.65
Race	Caucasian	1505(84.6)	92.0	8.0		86.2	13.8		98.5	1.5	
	Non-Caucasian	273(15.4)	89.1	10.9	2.38	91.8	8.2	6.26[a]	95.9	4.1	8.06*
SES	Low	703(38.1)	87.8	12.2		86.2	13.8		97.2	2.8	
	Middle	527(28.6)	91.4	8.6		87.5	12.5		98.5	1.5	
	High	615(33.3)	95.1	4.9	21.4**	87.1	12.9	0.43	98.4	1.6	2.98

**p<0.0001, *p<0.005, [a]p<0.05 but does not meet Bonferroni adjustment criteria (p≤0.005)

6.3.2 Media Use and Sleep/wake patterns

Spearman‟s Rho coefficients are reported in Table 6.4. Results for the step-wise hierarchical linear regression analysis for media use and sleep/wake patterns is reported in Table 6.5. An increased screen time on both school days and weekends was predictive of corresponding later bedtime, reduced time in bed and total sleep time. Weekend screentime was also associated with an increase in bed and risetime variability and risetime shift on weekends.

Table 6.4: *Spearman's Rho correlation coefficients between sleep/wake patterns, Sleep Problem sub-scales and media use*

	Screentime		Media in Bedroom		
Sleep Variable	School	Weekend	TV	Music	Games
BT_{school}	0.14***	0.09**	0.10***	-0.06*	0.05*
$BT_{weekend}$	0.16***	0.20***	0.13***	-0.06**	0.07**
RT_{school}	-0.01	-0.00	0.05*	0.02	0.03
$RT_{weekend}$	0.06*	0.07**	0.08**	-0.04	0.02
TIB_{school}	-0.14***	-0.10***	-0.09***	0.08**	-0.03
TST_{school}	-0.12***	-0.10**	-0.13***	0.02	-0.06
$TIB_{weekend}$	-0.12***	-0.15***	-0.07*	0.04	-0.02
$TST_{weekend}$	-0.13***	-0.15***	-0.09**	0.01	-0.05
BTV_{school}	-0.00	0.01	0.15***	-0.03	0.03
$BTV_{weekend}$	0.06*	0.09**	0.12***	0.02	0.03
RTV_{school}	-0.00	0.01	0.09***	-0.02	-0.01
$RTV_{weekend}$	0.02	0.06*	0.10***	0.00	0.03
BTL_{school}	0.02	0.04	0.05	0.09**	0.03
$BTL_{weekend}$	0.03	0.04	0.08**	0.11**	0.01
BTSFT	0.09***	0.19***	0.08**	-0.00	0.02
RTSFT	0.11***	0.14***	0.08**	-0.05***	0.03
Sleep Routine	0.07***	0.09***	0.14***	0.06*	-0.09***
Bedtime Anxiety	-0.06*	-0.06**	0.16***	-0.05*	0.03
Morning Tiredness	0.06*	0.09***	0.11***	0.07**	-0.02
Night Arousals	0.01	0.01	0.15***	0.02	0.05*
SDB	0.06*	0.04	0.07**	0.05*	0.02
Restless Sleep	0.08*	0.06*	0.12***	0.07**	0.02
Total Problems	0.07**	0.07**	0.19***	0.05*	0.05

*p<0.05, **p<0.01, ***p<0.0001. BT_{school} = Bedtime school night, $BT_{weekend}$ = Bedtime weekend, RT_{school} = Risetime school night, $RT_{weekend}$ = Risetime weekend, TIB_{school} = Time in Bed school night, TST_{school} = Total Sleep Time school night, $TIB_{weekend}$ = Time in Bed weekend, $TST_{weekend}$ = Total Sleep Time weekend, BTV_{school} = Bedtime Variability school night, $BTV_{weekend}$ = Bedtime Variability weekend, RTV_{school} = Risetime Variability school night, $RTV_{weekend}$ = Risetime Variability weekend, BTL_{school} = Bedtime Latency school night, $BTL_{weekend}$ = Bedtime Latency weekend, BTSFT = Bedtime Shift, RTSFT = Risetime Shift

Watching TV after going to bed was associated with all sleep/wake patterns across school days and weekends, predicting later bedtimes, reduced TIB and TST, increased bed and risetime variability, increased bedtime latency, bed and risetime shift. Listening to music after going to bed was predictive of earlier bedtimes but longer bedtime latencies on school days and weekends, resulting in associations with longer TIB but not TST. Listening to music was also associated with longer bedtime shift and shorter risetime shift between school days and weekends. Playing electronic games after going to bed was not predictive of any sleep/wake pattern.

6.3.3 Media use and Sleep Problem sub-scales

Similar to associations with sleep/wake patterns, watching TV after going to bed was predictive of all sleep problem sub-scales (Table 6.6). Decreased screentime on school days was predictive of increased bedtime anxiety. A positive predictive relationship was found between screentime on weekends and sleep routine, morning tiredness and restless sleep. Listening to music after going to bed was predictive of increased scores on sleep routine, morning tiredness, sleep disordered breathing, and restless sleep sub-scales. Playing electronic games after going to bed was predictive of poor sleep routine.

Table 6.5: *Step-wise hierarchical linear regression predicting sleep/wake behaviours from media use*

	Regression Analysis															
	Demographics		Screentime						Media in Bedroom						Total Model	
			School			Weekend			TV			Music				
Sleep Variables	F	R^2	β	FΔ	R^2Δ	β	FΔ	R^2Δ	β	FΔ	R^2Δ	β	FΔ	R^2Δ	F	R^2
BT_{School}	139.2***	0.25	0.08	12.8***	0.01				0.09	16.2***	0.01	-0.05	5.3*	<0.01	86.0***	0.27
$BT_{weekend}$	134.8***	0.25				0.13	34.9***	0.02	0.11	25.5***	0.01	-0.05	6.0*	<0.01	89.7***	0.28
RT_{school}	14.7***	0.04													14.7***	0.04
$RT_{weekend}$	27.4***	0.07				0.06	5.2*	<0.01	0.07	9.2**	0.01				20.8***	0.07
TIB_{school}	76.5***	0.16	-0.09	14.1**	0.01				-0.07	9.8**	0.01	0.07	8.7**	<0.01	49.2***	0.17
TST_{school}	51.0***	0.17	-0.08	7.4*	0.01				-0.12	16.7***	0.01				38.8***	0.19
$TIB_{weekend}$	63.3***	0.14				-0.08	11.6**	0.01							53.3***	0.15
$TST_{weekend}$	37.3***	0.13				-0.10	9.8**	0.01	-0.08	6.3*	0.01				27.9***	0.15
BTV_{school}	10.3***	0.02							0.18	58.3***	0.03				20.2***	0.06
$BTV_{weekend}$	6.7***	0.02				0.07	8.2**	0.01	0.13	25.8***	0.02				10.2***	0.04
RTV_{school}	7.2***	0.02							0.10	15.0***	0.01				8.8***	0.03
$RTV_{weekend}$	7.6***	0.02				0.06	6.3**	<0.01	0.12	24.3***	0.02				10.3***	0.04
BTL_{school}	5.8***	0.02							0.08	6.7*	0.01	0.10	9.9**	0.01	6.7***	0.04
$BTL_{weekend}$	2.6*	0.01							0.11	13.5***	0.03	0.08	7.1**	0.01	5.2***	0.03
BTSFT	25.0***	0.06				0.16	43.0***	0.02	0.06	6.1***	<0.01				25.3***	0.09
RTSFT	16.4***	0.04				0.10	15.5*	0.01	0.07	8.2**	0.01	-0.05	4.8*	<0.01	13.5***	0.06

**p*<0.05, ***p*<0.01, ****p*<0.0001. BT_{school} = Bedtime school night, $BT_{weekend}$ = Bedtime weekend, RT_{school} = Risetime school night, $RT_{weekend}$ = Risetime weekend, TIB_{school} = Time in Bed school night, TST_{school} = Total Sleep Time school night, $TIB_{weekend}$ = Time in Bed weekend, $TST_{weekend}$ = Total Sleep Time weekend, BTV_{school} = Bedtime Variability school night, $BTV_{weekend}$ = Bedtime Variability weekend, RTV_{school} = Risetime Variability school night, $RTV_{weekend}$ = Risetime Variability weekend, BTL_{school} = Bedtime Latency school night, $BTL_{weekend}$ = Bedtime Latency weekend, BTSFT = Bedtime Shift, RTSFT = Risetime Shift

Table 6.6: *Step-wise hierarchical linear regression predicting sleep problems from media use*

	Regression Analysis																		
			Screentime						Media in Bedroom									Total Model	
	Demographics		School			Weekend			TV			Music			Games				
Sleep Problems	F	R^2	β	FΔ	R^2Δ	β	FΔ	R^2Δ	β	FΔ	R^2Δ	β	FΔ	R^2Δ	β	FΔ	R^2Δ	F	R^2
SR	2.4*	0.01				0.08	9.5**	0.01	0.14	32.3***	0.02	0.07	7.1**	<0.01	0.06	6.5*	<0.01	8.2***	0.04
BA	52.7***	0.11				-0.07	8.8**	0.01	0.16	50.7***	0.03							46.4***	0.15
MT	7.8***	0.02				0.07	8.7**	0.01	0.10	16.4***	0.01	0.08	9.8**	0.01				9.6***	0.04
NA	14.8***	0.04							0.15	36.5***	0.02							19.4***	0.06
SDB	5.9***	0.01							0.06	6.2*	<0.01	0.06	6.4*	<0.01				6.0***	0.02
RS	5.9***	0.01							0.10	17.3***	0.01	0.08	10.2**	0.01				8.6***	0.03
TOT	9.5***	0.03	0.06	5.6*	<0.01				0.17	42.7***	0.03	0.07	6.7**	<0.01				13.5***	0.06

*p<0.05, **p<0.01, ***p<0.0001. SR = Sleep Routine, BA = Bedtime Anxiety, MT = Morning Tiredness, NA = Night Arousals, SDB = Sleep Disordered Breathing, RS = Restless Sleep, TOT = Total Problems

6.4 DISCUSSION

The current study adds some support to the emerging postulation that media use in children, particularly at bedtime, is detrimental to sleep quantity and quality. In the current study, mean screentime for school days and weekends was reported at approximately 103(±62) and 178(±94) minutes per day respectively. 16.5% of children watched T.V, 23.8% listened to music, and 7.7% played electronic games after going to bed at least once per week. Perhaps not surprisingly, unlike reports in adolescents (Van den Bulck, 2007), mobile phone use after going to bed was rare in this young cohort with only 4 children (< than 1%) reported to engage in this activity at least once per week. Screentime and media use in the bedroom were significant, albeit weak, predictors of many sleep/wake patterns and sleep problems. Although these results must be interpreted with extreme caution considering most of the associations explain only 1% of the variance, the findings are worthy of discussion. In particular the result that watching television after going to bed appears the greatest risk factor of poor sleep habits.

6.4.1 Screentime and Sleep

The current results suggest that the amount of daily screentime consumed by children has increased by 30 minutes in the last 5-6 years. In 2003, Wake et al., 2003) reported 79% of a large Australian cohort (N=2862), aged 5-13 years, spent more than 10 hours per week (85 mins/day) – calculated as the summed average of school days and non-school days – watching television. Less time was spent on computer use with 8% reporting more than 10 hours per week. Retrospective examination of the current data revealed 75% of the SAPSS cohort reported a weekly mean screentime greater than 120 minutes. Even when computer use is taken into account, the current cohort appears to spend approximately 30 minutes more than the Wake cohort.

Olds et al. (2006) also reported an increase in screentime when compared with Wake et al. In that study, median screentime was reported at 190 minutes on school days and 260 minutes on weekends in a cohort of children aged 10-13 years (N=1039). However, this is also well above the current study with medians of 90 and 180 minutes, respectively (results not reported above). The age difference in the two studies may account for some of this discrepancy, but it is more likely to be due to methodological differences. In the Olds study, children were required to report the previous day"s activities in 5 minute durations on two occasions: during the school week and on a non-school period. It is reasonable to assume that the more detailed reporting requirements and self-report nature of this study resulted in the elevated reporting of screentime in comparison to the parent report of the current study. Regardless of these methodological differences, when compared with Wake et al., findings from the current study and Olds et al. suggest children are spending more time in front of a screen than ever before.

This may have consequences for sleep as an increase in screentime was predictive of later bedtimes and reduced time in bed in the SAPSS cohort across school days and weekends. Similarly, Van den Bulck (2004) reported an increased frequency in television viewing was related to a later bedtime on school days and weekends, later risetime on weekends and reduced time in bed on school days. In that study, playing computer games was also associated with later bedtimes on school days and weekends.

Whilst it may be argued that the relationships are trivial in the current study – explaining approximately 1% of the variance – extended periods of screentime during childhood may have long term effects, regardless of whether the habits change later in life. Johnson et al. (2004) reported that adolescents aged 14 years who watched more than 3 hours of television per day had a two-fold increase of reporting difficulties falling asleep and frequent awakenings at 22 years old than those who watched less than 1 hour per day. If viewing time was reduced after 16 years, no change was seen in reported sleep problems at 22 years. To date, no study has examined the long-term effects of screentime and sleep in younger children. It may be that the effects of extended screentime on sleep are trivial in young children, however become more concerning as the children age. As many children begin watching television during infancy (Thompson & Christakis, 2005), this is an important area for future research.

The amount of screentime on school days was not predictive of any of the Sleep Problem Sub-scales, however on weekends, was predictive of Sleep Routine and Morning Tiredness. Li et al. (2007a) reported watching television more than two hours per day on school days or weekends increased the risk of bedtime resistance, sleep onset delay, and sleep anxiety in children aged 5-12 years. In that study, extended television viewing (>2hrs/day) on school days was also predictive of sleep duration disorder, and on weekends with night awakenings, parasomnias, sleep disordered breathing and daytime sleepiness. These associations remained even after controlling for a number of demographic confounds including age, sex, ethnicity and SES factors. In the SAPSS cohort, only 20% of children were reported to have a screentime on school days greater than 2 hours which may explain why no association was found. Fifty seven percent, however, were reported with a screentime greater than 2 hours on weekends (results not reported).

Contrary to expectations, screentime on weekends was negatively associated with Bedtime Anxiety. That is, the greater the screentime, the lower the score on the Bedtime Anxiety sub-scale. Previous research by Li et al. (2007a) and Owens et al. (1999), reported an increase in the amount of television watched per day was associated with a corresponding increase in bedtime resistance. In the current study however, the Bedtime Anxiety sub-scale is comprised of items relating to the need for another at bedtime. Watching television or using a computer is an activity that children tend to do on their own (Christakis & Zimmerman, 2006), particularly if it is in the bedroom. Thus, it is reasonable that an increase in screentime may subsequently result in a decrease in parental or sibling involvement at bedtime. In addition, it may be that parents use television or other screen media as a way of reducing bedtime anxiety in children. These speculations are impossible to test in the current study, but may worthy of future investigation. If parents are using television as a means of reducing Bedtime Anxiety as measured on the SAPSS-Q, they may be placing their child at risk of poorer sleep overall.

6.4.2 Media Use after Going to Bed and Sleep

6.4.2.1 Television

Consistent with previous research, watching television after going to bed had a detrimental effect on sleep/wake patterns and was associated with a number of sleep problems. In particular, watching television after going to bed more than twice per week was predictive of later bedtimes, reduced TIB and TST and increased bedtime latency on both school days and weekends. Eggermont & Van den Bulck (2006) reported a linear relationship between the use of media as a sleep aid and bedtime in adolescents, with increased use corresponding to increased bedtimes across the week. In that study, bedtime was delayed approximately 30 minutes in those who usually used television to fall asleep compared to those who rarely used television for the same purpose. Correspondingly, increased media use as a sleep aid directly related to decreased sleep time. Adolescents who reported rarely using television as a sleep aid slept approximately 9 hours per night, whereas those who usually used television as a sleep aid slept approximately 8.4 hours. The use of music or computer games as a sleep aid revealed the same pattern (Eggermont & Van den Bulck, 2006). Not surprisingly, the use of books as a sleep aid promoted healthy sleep habits. The more often books were used as a sleep aid, the earlier the bedtimes and the longer the sleep duration. Reading in bed was not tested in the current study, but may be an important consideration for future research on the effects of bedtime activities on sleep.

A particularly noteworthy finding of the current study is watching television after bedtime was the strongest predictor – stronger even than demographic variables – of bed and risetime variability and Sleep Routine. Thompson & Christakis (2005) also reported watching television increased the risk of irregular sleep schedules in children aged 4-35 months (N=2068), independent of other psychosocial factors known to effect sleep schedules. This result is important considering the findings outlined in Chapter 5, stating variability and Sleep Routine measures are the strongest predictors of behavioural deficits. Indeed, retrospective Chi-square analysis revealed that proportionately more children who watched television after going to bed scored in the problem range ($\geq 95^{th}$ centile) of Anti-social (7.3 vs 13.5%; χ^2=7.4, p=0.007), Internalising (6.4 vs 17.3%; χ^2=12.2, p<0.0001), Hyperactive (7.4 vs 16.7%; χ^2=12.3, p<0.0001) and Total Problem behaviour (4.9 vs 14.4%; χ^2=22.8, p<0.0001) sub-scales on the SDQ (not reported in above results). Further research is required to determine the nature of the association between watching television after going to bed, Sleep Routine and behavioural concerns.

Bedroom television watching in the current study was also predictive of high scores on all other Sleep Problem sub-scales. This is in agreement with Owens et al. (1999) who reported having a television in the bedroom as the most powerful predictor of bedtime resistance and overall sleep disturbance. Li et al. (2007a) reported a television in the bedroom increased the risk of reported parasomnias and sleep disordered breathing. In that study, having a computer in the bedroom was also related to an increased risk of bedtime resistance, sleep duration disorder, and sleep anxiety.

There are a number of proposed hypotheses as to why television and/or computer games have a negative impact on sleep. First, it has been proposed that watching television may simply supersede the time traditionally used for sleeping thus reduce sleep opportunity (Christakis & Zimmerman, 2006; Owens et al., 1999). Second, the exposure to the bright, fast frequency light of the television/computer screen may contribute to a delay in the circadian system through the suppression of melatonin secretion (Cajochen et al., 2000; Higuchi et al., 2003; Salti et al., 2006), resulting in decreased sleepiness leading to a difficulty going to sleep. Salti et al. (2006) conducted a repeated measures design in which they measured urinary melatonin in children aged 6-13 years after one week of habitual television watching and one week of television abstinence. Watching television was related to lower urinary melatonin levels, particularly in the younger children. Higuchi et al. (2003) examined melatonin secretion, core temperature, subjective sleepiness and heart rate in seven young adult males during a period of extended wakefulness in which exciting (shooting game) or boring (addition task) video games were played in bright or dim light. That study found that melatonin production was suppressed after the subjects played the exciting game in bright light only. Melatonin levels were equivalent when the boring game was played in bright light, and in both dim light conditions (exciting and boring game).

The above study also supports the third postulation regarding the influence of television and/or computers on sleep which is that the content of the television program or computer game may simply increase alertness and physiological arousal, making it difficult for the child to fall asleep. In a similar study to that reported above, Higuchi et al. (2005) reported that just the act of playing a computer game, irrespective of the light condition, increased sleep latency and decreased subjective sleepiness when compared with a low level cognitive task. In the media and sleep literature, the content of television viewing is rarely measured. One exception is Paavonen et al. (2006) who reported that active viewing of television programs with adult content, such as police dramas, current affairs or >PG rated movies, was associated with an almost three-fold risk increase of sleep problem severity in children aged 5-6 years (N=297). Understandably, if the content of the program is considered scary or upsetting by the child, it is likely that they will have difficulty falling asleep and may experience nightmares.

Whilst, the American Academy of Pediatrics have posted guidelines for recommended amounts of television viewing for children (American Academy of Pediatrics, 1999) the current results suggest that guidelines for the introduction of television into children‟s bedrooms may also need to be developed and implemented.

6.4.2.2 Music

The effects of listening to music prior to sleep have received less attention than screentime in children. In the current study, the relationship between listening to music after bedtime, sleep/wake patterns and sleep problems were weak with the majority of the significant predictive relationships explaining less than 1% of the variance. The direction of the relationships however are worthy of mention.

Listening to music after going to bed was predictive of earlier bedtimes but longer bedtime latencies. Thus, whilst children who listened to music went to bed earlier, they did not necessarily sleep longer. Additionally, listening to music after bedtime was predictive of poorer Sleep Routine, increased Morning Tiredness, increased SDB and Restless Sleep. This suggests that music may not necessarily promote healthier sleep practices as is claimed in adults (de Niet et al., 2009; Harmat et al., 2008; Johnson, 2003; Mornhinweg & Voignier, 1995). Indeed, previous results regarding the effects of music on sleep in children are inconsistent. Tan (2004) examined the effects of music on sleep quality in a sample of fifth grade children (N=86). The children were randomly allocated to a treatment or control group where the treatment group was instructed to play a 45 minute CD containing classical music when going to sleep for a period of three weeks. The control group had no intervention and maintained habitual sleep routines. All children were asked to complete the Pittsburgh Sleep Quality Index (PSQI) before and after the three week period. Tan reported that the experimental group showed significant improvements in sleep duration and sleep efficiency, but did not have any improvement in perceived sleep quality. It is possible however, that the process of participating in a research experiment and the requirement to play music every night, improved sleep duration through an improvement in sleep routine, not specifically due to the music itself.

Eggermont and Van den Bulck (2006) found that adolescents who used music as a sleep aid reported similar patterns of bedtime and sleep duration as those who watched television or played computer games. That is, an increase in the frequency of music use was directly related to later bedtimes and shorter sleep duration. However, an important factor here may be the type of music these children are listening to. If the children are self-selecting the music, it is unlikely that they would be choosing soothing classical or instrumental music. It is more likely that their choice in music would be arousing, perhaps pop or rock. This arousing effect, just prior to sleep, could subsequently result in increased sleep problems.

The current results are inconclusive and it may be that parents are using music as a way of improving sleep onset and/or quality in children who have a pre-existing sleep problem such as disorder of initiating and maintaining sleep (DIMS) or sleep disordered breathing (SDB). Nonetheless, more research is needed particularly as more and more children are using personalised music players such as Ipods. Lazic and Ogilvie (2007) recently reported no effect of music on physiological sleep activity throughout the night in young women (N=10, age 17-24). However, in that study, a change in electroencephalogram activity, in particular increased delta power, was observed when music was played during the sleep onset period. In that small study, the music was turned off 5-minute into sleep onset thus it is unknown if sleep architecture would continue to be effected throughout the night. As children who fall asleep listening to music are likely to have it playing for more than 5 minutes, future research examining the effect of falling asleep with the Ipod playing in the ear on sleep quality and sleep architecture would be beneficial.

6.5 SUMMARY

These results support the notion that media use, both in and out of the bedroom, has a detrimental effect on sleep/wake patterns and sleep problems in children. In particular, watching television after going to bed negatively impacts on sleep/wake patterns as well as increased the likelihood of sleep problems. This may have considerable consequences for daytime functioning. Although this study adds to the current knowledge of media use and sleep in children in Australia, the lack of statistical strength requires that the results be discussed in context of the limitations.

General limitations of the study are discussed in Chapter 7, however of particular relevance to these results, the measure used to determine screentime is subject to potential bias on two counts. Social desirability bias may have caused parents to under-report the amount of time their children spend in front of a screen as a public health campaign to increase physical activity and decrease sedentary behaviours in children was predominant in the media 6 months prior to the study (http://www.health.gov.au/internet/healthyactive/publishing.nsf/Content/campaign). In addition, although parents were asked to report overall screentime, it may be that only television viewing was reported. Separating each screen media, i.e. television, computer, game console, may have provided more accurate estimate of total screentime. Indeed, when television was separated from other screen media in the Olds cohort, median television viewing on weekends was equivalent to the current sample (180 minutes).

This may have contributed to the weak associations however predictive relationships in previous research are of similar strength. The Van den Bulck, 2004) study had a larger sample (N=2546) of older children (>12 years) with a greater proportion with televisions in their rooms (23-44%), yet the amount of variance in sleep/wake patterns explained by television was comparable to the current study (~2%). Similarly, Li et al. (2007a), in a cohort of just under 20,000 children, reported weak relationships between media use and sleep problems with odds ratios of less than 1:2. This suggests that while digital media does impact on sleep, it may not be as big a concern as anticipated.

Nonetheless, with the increasing intrusion of digital technology into the lives and bedrooms of children, even these tentative associations are worthy of further study. To date, the association between media and sleep in children is not well studied and data collection regarding media use and sleep has been either parent or self-report questionnaire. Tighter controlled studies, using more objective sleep and media use measures, are needed.

CHAPTER 7: GENERAL DISCUSSION

Almost a century ago Lewis Terman and Adeline Hocking (1913) questioned the importance of sleep duration for healthy development and well-being in school-aged children. As described in Chapter 1, research since this time has revealed that it is not only inadequate sleep duration but also sleep disruption which can adversely impact on healthy daytime functioning in children. Unfortunately, the associations of disrupted sleep/wake patterns and sleep problems and daytime functioning remain not well understood, predominantly due to the limited amount of research and lack of standard methodological protocols.

The current study attempted to address some of the research gaps by developing a statistically robust, omnibus sleep questionnaire. This in turn provided normative data on sleep/wake patterns, prevalence of sleep problems and biopsychosocial associates in a representative community cohort of Australian children. Further analysis then determined the impact of poor sleep/wake patterns and sleep problems on daytime behaviour in this cohort. Returning to Terman and Hocking‟s initial questions posed in 1913, it is evident that the study of sleep in children is still in its infancy and the current study proposes more questions than it provides answers.

7.1 WHAT IS THE OPTIMUM AMOUNT OF SLEEP FOR PHYSICAL AND MENTAL EFFICIENCY, AND HOW ARE WE AFFECTED BY VARIATIONS ABOVE OR BELOW THIS AMOUNT?

Much as it was 100 years ago, the studies summarised in Chapter 1 highlight that the optimum amount of sleep required for children remains unknown. Many studies have examined how much sleep, on average, children are getting, yet sleep duration and sleep need are not always equivalent. In addition, as sleep/wake patterns vary so substantially across the globe, prescribing a universal sleep amount may be unrealistic.

Chapter 3 reveals that children aged 5-10 years in South Australia obtain on average 10½ hours of nocturnal sleep on school nights, equivalent to some previous studies (e.g. Iglowstein et al., 2003; Spruyt et al., 2005) yet well above others (e.g. Adam et al., 2007; BaHammam et al., 2006; Spilsbury et al., 2004; Thorleifsdottir et al., 2002). It is accepted that nocturnal sleep duration declines with age as a result of later bedtimes. The current study does not dispute this however sleep/wake patterns between school and weekend nights and the practice of napping varies from what has been previously published elsewhere. Thus, whilst the need for sleep is biologically driven, how the need is fulfilled appears largely dependent on cultural and social norms.

Examination of previous sleep duration and behaviour studies as outlined in Chapter 1 suggests that both short and long sleep periods affect daytime behavioural outcomes. However, Chapter 5 highlights the need for a focussed debate on the value of using bedtime and sleep duration as the measure of healthy sleep in children. In addition to the traditional indicators of sleep/wake patterns, the current study also examined sleep schedules, especially the consistency of bedtimes and risetimes across the week. This proved to be an important inclusion. More children reported poor sleep schedules than traditional indicators of poor sleep habits and it appears that consistency of sleep schedules and sleep routines have a greater impact on daytime functioning than sleep length.

Current recommendations for healthy sleep focus on optimal sleep length and undoubtedly extreme short or long sleep duration is detrimental to healthy functioning. However, as the current study shows, the majority of children, at least in Australia, appear to be meeting their sleep need yet many have poor sleep schedules. Thus, the development of new recommendations, education and health messages which include the benefits of consistent sleep schedules are needed.

7.2 HOW GREAT ARE THE NORMAL INDIVIDUAL DIFFERENCES?

Although research is still limited, Chapter 1 demonstrates that there are great differences in sleep/wake patterns dependant on age, sex, culture and social factors. The biopsychosocial associates of sleep/wake patterns reported in Chapter 3 confirm these differences. In particular, unlike other cultures, napping does not appear to be an integral part of the sleep/wake cycle in children over 5 years old in Australia, irrespective of cultural heritage. Cultural background does however have a substantial influence on nocturnal sleep/wake patterns, with Non-Caucasian children going to bed later, getting up later and sleeping less than their Caucasian counterparts . Differences are also seen across the sexes, with the current study reporting that girls sleep longer and experience more problems waking than boys.

The current paradigm regarding sleep in children is that „one size fits all‟, yet these findings beg the question as to whether certain groups need more or less sleep than others. Indeed, fatigue research has shown great individual differences in response to sleep deprivation (Van Dongen et al., 2005). Whilst the functions of sleep remain largely unknown (Dahl, 1996b), it is nonetheless reasonable to imagine that sleep need may change with biological determinants of ethnicity or sex, just as it does with age. To date, an understanding of the normal individual differences in children‟s sleep are, for the most part, incidental. The current study indicates that more targeted research is required to precipitate a much needed paradigm shift in order to improve children‟s daytime functioning and long-term health.

7.3 HOW IS IT INFLUENCED BY VARIOUS EVENING OCCUPATIONS?

With the first television broadcast still fifteen years away (http://www.tvhistory.tv/W2XB%20WGY%20WRGB%20TV%20Station.htm), Terman and Hocking (1913) could not have envisaged how important this question would become. Although their concern for homework load is still valid, a more apparent issue today is the increasing intrusion of digital technology into the bedroom. As described in Chapter 6, the amount of screentime and watching television after going to bed negatively impacts on sleep/wake patterns and increases the likelihood of sleep problems. Considering the consequences of poor sleep for daytime functioning, this is an important area for further consideration. To date, the associations between media and sleep in children are tentative and not well studied. More research is needed to inform a debate on guidelines for the introduction of television into children‟s bedrooms.

7.4 BUT EXACTLY HOW MUCH SLEEP IS REQUIRED BY THIS DEVELOPING ORGANISM *(THE CHILD)* FOR ITS HEALTHY FUNCTIONING AND GROWTH?

As alluded to above, perhaps the question should not only be how much is required, but also how well does a child need to sleep for healthy functioning and growth? The current study adds considerably to the current state of knowledge by revealing a regular sleep routine, in otherwise healthy children, had the strongest effect on daytime functioning. In particular, a change in bedtimes greater than 2 hours across the week or a high score on the Sleep Routine sub-scale resulted in up to four times the risk of reported behavioural problems. It may be that children with highly variable bed and sleep times are experiencing impairments similar to that of flying from Adelaide to New Zealand, and back, every week.

In addition, according to the results described in Chapter 4, parasomnias and dyssomnias are more pervasive than short sleep duration in Australian children aged 5-10 years. As seen in Chapter 1, there is ample evidence that nocturnal sleep disruption is associated with behavioural deficits in children and indeed, the predictive relationships between the SAPSS-Q sub-scales and SDQ sub-scales confirm that the more severe the sleep problem, the greater the chance of behavioural concerns. In particular, Chapter 5 reports that Bedtime Anxiety, Restless Sleep, Night Arousals, bruxism, hyperhydrosis and sleepwalking were all associated with behavioural deficits, either independently or comorbidly.

Therefore, as this study shows, questions limited to how much sleep is needed, although important, are restrictive. Examination of the link between sleep and healthy development must include the circumstances around which sleep is obtained, how well the child is considered to sleep throughout the night and how well they function in the morning.

7.5 LIMITATIONS

Despite the extensiveness of this questionnaire study, there are some limitations which are worth mentioning. Although the sample size was large (N=1895), the overall response rate was low, limiting the generalisability of the results. In addition, the comprehensive nature of the questionnaire may have produced a sample bias potentially excluding participants with low reading skills, English as a second language, or simply just time poor, automatically excluded. Given the nature of this anonymous survey however, these suppositions were untestable.

Response rates less than 30% however are not unusual in Australia when recruitment is conducted through schools. For example, Fitzharris and Bowman (2008) sent questionnaires to parents of schools across two states, New South Wales and Victoria and obtained a response rate of 18% for their study examining the relationship between child overweight and booster seat use. Salmon et al. (2007) conducted a national survey on barriers to walking or cycling to school through schools in all capital cities in Australia and obtained an overall response rate of 27%. Thus, whilst response rate was not ideal, it is consistent with previous studies and the equal distribution of respondents across SES groups and the relatively high representation of minority groups was suggestive of a representative sample of Australian children.

As with all parent-report sleep surveys, the current study was subject to another possible bias. Chapter 6 describes how social desirability bias may have influenced responses; however parents may have also unintentionally provided inaccurate information simply from lack of knowledge. For example, estimates of sleep/wake patterns may have resulted in an overestimate of sleep duration. In order to combat this limitation, parents in this study were asked what time their child went to sleep, in addition to what time they went to bed. On average, the former was 25-30 minute after the latter. Nixon et al. (2008) recently reported that parental estimates of time in bed were 50 minutes more than actual sleep time when measured with actigraphy. This suggests that if there is an overestimation in the current study, it is likely to be small (i.e. <20 minutes on average). In addition, nocturnal sleep problems, such as night awakenings, snoring or nightmares, may have been under-reported as parents may not have been disrupted by such events and thus were not unaware of them. Using objective measures of sleep, such as actigraphy, would have been ideal however in this type of research is fiscally and time prohibitive. Survey designs are still the best way to gather information from large groups of people and determine community trends on which to base future objective and targeted research. Moreover, the thoroughness of the current analysis ameliorates much of this limitation.

As mentioned in Chapter 5, the cross-sectional nature of this study precludes any conclusions regarding directionality between sleep and daytime functioning. It may be that the behavioural concerns result in sleep difficulties rather than vice versa. Behavioural intervention studies are required to provide evidence for a cause and effect relationship. However, the association between sleep and behaviour is an important one for children‟s well-being, regardless of the direction.

Finally, as discussed throughout this thesis, the small effect sizes and somewhat trivial statistical relationships necessitates that these results are interpreted with caution. Few epidemiological studies examining sleep and behaviour in children report effect sizes, however the statistical strength of the results are similar to the current study. For example, Carvalho Bos et al. (2009) report that the amount of variance explained by sleep on behavioural outcomes is ≤2%. Paavonen et al. (2009) reported correlations between Sleep Disturbance Scale for Children (SDSC: Bruni, 1996) sub-scales and hyperactive/inattentive behaviours to be less than r=0.2. Stein et al. (2001) reports stronger correlations between sleep problem sub-scales and behavioural outcomes as measured on the CBCL, however these were still only moderate (r≤0.4). Thus, whilst caution must be taken, the similarities with previous research and the statistical rigour of the factor analysis, ensures confidence as to the validity of the current results.

7.6 STRENGTHS

Despite these limitations, the strengths of this study assure its scientific value. This is the first study to examine sleep habits within a large Australian sample, providing for the first time, culturally relevant comparative norms for future Australian studies. As the nature of sleep is embedded in social and cultural expectations as well as biological mechanisms, this study will aid future research in targeting socially and culturally appropriate research and intervention strategies to improve the health and well-being of children in Australia.

This study also adds substantially to the field of sleep research through the examination of sleep schedules as well as traditional sleep/wake indicators. This has provided a new, and perhaps more relevant, focus for future research regarding recommendations for healthy sleep in children. As over 40% of children in the current study were reported to have poor sleep schedules, the potential health benefits of this are vast.

The precision of the factor analysis has provided, for the first time, a robust set of sleep problem factors that allow for more accurate parental assessments of sleep problems in community samples of children. For example, the current study suggests that the Morning Tiredness sub-scale provides a better indicator of nocturnal sleep problems than daytime sleepiness when measured through parent report. In addition, the strong associations between the Sleep Routine sub-scale and behavioural outcomes suggests that, in otherwise healthy children, what happens prior to sleep is more salient to parents than what happens during sleep.

Definitions of sleep complaints are highly subjective and prevalence is often determined by the amount of disruption to the parents (Owens, 2007). The factors extracted from the SAPSS-Q are an exemplar of this. That is, it does not determine sleep disorders as such but parental perceptions of sleep problems or disturbance. In an otherwise healthy sample, this may be a more relevant measure than clinical diagnosis.

7.7 CONCLUDING COMMENTS – IS THE INSTINCT OF SLEEP EDUCABLE?

This study attempted to provide better tools to measure sleep in large community samples and address the lack of data on sleep/wake patterns, sleep problems and behavioural associates in Australian school-aged children and in doing so has uncovered a number of likely productive future research directions. Firstly, given the overwhelming impact of sleep schedules and sleep routine, it is now vital to attempt to answer Terman and Hockings question of whether the instinct of sleep is educable. Intervention studies, aimed at improving sleep schedules and routines, are required to determine if concomitant improvements occur in behavioural functioning. Secondly, further research is required to provide more accurate information regarding potential differences in sleep need in children to better inform educators and health professionals. Finally, further validation studies of the SAPSS-Q are needed to confirm its utility, the replicability of factors, and generalisability of T-score cut-offs.

Sleep/wake patterns and sleep problems in Australian school-aged children are determined by a number of biopsychosocial factors which makes it almost impossible to describe „normal" sleep in these children. Nonetheless, sleep and daytime functioning are inextricably linked emphasising the need for informed strategies for sleep education and health messages. This study provides the first step to initiating an informed debate on the healthy sleep habits of Australian school-aged children.

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APPENDICES

Appendix A

Government of South Australia
Children, Youth and Women's Health Service

Women's & Children's Hospital

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Child Sleep, Health and Behaviour Questionnaire

Thank you for your valuable time. By completing the following questionnaire, you agree to provide information about the sleep, health and behaviour of your child. All questions are voluntary, however we ask that you complete as much of the questionnaire as possible, as all information is useful.

Sleep Disorders Unit, WCH,
Level 2, Good Friday Building, 72 King William Road,
North Adelaide, South Australia 5006; Phone: 8161 6456.

Note: THERE ARE NO WRONG ANSWERS. If you are not sure how to answer a particular question, pick the answer that seems MOST APPROPRIATE to your child"s situation at the present time. ALL INFORMATION PROVIDED IS CONFIDENTIAL. If you have any questions or concerns, please contact the Sleep Disorders Unit, on (08) 8161 6456.

Section 1: General Information

This section will provide the researchers with some important details about your child. It WILL NOT be used to identify you or your child in any way.

Today"s Date	_____/______/_____	
Child"s gender (please circle):	Male / Female	
Child"s date of birth:	_____/_____/______	
Length of pregnancy (example: 38 weeks)	______________ weeks	
Child"s birth weight	______________ kg or _____ lbs _____ oz	
Child"s current height:	_____________cm	**Please measure current height and weight for accuracy**
Child"s current weight:	_____________ kg	
Your relationship to the child (please circle):	Mother / Father / Guardian / Care Giver	
Number of children in the family:	_________________	
Birth order of this child (example: eldest, 2^{nd}, youngest etc)	_________________	
Your postcode:	_________________	

Child"s ethnicity (please circle): Caucasian / Indigenous / African / Asian / Polynesian / Caribbean / Other _____________

Section 2: Sleep Habits

This section is about your child‟s sleep. When answering these questions, think about the **last school week** in your child‟s life. If recent weeks were unusual for any reason (such as school holidays, or your child had a cold and did not sleep well, etc), answer for the most recent typical school week.

NEVER = did not occur
RARELY = occurred **1 time** during the week.
SOMETIMES = occurred **2-4 times** in the week;
USUALLY = occurred **5 or more times** in the week;

Also, please indicate whether or not you consider the sleep habit a problem by marking the box under "Not Applicable (N/A)", "No", "Somewhat", or "Yes". Please attempt to answer all questions.

Please indicate your answer by placing an ☒ in the appropriate box

	How Often				**Do you consider it a problem?**			
During the most recent typical school week:	**Never**	**Rarely 1/week**	**Sometimes 2-4/week**	**Usually 5-7/week**	**N/A**	**No**	**Somewhat**	**Yes**
1. Your child went to bed at the same time every night	☐	☐	☐	☐	☐	☐	☐	☐
2. Your child fell asleep within 20 minutes after going to bed	☐	☐	☐	☐	☐	☐	☐	☐
3. Your child shared a bedroom with siblings/parents	☐	☐	☐	☐	☐	☐	☐	☐
4. Your child fell asleep alone in own bed	☐	☐	☐	☐	☐	☐	☐	☐
5. Your child fell asleep in parent‟s or siblings bed	☐	☐	☐	☐	☐	☐	☐	☐
6. Your child needed parent in the room to fall asleep	☐	☐	☐	☐	☐	☐	☐	☐
7. After going to bed, your child spent time watching TV/DVD/Video in their bedroom	☐	☐	☐	☐	☐	☐	☐	☐
8. After going to bed, your child spent time listening to music in their bedroom	☐	☐	☐	☐	☐	☐	☐	☐
9. After going to bed, your child spent time talking to friends on the phone	☐	☐	☐	☐	☐	☐	☐	☐
10. After going to bed, your child spent time playing electronic games (Xbox/Playstation/PC games/Gameboy)	☐	☐	☐	☐	☐	☐	☐	☐
11. Your child struggled at bedtime (cried, refused to stay in bed etc)	☐	☐	☐	☐	☐	☐	☐	☐
12. Your child was afraid of sleeping in the dark	☐	☐	☐	☐	☐	☐	☐	☐
13. Your child was afraid of sleeping alone	☐	☐	☐	☐	☐	☐	☐	☐
14. Your child‟s bedroom was noisy (could hear road or outside noise, TV etc)	☐	☐	☐	☐	☐	☐	☐	☐

Section 2: Sleep Habits (Continued)

Please indicate your answer by placing an ☒ in the appropriate box

During the most recent typical school week:	How Often: Never	Rarely 1/week	Sometimes 2-4/week	Usually 5-7/week	Do you consider it a problem?: N/A	No	Somewhat	Yes
You felt your child slept too little	☐	☐	☐	☐	☐	☐	☐	☐
You felt your child slept the right amount	☐	☐	☐	☐	☐	☐	☐	☐
Your child slept about the same amount each day	☐	☐	☐	☐	☐	☐	☐	☐
Your child wet the bed at night	☐	☐	☐	☐	☐	☐	☐	☐
Your child twitched or jerked when **falling asleep**	☐	☐	☐	☐	☐	☐	☐	☐
Your child twitched or jerked violently **during the night** when asleep	☐	☐	☐	☐	☐	☐	☐	☐
Your child talked during sleep	☐	☐	☐	☐	☐	☐	☐	☐
Your child was restless and moved lots during sleep (changed positions, threw covers off)	☐	☐	☐	☐	☐	☐	☐	☐
Your child sleepwalked during the night	☐	☐	☐	☐	☐	☐	☐	☐
Your child moved to someone else"s bed during the night (parent, sibling)	☐	☐	☐	☐	☐	☐	☐	☐
Your child ground their teeth during the night (your dentist may have told you this)	☐	☐	☐	☐	☐	☐	☐	☐
Your child breathed heavily during the night (but did not snore)	☐	☐	☐	☐	☐	☐	☐	☐
Your child currently snores	☐	☐	☐	☐	☐	☐	☐	☐
Your child currently snores **loudly**	☐	☐	☐	☐	☐	☐	☐	☐
Your child seemed to stop breathing during the night	☐	☐	☐	☐	☐	☐	☐	☐
You watched your child while they slept at night, afraid that they would stop breathing	☐	☐	☐	☐	☐	☐	☐	☐
Your child snorted and/or gasped during sleep	☐	☐	☐	☐	☐	☐	☐	☐
Your child had trouble sleeping away from home (visiting relatives, vacation)	☐	☐	☐	☐	☐	☐	☐	☐
Your child woke during the night screaming, sweating or was inconsolable	☐	☐	☐	☐	☐	☐	☐	☐
Your child woke alarmed by a frightening dream	☐	☐	☐	☐	☐	☐	☐	☐

Section 2: Sleep Habits (Continued)

Please indicate your answer by placing an ☒ in the appropriate box

During the most recent typical school week:

	How Often				Do you consider it a problem?			
	Never	**Rarely 1/week**	**Sometimes 2-4/week**	**Usually 5-7/week**	N/A	No	Somewhat	Yes
Your child sweated excessively when **falling asleep**	☐	☐	☐	☐	☐	☐	☐	☐
Your child sweated excessively **after falling asleep**	☐	☐	☐	☐	☐	☐	☐	☐
Your child woke during the night	☐	☐	☐	☐	☐	☐	☐	☐
In total, how long did your child usually stay awake during the night? (no awakenings = 0 minutes)	________________ mins							
Your child woke up by him/herself	☐	☐	☐	☐	☐	☐	☐	☐

If your child usually woke up by themselves, did this happen on (please circle):
Weekdays / Weekends / Both ?

	Never	**Rarely 1/week**	**Sometimes 2-4/week**	**Usually 5-7/week**	N/A	No	Somewhat	Yes
Parent (or sibling) woke your child up in the morning	☐	☐	☐	☐	☐	☐	☐	☐
An alarm clock woke your child up in the morning	☐	☐	☐	☐	☐	☐	☐	☐
Your child usually woke up in a negative mood	☐	☐	☐	☐	☐	☐	☐	☐
Your child had difficulty getting out of bed in the morning	☐	☐	☐	☐	☐	☐	☐	☐
Your child took a long time to become alert in the morning	☐	☐	☐	☐	☐	☐	☐	☐
Your child seemed tired all the time	☐	☐	☐	☐	☐	☐	☐	☐

Please indicate your child"s level of sleepiness during each of the following activities:

	Not Sleepy	**Slightly Sleepy**	**Very Sleepy**	**Falls Asleep**
Watching T.V.	☐	☐	☐	☐
Riding in the car on a short trip	☐	☐	☐	☐
At school	☐	☐	☐	☐
Reading a book	☐	☐	☐	☐

Section 2: Sleep Habits (Continued)

During the most recent typical school nights, weekends nights and school holidays, please estimate to the nearest 5 minutes (eg 8:35pm). For each question, please indicate a specific time rather than a range.	**On school days (Sun-Thurs)**	**On school weekends (Fri & Sat)**	**On school holidays**
15. Bedtime			
a. Usual time your child went to bed at night			
b. Usual time the light was turned out			
c. Usual time your child went to sleep at night			
d. The **earliest** time your child went to bed			
e. The **latest** time your child went to bed			
47. Napping:			
Did your child nap during the day (please circle)? Yes / No			
If yes:			
a. At what time of day did your child usually nap			
b. In total, how much time did your child spend napping per day (non-nappers = 0 minutes)			
48. Waketime			
f. Usual time your child woke up in the morning			
g. The earliest time your child woke up			
h. The latest time your child woke up			

49. Please write any further comments about your child‟s sleep below:

____

____

____

Note: Please consult your family doctor if you have any immediate concerns about your child’s health.

Section 3: Activity

This section is about the level of activity in children. Please give your answers based on your child‟s activity **over the last typical school week**. If unsure about any question, please ask your child.

Please indicate your answer by placing an ☒ in the appropriate box

Over the last typical school week:	**How Often** Never	Sometimes 1-2/week	Usually 3-4 /week	Often 5 or more /week
1. How often did your child play sport?				
a. At school, organised by teachers or parents	☐	☐	☐	☐
b. At school, unorganised with friends	☐	☐	☐	☐
c. Outside of school, either organised or unorganised	☐	☐	☐	☐
2. How often did your child participate in any activity (excluding sport) that made them breathe hard?	☐	☐	☐	☐
How often did your child do the following during lunch-time at school?				
a. Sit and talk to friends	☐	☐	☐	☐
b. Train for school sports teams	☐	☐	☐	☐
c. Walk around the school grounds	☐	☐	☐	☐
d. Ride or walk home for lunch	☐	☐	☐	☐
e. Read or do homework	☐	☐	☐	☐
f. Play quietly	☐	☐	☐	☐
g. Play running type games with friends (eg chasey, basketball, soccer, footy, etc)	☐	☐	☐	☐

3. What organised sport or sports did your child play regularly? (Please answer on the line below)

____

During the most recent typical school days, weekends and school holidays, please estimate to the nearest 5 minutes:	On school days (Mon – Fri)	On school weekends (Sat - Sun)	On school holidays
1. The amount of time your child spends in front of a screen (eg TV, computer, video games, etc)	☐	☐	☐
2. The amount of time your child spends doing homework per day (eg 65 minutes)	☐	☐	☐
3. The usual time your child finishes their homework (eg 8:35pm)	☐	☐	☐

Section 4: Behaviour

This section is about the strengths and difficulties experienced by children. Please answer based on your child"s behaviour **over the last three months**. If you are unsure, please choose the box closest to what you think best represents your child"s behaviour.

Please indicate your answer by placing an ☒ in the appropriate box

Over the last three months, your child has been:

	Not True	Somewhat True	Certainly True
1. Considerate of other people"s feelings	☐	☐	☐
2. Restless, overactive, cannot stay still for long	☐	☐	☐
3. Often complaining of headaches, stomach-aches or sickness	☐	☐	☐
4. Sharing readily with other children, for example toys, treats, pencils	☐	☐	☐
5. Often losing their temper	☐	☐	☐
6. Rather solitary, prefers to play alone	☐	☐	☐
7. Generally well behaved, usually does what adults request	☐	☐	☐
8. Having many worries or often seems worried	☐	☐	☐
9. Helpful if someone is hurt, upset or feeling ill	☐	☐	☐
10. Constantly fidgeting or squirming	☐	☐	☐
11. Good friends with at least one person	☐	☐	☐
12. Often fighting with other children or bullies them	☐	☐	☐
13. Often unhappy, depressed or tearful	☐	☐	☐
14. Generally liked by other children	☐	☐	☐
15. Easily distracted, concentration wanders	☐	☐	☐
16. Nervous or clingy in new situations, easily loses confidence	☐	☐	☐
17. Kind to younger children	☐	☐	☐
18. Often lying or cheating	☐	☐	☐
19. Picked on or bullied by other children	☐	☐	☐

Section 4: Behaviour (Continued)

Please indicate your answer by placing an ☒ in the appropriate box

Over the last three months, your child has been:

	Not True	Somewhat True	Certainly True
20. Often volunteering to help others (parents, teachers, other children)			
21. Thinking things out before acting			
22. Stealing from home, school or elsewhere			
23. Getting along better with adults than with other children			
24. Easily scared, has many fears			
25. Having a good attention span, sees tasks through to the end			
26. Having problems doing anything that is physically demanding			
27. Happy doing chores around the house when asked			
28. Often missing school due to illness			
29. Having trouble paying attention at school			
30. Seeming to enjoy life			

Section 4: General Medical History

This section is about any breathing or health complaints your child may have which can affect sleep or behaviour.

Please indicate your answer by placing an ☒ in the appropriate box.

	Unsure	**No**	**Yes**
1. Has your child ever snored?			

If YES, at what age did you first notice your child‟s snoring? _______________

2. Do any of the following family members snore?

	Unsure	**No**	**Yes**
a. Mother			
b. Father			
c. Siblings			
d. Grandparents			

Section 5: General Medical History (Continued)

Please indicate your answer by placing an ☒ in the appropriate box	Unsure	No	Yes
3. If YES to Question 2 (family members snore), are any being treated for sleep apnoea with Continuous Positive Airway Pressure (CPAP)?	☐	☐	☐
4. Has your child ever been diagnosed with a sleep breathing disorder?	☐	☐	☐
5. Has your child had their tonsils taken out?	☐	☐	☐
6. Has your child had their adenoids taken out?	☐	☐	☐
7. Has your child been diagnosed with any of the following:			
a. Facial abnormalities that affects their breathing	☐	☐	☐
b. Cleft palate	☐	☐	☐
c. Neurological disorders	☐	☐	☐
d. Muscular dystrophy	☐	☐	☐
e. Intellectual delay	☐	☐	☐
f. Developmental delay	☐	☐	☐
g. Behavioural disorders	☐	☐	☐
8. In the last 12 months, has your child experienced any of the following medical conditions?			
a. Hayfever	☐	☐	☐
b. Asthma	☐	☐	☐
c. Eczema	☐	☐	☐
d. Rhinitis (Runny nose without a cold)	☐	☐	☐

9. Please list any prescriptive medication your child is currently taking (including ointments)?

____

____

10. How many cigarettes are smoked per week (in total) by members of the immediate household (anyone currently living in the house)? Please answer even if smoking occurs outside the house.

____

Note: Please consult your family doctor if you have any immediate concerns about your child's health.

Thank you for completing this questionnaire

Please complete the next section if you wish to receive further information regarding future sleep research

We will be asking a small number of families to participate in further research. If you would like further information on current sleep studies at the Adelaide Women‟s and Children‟s Hospital (WCH), please complete the section below. **The information that you provide in this section will be removed so that neither your or your child will be identified with the information provided in the questionnaire.**

We will be calling families who have filled out this section in the near future. Alternatively, to register your interest in future sleep research, you can call the Sleep Disorders Unit on (08) 8161-6456 during business hours, or email and request information from: sleep.studies@adelaide.edu.au.

Your full name: ____

Your child‟s name: ____

Your relationship to the child (eg: mother/father/carer) ____

Your address: ____

____

Your daytime telephone number: ____

Please place the completed questionnaire and consent form in the envelope provided and return it to school with your child.

Thank you again

Appendix B

Sleep Disorders Unit
Lv 2, Good Friday Building
Women‟s & Children‟s Hospital
72 King William Road
North Adelaide SA 5006
Tel 08 8161 6456
Fax 08 8161 7050

www.cywhs.sa.gov.au

Friday, October 02, 2009

«Title» «First_Name» «Last_Name»
«Company_Name»
«Address_Line_1»
«City» «State» «ZIP_Code»

Dear «Title» «Last_Name»

I am writing to introduce you to a new research and education group, the Sleep Activity Research Network Australia (SARNA), and to request for your consent to invite the parents and children of «School» to participate in a unique research project aimed at enhancing the lives and well-being of children in South Australia.

By way of information, SARNA is dedicated to disseminating new knowledge, undertaking research and formulating new policies and practices that address sleep, health and learning. Over the past few months there has been much media attention on the area of sleep and its effects on daytime functioning, especially in children. Indeed, recent research has revealed that reduced sleep, either through extended time awake or sleep disturbance, is associated with poor academic performance, behavioural difficulties and health problems in children. While it is now acknowledged that these associations exist, the magnitude of the problem within the wider community is still unknown.

As a result, SARNA, a multi-institutional group with representatives from the University of South Australia, University of Adelaide, Children, Youth and Women‟s Health Service (CYWHS) and Women‟s and Children‟s Hospital, are conducting the first comprehensive community based study into the prevalence of sleep disturbances in children in South Australia. Through the information provided by this research, it is the aim of SARNA to provide education and influence policy change that will promote BETTER SLEEP, BETTER HEALTH, and BETTER LEARNING.

Attached you will find an information sheet describing the project and what is required from all parties. In summary however, it is our aim to gather information, by way of questionnaire, from 3000 families on the sleep, health and behaviour habits of children between the ages of 5 and 10 years. The Department of Education and Children‟s Services (DECS) have expressed support for this initiative and as a result, this project has been accepted as part of the Research Partnership scheme of the Child Health and Education Support Services (CHESS). We are proud to be part of the CHESS initiative and undoubtedly, the success of this project relies heavily on the support of the schools and teaching staff. It is for this reason we ask for your approval to invite the parents and children of «School» to participate in this research.

«Title» «Last_Name», thank you for taking the time to consider this request. I will be calling you within the next week to enquire as to your decision. In the meantime, should you have any questions or require any further information, please do not hesitate to contact me on 8161 6456 or via email on Sarah.Biggs@adelaide.edu.au.

Yours Sincerely

Sarah Biggs
Secretary, SARNA
PhD Candidate
Discipline of Paediatrics
University of Adelaide

Sarah Biggs
PhD Candidate
C/- Sleep Disorders Unit
Women‟s & Children‟s Hospital
Lv2 Good Friday Building
72 King William Street
North Adelaide SA 5006
Tel 08 8161 6456
Fax 08 8161 7050

www.cywhs.sa.gov.au

INFORMATION SHEET FOR PRINCIPALS

Project: Prevalence of Sleep Disorders in a Community Sample of Children Aged 5 to 10 years and its effect on Neurocognitive and Behavioural functioning

It has recently been discovered that the quality of a child‟s sleep may have a profound effect on their daytime functioning. Sleep disturbances, such as snoring or breathing problems, have been connected to more serious problems such as behavioural difficulties, poor academic performance and poor weight management. However, while we do know that sleep disturbances can cause developmental problems for children, we don‟t actually know how many kids in the community have disrupted sleep. Therefore, this research aims to investigate how many children aged between 5-10 years in South Australia have sleeping difficulties, and what influence this has on behaviour and learning.

The research project involves gathering information on sleep habits of children from approximately 3000 families around Adelaide. Parents will be asked to complete one questionnaire for each of their children between the ages of 5 and 10 years (inclusive). This questionnaire asks about the child‟s sleep habits, health, behaviour, activity levels, and some general information for statistical purposes (copy enclosed). The questionnaire will take approximately 20 minutes to complete and will be completed in privacy in the home. **All information gathered will be kept confidential and in no way will parents or their children be identified in the analysis or reporting of this research.**

Below I have answered some of the most common questions that are asked in regards to school‟s participating in research. If you have any other questions, or require any further information, please do not hesitate to contact me either on by phone (8161 6456) or through email (Sarah.Biggs@adelaide.edu.au).

What is required by the staff and students and will it disrupt classroom activities?

The requirements of both staff and students are **minimal** and the disruption to classroom activity is **negligible**. If you agree to allow us to go ahead with this research, we can approach it in two ways. We can either arrange a time that is convenient to the teachers to speak to each participating class prior to handing out the questionnaires, or we can give the questionnaires directly to the teachers to distribute to the students just prior to the end of the day. The children will then be asked to take the questionnaires home to their parents. Each questionnaire contains a self-addressed stamped envelope for return. We can also place a communal collection box in a public location (such as the school office) if the children bring the questionnaire back to school. These boxes will then be collected by the researchers at an agreed upon time.

Will the school have any administration responsibilities?
Not directly. If you have a newsletter, we would appreciate the opportunity to put an article in the newsletter advising parents of the research and its importance. We also see this as an appropriate media for publishing reminders and updates, if it is available to us. We would prepare all items for the newsletter. All your staff would need to do is place it wherever they think appropriate.

All administration requirements for the questionnaire distribution and collection will be handled by the research team.

When will the research start and how long will it take?
It is our intention to start collecting data during **TERM 1**. It is envisioned that the collection process will take approximately 4 weeks. This includes advertising and promotion of research, distribution of questionnaires, follow-up reminders, and collection of questionnaires.

What will the school get out of participating in this research?
The members of SARNA have an international clinical and research profile in the field of sleep, health and behaviour. By participating in this research, your school will have access to up-to-date educational and informational material regarding sleep and health. In addition, members of the team will be available to provide information nights and seminars to promote **better sleep, better health and better learning** in children. Your school will also be in the unique position of being a part of establishing world best practices and benchmarks for promoting healthy sleep in children. This will not only improve the lives of South Australian children, but will improve the lives of children around Australia and the globe.

Does my school have to participate?
NO. Although we would be grateful for your school‟s participation, and by participating you will be contributing to research on improving the lives of children, you are under no obligation to agree to this research.

Who has approved this research?
This research has been approved by the **Children, Youth & Women's Health Service** and **Adelaide University** Ethics Committee and the **Department of Education and Children's Services** (approval and support letters are enclosed in this folder). Should you wish to discuss the approval process with a representative of the Ethics committee, or have any concerns about the ethics of this study, please contact Ms Brenda Penny, Secretary of the CYWHS Research Ethics Committee, on 8161 6521.

If my school participates, are the parents obligated to complete the questionnaire?
NO. Any and all information provided is voluntary. Prior consent will be obtained before any information is gathered or reported.

Will anonymity of the participants be assured?
YES. None of the school"s or participating families will be identified in any way in the analysis. Data about the child"s sleep, health and behaviour will be grouped with responses from other families and reported together. We can guarantee that any information supplied will remain completely confidential.

What will happen with the information supplied?
From the data supplied by this study, SARNA has proposed the following outcomes to be achieved over the next 3 years:

- Systematic documentation and analysis of young children"s sleeping habits and behaviours in the home that can promote policy and practice of healthy sleep habits.
- Development of a sleep education network to promote and enhance the health, well-being, and learning of children by improving their sleeping habits.
- Development of a Sleep Awareness curriculum resource, focussed specifically on the applicability of healthy sleep hygiene to all Australian children and their families.
- Development of a national campaign for Sleep Awareness Week, 2007, which will promote the research findings and the Sleep Awareness Curriculum.
- A range of publications, professional and popular, that show the importance of healthy sleep hygiene to a child"s development.

.
Will the school be informed of the results of this study?
Absolutely. It is the intention of the research team to publish the results through the Department of Education and Children"s Services newsletter and on their website. After finalising the results, the researchers will be available to make presentations to participating schools upon request. In addition, each participating school can request their individual results in the form of a short report.

Thank you for taking the time to consider this request. Your school"s participation in this research is highly appreciated and will provide valuable information for the health and well-being of children. Should you require any additional information regarding this research, please contact Sarah Biggs on **8161 6456** or **Sarah.Biggs@adelaide.edu.au.**

Appendix C

Sarah Biggs
PhD Candidate
C/- Sleep Disorders Unit
Women"s & Children"s Hospital
Lv2 Good Friday Building
72 King William Street
North Adelaide SA 5006
Tel 08 8161 8394
Fax 08 8161 7050

www.cywhs.sa.gov.au

Research Information Sheet

Dear Parent / Guardian

I am writing to introduce myself and to invite you to participate in a unique research project aimed at enhancing the lives and well-being of children in South Australia. It has recently been discovered that the quality of a child"s sleep may have an effect on more serious problems such as obesity and behavioural disorders (eg hyperactivity). While we know that this issue can cause developmental problems for children, we don"t actually know how many kids in the community have sleep disturbances. Thus, it is the purpose of this project to see how extensive this problem might be, and to gather a bit more information about how sleep may relate to behaviour and activity.

The research project involves gathering information on sleep habits of children from approximately 5000 families around Adelaide. If you agree to participate, you will be required to complete one questionnaire for each of your children between the ages of 5 and 10 years (inclusive). This questionnaire asks about your child"s sleep habits, health, behaviour, activity levels, and some general information for statistical purposes. The questionnaire should take approximately 20 minutes to complete. **All information gathered will be kept confidential and in no way will you or your child be identified in the analysis or reporting of this research.**

Below I have answered some of the most common questions that are asked in regards to research. If you have any other questions, or require any further information, please do not hesitate to contact me either on by phone (8161 8394) or through email (sarah.biggs@adelaide.edu.au).

Do I have to participate?
NO. Although we would be grateful for any information you could provide us, and by participating you will be contributing to research on improving the lives of children, you are under no obligation to complete the questionnaire.

Will my child and I be able to remain anonymous?
YES. Neither you nor your child will be identified in any way in the analysis. Information about your child"s sleep, health and behaviour will be grouped with responses from other parents and reported together. Not even the school your child attends will be identified. Although there will be some identifying information on the questionnaires that will allow us to contact you if you consent to participate further, we can guarantee that any information you supply will remain completely confidential.

What will happen with the information I supply?

All information will be entered into a database and analysed by the researchers with the view to determining how prevalent childhood sleep problems are and give us a better idea of how this may relate to behaviour problems and activity levels. This information will have a huge impact on how sleep, weight and behaviour in children is managed both at home and by health professionals.

Will my child or I have to do anything else beside complete the questionnaire?
That is completely up to you and your child. This research is the first stage of a larger project. Depending on your responses to the questionnaire, your child may be eligible to participate in the next phase of the research, but again, participation is voluntary. After the initial questionnaire study is completed, we will be collecting more information on the effects of sleep on daytime functioning by conducting further assessments of brain function and behaviour in our sleep laboratory. This phase of the study will involve things such as:

- Sleep study in the sleep laboratory
- Intelligence testing
- Memory and attention testing
- Behaviour monitoring

If you wish for your child to participate in the second stage of this study, all you need to do is complete the appropriate section at the bottom of the questionnaire. A researcher will then contact you and will give you more in-depth details about what is involved. In the mean time however, if you have any questions about any part of the study, please contact Sarah Biggs (8161 6456) for further information. It is important to note that if you do not wish to continue with the study, you can withdraw your consent at any time without explanation and we will immediately remove all information that you have provided on your child (or children) from our records.

Will I be informed of the results of this study?
Absolutely. It is the intention of the research team to provide participating schools with a report of the results. We will also be available to make presentations upon request. In addition, you can request your child"s individual results to be sent to you.

How do I know this research is legitimate?
This research has been approved by the **Children, Youth & Women's Health Service** and **Adelaide University** Ethics Committee"s. Should you wish to discuss the approval process with a representative of the Ethics committee, or have any concerns about the ethics of this study, please contact Ms Brenda Penny, Secretary of the CYWHS Research Ethics Committee, on 8161 6521.

Will I be paid to participate?
No, your participation in the first phase of the study is entirely voluntary.

Yes, I want my child to participate. What do I do now?
If you agree for your child to take part, a Consent Form is attached for you to sign and the questionnaire is enclosed. Once the consent form is signed and the questionnaire completed, please place them **both** in the envelope provided and return them to school with your child.

Thank you for taking the time to consider this request. Your participation in this research is highly appreciated and will provide valuable information for the health and well-being of children. Should you require any additional information regarding this research, please contact Sarah Biggs on **8161 8394** or **sarah.biggs@adelaide.edu.au.**

Yours sincerely

Sarah Biggs
PhD Candidate
Discipline of Paediatrics
University of Adelaide

CONSENT FORM

I (name)_______________________________

hereby consent to my child‟s involvement in the first stage of the research project entitled:

Prevalence of Sleep Disturbances in Children Aged 5 to 10 years and its effect on daytime functioning

Please Tick ✓

- I have read and understood the Information Sheet on the above project and understand that I am being asked to provide details of my child. ☐
- I understand that my child or I may not directly benefit by taking part in this research. ☐
- I understand that the information obtained in this study is part of on-going research and, if I choose, I may be contacted in regards to my child assisting in future research. I understand that I am under no obligation to agree to my child participating in this future research. ☐
- I understand that while information gained in the study may be published, neither my child nor I will be identified and all individual information will remain confidential. ☐
- I understand that I can withdraw my child from the study at any stage up until the end of the collection of data. ☐
- I understand that there will be no payment for taking part in this part of the study. ☐
- I am aware that I should retain a copy of the Information Sheet and Consent Form for future reference. ☐

Name of Child: ____

Parent/Guardian‟s Signature: ____

Your Relationship to Child (mother/father/guardian etc): ____

Date: ____

Contact Number: ____

Please place the completed consent form in the envelope provided and return it with the completed questionnaire.

Appendix D

BETTER SLEEP: BETTER HEALTH: BETTER LEARNING

Did you know that sleep disturbances have been connected to more serious concerns such as conduct problems, hyperactivity, lower IQ and obesity?

<school name> is proud to have been selected to be part of very important research looking at sleep habits in children and its effects on daytime functioning.

Shortly all children between 5 and 10 years will be bringing home a questionnaire regarding sleep habits, activity, behaviour and general health. This questionnaire will take approximately 15 minutes to complete. Whether your child sleeps soundly or not, the information you provide will be invaluable in improving the understanding of the link between sleep, health and daytime functioning.

Don‟t sleep on it. Fill out your questionnaire and be a part of improving the future health and wellbeing of children in South Australia.

Child Sleep, Health and Behaviour Questionnaire

LAST CHANCE TO BE INVOLVED!!!!!

Very soon all children between 5 and 10 years will be bringing home the questionnaire regarding sleep habits, activity, behaviour and general health for the last time. So, if you didn‟t get a chance to fill it out the first time, it is not too late to be involved. It only takes a few minutes to complete and then just return it to school with your child.

Whether your child sleeps soundly or not, the information you provide will be invaluable in improving the understanding of the link between sleep, health and daytime functioning.

Don‟t sleep on it. Fill out your questionnaire and be a part of improving the future health and well-being of children in South Australia.

All completed questionnaires must be returned by Friday 7 Sept.

Appendix E
SAPSS-Q SLEEP DISTURBANCE PROFILE - MALE

NAME: ______________________________

IDCODE: ______________

DATE: ____/____/____

DOB: ____/____/____

A T-score above 70 is considered in the problem range

T	Younger (5-7 years)						Older (8-10 years)					
	SR	BA	MT	NA	SDB	RS	SR	BA	MT	NA	SDB	RS
100+								12		11+		
99												
98												
97										10		
96	17+							11				
95							18					
94												
93	16		12									
92							17			9		
91								10				
90	15										11+	
89							16					
88			11									
87	14			10+	10+							
86		12					15	9		8	10	
85												12
84			10									
83	13	11			9		14		12			
82				9				8				
81						11+					9	11
80	12						13			7		
79		10	9						11			
78					8	10						
77	11			8			12	7			8	10
76		9							10			
75			8							6		
74	10				7	9	11					
73				7				6			7	9
72		8							9			
71	9		7				10					
70						8						
69		7			6					5		8
68				6			9	5	8		6	
67	8											
66			6			7						
65		6			5		8		7			7
64	7									4	5	
63				5				4				
62			5			6	7					
61	6	5			4				6			6
60											4	
59				4			6	3				
58	5	4	8			5				3		
57									5			5
56					3		5					
55											3	
54	4	3		3		4		2				
53			3				4		4			4
52					2					2		
51	3	2									2	
50						3	3	1	3			
49			2	2								3
48	2											
47		1			1		2			1	1	
46						2			2			
45				1				0				2
44	1	0	1				1					
43					0							
42						1			1		0	
41	0						0			0		1
40			0	0								
39						0			0			
38												
37												0

SAPSS-Q SLEEP DISTURBANCE PROFILE - FEMALE

NAME: ______________________________

IDCODE: ______________

DATE: ____/____/____

DOB: ____/____/____

A T-score above 70 is considered in the problem range

	Younger (5-7 years)						Older (8-10 years)					
T	SR	BA	MT	NA	SDB	RS	SR	BA	MT	NA	SDB	RS
100+					12					9+	12	
99												
98				12								
97					11						11	
96												
95								12				
94										8		
93				11							10	
92					10							
91	14+							11				
90												
89												
88	13			10						7	9	
87					9		14+	10				12
86												
85			12									
84	12	12		9		12	13					11
83											8	
82			11		8			9	12			
81		11				11	12			6		
80	11											10
79				8								
78			10		7			8	11		7	
77	10	10				10	11					
76												
75									10			9
74		9	9	7			10	7		5		
73	9				6	9					6	
72												
71							9		9			8
70		8						6				
69	8		8	6		8						
68					5					4	5	
67		7					8		8			7
66	7		7									
65						7		5				
64		6		5			7		7			
63					4						4	6
62	6		6									
61						6	6	4		3		
60		5							6			
59	5			4								5
58			5		3						3	
57		4				5	5	3	5			
56												
55	4			3						2		
54		3	4				4					4
53					2	4		2	4		2	
52	3											
51			3				3					
50		2		2		3			3			3
49												
48	2				1			1		1	1	
47		1	2				2					
46						2			2			2
45	1			1								
44		0					1	0			0	
43			1		0							
42						1			1			1
41	0						0			0		
40				0								
39			0									
38						0			0			0
37												