Exploring the association between perceived excessive daytime sleepiness in children and academic outcomes

Beris Ludwig, Simon S. Smith
University of Queensland, Australia
Helen Heussler
University of Queensland, and Queensland Children's Hospital, Australia

Excessive daytime sleepiness (EDS) in children has been associated with a number of problems. In contrast to adults who experience EDS and who may fall asleep or doze when in a monotonous or boring situation, children with EDS may present as hyperactive or poorly behaved. This community-based study aims to identify the prevalence of EDS in children from three perspectives: parent report, self-report, and teacher report. The study also explores the association between EDS and academic outcomes in children. The participants were 365 students (161 males) aged 4-12 years, their parents, and their teachers at a regional school. Academic outcomes were based on each student's school grades at the conclusion of the semester in which the community-based survey was administered. Using a cutoff score of 15 or greater on the PDSS, 113 (31%) students were identified by at least one respondent as displaying or experiencing EDS. EDS as observed by teachers using the PDSS was found to be associated with the student's academic outcomes, higher sleepiness scores being associated with poorer academic outcomes. Our findings suggest that the prevalence of EDS in a community setting may be higher than previously identified.

Introduction

Hypersomnolence or excessive daytime sleepiness (EDS) in children has been associated with a number of problems at home and school. These include an association with increased anxiety (Alfano, Patriquin & De Los Reyes, 2015), depression (Zhou, Siu & Tse, 2015), poor behaviour (Calhoun, Vgontzas, Fernandez-Mendoza, Mayes, Tsaoussoglou, Basta & Bixler, 2012), and inattention (Avis, Gamble & Schwebel, 2014). Children and adolescents with clinical sleep disorders such as narcolepsy and idiopathic hypersomnia characteristically experience hypersomnolence or EDS, with research finding clear associations between their EDS and problems with academic outcomes, behaviour and emotion (Ludwig, Smith & Heussler, 2018). The extent to which EDS impacts academic outcomes in children without a clinical sleep disorder is not as well known.

A major challenge in understanding the nature and magnitude of these links has been the definition and understanding of EDS. The *International Classification of Sleep Disorders, Third Edition* (American Academy of Sleep Medicine, 2014) defines EDS as "the inability to stay awake and alert during the major waking episodes of the day, resulting in periods of irrepressible need for sleep or unintended lapses into drowsiness or sleep; [whilst] the term hypersomnolence is used to describe the symptom of excessive sleepiness" (p. 143). Due to the use of a variety of different sleepiness surveys, multiple working definitions, and variance across and also within populations, the prevalence of EDS in populations of children has been found to range from 2% to as high as 25% (Calhoun et al., 2011; Li et

al., 2013; Neveus, Cnattingius, Olsson & Hetta, 2002; Saarenpaa-Heikkila, Rintahaka, Laippala & Koivikko, 1995; C.-K. Yang, Kim, Patel & Lee, 2005; Zhou et al., 2015).

Determination of daytime sleepiness in children is frequently conducted through parent reporting of the child's history, or via the use of standardised self-report scales such as the *Pediatric Sleep Questionnaire* (PSQ; Chervin, Hedger, Dillon & Pituch, 2000), the *Sleep Self Report* (SSR; Owens, Spirito, McGuinn & Nobile, 2000) or the *Pediatric Daytime Sleepiness Scale* (PDSS; Drake et al., 2003; Nixon, Wawruszak, Verginis,; & Davey, 2006; Vlahandonis, Nixon, Davey, Walter & Horne, 2013). These investigative approaches are generally utilised in a medical setting, with neither parent report nor self-report scales consistently adapted for use in education settings.

Children with EDS may not explicitly realise they are tired. However, their behaviour may reflect their efforts to stay awake in the context of a developmentally limited ability to utilise executive functions such as inhibition (Horne, 2012; Rossa, Smith, Allan & Sullivan, 2014). In contrast to adults who experience EDS and who may fall asleep or doze when in a monotonous or boring situation, children with EDS may display increased hyperactivity, inattention, impulsivity and poor behaviours (Hoban & Chervin, 2001; Mindell & Owens, 2015). A change in the presentation of EDS between pre-adolescence and adolescence may not be recognised or understood by parents and educators; nor might the impact of EDS upon academic outcomes in these different populations. In the adult population, EDS impacts directly upon safety and performance at work (Philip, Chaufton, Nobili & Garbarino, 2014). In a population of children and adolescents, their 'work' is attending school for educational purposes. Exploring the impact of EDS on academic outcomes in children is therefore an essential area of investigation.

Seven investigations into the specific associations between EDS and academic outcomes in children (5-12 year old) have been identified. Table 1 summarises those findings. As can be seen from the table, the prevalence of EDS identified in these studies varies from 4% through to 25.4%, with a variety of instruments being utilised. The authors of the latter study, Li et al. (2013), suggested that the high prevalence of EDS in their population was due to the shorter sleep time experienced by Chinese children compared to their American counterparts. An association between EDS and poor academic outcomes was found in a number of those studies. All seven studies asked parents to complete observations on their child's sleepiness, and only one of those also asked the children themselves to report their own perceptions (Liu et al., 2016).

Child self-reports have been used in other studies exploring daytime sleepiness (Saarenpaa-Heikkila et al., 1995; C.-K. Yang et al., 2005); however, it appears the majority of studies ask parents to complete the surveys as observers of their child's sleep-associated behaviours. Concerns have been raised regarding how well parents might identify their child's EDS, as it appears to be more conspicuous if the child also displays poor behaviours (Perfect, Levine-Donnerstein, Archbold & Goodwin, 2014). These poor behaviours may occur more frequently during the day when there is less parental observation possible, such as when the children are at school, or the parents at work or busy with demands in the home. Poor behaviours also may be context dependent, that is,

responsive on the demands associated with specific tasks, such as when learning new concepts or during assessment. Academic outcomes associated with EDS have been identified through simple parent questionnaires (Blunden & Chervin, 2009; Calhoun et al., 2012; Ng et al., 2005), teacher questionnaires (Bruni et al., 2006; Li et al.), and formal academic grades (Liu et al., 2016). Only one study used a standardised achievement test as a measure of academic outcome (Perfect et al., 2014).

Table 1: Summary of findings of the association between EDS and academic outcomes in children in the general population

Authors (Year)	N (% boys)	Age range	EDS assessment	Academic assessment	Findings
Blunden & Chervin (2009)	50 (54%)	7.01-11.11 years	Sleep Disturbance Scale for Children (SDSC) [completed by parent]	3 questions relating to school performance [completed by parent]	EDS: 20% of indigenous children; 16% non-indigenous children. No relationship found between EDS and school performance.
Bruni et al. (2006)	264 (53.4%)	8-11 years	Sleep Disturbance Scale for Children (SDSC) [completed by parent]	Academic Achievement subscale from Teacher School Achievement Form (TSAF) [completed by teacher]	EDS: prevalence not reported. School achievement index (from TSAF) negatively correlated to disorders of excessive somnolence.
Calhoun et al. (2012)	508 (51.8%)	6-12 years	Pediatric Sleep Questionnaire (PSQ) [completed by parent]	Learning Problems subscale from Pediatric Behavior Scale (PBS) [completed by parents]	EDS: 15.2% Learning problems reported by 57% of children reported as having EDS.
Li et al. (2013)	606 (51%)	Time 1: Mean age: 6.80±0.31 years Time 2: Mean age: 10.80±0.30 years	Children's Sleep Habits Questionnaire (CSHQ – Chinese version) [completed by parent]	Academic Achievement subscale from Teacher School Achievement Form (TSAF) [completed by teacher]	Time 1: EDS: 21% Daytime sleepiness was associated with poor academic achievement. Time 2: EDS: 25.4% Daytime sleepiness was associated with poor academic achievement.
Liu et al. (2016)	3768 (52.2%)	Mean age 10.99±0.90 years	Children's Sleep Habits Questionnaire (CSHQ Chinese ver.) [completed by parent]; Self-report sleep and health questionnaire [completed by children]	School performance on three subjects [Chinese, Math, English] for last semester [completed by teacher]	EDS: prevalence not reported Daytime sleepiness was associated with poor school performance.

Ng et al. (2005)	3047 (56.8%)	Mean age: 8.90±1.72 years Age range: 6-12 years	Tucson Children's Assessment of Sleep Apnea (TuCASA) [modified] [completed by parent]	Parents reported academic results from preceding school term	EDS: 6.7%. EDS indicators of *'falling asleep during a lesson'* and *'falling asleep while doing homework'* were each assoc-iated with poor academic results.
Perfect et al. (2014)	503 (50.8%)	6.0-12.3 years	Sleep Habits Questionnaire (SHQ) [completed by parent]	Academic abilities assessed using the standardised Woodcock Johnson Tests of Achievem-ent III (WJ III ACH)	EDS: 14.4% EDS was associated with lower grades.

Six of the seven investigations summarised in Table 1 explored the prevalence of EDS without examining any possible causes, which could include primary snoring, sleep apnea, sleep deprivation due to behavioural causes, circadian rhythm disorders, environmental causes such as sharing a bedroom or having a shift worker in the home, or a central disorder of hypersomnolence. In children, primary snoring, sleep apnea and sleep deprivation due to behavioural causes, including technology use, are all relatively common (Muller, Signal, Elder & Gander, 2017; National Sleep Foundation, 2004, 2014). The Ng et al. (2005) study explored some of the possible causes of EDS through the questionnaire they used, a modified version of the *Tucson Children's Assessment of Sleep Apnea* (TuCASA). They were able to identify prevalences of sleep behaviours such as habitual snoring (10.9%), witnessed sleep apnea (1.5%), teeth grinding (20.5%), nocturnal enuresis (5.3%), asthma (10.3%), and allergic rhinitis (40.8%), and each of these associations to EDS.

There appears to be a strong association amongst habitual snoring, EDS and poor academic outcomes. The Brockmann, Bertrand, Tinidad Pardo, Cerda and Holmgren (2012) study (N = 523, age range 7-17 years) found that habitual snorers (18.2%) were more likely to have EDS and their academic outcomes were significantly lower than children who had never snored. Other studies have also found an association between habitual snoring, EDS and academic outcomes (Sahin et al., 2009; Urschitz et al., 2004). As with the seven studies discussed earlier, these studies also used a variety of instruments to assess EDS.

Further investigations of perceptions of EDS from a number of perspectives using a strong and validated measure are required. An examination of the association between those data and formal academic outcomes is also essential to understand the role of EDS in the lives of young children. Investigating the prevalence of EDS from the perspectives of parents, the children themselves, and from their teachers would give insight into whether EDS is readily identifiable in children as well as the degree of congruity amongst the three perspectives.

The community-based study reported in this paper aimed to identify the incidence of EDS in children from three perspectives: parent report, self-report, and teacher report. To

date, few studies have explored the alignment of parent/carer observations of a child's daytime sleepiness with the child's self report (Saarenpaa-Heikkila et al., 1995), and no studies have explored reports from three perspectives. This study utilised a naturalistic approach; that is, identification of EDS in the context of a school day. The study also aimed to explore the association between perceived EDS using a standardised measure and formal academic outcomes in children.

Method

Ethical issues

This project was approved by the University of Queensland Human Research Ethics Committee A [Approval Number 2016001471] and by the Queensland Government Department of Education and Training [File Number 550/27/1804].

Design

This exploratory study utilised a cross-sectional design to gain information about children's daytime sleepiness at one specific point in time.

Participants

We invited all students (aged 4-12 years), their parents/carers, and their teachers at a large regional primary school (N=727) in Queensland, Australia to participate in a study. 'Parents/carers' are defined as adults directly responsible for the care of the child. The term 'parents' will therefore be used as the universal term throughout this report. All students were eligible to participate, with no exclusion criteria applied. Further details of the participants in this study can be found in the report on how well children understand the vocabulary associated with sleep (Ludwig, Heussler & Smith, 2019).

Materials

The *Pediatric Daytime Sleepiness Scale* (PDSS) was developed by Drake et al. (2003) as a measure of daytime sleepiness for use by middle-school children, that is, children aged 11 through to 15 years. It has subsequently been translated and validated for use with a number of populations including Chinese (C.-M. Yang, Huang & Song, 2010), Spanish (Perez-Chada et al., 2007), Korean (Rhie, Lee & Chae, 2011), and Turkish (Bektas et al., 2016). The PDSS has also been utilised with elementary school children age 5 to 12.9 years (Nixon et al., 2006; Vlahandonis et al., 2013). The PDSS has eight questions which are scored from 0 through to 4. The maximum PDSS score can therefore be 32 with a cutoff equal to or greater than 15 being used to determine EDS for this research, following findings by Meyer et al. (2018).

As the PDSS was to be used by children as young as four years of age, a modification was included to support the five-point Likert scale of 'never' to 'always'. The modification consisted of faces representing the various states of sleepiness from being fully asleep to

fully awake. These faces were developed by Maldonado, Bentley and Mitchell (2004) to be used in clinical and research settings to support people who were too young or not well educated to report their level of sleepiness. In the current study, parents were requested to read and explain the meaning of each question to younger children or to those who may not fully comprehend the intent of the questions. All eight PDSS items were included on the student scale.

The parent version of the PDSS was the same as the original with a slight modification of the language to reflect the parents answering the scale, based on observations of their children's presentation. For example, Question 4 asks *"How often are you ever tired and grumpy during the day?"* The parent modification read: *"How often is your child ever tired and grumpy during the day?"* As the full version contained questions regarding sleep/wake behaviours of children at home, the teacher version was modified to reflect the difference and thus contained only three of the original questions, including Question 4: *"How often is this child ever tired and grumpy during the day?"* Two additional questions dealing with the parent or child discussing bedtime behaviours with the teacher and a subjective question (*"Do you think this child is getting enough sleep?"*) were included to complete the scale at only six questions. Total scores of the four questions associated with the PDSS were then weighted to produce a score enabling comparisons with the parent and child self-report responses.

Academic outcomes were based on each child's school grades at the conclusion of the semester in which the community-based survey was administered and were provided by the school principal, to ensure formal outcomes were captured. Grades in each of the key learning areas range from A (highest) through to E, and are derived from the Foundation-Year 12 Australian Curriculum guidelines. The key learning areas of English, mathematics and science were used to reflect academic outcomes. For statistical analysis, scores were assigned from one through to six, with one being allocated for A in the three core subjects, through to six being allocated for a range of C, D, and/or E. Effort was similarly ranked, with scores assigned from one through to five, with one being allocated for effort in all three learning areas being in the very High (Years 1 and 2) or Excellent (Years 3 to 6) range, and five being allocated for effort in the Support Required (Years 1 and 2) or Unacceptable (Years 3 to 6) range. Effort is a subjective rank assigned by the teacher and reflects how well the student is considered to be engaging with the expected learning, and is a 'standard' education measure in the Queensland education system.

Background data were collected on each parents' highest level of education, employment status, and annual family income. Data were not collected on family structure, cultural or linguistic backgrounds.

Procedure

One week prior to distribution of the surveys, the researcher (BL) outlined the study rationale and process at a whole school assembly to which parents had also been invited. The researcher also attended a staff meeting and explained the purpose of the research. Students and parents were provided with information sheets and the surveys in labelled

sealed envelopes for completion at home. A checklist of contents was provided on the front of the envelope to assist parents in ensuring all forms were completed and returned.

Prior to completing the PDSS, each parent was asked to carefully read the participant information sheet and complete a consent form. They were then asked to assist their child to read the participant information sheet for children and assist their child in signing their consent form. The teacher information sheets, consent forms, and modified PDSS surveys were distributed at the staff meeting.

The children and their parents were given one week to return the forms that were distributed on a Friday. The quick turn-round was designed to ensure completion of the forms was prioritised in family households that are frequently busy on school afternoons. Following the return of the forms, a list of parents who had given permission for teachers to complete surveys on the children was generated and distributed to the class teachers. The parents also completed demographic information and their children's academic outcomes. To ensure parents did not accidentally or deliberately report higher academic and effort outcomes, the school principal provided the formal academic and effort outcomes for all participating students for the semester in which this survey was completed.

Statistical analysis

All analyses were done with statistical software, *SPSS for Macintosh* V25.0 (IBM, 2017).

Results

The final sample consisted of 365 students (161 males) out of a school enrolment of 727 (50%), 352 of those student's parents, and by 21 teachers. Students ranged in age from 4 years 9 months through to 12 years. This large regional school has a diverse student population, with either the mother or father's highest level of education ranging from Year 9 through to postgraduate tertiary qualifications. Employment information was also captured. Annual family income ranged from $AU25,000 through to $AU400,000, suggesting a wide socio-economic range.

The overall results for prevalence of EDS are summarised in Table 2. Pearson correlation analysis was used to explore associations between parent observed PDSS scores, children's self-reported PDSS scores, and teacher observed PDSS scores, and to test if a child's EDS was associated with snoring, their academic outcomes or effort (Table 3). Parent observed PDSS scores and their children's self-reported PDSS scores were significantly strongly correlated, and both scores were correlated with whether the child was a snorer. A child's EDS as observed by their parent or through self-report was found to be weakly associated with poor academic outcomes; however, teacher reported EDS appears to be strongly associated with some aspect of their students' poor academic outcomes. This association was further investigated using simple regression analysis that found teacher reported EDS using the PDSS predicted 10.3% of the variance in a child's academic outcomes, $F(1, 254) = 30.133$, $p < .001$. Snoring was not correlated with either

academic outcomes or with effort. Significant associations were also found between effort and self-reported and teacher-reported PDSS scores.

The parent and child self-report PDSS scores were each asymmetrically skewed to the right, indicating slight positive skewness; although the overall curve was reflective of a normal curve. The skewness for teacher-reported PDSS scores on the same students was extremely asymmetrically skewed to the right, and was not reflective of a normal curve (see Figure 1).

Table 2: Excessive daytime sleepiness according to age and respondent; showing number of children who were surveyed and subsequent number with PDSS ≥ 15.

		4-5 yrs	6 yrs	7 yrs	8 yrs	9 yrs	10 yrs	11-12 yrs	Total
Parent on their child	*n children* (boys)	60 (21 boys)	45 (24 boys)	39 (15 boys)	52 (21 boys)	62 (29 boys)	50 (20 boys)	44 (21 boys)	352 (151 boys)
	EDS (%)	4 (7%)	6 (13%)	5 (13%)	9 (17%)	9 (15%)	4 (8%)	7 (16%)	44 (12.5%)
Child self-report	*n children* (boys)	61 (23 boys)	45 (24 boys)	44 (17 boys)	53 (22 boys)	64 (31 boys)	53 (22 boys)	45 (22 boys)	365 (161 boys)
	EDS (%)	11 (18%)	13 (29%)	10 (23%)	13 (25%)	21 (33%)	12 (23%)	7 (16%)	87 (24%)
Teacher report on the child	*n children* (boys)	47 (17 boys)	38 (18 boys)	26 (12 boys)	38 (15 boys)	49 (23 boys)	43 (21 boys)	20 (9 boys)	261 (115 boys)
	EDS (%)	5 (11%)	0 (0%)	3 (12%)	3 (18%)	7 (14%)	3 (7%)	1 (5%)	22 (8%)

Table 3: Pearson correlations between PDSS scores for each respondent group and child's snoring, academic outcomes and effort

	PDSS parent (*N* = 352)	PDSS child (*N* = 365)	PDSS teacher (*N* = 261)	Snoring	Academic outcomes	Effort
PDSS parent		.706**	.114	.227**	.117*	.097
PDSS child			.113	.124*	.107*	.186**
PDSS teacher				.122	.326**	.361**
Snoring					.037	.046
Academic outcomes						.666**

Note: Academic outcomes were scored with higher scores reflecting poorer outcomes (i.e., 1 = all As).

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

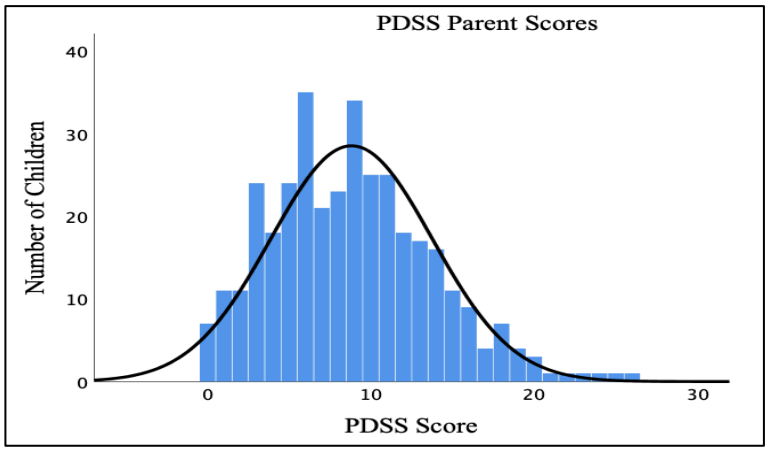

Figure 1a: PDSS parent scores

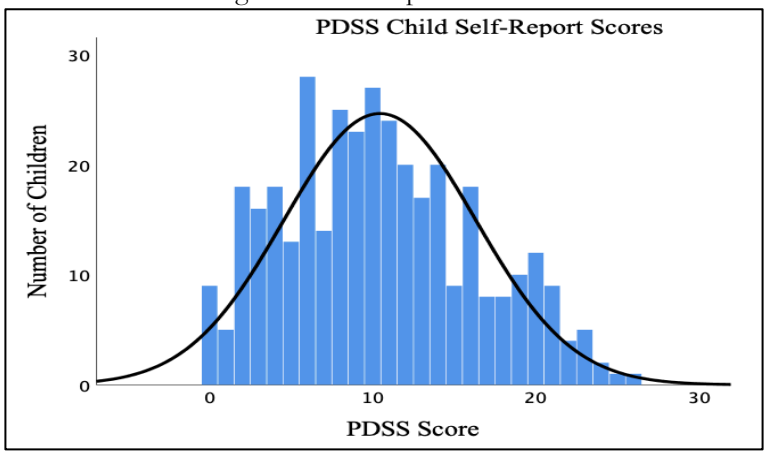

Figure 1b: PDSS child self-report scores

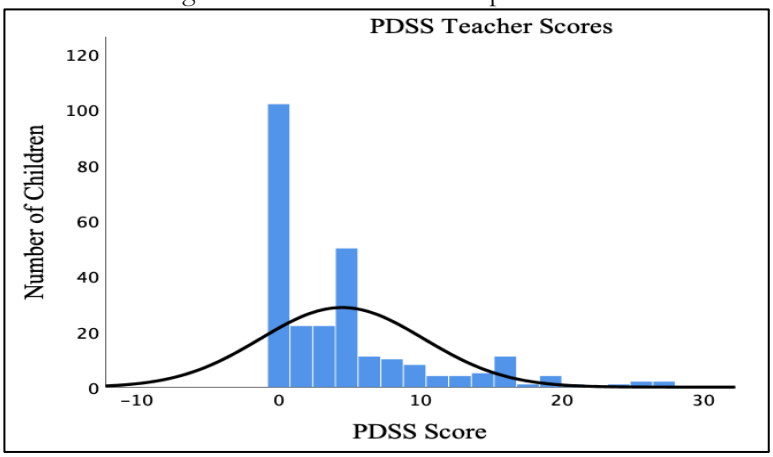

Figure 1c: PDSS teacher scors

Figure 1: Distribution of PDSS scores according to respondent

Table 4 explores the numbers of children identified as having a PDSS score ≥ 15 by one, two or all three respondents. Overall, 113 children were identified with EDS by at least one respondent; however only four children were identified as exhibiting EDS by all three respondents. As can be seen from the table, 51 children self-reported EDS but neither their parents nor their teacher identified them as displaying EDS. Interestingly, their teachers identified 14 children with EDS; however, neither those children nor their parents identified symptoms of EDS according to the PDSS.

Table 4: Number of children with EDS (defined by PDSS ≥ 15) according to respondent groups (*N*=113)

	Parents	Children	Teachers	All three respondents
Parents	10 a	29	1	
Children		51 b	4	
Teachers			14 c	
All respondents				4

Note: [a] 10 children identified with PDSS ≥ 15 by parents only
b 51 children identified with PDSS ≥ 15 self-report only
c 14 children identified with PDSS ≥ by teachers only

Further exploration of the data through gender associations was also conducted. Table 5 presents the results of these investigations. As can be seen from the table, gender did not alter the findings of total population correlations as outlined in Table 3.

Table 5: Gender-based correlations between PDSS scores and academic results

	Parent (*n*)	Child (*n*)	Teacher (*n*)
Girls	.156* (*n*=199)	.138 (*n*=199)	.347** (*n*=143)
Boys	.068 (*n*=151)	.060 (*n*=159)	.311** (*n*=113)

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Explorations were also undertaken to determine whether income, as indicated by socio-economic status, was associated with sleepiness, academic outcomes and effort. There was a weak significant negative correlation between teacher reported sleepiness and income, that is, greater sleepiness being weakly associated with lower income (r = -.152, n = 192, p = .035); and a significant but small correlation between academic outcomes and income, higher academic outcomes being weakly associated with higher income (r = .211, n = 270, p = <0.01).

Discussion

This community-based study was designed to build upon current knowledge of prevalence of EDS in pre-adolescent children and to identify any associations between EDS and academic outcomes in this population.

In our school population sample, the prevalence for EDS was identified as 12.5% by 352 parents. This is comparable to parent-reported EDS prevalence in other Western populations including Pennsylvania (15% of 508 children, Calhoun et al., 2011), Arizona (14.4% of 503 children, Perfect et al., 2014) and Australia (18% of 50 children, Blunden & Chervin, 2009). Parent-reported prevalence of EDS differed in Asian countries, with a prevalence of 25.4% of 606 children in Shangai, China (Li et al., 2013). Our sample of 365 children self-reported an EDS prevalence of 24%. This differs significantly to prevalence self-reported elsewhere with a range from 2.1% of 525 children in Korea (C.-K. Yang et al., 2005), 7.42% of 911 children in Hong Kong (Zhou et al., 2015), through to 17% of 161 children in Finland (Saarenpaa-Heikkila et al., 1995). These differing results from around the world may reflect differences in methodologies, scales, and culture (refer to Table 1). In the age group for this study, parents are still generally monitoring bedtime and bedtime behaviours, ensuring an adequate night's sleep (Pyper, Harrington & Manson, 2017).

Of greater interest in this study is the disparity of prevalence of EDS (PDSS $\geq$ 15) reported by parents, children, and teachers. Teacher reports identified only 8% of their students as demonstrating characteristics of EDS as identified using the PDSS. The lower prevalence identified by teachers could be due to how well the teachers know each student and their typical behaviours in the classroom, resulting in a more specific characterisation or attribution. Alternatively, this difference may reflect an underestimation of sleepiness by teachers, and points to a need for teachers to be better trained to identify the signs of EDS in children. Finally, this difference may reflect the way that a sleepy child interacts, adapts or compensates for sleepiness in the overall social context of the school setting. No previous study has explored these three perspectives of observed EDS, so these explanations remain speculative.

The findings do direct a number of future research possibilities. One possibility is that the parents know their child better than do teachers, and this would further support the strong association between parent PDSS scores and child self-report PDSS scores. The distribution curves for each set of PDSS scores (Figure 1) is also suggestive of a differential response style from the teachers. It would be expected that the distribution of scores would reflect that of a normal curve, as do the parent-reported and self-reported PDSS score distributions. The distribution for teacher-reported PDSS scores is not reflective of a normal curve. Out of the 261 teachers who completed the PDSS surveys on their students, 39.2% did not observe any behaviours indicative of EDS. This is further suggestive that either the teachers require education prior to completing the surveys or that the PDSS is not a sensitive enough instrument for use in an educational setting.

With 113 children identified as having EDS by at least one respondent, the overall EDS prevalence for the school population of children aged 4 to 12 years could be 31%. If that proportion of children are truly experiencing EDS, then teachers could be attempting to manage poor focus and attention behaviours for at least one quarter of their class each day.

Although the parent and child self-report PDSS scores do not suggest EDS has a strong negative impact on children's academic outcomes or effort, the teacher observations

suggest that EDS is a factor requiring consideration. It is therefore essential that parents and teachers be alerted to the negative impact that EDS may have on children's learning and ability to learn. As the teacher's observed PDSS score was the only score to demonstrate a moderate impact on their students' academic outcomes and effort, it is questioned whether hypersomnolence in children is more easily identified when children are challenged, such as when they are undertaking assessment tasks, and thus having to focus and attend.

The associations between EDS, snoring, academic outcomes and effort were also explored. This study found an association between parent-reported and self-reported PDSS scores and snoring, but not between teacher-reported PDSS scores and snoring. The former is reflective of previous research in this field; however, associations between teacher-reported EDS and snoring have not been adequately researched to date. This research did not reflect findings of previous research in identifying associations between snoring and academic outcomes, and snoring and effort. There was only one question relating to snoring on the questionnaire and this was phrased in a similar manner to the eight PDSS questions on the parent survey: *How often does your child snore or have difficulty breathing at night?* The same five-point Likert scale was used for this question as well.

Limitations

There were a number of limitations with this study. As a community-based study, motivation to complete and return surveys is dependent on individual families and their opinion regarding giving what is essentially confidential information. Although sleep is not a commonly discussed topic, disclosing information about bedtime behaviours can be sensitive. Parents had been reassured that results would be anonymous and group data only would to be published; however, some concerns were still expressed regarding confidentiality. Despite these variables a 50% return rate was typical for community-based studies in disciplines associated with health or psychology (Carley-Baxter et al., 2009). Providing an opt in / opt out option for this survey may have also unconsciously provided a bias in support of parents who are generally more involved in and observant of their children's lives. To overcome the issue of non-participation by sleepy children, teachers could have been asked for an overall number of how many children in their class could be considered as sleepy. Alternatively, teachers could have been asked for broad classroom-based behavioural observations with full de-identification to ensure anonymity. These options have not been identified in other community-based research and could provide an additional source of data for future research.

Self-report and observational studies also introduce a risk of rater bias, as the study focused on symptoms of EDS as defined by the PDSS. Further naturalistic studies which explore aspects such as the differences between EDS during the week and on week-ends, does EDS increase across the week, is EDS related to sleep duration, and times of day which are more associated with EDS could better support the understanding required for educational programs. Contemporary sleep science is moving towards a more naturalistic view of sleep exploration within the community, and associated sleep education for parents, teachers, and general practitioners is required.

Directions for research

Given the lack of strong associations between each of the parent and self-reported surveys and academic outcomes for each child, using the PDSS in this elementary school age group may not be an accurate reflection of children's sleepiness. Development of a simpler sleepiness scale for use with this age group, ensuring use of simpler and 'plain language' vocabulary, along with single constructs for each question is necessary (Ludwig, Heussler & Smith, 2019). In addition, motivation for alertness will influence the response, as children will be motivated to stay alert for subjects in which they are more interested, and conversely may feel sleepier in subjects in which they struggle. The processes of 'effortful control' and motivation may modify the impact of EDS at certain times during the school day (Roeser, Schlarb & Kubler, 2013). Diaz et al. (2017), for example, found that 'effortful control' moderated the association between multiple aspects of sleep such as sleep duration and academic achievement (N = 103, age range 4.5-7 years). EDS was not one of the sleep aspects assessed, although sleep duration was, and was significantly associated with effortful control. 'Effortful control' as well as day-to-day variation in routine, effects associated with the day of week, and responses to the previous night's sleep may modify the effect of EDS on academic outcomes. Further investigation of these modifiers in this age group is warranted. Development of a scale that looks specifically on the impact of EDS on classroom behaviours, and focus, attention, and outcomes for key subject areas as well as the social aspects of a school day would provide deep insights and guide interventions.

To our knowledge, this is the first study that has attempted to conduct this breadth of investigation into EDS. The high incidence of EDS identified in this population is a concern and suggests that exploration of the causes of EDS is necessary, as is education regarding the importance of a healthy night's sleep. This study highlights the need for further research to better understand the range of educational, and broader emotional, behavioural, and social impacts excessive daytime sleepiness has on children.

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Beris Ludwig (corresponding author) is a psychologist in private practice and is currently completing a PhD through the University of Queensland. Her research interests include the learning implications of children and adolescents with hypersomnolence, and the impact of sleepiness on children's intellectual, academic, behavioural and emotional functioning.
Email: beris.ludwig@uq.net.au

Dr Simon S Smith is an Associate Professor at the Institute for Social Science Research (University of Queensland) within the Child Development Education and Care Group. He is a psychologist who works to understand the role of sleep and circadian rhythms in a healthy, safe, and productive life.
Email: simon.smith@uq.edu.au
Web: https://researchers.uq.edu.au/researcher/15205

Dr Helen Heussler is an Associate Professor with the Child Health Research Centre (University of Queensland) and a developmental and behavioural paediatrician with a dual qualification in sleep medicine. Her clinical work involves children with a variety of developmental and behavioural problems as well as clinics that specialise in sleep disorders.
Email: h.heussler@uq.edu.au
Web: http://researchers.uq.edu.au/researcher/7226

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