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Original Research

Sleep problems in children and adolescents in an attention deficit hyperactivity disorder service

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Abstract

Objectives: Sleep problems are common amongst children and adolescents with attention deficit hyperactivity disorder (ADHD). The purpose of this study was to investigate sleep problems in children and adolescents attending a specialist ADHD service.

Methods: This was a cross-sectional online survey combined with a retrospective chart review, conducted in the ADHD Assessment, Diagnosis, Management, initiation, Research and Education (ADMiRE) service, the first public specialist ADHD service for young people in Ireland. Participants were caregivers of children and adolescents with ADHD attending ADMiRE. Sleep was assessed using The Children's Sleep Habits Questionnaire (CSHQ) and ADHD symptoms were assessed using an abbreviated version of the Swanson, Nolan and Pelham Teacher and Parent Rating Scale (SNAP-IV). Details regarding patient demographics, co-morbidities and medication were collected from patient records.

Results: Eighty-four percent of young people scored above the clinical cut-off for a sleep disorder. The most frequently reported sleep problems were related to sleep onset and sleep duration, and 64% of respondents met the criteria for two or more sleep problems. ADHD severity was associated with greater sleep problems. Co-morbid physical, neurodevelopmental, and mental health disorders as well as stimulant use were not associated with greater sleep problems.

Conclusion: Sleep problems are very common amongst children and adolescents with ADHD. This study has demonstrated an association between more sleep problems and ADHD severity. These findings highlight the need for both effective ADHD treatment to ensure optional sleep in young people as well as effective interventions for sleep problems to prevent worsening of ADHD symptoms.

Keywords: ADHD; children; adolescents; sleep

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Introduction

Attention Deficit Hyperactivity Disorder (ADHD) is a neurodevelopmental disorder characterised by core psychopathological features of inattention, hyperactivity, and impulsivity. In Ireland, ADHD is the most common primary presentation to child and adolescent mental health services (CAMHS), with more than 30% of new patients endorsing it as their main ailment (Health Service Executive 2013). Untreated ADHD is associated with poor educational and occupational outcomes (Kuriyan *et al.*, 2013), interpersonal and family difficulties and maladaptive psychological and physiological traits (Posner *et al.*, 2020).

Sleep is a complex and dynamic biological process where the level of consciousness and sensory activity is phasically and reversibly altered (Mesarwi *et al.*, 2013). There are multiple stages of sleep, including rapid eye movement (REM) and non-REM stages. Sleep supports many key physiological and psychological processes such as innate and adaptive immune responses, metabolism, memory consolidation, and affective, executive, and cognitive function (Zielinski *et al.*, 2016). Sleep also plays an important role in child development and inadequate sleep is linked to deterioration in mental and physical health (Sutton 2014), neurocognitive functioning (Fortier-Brochu *et al.*, 2012), social functioning (Shochat *et al.*, 2014) and academic performance (Dewald *et al.*, 2010).

Sleep problems are commonly reported in children, young people, and adults with ADHD (Bondopadhyay *et al.*, 2022; Coogan and McGowan 2017; Wynchank *et al.*, 2018; Turan and Akay 2020). For young people with ADHD, the odds of having sleep problems are 6.2 times greater compared to young people without ADHD (Becker *et al.*, 2019). Sleep problems may aggravate "core" ADHD symptoms including impulsivity and inattention (Schneider *et al.*, 2016) and disruptions to the sleep-wake cycle can cause "social jetlag," worsening the cognitive and social implications of ADHD (Raman and Coogan 2019). Conversely, ADHD symptoms such as impulsivity and associated difficulties such as poor decisions regarding bedtime may contribute to sleep problems in ADHD (Raman and Coogan 2019). Prevalence rates of sleep disorders in children and adolescents with ADHD are reported to range from 25 to 85% (Fisher *et al.*, 2014; Hvolby 2015; Sung *et al.*, 2008; Wajszilber *et al.*, 2018; Yürümez and Kılıç 2016). Children and adolescents with

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both ADHD and sleep disturbances have been found to have poorer academic and social outcomes compared to those with ADHD alone (Bartholomew and Owens 2006).

Although sleep difficulties in young people with ADHD are common, they remain incompletely understood (Kirov and Brand 2014; Gruber 2009) and there are inconsistencies in the literature regarding the types of sleep disturbances associated with ADHD symptoms and subtypes (LeBourgeois *et al.*, 2004; Kirov and Brand 2014). It is, therefore, challenging for ADHD clinical services to recognise and manage sleep disturbances effectively in their young patients using an evidence-based approach. As such, there is a strong imperative to further research in sleep problems within CAMHS to better serve the needs of children and adolescents with ADHD.

The overall aim of this study was to enhance our understanding of sleep problems in children and adolescents with ADHD and to inform the development of improved recognition and management strategies in a specialist ADHD service. There were three objectives. (1) assess the sleep of children and adolescents with ADHD attending a specialised ADHD service in Ireland, using a validated and comprehensive sleep questionnaire; (2) cross reference sleep features with demographic features derived from clinical records; and (3) to explore associations between sleep problems and ADHD subtypes and severity, co-morbid disorders, and medications.

Methods

Study design

This is a cross-sectional between-groups study design using quantitative measures. Data were collected between May and October 2021.

Participants

All parents/guardians of children and adolescents with a diagnosis of ADHD who were attending an ADHD specialist service in Ireland (ADHD Assessment, Diagnosis, Management, initiation, Research and Education (ADMiRE)), were invited to participate in the study ($n = 247$). Informed consent was obtained from all participants. ADMiRE is a specialist ADHD service that has been developed in South Dublin, Ireland, by Linn Dara Child and Adolescent Mental Health Services. The service was set up in September 2018 and is the first public specialist ADHD service for children and adolescents in Ireland. The ADMiRE service aims to provide early access to comprehensive ADHD assessment and intervention for young people between the ages of 6 and 18 (McGrath 2020). ADMiRE accepts referrals from local CAMHS teams. Currently, the service has more than 230 families attending. In ADMiRE, ADHD diagnoses are made in accordance with DSM-5 criteria and ascertained by clinical history from the young person and parents/guardians, collateral information from the young person's school, standardised diagnostic clinical interviews, Conner's questionnaires (Conners 1997) and in certain cases a Qb Test, Version 3.8.3.0 (Qbtech, n.d). If a young person is diagnosed with ADHD, the ADMiRE team will provide information about ADHD, outline treatment options and develop a care plan with the young person and their family. When a young person attends ADMiRE, they remain under the joint care of their CAMHS team. If a non-ADHD mental health concern arises, the young person attends both ADMiRE and their local CAMHS team. When a young person is optimised on ADHD medication, they will continue to follow-up with their local CAMHS team.

Ethical approval

Ethical approval was granted by the Health Service Executive Linn Dara Research Ethics Committee in December 2020 prior to commencement of the study.

Procedures and instruments

The Children's Sleep Habits Questionnaire (CSHQ)

Sleep was assessed using 'The Children's Sleep Habits Questionnaire (CSHQ) (Owens *et al.*, 2000). This is a retrospective, 45-item parent-rated questionnaire, which has been widely utilised to examine sleep behaviour in young people. Parents are asked to recall sleep behaviours occurring over the previous week or if the week was not representative then the most recent "typical" week. Items are rated on a three-point Likert scale: "usually" if the sleep behaviour occurred five to seven times/week; "sometimes" if the sleep behaviour occurred for two to four times/week; and "rarely" if the sleep behaviour occurred for zero to one time/week. Some items are reversed to consistently make a higher score indicative of more disturbed sleep.

Higher scores indicate more frequent occurrence of sleep problems (Okada *et al.*, 2017). We used the definition of previous studies, which defines a total score of >41 as a clinical sleep disorder (Owens *et al.*, 2000). Sub-domains describing specific sleep problems include bedtime resistance, sleep onset delay, sleep duration, sleep anxiety, night waking, parasomnias, sleep-disordered breathing, and daytime sleepiness. Clinical cut-off scores for each sleep domain were defined as scores >2 standard deviations above the published community control reference mean values (Owens *et al.*, 2000); bedtime resistance >10.84, sleep onset delay >2.31, sleep duration >5.27, sleep anxiety >7.79, night waking's >5.29, parasomnias >10.61, sleep-disordered breathing >4.50 and daytime sleepiness >15.24 (Zhao *et al.*, 2020).

SNAP-IV (Swanson, Nolan and Pelham Teacher and Parent Rating Scale)

ADHD symptoms and severity were assessed using an abbreviated version of the SNAP-IV Swanson, Nolan and Pelham Teacher and Parent Rating Scale (Swanson *et al.*, 2012). The SNAP-IV is a 90-item rating scale used to assess ADHD and ODD symptoms and severity. Symptom severity is rated on a 4-point Likert scale. Responses are scored as follows: "not at all" = 0, "just a little" = 1, "quite a bit" = 2 and "very much" = 3. The SNAP-IV has demonstrated high internal consistency for overall parent ratings ($\alpha = .94$) and for teacher ratings ($\alpha = .97$) (Bussing *et al.*, 2008).

In this study, an abbreviated version of the Swanson, Nolan, and Pelham (SNAP) Questionnaire (Swanson 1992; Swanson *et al.*, 1983) was administered using a 31-item version. Items from the DSM-IV criteria for ADHD were included for the two subsets of symptoms: inattention (items 1–9) and hyperactivity/impulsivity (items 10–18). Items from the DSM-IV criteria for ODD (items 19–28) and CD (items 29–31) were included as these are often co-morbid presentations in young people with ADHD.

Data collection

This study used an online survey, hosted by Qualtrics, a web-based survey software. A secure link to the survey was sent via text to all parents/guardians of children and adolescents with ADHD attending the ADMiRE service. Follow-up Short Message Service reminders with potential respondents were also conducted to enhance the survey response rate four weeks after the initial text message. To augment the survey data, where consent was provided, data regarding demographics, social conditions, clinical diagnoses, co-morbid disorders, symptom severity and medication were combined with the survey data. Clinical data were obtained from the service users' clinical records.

The Pobal HP Deprivation Index, a quantitative measure of socio-economic status (Haase *et al.*, 2015) derived using home address and data from the 2016 Census (Central Statistics Office, 2017) was used to assess the service user's social conditions. The Pobal HP Deprivation Index is based on small areas, which are homogeneous in their social composition and have a uniform population size with a mean of just under 100 households (Haase and Pratschke 2017). The Pobal HP Deprivation Index was recorded for each participant, and they were grouped into one of three categories; advantaged (extremely affluent, very affluent, affluent), average (marginally above average and marginally below average) and disadvantaged (disadvantaged, very disadvantaged and extremely disadvantaged).

The four most commonly occurring co-morbid mental and medical disorders were included in the analysis; atopic conditions (allergic rhinitis / asthma), ASD, and behavioural disorders (ODD and CD). Diagnoses of atopy or other co-morbid medical health diagnoses were made the patient's general practitioner or paediatrician. Diagnoses of ASD were made externally in public services such as Assessment of Need or the Children's Disability Network Team or following private assessment. Patient's co-morbid mental health diagnoses were made by the child and adolescent psychiatry consultants using the International Classification of Diseases, Tenth Revision (World Health Organisation, 1993) in collaboration with the multi-disciplinary team. The diagnoses of CD and ODD were made from clinical assessments in conjunction with Conner's questionnaires (Conners 1997). Cut-off scores of 65 in both parents and teachers Conner's questionnaires were used for CD and ODD as recommended in the literature (Conners 1997).

Statistical analysis

Statistical analyses were conducted using Statistical Package for the Social Sciences Version 22.0 (International Business Machines Corp, 2013). Kolmogorov–Smirnov tests for normality were applied to the CSHQ scores and SNAP-IV scores and indicated that the data were not normally distributed for either CSHQ scores (positive skew) or ADHD scores (negative skew). Inferential correlation between CSHQ total scores with age as a continuous variable were made using Spearman rank order coefficient. Associations of CSHQ and SNAP-IV total scores with age as discrete categories (under 12 and 12 and over), gender, co-morbidities and medications were analysed using Mann–Whitney U tests. Discrete categories of age were included to investigate differences between primary and post-primary school students. Relationships between sleep scores and the HP deprivation index was analysed using a Kruskal Wallis one-way analysis of variance test. Correlations between CSHQ total score and SNAP-IV scores were analysed using Spearman's correlation analysis. *P* value threshold of 0.05 was chosen as the significance level

Table 1. Summary of patient demographics

	Number of patients	% of sample
Gender		
Male	69	83.1
Female	14	16.9
Age		
Under 12	41	49.4
12 and over	42	50.6
HP deprivation index		
Advantaged	7	8.4
Average	34	41.0
Disadvantaged	42	50.6
ADHD subtype		
Combined type	73	88.0
Inattentive type	10	12.0
Hyperactive/impulsive type	0	0

Results

Patient demographics

Eighty-three participants responded to the survey and were included in the study, representing a response rate of 34% of families attending ADMiRE. There were 69 male patients with ADHD (83.1%) and 14 female patients with ADHD (16.9%; male to female ratio as 4.9:1). Ages of patients ranged from 6 years to 18 years old (mean 12.61 years, S.D. 3.06). Forty-one patients (49.4%) were under the age of 12 years old (primary school aged children), and 42 patients (50.6%) were 12 years or older (post-primary school aged children). Forty-two participants (50.6%) resided in a disadvantaged area, 34 participants (41.0%) resided in an average area and 7 participants (8.4%) resided in an advantaged area. Seventy-three patients (88%) had a diagnosis of ADHD combined subtype, and 10 patients (12.0%) had a diagnosis of ADHD-inattentive subtype. No patients met criteria for hyperactive/impulsive subtype. A summary of patient demographics is shown in Table 1.

Prevalence and types of sleep problems in children and adolescents with ADHD

Seventy patients (84%) scored above the clinical cut-off for a sleep disorder (95% CI 0.72–0.91). Types of sleep problems are illustrated in Fig. 1. The most frequently reported sleep difficulties were related to sleep onset and sleep duration. There were no differences in the type of sleep disorders for the different subtypes of ADHD.

Overlap of seep features

Most participants ($n = 53$, 64.4%) met clinical cut-off for problems in two or more sleep domains. The most common combinations were; sleep onset and sleep duration ($n = 30$, 56.6% of participants with multiple sleep problems), sleep onset and daytime sleepiness ($n = 16$, 30.2% of participants with multiple sleep problems), sleep

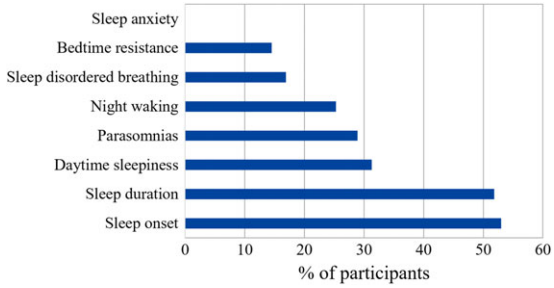

Figure 1. Sleep disorder domains in ADHD patients.

duration and daytime sleepiness ($n = 16$, 30.2% of participants with multiple sleep problems) and night waking and sleep duration ($n = 16$, 30.2% of participants with multiple sleep problems).

Associations between demographic factors and sleep problems

There was no statistically significant correlation between CSHQ total score and age (correlation coefficient −0.15, $p = 0.16$) or for those under 12 (primary school aged children) and those 12 and over (post-primary school aged children) ($p = 0.13$). There was no statistically significant difference between CSHQ scores in males and females ($p = 0.99$) or those living in deprived, average, or affluent areas. ($p = 0.78$).

Associations between ADHD subtype, severity, and sleep problems

There was a positive correlation between the CSHQ total scores and SNAP-IV total scores (correlation coefficient = 0.389. $p < 0.001$) (see Fig. 2A) and both the SNAP-IV inattentive scores (correlation coefficient = 0.327, $p = 0.003$) (see Fig. 2B) and the SNAP-IV hyperactive/impulsive scores (correlation coefficient = 0.301. $p = 0.006$) (see Fig. 2C).

Associations between medical and mental health co-morbid disorders and sleep problems?

All participants had at least one medical and/or mental health co-morbidity with 89.2% ($n = 74$) having more than one co-morbidity. The four most prevalent co-morbidities in the sample were atopic conditions ($n = 32$, 38.6%), ASD ($n = 29$, 34.9%), CD ($n = 27$, 32.5%) and ODD ($n = 41$, 49.4%). There were no significant differences in the CSHQ scores in those with these conditions compared to those without (see Fig. 3A-D).

Associations between medications and sleep problems

Most of the study participants were on ADHD and/or sleep medication ($n = 66$, 79.5%) (see Table 2).

There were 17 patients who were not on any medication. Of these patients 15 (88.2%) scored above the cut-off for a sleep disorder. There were no significant differences between CSHQ scores in participants taking or not taking stimulant medication or taking or not taking melatonin medication (see Table 3).

Associations between medications with SNAP-IV scores

Stimulant use was associated with significantly lower SNAP-IV scores ($p = 0.01$), however, there was no significant differences between SNAP-IV scores in participants taking or not taking melatonin ($p = 0.88$) (see Table 3).

Stimulants and CSHQ sub-domains

Stimulant use was associated with significantly lower scores of the CSHQ subscales of night wakening's ($p = 0.04$) and parasomnias ($p = 0.02$).

Discussion

This study explored sleep disorders in children and adolescents with ADHD attending a specialist ADHD service in Ireland. The study found that the majority (84%) of those included in this study met the clinical cut-off for a sleep disorder. Prevalence rates of sleep disorders in ADHD children and adolescents range from 25 to 85% in the literature (Fisher *et al.*, 2014; Hvolby 2015; Sung *et al.*, 2008; Wajszilber *et al.*, 2018; Yürümez and Kılıç 2016). Differences in reported prevalence rates may be related to how sleep disorders are identified (e.g., self-report vs. parent report), variation in the quantitative measures used and whether physical investigations were used to aid diagnosis.

Long sleep onset latency and short sleep duration were the most common sleep problems reported. Similar sleep problems were reported by Fisher *et al.* (2014) who reported that initial insomnia, nocturnal wakening's and shortened duration of sleep were most frequently endorsed by adolescents with ADHD. Some authors have proposed that children and adolescents with ADHD may have a circadian rhythm sleep disorder in the form of chronic sleep onset insomnia (Van der Heijden *et al.*, 2005; Van der Heijden *et al.*, 2007), which would be congruent with our findings. Circadian rhythm disorders (CRDs) are common in children and adolescents with psychiatric conditions and emerge from complex interactions between biological and social factors (Arns *et al.*, 2020). It has been suggested that individuals with ADHD may have a greater circadian evening preference and delayed onset of endogenous melatonin increase in the evening (Gruber *et al.*, 2012). Studies have shown that adults with childhood-onset ADHD are frequently "night owls" who show delayed circadian preference and increased alertness in the evening (Kooij 2017; Coogan & McGowan, 2017; Bondopadhyay et al., 2022). Interventions targeting CRDs in children with ADHD may improve not only sleep but also cognitive, affective, and behavioural outcomes (Arns *et al.*, 2020).

ADHD severity was significantly associated with greater sleep difficulties, and our findings are in keeping with the literature (Sung *et al.*, 2008; Mayes *et al.*, 2009). The relationship may be unidirectional where sleep problems can have a negative impact on daytime functioning and therefore worsen ADHD severity (American Psychiatric Association, 2000). Alternatively, there may be a bidirectional pathway between sleep problems and ADHD where ADHD symptoms impact negatively on sleep, and poor sleep leads to worsening of ADHD symptoms (Mulraney *et al.*, 2016). A third possible mechanism is that ADHD and sleep problems are co-morbid and share a common neurophysiological aetiology (Mayes *et al.*, 2009).

Most respondents had the combined ADHD subtype, followed by predominantly inattentive and no patients had the hyperactive/impulsive subtype. Similar rates of ADHD subtypes have been reported in the literature (Salvi *et al.*, 2019). There were no differences in the type of sleep disorders for the subtypes of ADHD, although the group with inattentive ADHD was small and so differences between this group and those with the combined type

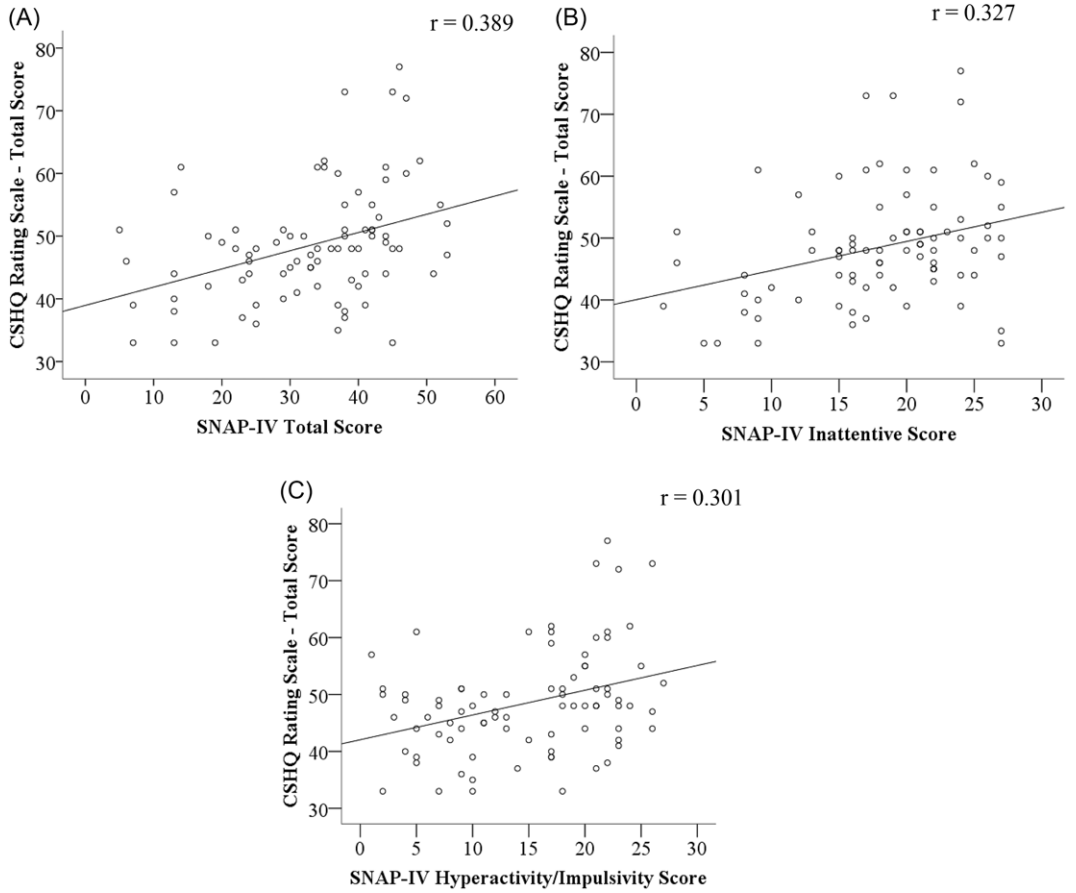

Figure 2. Scatterplots of SNAP-IV scores and the CSHQ total scores.

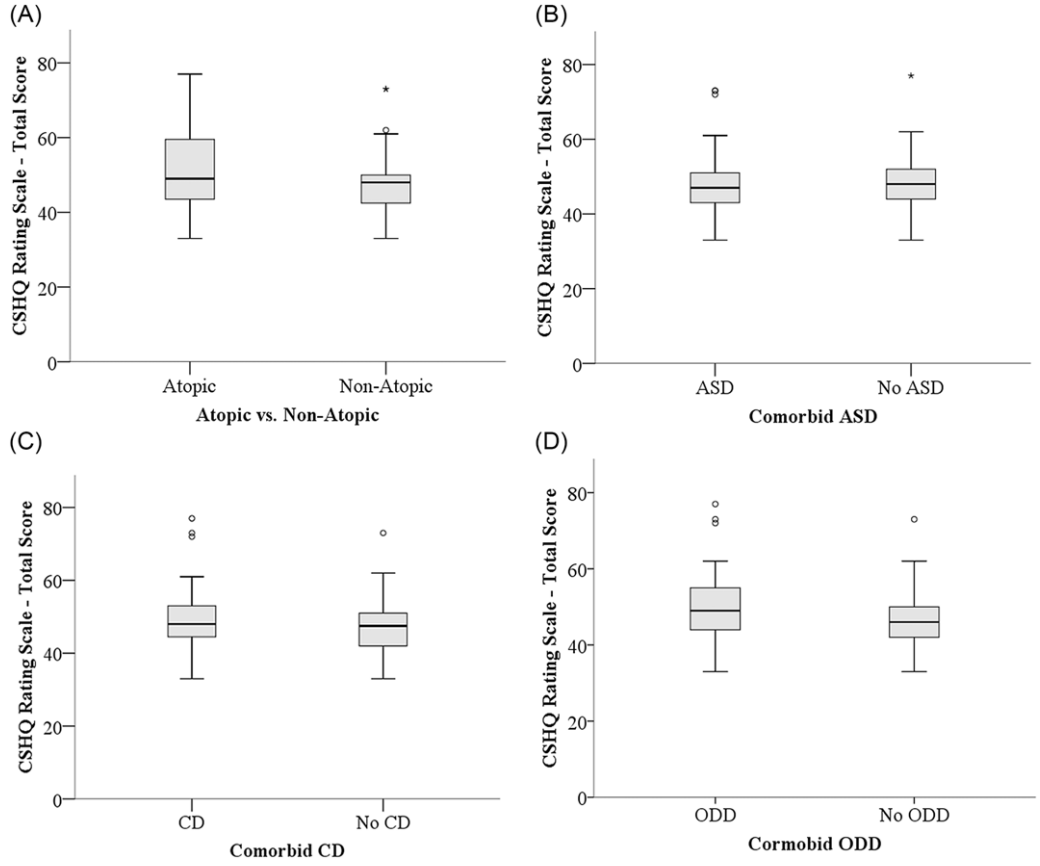

Figure 3. Boxplots of co-morbid disorders and CSHQ score.

Table 2. Medication use in a specialist ADHD service

Medication	Number of patients	% of patients
No medication	17	20.5
On stimulants	58	69.9
On melatonin	43	51.8
On non-stimulants	11	13.3
On stimulant AND melatonin	36	43.4

may have been difficult to identify in the current sample. Sleep problems did not differ between ADHD combined subtype and ADHD-inattentive subtype in our study and this was similarly reported in a study by LeBourgeois *et al.* (2004) using parent-reports. Studies which have used objective measures however have reported some differences. A study carried out by Lecendreux *et al.* (2000) using multiple sleep latency reported increased daytime sleepiness in ADHD-inattentive compared to ADHD-hyperactive/impulsive. Additionally, Ramos *et al.* (1990) confirmed using polysomnography that children with ADHD-hyperactive/impulsive had more fragmented sleep and reduced sleep efficacy compared to children with ADHD-inattentive.

Although the literature supports worsening sleep post-puberty (Lunsford-Avery *et al.,* 2016), there was no correlations between age and sleep problems in this study suggesting that sleep problems in our sample of young people with ADHD were not attributable to ageing effects on sleep. Sleep programmes should, therefore, be tailored to both primary and post-primary school aged children.

The current sample showed significantly high rates of atopic disorders, although this was not associated with greater sleep problems. Although not the focus of this paper, the high rates of atopy are interesting as recently it has been proposed that an atopic response may lead to the development of ADHD (Xu *et al.*, 2020). A systematic review and meta-analyses carried out by Schans *et al.* (2017) reported atopic disorders are independently associated with ADHD in childhood and children with atopy have a 30–50% higher probability of developing ADHD as they get older. Additionally, two further systematic reviews and meta-analyses conducted by Chuang *et al.* (2022) found that atopic diseases are not just associated with ADHD but also with ADHD symptom severity. Further research into possible underlying mechanisms may improve management for both disorders.

Our study confirmed high co-morbid rates of ASD, ODD and CD, which is in keeping with the literature (Connor & Doerfler, 2008; Rong et al., 2021). High rates of sleep disorders have been reported in these disorders (Cuomo *et al.*, 2017, Aronen *et al.*, 2014). We did not find that co-morbid ASD, OD, or CD were associated with greater sleep problems in children and adolescents with ADHD, a finding in keeping with a study by Mayes *et al.* (2009) who reported no differences in sleep problems in children with ADHD and ODD compared to ADHD children without ODD. Together the findings suggest that these co-occurring conditions themselves may not be key mediating variables in the relationship between ADHD and sleep disorders, however, the burden of having multiple mental and physical co-morbidities may contribute to poor sleep.

Medication use was not associated with greater sleep problems in our sample. Mayes *et al.* (2009) similarly found that when ADHD severity was controlled, there were no significant differences in total sleep problems between medicated and un-medicated children with ADHD. The authors reported that sleep disorders were primarily related to ADHD severity rather than co-occurring ODD or medication, a similar finding to that reported in the current study. There appears to be a concern amongst clinicians regarding stimulant use causing problems in sleep, however, stimulant use was associated with fewer night-time awakenings and parasomnias in this study.

The high prevalence of sleep disorders in children and adolescents with ADHD in our clinic has important clinical indications. Several studies have reported a link between sleep disorders and poor prognosis in young people with ADHD. Liu *et al.* (2020) found during a 1 year follow-up in adolescents without clinically relevant ADHD symptoms that insomnia and snoring were independently associated with elevated risk of subsequent ADHD symptoms and severity at 1-year follow-up after adjusting for covariates. Additionally, Sung *et al.* (2008) reported that sleep problems in children with ADHD were associated with poorer quality of life, daily functioning, primary care giver mental health, participation in daily responsibilities and family functioning. These studies highlight the importance of early identification, prevention, and treatment of sleep disorders in people with ADHD to improve prognostic outlook.

Given the high level of sleep disorders in young people attending ADMiRE alongside the known risk of negative outcomes if they are not adequately managed, it would be clinically prudent to establish a best practice guideline or pathway in managing sleep disorders in the clinic. Behavioural therapies focussing on alleviating sleep disturbances in patients with ADHD have shown promise and should be included in the overall management plan (Wolraich *et al.*, 2019). Since most of our participants met criteria for two or more specific sleep disturbances, a variety of interventions targeting multiple sleep domain issues may be required. An estimated one third of young people attending CAMHS have a diagnosis of ADHD (Health Service Executive 2013), so the development of an evidence-based practice guideline for management of sleep difficulties in young people with ADHD would potentially be of significant value to the 73 national CAMHS in Ireland.

Sleep hygiene measures are defined as a group of behavioural and environmental recommendations aimed to promote healthy sleep (Irish *et al.*, 2015). Mindell and Owens (2009) published a set of sleep hygiene measures specifically for children and adolescents, which include having a set bedtime and routine, similar bedtime and wakeup times during the week and weekends, avoiding caffeine and use of electronic devices before bed etc. There is growing evidence that sleep hygiene measures and cognitive behavioural therapy for insomnia (CBT-I), are useful in managing sleep disorders in children and adolescents with ADHD (Weiss *et al.*, 2006, Nikles *et al.*, 2020, Jernelöv *et al.*, 2019, Åslund *et al.*, 2020).

Melatonin is commonly prescribed in the paediatric population for sleep disorders and in those with neurodevelopmental disorders (Hartz and Ross 2012). More than half of the young people included in our study were prescribed it for sleep disorders. Melatonin promotes sleep through the regulation of the sleep-wake cycle through actions on melatonin receptors in the supra-chiasmatic nucleus (Srinivasan *et al.*, 2009). The benefits of melatonin in improving sleep disorders in children and adolescents with ADHD as well as its tolerability and limited side effect profile have been well documented (Anand *et al.*, 2017; Masi *et al.*, 2019). Unlike benzodiazepines and other hypnotics, there is no

Table 3. Medications and CSHQ scores/SNAP-IV scores

Medication group	Number of patients	% of patients	CSHQ mean score	CSHQ median score	*p* value	SNAP-IV mean score	SNAP-IV median score	*p* value
Stimulant								
Yes	58	69.9	51.12	49.00	0.107	30.72	33.50	0.01
No	25	30.1	47.41	47.00		38.04	40.00	
Melatonin								
Yes	43	51.8	50.07	49.00	0.235	32.93	35.00	0.88
No	40	48.2	46.88	47.00		32.93	35.50	

clinical evidence of tolerance or dependency (Srinivasan *et al.*, 2009). Although short-term use of melatonin is considered safe, a recent study by Zwart *et al.* (2018) highlighted concerns that long term use may be linked to a delay in puberty onset. It is difficult to draw definitive conclusions due to limited and inconsistent findings in studies with small sample sizes and poor measures of puberty development (Boafo *et al.*, 2019).

Strengths and limitations

Our study had several strengths in that validated outcome measures were utilised and, as the setting was a specialised ADHD clinic where children and adolescents are diagnosed per clinical interview, validated scales, and standardised diagnostic interviews, there was a low risk of incorrect ADHD diagnoses. The study also has some limitations, which should be acknowledged. First, the data were cross-sectional and thus causality between ADHD and sleep disorders cannot be inferred. Secondly, although validated outcome measures were utilised, the sleep measures were based on subjective caregiver reports, which may have overestimated sleep problems and resulted in the higher prevalence rate compared with the literature. It should be noted, however that parental reports have been found to be reliable indicators of sleep disorders in children and adolescents when compared with objective sleep measures (Minde *et al.*, 1993). The inclusion of caregivers of young people treated with Melatonin may mean that some service user's sleep problems were already treated or partially treated. Our response rate was 34%, which was lower than we had anticipated, however, is similar to rates published in the literature (Fincham 2008). Nevertheless, there is a risk of non-response bias in our study. As the study was carried out in a specialist ADHD clinic, the findings may not be generalisable to other settings. Studies in other clinical settings such as general paediatric clinics should be conducted to see if they support our findings.

Despite these limitations, our study has provided important information regarding the prevalence and types of sleep disorders in children and adolescents with ADHD in our clinic. Results suggest that sleep disorders are extremely common in children and adolescents with ADHD and are primarily related to ADHD severity rather than co-morbidities and medication. Studies using objective sleep measures should be conducted to see if they support our findings. Additionally, future research should focus on possible underlying mechanisms into how sleep disorders could contribute to worsened clinical presentations and prognosis, as well as possible tools for early identification, prevention, and intervention to target sleep disorders.

Conclusion

This study has demonstrated a very high level of sleep disorders in young people attending a specialist ADHD service, highlighting the need for recognition and appropriate management of sleep disorders in young people with ADHD. The study has also reported an important association between poor sleep and more severe ADHD symptoms, a finding that highlights the need for optimal ADHD treatment for young people with this condition. Future research investigating the effectiveness of different interventions for sleep disorders in young people with ADHD (e.g., CBT-I) is required to guide best practice management.

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Author contribution.
Bond, L.: Study design, data collection, data analysis, write up of manuscript.
McTiernan, D.: Study design, data collection, review of manuscript.
Connaughton, M.: Data analysis, review of manuscript.
Heron, E.: Data analysis, review of manuscript.
Coogan, A.N.: Data analysis, review of manuscript.
McGrath, J.: Study design, data analysis, review of manuscript, supervisor of project.

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Ethical standard. The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committee on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008. The authors assert that ethical approval for publication of this *original research* has been provided by their local Ethics Committee.

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