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# Sleep Disturbance in Children and Adolescents with ADHD: Unique Effects of Medication, ADHD Subtype, and Comorbid Status

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# Sleep Disturbance in Children and Adolescents with ADHD: Unique Effects of Medication, ADHD Subtype, and Comorbid Status

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ABSTRACT

ADHD is among the most common childhood psychiatric disorders, estimated to affect approximately 3% to 5% of elementary school-aged children, with 11% to 37% reporting sleep disturbance (American Psychiatric Association, 2000; Owens, Spirito, McGuinn, & Nobile, 2000). Disturbed sleep can result in daytime sleepiness and behavioral difficulties that affect cognitive functions in children, such as attention and memory, as well as exacerbate symptoms of ADHD (Fallone, Owens, & Deane, 1998; Owens, 2005). The primary aim of this study was to determine the prevalence of ICD-9 sleep disorders, prescribed sleep medications, and complaints of sleep problems as diagnosed by pediatric primary care providers in children and adolescents with ADHD across medication status, ADHD subtype, and comorbidity. Electronic medical records were reviewed for 5,881 patients (6-18 years) diagnosed with ADHD and 5,881 patients without ADHD matched by age, gender, and primary care practice and seen for a well-child visit in 2007. Information was collected on ICD-9 sleep diagnoses, medications potentially used to treat sleep disorders, demographic variables, medications commonly used to treat symptoms of ADHD, ICD-9 ADHD subtype, and comorbidity. A secondary analysis was conducted on 556 participants to examine parent and/or patient complaint of sleep problems. Results indicated that children and adolescents with ADHD were more likely to be diagnosed with a sleep disorder or prescribed a sleep medication compared to their pediatric counterparts with no ADHD diagnosis. The significance of medications commonly used to treat symptoms of ADHD, ICD-9 ADHD subtype, and comorbidity as risk factors of sleep disturbance was discussed. This is one of the first studies to highlight the subgroups of children and adolescents with ADHD significantly more likely

to exhibit sleep disturbance across a large primary care network. These risk factors and their subsequent effects on the severity of symptoms associated with ADHD must be considered when assessing and treating children and adolescents with ADHD.

# CHAPTER I. INTRODUCTION

Attention Deficit Hyperactivity Disorder (ADHD) is composed of three core characteristics: Inattention, impulsivity, and overactivity (American Psychiatric Association, 2000). It is among the most common childhood psychiatric disorders, estimated to affect approximately 3% to 5% of elementary school-aged children (American Psychiatric Association, 2000). Although the association between ADHD and other psychiatric and developmental disorders such as oppositional defiant disorder, anxiety disorders, depressive disorders, and speech and learning disorders has been extensively studied, the association between ADHD and sleep disturbances has been relatively overlooked (Lecendreux & Cortese, 2007).

Sleep disturbance includes diagnosed *sleep disorders*, such as obstructive sleep apnea, restless legs syndrome, periodic limb movement disorder, enuresis, and narcolepsy, and complaints of *sleep problems*, including daytime sleepiness, change in sleep location, difficulty falling asleep, waking during the night, early morning waking, and restless sleep (Brown & McMullen, 2001; Owens, 2005). These sleep problems are often signs of an underlying sleep disorder. Sleep disturbance in children and adolescents is commonly treated through medical (i.e., tonsilloadenoidectomy or continuous positive airway pressure) or behavioral (behavioral sleep training) interventions (Mindell, Owens, & Carskadon, 1999). Although the Food and Drug Administration (FDA) does not currently approve any medications for the treatment of sleep disorders in children and adolescents, several studies have found that primary care physicians frequently prescribe medications to treat sleep disturbance in this population (Owens, Rosen, & Mindell,

2003; Rappley, Luo, Brady, & Gardiner, 2003; Stojanovski, Rasu, Balkishnan, & Nahata, 2007).

Estimates of parent-reported sleep disturbance in school age children range from 11% to 37% (Owens, Spirito, McGuinn, & Nobile, 2000). Specifically within the population of children and adolescents with ADHD, it is estimated that 25% to 50% present with sleep disturbance (Corkum, Tannock, Moldufsky, 1998). Sleep complaints in children with ADHD were so common that restless and disturbed sleep were part of previous versions of the *DSM* diagnostic criteria for *ADHD* (Owens, 2005), although these sleep problems have not been included in the last three versions of the DSM (American Psychiatric Association, 1987, 1994, 2000).

Insufficient and/or poor quality sleep can result in daytime sleepiness and behavioral difficulties that affect cognitive functions in children, such as attention and memory (Fallone, Owens, & Deane, 1998). In addition, sleep loss can have a direct impact on mood as symptoms associated with ADHD may be exacerbated by sleep problems (Owens, 2005). For example, rather than getting tired and lethargic like adults, children deprived of sleep typically display restlessness, irritability, and are easily frustrated (Anstead, 2000). Further, psychotropic medications commonly used to treat symptoms of ADHD in children may result in sleep problems (Corkum, Tannock, & Moldofsky, 1998). As a result, sleep disturbance in children with ADHD can have a negative impact on the severity of ADHD symptoms present during the day as well as pose a challenge for clinicians in developing effective treatment strategies. Given the importance of sleep issues in the diagnosis and treatment of ADHD, it is important to understand the variety of ways in which ADHD and sleep can interact. It is clear that

sleep disturbance in children and adolescents with ADHD has the potential to impact ADHD related symptoms. Further, this relationship may be moderated by medication, subtype, and comorbid diagnoses.

**Medication Status**

Stimulant medication (e.g., methylphenidate or MPH) is the most common treatment for ADHD, as 70-90% of children with ADHD who receive treatment are treated with stimulants alone or in combination with behavioral strategies (Jensen et al., 1999). Stimulant medications provide an immediate reduction in symptoms associated with ADHD that continues for as long as an adequate level of medication is sustained (Greenhill, Beyer, & Finkleson, 2002). In addition, stimulant medication also produces a decreased need for sleep and awareness of fatigue (Bricard & Boiden, 2001). Although some studies found differences in sleep problems between children with ADHD treated with stimulant medication, unmedicated children with ADHD, and children without ADHD (Corkum et al., 2007; Galland, Tripp, & Taylor, 2010; Mayes et al., 2009; Schwartz et al., 2004; Stein, 1999), other studies indicate that there are no differences in sleep between medicated and unmedicated children with ADHD (O'Brien et al., 2003).

**ADHD Subtype**

The Diagnostic and Statistical Manual, Fourth Edition, Text Revision (American Psychological Association, 2000) identifies three subtypes of ADHD: Predominantly Inattentive Type, Predominantly Hyperactive-Impulsive Type, and Combined Type. The International Classification of Diseases, Ninth Revision (ICD-9) is the diagnostic criteria used in primary care facilities and classifies ADHD subtypes as with and without mention of hyperactivity, essentially collapsing the Predominantly Hyperactive-

Impulsive Type and Combined Type. As ADHD subtypes differ regarding diagnostic criteria and functional impairment (American Psychological Association, 2000), it is necessary to investigate sleep problems across both subtypes. Several studies offer conflicting results regarding differences in sleep quality, dyssomnias, and daytime sleepiness between ADHD subtypes. Although LeBourgeois et al. (2004) suggested that there were no differences in sleep quality among subtypes of ADHD, Corkum et al. (1999) found subtype differences in sleep-related involuntary movements . Lecendruex et al. (2000) found that children with elevated levels of hyperactivity fell asleep faster at night and more often during the day compared to children with elevated levels of inattention. Similarly, Chiang et al. (2010) found that children with ADHD-Combined Type had higher relative rates of circadian rhythm problems, sleep talking, and nightmares whereas children with ADHD-Inattentive Type had higher relative rates of hypersomnia. In contrast, other results have indicated that differences in dyssomnias were not significant when psychiatric comorbidity was controlled (Corkum et al., 1999; Willoughby et al., 2008). Although several investigators found that daytime sleepiness was more common in children with ADHD compared to controls and was greatest in ADHD-Inattentive type compared to other subtypes of ADHD (LeBourgeois et al., 2004; Mayes et al., 2009; Willoughby et al., 2008), others noted that children with elevated levels of hyperactivity fell asleep more often during the day (Lecendreux et al., 2000).

**Comorbidity**

Children with ADHD are at increased risk for developing a comorbid psychiatric diagnosis, such as anxiety disorder, depression, oppositional defiant disorder, and conduct disorder, when compared to children without ADHD (Biederman, 2005; Jensen

et al., 2001). It is currently estimated that 65% of children with ADHD may have a comorbid psychiatric disorder (Bartholomew & Owens, 2006). Despite documentation that common comorbid conditions appear to be an important influence on sleep behavior, few studies have investigated or controlled for the effect of psychiatric comorbidity on sleep problems (Cortese et al., 2006). ADHD with comorbid oppositional defiant disorder has been linked with increased rates of dyssomnias (Corkum et al., 1999). Similarly, ADHD with comorbid anxiety disorders is associated with increased levels of sleep-related involuntary movements (Ivanenko et al., 2006). Finally, Mayes et al. (2009) concluded that comorbid internalizing disorders increased sleep problems whereas comorbid externalizing disorders, such as oppositional defiant disorder, did not.

**Limitations of the Literature**

Taken together, most studies in this body of literature included relatively small samples and none examined children with ADHD in the setting where they are most commonly treated – primary care. In addition, none of these studies compared the effects of different types of medication commonly used to treat ADHD (i.e., non-stimulant medication, stimulant medication, and no medication) on sleep problems or disorders. Similarly, most studies excluded children with ADHD and a documented comorbid condition, and none of the studies included participants with both a comorbid internalizing and externalizing condition. Finally, the samples typically examined sleep problems in a narrow age range (i.e., included only children or only adolescents) and only examined diagnosed sleep disorders, instead of including sleep problems and medications commonly used to treat sleep disturbance.

**Purpose of the Proposed Study**

The purpose of this study was to determine the prevalence of sleep disturbance in children and adolescents with and without ADHD. This was accomplished by examining diagnosed sleep disorders, complaints of sleep problems, and medications commonly used to treat sleep disturbance. In addition, this study explored the frequency, type, and significance of sleep disturbance reported to the primary care provider during a well-child visit in children and adolescents diagnosed with ADHD. This analysis focused on improving the understanding of the epidemiology of sleep problems in children and adolescents with ADHD reported to the primary care provider and thereby strengthening the design of more effective identification, prevention, and intervention strategies.

The specific research questions of the proposed study were:

1.0 Is ADHD a predictor of sleep disorders and use of sleep medication in children (ages 6-12) and adolescents (ages 13-18)?

1.01 It was hypothesized that children and adolescents with ADHD will be diagnosed with more sleep disorders compared to normal controls.

1.02 It was hypothesized that children and adolescents with ADHD will be prescribed more sleep medications compared to normal controls.

2.0 In children (ages 6-12) and adolescents (ages 13-18) with ADHD, to what degree are ADHD medication status, ADHD subtype, and psychiatric comorbidity predictive of sleep disorders, use of sleep medication, and sleep problems?

2.01. It was hypothesized that in both children and adolescents with ADHD, stimulant medication will be predictive of sleep problems.

2.02 It was hypothesized that in both children and adolescents with ADHD, stimulant medication will not be predictive of sleep disorders.

2.03 It was hypothesized that in children and adolescents with ADHD, stimulant medication will be predictive of sleep medication.

2.04 It was hypothesized that in children and adolescents with ADHD, ADHD subtype will not be predictive of sleep problems.

2.05 It was hypothesized that in children and adolescents with ADHD, ADHD with hyperactivity will be predictive of sleep disorders.

2.06 It was hypothesized that in children and adolescents with ADHD, the presence of a diagnosed psychiatric comorbidity (internalizing, externalizing, or both internalizing and externalizing) will be predictive of sleep problems.

2.07 It was hypothesized that in children and adolescents with ADHD, the presence of a diagnosed psychiatric comorbidity (internalizing, externalizing, or both internalizing and externalizing) will be predictive of sleep disorders.

# CHAPTER II. LITERATURE REVIEW

## Attention Deficit Hyperactivity Disorder (ADHD)

ADHD is composed of three core characteristics: Inattention, impulsivity, and overactivity (American Psychiatric Association, 2000). It is among the most common childhood psychiatric disorders, estimated to affect approximately 3% to 5% of elementary school-aged children (American Psychiatric Association, 2000). ADHD is associated with several other difficulties, including deficits in academic skills, oppositional and defiant behavior, conduct problems, and internalizing symptoms, such as anxiety and depression (Smith, Barkley, & Shapiro, 2007).

These three symptom clusters (inattention, impulsivity, and overactivity), by definition, can influence many areas of a child's life and are associated with impairments in academics, disturbances in peer relationships, and conflict with parents and figures of authority (American Psychiatric Association, 2000; Barkley, 2006). Specifically, students with this disorder are at increased risk for special education placement, school dropout, and lower rates of completion of post-secondary education (Barkley, Murphy, & Fischer, 2008).

Children with ADHD may have difficulty sustaining attention to teacher instructions and classroom activities (e.g. circle time, independent seat work) due to high levels of off-task and disruptive behavior. Students with this disorder frequently do not complete assigned tasks or do so in a hasty, inaccurate fashion (Barkley, 2006; DuPaul & Stoner, 2003). There also are reports of high rates of noncompliance and aggression toward parents, teachers, other authority figures, and peers (Barkley, 2006). These factors demand more time and resources from a teacher, add to the stress level of the

teacher, and further hinder the academic success of the child. It is important to note that these academic difficulties may appear early, as preschool children with ADHD have been shown to perform significantly below preschool children without ADHD on tests of pre-literacy skills (DuPaul, McGoey, Eckert, & VanBrakle, 2001).

The behavioral symptoms of ADHD (i.e., inattention and hyperactivity-impulsivity) cause problems in learning new material and completing tasks (DuPaul & Stoner, 2003). Children with ADHD are at greater risk for academic difficulties, below average academic achievement, school dropout, and failure (Cole, Usher, & Cargo, 1993; Hinshaw, 1992). In addition, children with this disorder are at-risk for grade retention and/or referral for special education services (Barkley, 2006; DuPaul & Stoner, 2003). They may also exhibit expressive language skills that are well below average (Bain, 2001; McGee et al., 1991) at levels that are similar to that of children with pervasive developmental disorders (Stein, Szumowski, Blondis, & Roizen, 1995). Further, approximately 30% of children with ADHD have one or more learning disability (Barkley, 2006; DuPaul & Stoner, 2003).

In addition to the problems surfacing in academic performance, children with ADHD commonly have trouble creating and maintaining healthy peer relationships and are often rejected by same-aged peers (DuPaul & Stoner, 2003). Children with ADHD have difficulty initiating and maintaining friendships because of impulsive behavior. They break social norms on a regular basis by barging in on games or by not following game rules, usually because they cannot maintain their attention when learning the rules and/or receiving direction. These deficiencies may also cause some children to have difficulties maintaining a conversation with others because they lack the ability to keep

their attention focused on one thing. Social problems do not result because they do not have the skills to interact with others; rather, children with ADHD have problems exhibiting these skills on a consistent basis (Barkley, 2006).

These behavioral difficulties are frequently associated with peer rejection (Erhardt & Hinshaw, 1994) resulting in an increased risk of academic failure and school dropout (Lane, 1999). Similar to academic difficulties that can emerge early in life, there is also evidence that social difficulties can be present as early as preschool. For example, young children with ADHD exhibited more negative social behavior during peer interactions and had poorer social skills than peers without ADHD as rated by both parents and teachers (DuPaul, McGoey, Eckert, & VanBrakle, 2001). Importantly, these difficulties in the social domain may persist from childhood to adolescence, even if the child no longer meets criteria for ADHD (Bagwell, Molina, Pelham, & Hoza, 2001).

**Sleep Disturbance**

Sleep disturbance includes diagnosed *sleep disorders*, such as obstructive sleep apnea, restless legs syndrome, periodic limb movement disorder, enuresis, and narcolepsy, and complaints of *sleep problems*, including daytime sleepiness, change in sleep location, difficulty falling asleep, waking during the night, early morning waking, and restless sleep (Brown & McMullen, 2001; Owens, 2005). These sleep problems are often signs of an underlying sleep disorder. Sleep disturbance is children and adolescents is commonly treated through medical (i.e., tonsilloadenoidectomy or continuous positive airway pressure) or behavioral (behavioral sleep training) interventions (Mindell, Owens, & Carskadon, 1999). Although the Food and Drug Administration (FDA) does not currently approve any medications for the treatment of sleep disorders in children and

adolescents, several studies have found that primary care physicians frequently prescribe medications to treat sleep disturbance in this population (Owens, Rosen, & Mindell, 2003; Rappley, Luo, Brady, & Gardiner, 2003; Stojanovski, Rasu, Balkishnan, & Nahata, 2007).

Estimates of parent-reported sleep disturbance in school age children range from 11% to 37% (Owens, Spirito, McGuinn, & Nobile, 2000). This makes sleep disturbance one of the most common complaints in pediatric practice (Owens, 2005). Specifically within the population of children and adolescents with ADHD, it is estimated that 25% to 50% present with sleep disturbance (Corkum, Tannock, Moldufsky, 1998). So common were sleep complaints in children with ADHD that restless and disturbed sleep were part of previous versions of the DSM diagnostic criteria for ADHD (Owens, 2005), although it has not been included in the last three versions of the DSM (American Psychiatric Association, 1987, 1994, 2000).

Insufficient and/or poor quality sleep can result in daytime sleepiness and behavioral difficulties that affect cognitive functions in children, such as attention and memory (Fallone, Owens, & Deane, 1998). In addition, sleep loss can have a direct impact on mood as symptoms associated with ADHD may be exacerbated by sleep problems (Owens, 2005). For example, rather than getting tired and lethargic like adults, children deprived of sleep typically display restlessness, irritability, and are easily frustrated (Anstead, 2000). Further, psychotropic medications commonly used to treat symptoms of ADHD in children may result in sleep problems (Corkum, Tannock, & Moldofsky, 1998). As a result, sleep disturbance in children with ADHD can have a

negative impact on the severity of ADHD symptoms during the day as well as pose a challenge for clinicians in developing effective treatment strategies. Given the importance of sleep issues in the treatment of ADHD, it is important to understand the variety of ways in which ADHD and sleep can interact.

**Sleep Disorders**

Sleep disorders include obstructive sleep apnea (OSA), restless legs syndrome (RLS), periodic limb movement disorder (PLMD), and narcolepsy (Owens, 2005). These disorders and subsequent disturbed sleep have been associated with altered mood and cognitive performance in adults and children (Cooper et al., 2004). It is possible that these sleep disorders may lead to symptoms of ADHD in children (Chervin, 2001). In contrast, children with ADHD may have intrinsic differences in sleep that are associated with these disorders (Golan et al., 2004; Lecendreux et al., 2000). In other words, similarly to the difficulty children with ADHD experience in regulating their behavior and emotions, they may also have an innate difficulty regulating their sleep/wake cycle. It is important for psychologists and other clinicians to be able to navigate the bi-directional relationship between sleep and ADHD to ensure optimal diagnosis and treatment of children with ADHD.

One study did not detect differences between children with and without ADHD with regards to sleep-disordered breathing. Cooper et al. (2004) used measures of sleep-disordered breathing that included nasal resistance and nasal flow, a physical exam, and an overnight polysomnography (PSG). All participants discontinued medication for at least 24 hours prior to completing the PSG. Results did not show group differences in

overnight PSG variables indicative of sleep disordered breathing, specifically obstructive sleep apnea.

Several other studies have suggested an association between ADHD and PLMD. For example, Picchietti et al. (1999) conducted a neurologic history, physical exam, and overnight PSG. Results indicated that PLMD occurs in a significant subset of children diagnosed with ADHD. Similarly, Crabtree et al. (2003) conducted an overnight PSG on all participants and suggested that a large proportion of children with PLMD also had ADHD; however, those children with both disorders were significantly more likely to have a high number of arousals associated with periodic limb movements (PLM). More research is needed to clarify the directional link between PLMD and ADHD. Specifically, fragmented sleep due to PLMD may be linked with hyperactive behavior. Alternatively, arousal associated with PLM may be the result of the pathophysiology of ADHD (Crabtree et al., 2003).

Finally, several other studies have demonstrated a link between ADHD symptom severity and a family history of RLS as well as a possible association directly between ADHD and RLS. Specifically, parents of children with ADHD are more likely to have RLS than parents of children without ADHD (Picchietti et al., 1999). Further, results from Konofal et al. (2007) indicated that ADHD symptoms were more severe in children with ADHD and RLS compared to children with only ADHD; however, this difference was not statistically significant. Therefore, it is possible that sleep fragmentation linked to RLS may negatively impact daytime behavior and positively contribute to symptoms of inattention, hyperactivity, and impulsivity.

Overall, studies investigating the association between ADHD and several primary sleep disorders included the use of validated measures to assess sleep disorders and behavior symptoms. Despite this, none of the studies controlled for demographic characteristics and none of the reviewed studies provided documentation of the medications the participants were currently taking, ADHD subtype, or diagnosed comorbidity. These studies only included children and the sample sizes were consistently small. It is possible that a much larger sample size is needed to see significant differences in primary sleep disorders, specifically sleep-disordered breathing, between children with ADHD and their typically developing peers.

**Sleep Problems**

Sleep problems include daytime sleepiness, change in sleep location, difficulty falling asleep, waking during the night, early morning waking, and restless sleep (Brown & McMullen, 2001). It is estimated that 25 to 50% of children with ADHD have difficulty initiating and maintaining sleep (Corkum et al., 1998), making insomnia a frequently reported problem in mental health practice settings (Owens, 2005). A literature review conducted by Cortese et al. (2009) concluded that children with ADHD not currently prescribed stimulant medication had increased parent reports of behavior problems at bedtime and early morning as well as objective incidents of fragmented sleep, poor sleep efficiency, sleep disordered breathing, and excessive daytime sleepiness when compared to children without ADHD. Prolonged sleep onset latency and restless or fragmented sleep can result in significantly shortened sleep duration, insufficient sleep, and decreased total sleep efficiency (Owens, 2005). These problems can be especially problematic for children with ADHD, as consequences include daytime sleepiness,

difficulty in behavior regulation, and decreased function in the prefrontal cortex, specifically involving tasks requiring attention and working memory (Fallone, Owens, Deane, 2002). Further, consequences can include a negative impact on mood, such as irritability and decreased positive mood. Finally, children with sleep problems are associated with increased parental stress levels as parent ratings of health-related quality of life can be negatively affected (Wolfson, Lacks, Futterman, 1992). The impact of sleep disturbance in children and adolescents with ADHD may be affected by three variables that have been overlooked in previous research: medication, subtype, and comorbidity.

**Possible Contributing Factors of Sleep Problems**

**Medication**. Stimulant medication (e.g., methylphenidate or MPH) is the most common treatment for ADHD, as 70-90% of children with ADHD are treated with stimulants alone or in combination with behavioral strategies (Jensen et al., 1999). Current estimates are that 2-9% of children are treated with this type of medication (Habel, Schaefer, & Levine, 2005). Stimulant medications provide an immediate reduction in symptoms associated with ADHD, which continues for as long as an adequate level of medication is sustained (Greenhill, Beyer, & Finkleson, 2002). In addition, stimulant medication produces a decreased need for sleep and awareness of fatigue (Bricard & Boiden, 2001). Thus, it is reasonable to investigate if children with ADHD treated with stimulant medication have increased levels of sleep disturbance.

Some studies have indicated that children with ADHD and treated with stimulant medication report more sleep problems than do children with ADHD who are not treated with stimulant medication. For example, Stein (1999) surveyed the parents of children

with ADHD treated with and without stimulant medication, the parents of children with other psychiatric disorders, and the parents of children with no psychiatric diagnosis. Results indicated that children with ADHD, regardless of the use of medication, had more sleep problems when compared to pediatric controls. Specifically, children with ADHD displayed higher rates of insomnia and enuresis compared to the control group. Further, parents of children with ADHD treated with stimulant medication were three times more likely to report severe sleep problems versus parents of psychiatric or pediatric controls. Similar results were found by Meyes et al. (2009) and Corkum et al. (2007) in that children treated with stimulant medication reported greater difficulty falling asleep than children with ADHD not treated with stimulant medication. Specifically, actigraph and sleep diary data indicated that children treated with stimulant medication slept an average of 57 minutes less per night than unmedicated children (Corkum et al., 2007). This significant reduction in sleep was primarily due to delayed sleep onset. Subjective parent reports of sleep problems in this population were further validated by Schwartz et al. (2004) through actigraphically recorded sleep parameters, a more objective measure of sleep problems. Results from this study indicated a significant increase in activity at sleep onsets and throughout the night resulting in an increase in sleep latency and a decrease in sleep efficiency and total sleep time for children receiving stimulant medications.

In order to further investigate these findings that indicate a difference in sleep quality and quantity between children with ADHD treated with stimulant medication and unmedicated children with ADHD, several studies attempted to control for medication status. Mick et al. (2000) used sleep questionnaires to assess sleep problems and

characteristics in adolescents with ADHD. When controlling for stimulant medication, significant differences in self-reported sleep problems were no longer found between adolescents treated with and without stimulant medication. Similar results were found by Corkum et al. (1999), who investigated the relationship between sleep problems and medication status in children with and without ADHD. Results indicated that dyssomnias, such as bedtime resistance, sleep onset problems, and difficulty arising, were related to confounding factors, such as the use of stimulant medication, rather than a true difference in sleep problems between children with and without ADHD.

Galland, Tripp, and Taylor (2010) used a match case-control design to assess sleep-related effects of regular use of methylphenidate. Specifically, sleep timing, sleep duration, and sleep architecture were examined. Results indicated that the use of methylphenidate in children diagnosed with ADHD resulted in prolonged sleep onset by an average of 29 minutes and shortened overall sleep duration by an average of 1.2 hours. There were no differences noted between children diagnosed with ADHD with and without methylphenidate regarding sleep architecture.

In contrast, some studies have indicated that children with ADHD treated with stimulant medication do not have additional sleep problems when compared to unmedicated children with ADHD. For example, O'Brien et al. (2003) gathered information through subjective parent reports and objective overnight polysomnogram (PSG). Parents of children with ADHD reported significantly more sleep complaints, regardless of medication status, when compared to parent ratings of children without ADHD. Similarly, results of the PSG indicated that children with ADHD, regardless of

medication status, had a decreased percentage of rapid eye movement (REM) sleep compared to controls.

Taken together, these studies provide a conflicting picture of the relationship between sleep problems and medication status in children and adolescents with ADHD. Although some studies found sleep problems between children with ADHD treated with stimulant medication, unmedicated children with ADHD, and children without ADHD (Corkum et al., 2007; Mayes et al., 2009; Schwartz et al., 2004; Stein, 1999), other studies indicate that there are no differences in sleep between medicated and unmedicated children with ADHD (O'Brien et al., 2003). It is important to note, however, that none of these studies compared the effects of non-stimulant medication treatment to stimulant medication or no medication. Further, these studies did not examine the relationship between sleep problems and ADHD symptom severity in this population. With the exception of Mayes et al. (2009) and Mick et al. (2000), all of the reviewed studies utilized a small sample size, limiting the ability to detect true differences between groups. Finally, the samples typically included only children or only adolescents.

**ADHD Subtype**. The Diagnostic and Statistical Manual, Fourth Edition, Text Revision (American Psychiatric Association, 2000) identifies three subtypes of ADHD: Predominantly Inattentive Type, Predominantly Hyperactive-Impulsive Type, and Combined Type. The International Classification of Diseases, Ninth Revision (ICD-9) is the diagnostic criteria used in primary care facilities and classifies ADHD subtypes as with and without mention of hyperactivity, essentially collapsing the Predominantly Hyperactive-Impulsive Type and Combined Type. As each subtype is characterized by

different diagnostic criteria, it is necessary to investigate sleep problems across both subtypes.

Several studies investigated differences in sleep quality between ADHD subtypes. For example, LeBourgeois et al. (2004) attempted to determine whether chronic snoring is found in relation to each of the ADHD subtypes. Lower levels of sleep quality were reported among children with ADHD compared to control children; however, there were no differences in sleep quality among subtypes of ADHD. In contrast, Corkum et al. (1999) found differences in sleep quality between subtypes of ADHD. Specifically, sleep-related involuntary movements, such as talking, bruxism, and restless sleep, were associated with children diagnosed with ADHD-Combined Type. Similarly, Chiang et al. (2010) found that a diagnosis of ADHD-Combined subtype was associated with higher rates of circadian rhythm problems, sleep talking, and nightmares relative to controls, while a diagnosis of ADHD-Inattentive subtype was associated with higher rates of hypersomnia relative to controls.

Another group of studies attempted to explore the relationship between ADHD subtype and dyssomnias in children. Lecendruex et al. (2000) found that children with elevated levels of hyperactivity fell asleep faster at night and more often during the day compared to children with elevated levels of inattention. In contrast, results from Willoughby et al. (2008) indicated that elevated levels of hyperactive-impulsive symptoms were associated with sleep resistance, parasomnias, and dyssomnias. However, these effects were not significant when psychiatric comorbidity was controlled. Simiarly, Corkum et al. (1999) found that dyssomnias, such as bedtime resistance, sleep onset problems, and difficulty arising, were related to confounding factors, such as

comorbid oppositional defiant disorder and stimulant medication rather than ADHD subtype.

A final group of studies examined daytime sleepiness across ADHD subtypes. Several investigations found that daytime sleepiness was more common in children with ADHD compared to controls and was greatest in ADHD-Inattentive type compared to other subtypes of ADHD (LeBourgeois et al., 2004; Mayes et al., 2009; Willoughby et al., 2008). Interestingly, Mayes et al. (2009) noted that this relationship was associated with children with ADHD-Inattentive type sleeping more during the night compared to children with other subtypes of ADHD. Further, Willoughby et al. (2008) found that elevated levels of inattentive symptoms were associated with daytime sleepiness even after psychiatric comorbidities were controlled. In contrast, Lecendreux et al. (2000) noted that children with elevated levels of hyperactivity fell asleep more often during the day compared to children with elevated levels of inattention and the number of daytime sleep onsets were found to accurately discriminate between ADHD subtypes, with ADHD-Combined having the most.

Taken together, the reviewed studies offer conflicting results with regard to sleep quality, dyssomnias, and daytime sleepiness across ADHD subtype. The inability to detect group differences and produce a reliable description of sleep problems across ADHD subtypes may be due to several common limitations. With the exception of Willoughby et al. (2008) and Mayes et al. (2009), most studies contained a relatively small sample size. Finally, the samples typically included only children or only adolescents and none of the studies controlled for demographic characteristics, such as ethnicity and socioeconomic status

**Internalizing and Externalizing Comorbidity**. Children with ADHD are at increased risk for developing a comorbid psychiatric diagnosis, such as anxiety disorders, depression, oppositional defiant disorder, and conduct disorder, when compared to children without ADHD (Biederman, 2005; Jenson et al., 2001). It is currently estimated that 65% of children with ADHD may have a comorbid psychiatric disorder (Bartholomew & Owens, 2006). Specifically, oppositional defiant disorder is the most common comorbid disorder and can affect 40 to 60% of children with ADHD. Similarly, anxiety disorders are estimated to affect 30% and conduct disorder can affect 14% of children with ADHD. Many comorbid conditions are commonly associated with sleep disruption in children (Bartholomew & Owens, 2006). For example, children with anxiety disorders typically display bedtime resistance, refusal to sleep alone, increased nighttime fears, and nightmares. Further, depressive disorders are associated with bedtime resistance, delayed sleep onset, problems with sleep maintenance, and excessive daytime sleepiness (Mindell & Owens, 2003). Finally, children with oppositional defiant disorder are more likely to demonstrate problems with limit setting and bedtime resistance. Despite documentation that common comorbid conditions appear to be an important influence on sleep behavior, few studies have investigated or controlled for the effect of psychiatric comorbidity on sleep problems (Cortese et al., 2006).

Only three studies have examined the impact of internalizing or externalizing comorbidity on sleep problems in children or adolescents with ADHD. Corkum et al. (1999) found that dyssomnias, such as bedtime resistance, sleep onset problems, and difficulty arising, were related to comorbid oppositional defiant disorder. In addition, sleep-related involuntary movements, such as sleep talking, bruxism, and restless sleep

were associated with separation anxiety disorder. In another study, Ivanenko et al. (2006) found that the presence of limb movements during sleep was more frequent in children with ADHD compared to children with other psychiatric disorders. Importantly, children with ADHD and a comorbid psychiatric disorder were more likely to report sleep problems compared to children with ADHD and no comorbidity. Finally, Mayes et al. (2009) concluded that comorbid internalizing disorders increased sleep problems whereas comorbid externalizing disorders, such as oppositional defiant disorder, did not.

It is difficult to draw any definitive conclusions from this small body of literature examining sleep problems in children with ADHD and comorbid internalizing and externalizing disorders. All three studies utilized a sample containing only children and neglected to examine sleep problems in adolescents. As Stein et al. (2002) noted, it is important to examine sleep problems in adolescents as this age group had the greater amount of self-reported sleep problems when compared to children younger than 13 years. Further, none of the studies included participants who had both internalizing and externalizing comorbid conditions. Finally, none of the studies controlled for demographic characteristics, such as ethnicity and socioeconomic status.

**Contributions of the Proposed Study**

The present study is unique in that it examined diagnosed sleep disorders, sleep problems, and medications commonly used to treat sleep disturbance across three variables that have been relatively overlooked in previous research: medication, subtype, and comorbidity. Importantly, the proposed study investigated all levels of each variable, including stimulant medication, non-stimulant medication, no medication, internalizing comorbidity, externalizing comorbidity, internalizing and externalizing comorbidities, no

comorbidity, with hyperactivity subtype, and without hyperactivity subtype. The sample was sufficiently large and provided power to detect between-group differences not previously identified by other studies with small samples. Finally, this study included children and adolescents in separate analyses, allowing for comparison within age groups across the described variables and examined children and adolescents with ADHD in the setting where they are most commonly treated – a primary care facility.

# CHAPTER III. METHODS

## Participants and Setting

Participants in this study were 11,762 children ages 6 through 18 years old seen for a well-child visit within the network of 32 pediatric practices (175 physicians and 22 nurse practitioners) affiliated with a large tertiary care children's hospital between January 1, 2007 and December 31, 2007. For children with more than one well-child visit during this specified time, only the most recent visit was used. Participants were eligible for inclusion in the study if they had a diagnosis of ADHD documented by their primary care provider in their electronic medical file ($N$ = 5,881) or were matched by gender, age, and primary care practice without a diagnosis of ADHD ($N$ = 5,881). Participants were excluded from this study if they had a diagnosis of an autism spectrum disorder or mental retardation. From this sample, 556 participants were randomly selected for a more in-depth secondary analysis of sleep problems. This number of participants was chosen based on the recommendation by Pedhazur (1997) that the sample size be at least 30 times the number of parameters being estimated. Please see Figure 1 for a visual depiction of the samples used to investigate each research question.

In most cases, the diagnosis of ADHD was made by the primary care provider (PCP) in compliance with the clinical practice guidelines provided by the American Academy of Pediatrics (American Academy of Pediatrics, 2000). The guidelines for diagnosis of ADHD in school aged children include: (1) meets the *DSM-IV-TR* (American Psychiatric Association, 2000) or The International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM; National Center for Health Statistics, 2009) diagnostic criteria; (2) evidence is directly obtained from parents or caregivers and

classroom teacher regarding the core symptoms of ADHD in various settings, age of onset, duration of symptoms, and degree of functional impairment; and (3) an assessment for co-existing difficulties, including motor disability, problems with parent-child interaction, and other common psychological disorders, such as conduct and oppositional defiant disorder, mood disorders, anxiety disorders, and learning disabilities; however, participants diagnosed with these comorbidities will not be excluded from this study.

In order to provide an estimate of the process by which the diagnosis of ADHD was made for participants in this study, the following information was collected from a random sample of 556 participants (280 children and 276 adolescents): type of provider who made the ADHD diagnosis (primary care provider, psychiatrist, other); presence of a broadband rating scale completed by a parent (yes or no); title of the broadband rating scale completed by the parent; presence of a narrowband rating scale designed to assess symptoms of ADHD completed by a parent (yes or no); title of the narrowband rating scale designed to assess symptoms of ADHD completed by a parent; presence of a broadband rating scale completed by a teacher (yes or no); title of the broadband rating scale completed by the teacher; presence of a narrowband rating scale designed to assess symptoms of ADHD completed by a teacher (yes or no); title of the narrowband rating scale designed to assess symptoms of ADHD completed by a teacher; structured or unstructured interview data collected from a parent (yes or no); and structured or unstructured interview data collected from a teacher (yes or no).

**Measures**

The database of demographic and medical variables was provided by the Pediatric Research Consortium (PeRC), the department responsible for research using the

electronic medical records. Data extraction for secondary review included the following medical and sleep problems obtained through parent and child interview. Medical characteristics included comorbid psychiatric diagnoses and current sleep medications. Sleep problems are included in the template for well-child visits as options for practitioners to select and include the following choices for children 6 to 12 years: normal, sleeps through the night, and other; and for adolescents 13 to 18 years: normal, sleeps through the night, sleeps from ___ to ___ (times were completed by the PCP), difficulty falling asleep, snoring, apnea, nighttime awakenings, daytime sleepiness, and other.

**Procedures**

This was a chart review study. Electronic data were accessed via PeRC for the most recent well-child visit from 1/1/2007 to 12/31/2007 for participants ages 6 years to 18 years seen within the network of Kids First, primary care, and faculty practices. Well-child visit records were reviewed for all patients with a diagnosis of ADHD documented in their electronic medical file. For all children, only the most recent well-child visit was reviewed.

The following demographic and medical information was extracted for all participants ($N$ = 11,762). Demographic information included age (classified as 6-12 or 13-18), gender, race, zip code, and primary care practice. Patient zip codes were used to determine median household income through U.S. Census data, which served as an estimate of socioeconomic status. Medical information included ICD-9 ADHD diagnosis (ADHD with hyperactivity, ADHD without mention of hyperactivity, none for participants in the comparison sample), ICD-9 sleep diagnosis (insomnia, hypersomnia,

parasomnias, restless legs syndrome/periodic limb movement disorder, sleep disordered breathing, enuresis, bruxism, circadian rhythm disorder, narcolepsy, sleep disorder not otherwise specified), sleep medications (alpha agonists, antidepressants, SSRI's, antihitamines, antipsychotic agents, benzodiazepines, hypnotic agents, and chloral hydrate), ADHD medication (stimulant, non-stimulant, none), and comorbidity (internalizing, such as anxiety or depression, externalizing, such as oppositional defiant disorder or conduct disorder, none).

From the total sample of children and adolescents with ADHD, 556 participants were randomly selected for a more in-depth and manual secondary analysis of parent and/or patient complaint of sleep problems. Parent and/or patient complaint of sleep problems were included in the template for well-child visits as options for practitioners to select and were coded as change in sleep location, daytime sleepiness, delayed sleep schedule, difficulty falling asleep, early morning waking, insufficient sleep, symptoms of nocturnal enuresis, parasomnia, poor sleep, restless sleep, RLS symptoms, snoring, use of medication, waking during the night, bedtime struggles/limit setting, daytime fatigue, insufficient sleep, and none. Because these data were coded manually, interrater reliability was conducted on 20% of participants randomly selected from the total sample. Coding was conducted by the investigator and an advanced doctoral level graduate student with two years of specialized training in behavioral sleep medicine. Agreement for both subgroups (children ages 6-12 and adolescents ages 13-18) was 100%.

**Data Analysis**

Descriptive results were provided regarding the demographic information (age, gender, race, and zip code) collected from participants. In addition, frequencies of each

type of sleep disorder, sleep medication, sleep problem, and the overlap between these three measures of sleep disturbance were reported. Finally, a description of the process by which the diagnosis of ADHD was made for 556 participants was presented in frequency form.

**Research Question One**. Logistic regression was used to determine the odds ratio of diagnosed sleep disorders and prescribed sleep medication in children and adolescents.

In the sample of children (aged 6-12), two logistic regressions were completed. The first logistic regression used ADHD diagnosis (yes or no) as the predictor, and sleep disorder diagnosis (yes or no) as the outcome measure. The second logistic regression used ADHD diagnosis (yes or no) as the predictor, and prescribed sleep medication (yes or no) as the outcome variable. These analyses were completed with a sample of 6,956 children (3,478 with ADHD and 3,478 without ADHD), which exceeded the 60 participants recommended by Pedhazur (1997) to allow the sample size to be at least 30 times the number of parameters being estimated.

In the sample of adolescents (aged 13-18), two logistic regressions were completed. The first logistic regression used ADHD diagnosis (yes or no) as the predictor, and sleep disorder diagnosis (yes or no) as the outcome measure. The second logistic regression used ADHD diagnosis (yes or no) as the predictor, and prescribed sleep medication (yes or no) as the outcome variable. These analyses were completed with a sample of 4,806 adolescents (2,403 with ADHD and 2,403 without ADHD), which exceeded the 60 participants recommended by Pedhazur (1997) to allow the sample size to be at least 30 times the number of parameters being estimated.

**Research Question Two**. Three separate logistic regression analyses were used to determine the odds ratio of diagnosed sleep disorders, sleep problems, and prescribed sleep medication in children and adolescents.

In the sample of children (aged 6-12), three logistic regressions were completed. The first logistic regression used medication status (no medication, stimulant medication, non-stimulant medication, stimulant and non-stimulant medication), ADHD subtype (with hyperactivity, without hyperactivity), and comorbidity (no comobidity, internalizing comorbidity, externalizing comobidity, and both internalizing and externalizing comorbidity) as the predictors, and sleep disorder diagnosis (yes or no) as the outcome measure. The second logistic regression used medication status (no medication, stimulant medication, non-stimulant medication), ADHD subtype (with hyperactivity, without hyperactivity), and comorbidity (no comobidity, internalizing comorbidity, externalizing comobidity, and both internalizing and externalizing comorbidity) as the predictors, and prescribed sleep medication (yes or no) as the outcome variable. These analyses were completed with a sample of 3,478 children, which exceeded the 270 participants recommended by Pedhazur (1997) to allow the sample size to be at least 30 times the number of parameters being estimated. The third logistic regression used medication status (no medication, stimulant medication, non-stimulant medication, and stimulant and non-stimulant medication), ADHD subtype (with hyperactivity, without hyperactivity), and comorbidity (no comobidity, internalizing comorbidity, externalizing comobidity, and both internalizing and externalizing comorbidity) as the predictors, and sleep problem (yes or no) as the outcome variable. These analyses were completed with 280 children. This met the recommended sample

size of at least 30 times the number of parameters being estimated (Pedhazur, 1997) except for children with both an internalizing and externalizing comorbidity. This subgroup had a total sample size of 10 children.

In the sample of adolescents (aged 13-18), three logistic regressions were completed. The first logistic regression used medication status (no medication, stimulant medication, non-stimulant medication, stimulant and non-stimulant medication), ADHD subtype (with hyperactivity, without hyperactivity), and comorbidity (no comobidity, internalizing comorbidity, externalizing comobidity, and both internalizing and externalizing comorbidity) as the predictors, and sleep disorder diagnosis (yes or no) as the outcome measure. The second logistic regression used medication status (no medication, stimulant medication, non-stimulant medication, stimulant and non-stimulant medication), ADHD subtype (with hyperactivity, without hyperactivity), and comorbidity (no comobidity, internalizing comorbidity, externalizing comobidity, and both internalizing and externalizing comorbidity) as the predictors, and prescribed sleep medication (yes or no) as the outcome variable. These analyses were completed with a sample of 2,403 adolescents, which exceeded the 270 participants recommended by Pedhazur (1997) to allow the sample size to be at least 30 times the number of parameters being estimated. The third logistic regression used medication status (no medication, stimulant medication, non-stimulant medication, stimulant and non-stimulant medication), ADHD subtype (with hyperactivity, without hyperactivity), and comorbidity (no comobidity, internalizing comorbidity, externalizing comobidity, and both internalizing and externalizing comorbidity) as the predictors, and sleep problem (yes or no) as the outcome variable. These analyses were completed with 276 children. This

met the recommended sample size of at least 30 times the number of parameters being estimated (Pedhazur, 1997) except for children with both an internalizing and externalizing comorbidity. This subgroup had a total sample size of 6 children.

# CHAPTER IV. RESULTS

## Demographic Characteristics

The overall sample of children with ADHD (ages 6-12 years) included 3,378 participants, with a mean age of 9.44 years (*SD* = 1.88 years). This sample was 73.60% male, 60.80% White, had a mean estimated median household income of $54,142.63 (*SD* = $20,153.12), and resided in a geographic area with 9.98% (*SD* = 9.87) of individuals living below the poverty line. For comparison purposes, a second sample of 3,478 children with no diagnosis of ADHD was matched by age, gender, and primary care practice. This control group had a mean age of 9.44 years (*SD* = 1.87 years), was 73.6% male, 57.6% White, had a mean estimated median household income of $54,048.16 (*SD* = $20,325.25), and resided in a geographic area with 10.28% (*SD* = 10.10) of individuals living below the poverty line. To further evaluate parent and child reported sleep problems, 280 children with ADHD were randomly selected. The subgroup of children with ADHD had a mean age of 9.90 years (*SD* = 1.87 years), was 73.6% male, 62.5% White, had a mean estimated median household income of $54,031.63 (*SD* = $19,442.18), and resided in a geographic area with 10.44% (*SD* = 10.50) of individuals living below the poverty line.

The overall sample of adolescents with ADHD (ages 13-18 years) included 2,403 participants, with a mean age of 15.01 years (*SD* = 1.57 years). This sample was 69.20% male, 69.10% White, had a mean estimated median household income of $58,293.12 (*SD* = $19,608.91), and resided in a geographic area with 8.12% (*SD* = 8.31) of individuals living below the poverty line. For comparison purposes, a second sample of 2,403 adolescents with no diagnosis of ADHD was matched by age, gender, and primary care

practice. This control group had a mean age of 15.01 years (*SD* = 1.57 years), was 69.20% male, 67.20% White, had a mean estimated median household income of $57,806.01 (*SD* = $19,767.93), and resided in a geographic area with 8.51% (*SD* = 8.88) of individuals living below the poverty line. To further evaluate parent and child reported sleep problems, 276 adolescents with ADHD were randomly selected. The subgroup of adolescents with ADHD had a mean age of 14.92 years (*SD* = 1.65 years), was 71.4% male, 70.3% White, had a mean estimated median household income of $57,387.40 (*SD* = $19,239.46), and resided in a geographic area with 8.74% (*SD* = 9.37) of individuals living below the poverty line.

Detailed demographic information for all participants is provided in Table 1.

**Frequency of Sleep Diagnoses and Prescribed Sleep Medication**

**Overall Sample of Children with ADHD**. Overall, 8.9% of children with ADHD (*n* = 308) were also diagnosed with a sleep disorder (Table 2). The most common sleep disorder diagnosis was nocturnal enuresis, affecting 4.10% (*n* = 144) of participants. This was followed by sleep disorder, not otherwise specified (*n* = 99, 2.80%), sleep disordered breathing (*n* = 74, 2.10%), insomnia (*n* = 14, 0.40%), restless legs syndrome/periodic limb movement disorder (*n* = 2, 0.10%), and parasomnias (*n* = 1, 0.01%). In addition, 16.10% of children with ADHD (*n* = 559) were prescribed a sleep medication (Table 3). The most common sleep medication was antihistamines, prescribed to 7.20% (*n* = 252) of participants. This medication was followed by alpha agonists (*n* = 188, 5.40%), antipsychotics (*n* = 138, 4.00%), melatonin (*n* = 20, 0.60%), SSRI's (*n* = 13, 0.40%), benzodiazepines (*n* = 6, 0.20%), antidepressants (*n* = 3, 0.10%), and chloral hydrate (*n* = 1, 0.01%).

**Control Sample of Children without ADHD**. Overall, 4.5% of children without ADHD (*n* = 158) were diagnosed with a sleep disorder (Table 2). The most common sleep disorder diagnosis was nocturnal enuresis, affecting 2.60% (*n* = 91) of participants. This was followed by sleep disorder, not otherwise specified (*n* = 38, 1.10%), sleep disordered breathing (*n* = 38, 1.10%), insomnia (*n* = 1, 0.00%), and bruxism (*n* = 1, 0.00%). In addition, 0.50% of children without ADHD (*n* = 17) were prescribed a sleep medication (Table 3). The most common sleep medications were antipsychotics and benzodiazepines, each prescribed to 0.20% (*n* = 7) of participants. These medications were followed by alpha agonists (*n* = 2, 0.10%), and SSRI's (*n* = 2, 0.10%).

**Subsample of Children with ADHD**. Overall, 8.21% of randomly selected children with ADHD (*n* = 23) were also diagnosed with a sleep disorder (Table 2). The most common sleep disorder diagnosis was nocturnal enuresis, affecting 4.28% (*n* = 12) of participants. This was followed by sleep disorder, not otherwise specified (*n* = 8, 2.86%), insomnia (*n* = 3, 1.07%), and sleep disordered breathing (*n* = 2, 0.71%). In addition, 17.85% of randomly selected children with ADHD (*n* = 50) were prescribed a sleep medication (Table 3). The most common sleep medication was alpha agonists, prescribed to 7.50% (*n* = 21) of participants. This medication was followed by antipsychotics (n = 13, 4.64%), antihistamines (*n* = 12, 4.29%), melatonin (*n* = 5, 1.79%), SSRI's (*n* = 3, 1.07%), and antidepressants (*n* = 1, 0.36%).

**Overall Sample of Adolescents with ADHD**. Overall, 5.0% of adolescents with ADHD (*n* = 120) were also diagnosed with a sleep disorder (Table 2). The most common sleep disorder diagnosis was sleep disorder, not otherwise specified, affecting 1.90% (*n* = 46) of participants. This was followed by nocturnal enuresis (*n* = 43, 1.80%), insomnia

(*n* = 20, 0.80%), sleep disordered breathing (*n* = 16, 0.70%), circadian rhythm disorder, (*n* = 2, 0.10%), and narcolepsy (*n* = 2, 0.10%). In addition, 12.10% of adolescents with ADHD (*n* = 290) were prescribed a sleep medication (Table 3). The most common sleep medication was antihistamines, prescribed to 4.30% (*n* = 104) of participants. This medication was followed by alpha agonists (*n* = 88, 3.70%), antipsychotics (*n* = 71, 3.00%), SSRI's (*n* = 36, 1.50%), benzodiazepines (*n* = 19, 0.80%), melatonin (*n* = 9, 0.40%), hypnotic agents (*n* = 3, 0.10%), and antidepressants (*n* = 1, 0.01%).

**Control Sample of Adolescents without ADHD**. Overall, 2.5% of adolescents without ADHD (*n* = 61) were diagnosed with a sleep disorder (Table 2). The most common sleep disorder diagnosis was nocturnal enuresis, affecting 1.00% (*n* = 25) of participants. This was followed by sleep disorder not otherwise specified (*n* = 19, 0.80%), sleep disordered breathing (*n* = 12, 0.50%), insomnia (*n* = 3, 0.10%), restless legs syndrome and/or periodic limb movement disorder, (*n* = 3, 0.10%), and circadian rhythm disorder (*n* = 1, 0.00%). In addition, 0.80% of adolescents without ADHD (*n* = 20) were prescribed a sleep medication (Table 3). The most common sleep medication was SSRI's, prescribed to 0.40% (*n* = 9) of participants. This medication was followed by benzodiazepines (*n* = 5, 0.20%), antipsychotics (*n* = 5, 0.20%), alpha agonists (*n* = 1, 0.00%), and hypnotic agents (*n* = 1, 0.00%).

**Subsample of Adolescents with ADHD.** Overall, 6.5% of randomly selected adolescents with ADHD (*n* = 18) were also diagnosed with a sleep disorder (Table 2). The most common sleep disorder diagnosis was sleep disorder, not otherwise specified, affecting 4.00% (*n* = 11) of participants. This was followed by nocturnal enuresis (*n* = 5, 1.80%), and sleep disordered breathing (*n* = 2, 0.70%). In addition, 17.00% of children

and adolescents with ADHD (*n* = 47) were prescribed a sleep medication (Table 3). The most common sleep medications were antihistamines and alpha agonists, as both were prescribed to 6.20% (*n* = 17) of participants. These medications were followed by antipsychotics (*n* = 10, 3.60%), SSRI's (*n* = 7, 2.50%), and benzodiazepines (*n* = 3, 1.10%).

**Parent and/or Child Reported Sleep Problem and Treatment Recommendations**

**Subsample of Children with ADHD.** Overall, 17.86% of randomly selected children with ADHD (*n* = 50) or their caregivers reported a sleep problem to their primary care provider during the well child visit (Table 4). The most common sleep problem was difficulty falling asleep, affecting 9.64% (*n* = 27) of participants. This was followed by waking during the night (*n* = 5, 1.79%), poor sleep/does not sleep well (*n* = 5, 1.79%), symptoms of nocturnal enuresis (*n* = 5, 1.79%), change in sleep location (*n* = 3, 1.07%), parasomnia (*n* = 3, 1.07%), bedtime struggles/limit setting (*n* = 3, 1.07%), delayed sleep schedule (*n* = 2, 0.71%), daytime fatigue (*n* = 2, 0.71%), early morning waking (*n* = 1, 0.36%), restless sleep (*n* = 1, 0.36%), snoring (*n* = 1, 0.36%), daytime sleepiness (*n* = 1, 0.36%), and the use of medication to aid in sleep (*n* = 1, 0.36%). Of the 50 children with a reported sleep problem, 84% (*n* = 42) were not provided a treatment recommendation by their primary care provider (Table 4). For those given a treatment recommendation, 4.00% (*n* = 2) were told to use melatonin, 2.00% (*n* = 1) were referred for a PSG, 2.00% (*n* = 1) were provided with a behavioral sleep recommendation, and 8.00% (*n* = 4) were given an "other" treatment recommendation.

**Subsample of Adolescents with ADHD.** Overall, 14.86% of randomly selected adolescents with ADHD (*n* = 41) or their caregivers reported a sleep problem to their

primary care provider during the well child visit (Table 4). The most common sleep problem was difficulty falling asleep, affecting 6.88% (*n* = 19) of participants. This was followed by waking during the night (*n* = 10, 3.62%), delayed sleep schedule (*n* = 5, 1.81%), daytime sleepiness (*n* = 4, 1.45%), poor sleep/does not sleep well (*n* = 4, 1.45%), parasomnia (*n* = 4, 1.45%), use of medication to aid in sleep (*n* = 3, 1.09%), symptoms of nocturnal enuresis (*n* = 1, 0.36%), restless sleep (*n* = 1, 0.36%), insufficient sleep (*n* = 1, 0.36%), and RLS symptoms (*n* = 1, 0.36%). Of the 41 adolescents with a reported sleep problem, 87.80% (*n* = 36) were not provided a treatment recommendation by their primary care provider (Table 4). For those given a treatment recommendation, 4.88% (*n* = 2) were prescribed a medication, 2.44% were referred for a PSG (*n* = 1), and 4.88% (*n* = 2) were given an "other" treatment recommendation.

**Frequency of Sleep Diagnosis, Sleep Medication, and Sleep Problems Within Participants and Across Variables**

**Overall Sample of Children with ADHD.** Of the 308 children with ADHD also diagnosed with a sleep disorder, 91.88% (*n* = 283) were diagnosed with one sleep disorder, 7.79% (*n* = 24) were diagnosed with two sleep disorders, and 0.32% (*n* = 1) was diagnosed with three sleep disorders (Table 5). Of the 559 children with ADHD also prescribed a sleep medication, 89.62% (*n* = 501) were prescribed one sleep medication, 10.02% (*n* = 56) were prescribed two sleep medications, and 0.36% (*n* = 2) were prescribed three sleep medications (Table 5). Regarding the overlap between sleep diagnoses and sleep medications, 55 participants were diagnosed with one sleep disorder and prescribed one sleep medication, 12 participants were diagnosed with one sleep disorder and prescribed two sleep medications, 5 participants were diagnosed with two

sleep disorders and prescribed one sleep medication, and 2 participants were diagnosed with two sleep disorders and prescribed two sleep medications (Table 6).

**Control Sample of Children without ADHD**. Of the 308 children without ADHD diagnosed with a sleep disorder, 93.70% (*n* = 148) were diagnosed with one sleep disorder, 5.70% (*n* = 9) were diagnosed with two sleep disorders, and 0.60% (*n* = 1) was diagnosed with three sleep disorders (Table 5). Of the 17 children without ADHD prescribed a sleep medication, 94.10% (*n* = 16) were prescribed one sleep medication, and 5.90% (*n* = 1) were prescribed two sleep medications (Table 5). Regarding the overlap between sleep diagnoses and sleep medications, three participants were diagnosed with one sleep disorder and prescribed one sleep medication (Table 7).

**Subsample of Children with ADHD**. Of the 23 children with ADHD randomly selected and also diagnosed with a sleep disorder, 95.65% (*n* = 22) were diagnosed with one sleep disorder and 4.35% (*n* = 1) was diagnosed with two sleep disorders (Table 5). Of the 50 children with ADHD randomly selected and also prescribed a sleep medication, 90.00% (*n* = 45) were prescribed one sleep medication and 10.00% (*n* = 5) were prescribed two sleep medications (Table 5). Of the 51 children with ADHD randomly selected and also reported a sleep problem, 72.55% (*n* = 37) reported one sleep problem, and 27.45% (*n* = 14) reported two sleep problems (Table 5). Regarding the overlap between sleep diagnoses, sleep medications, and sleep problems, two participants were diagnosed with one sleep disorder and prescribed one sleep medication, one participant was diagnosed with one sleep disorder and prescribed two sleep medications, and one participant was diagnosed with two sleep disorders and prescribed one sleep medication (Table 8). In addition, three participants were diagnosed with one sleep disorder and

reported one sleep problem, three participants were diagnosed with one sleep disorder and reported two sleep problems, and one participant was diagnosed with two sleep disorders and reported two sleep problems (Table 8). Finally, nine participants were prescribed one sleep medication and reported one sleep problem, three participants were prescribed one sleep medication and reported two sleep problems, and one participant was prescribed two sleep medications and reported one sleep problem (Table 8).

**Overall Sample of Adolescents with ADHD.** Of the 120 adolescents with ADHD also diagnosed with a sleep disorder, 92.50% (*n* = 111) were diagnosed with one sleep disorder and 7.50% (*n* = 9) were diagnosed with two sleep disorders (Table 5). Of the 290 adolescents with ADHD also prescribed a sleep medication, 86.90% (*n* = 252) were prescribed one sleep medication, 12.07% (*n* = 35) were prescribed two sleep medications, and 1.03% (*n* = 3) were prescribed three sleep medications (Table 5). Regarding the overlap between sleep diagnoses and sleep medications, 24 participants were diagnosed with one sleep disorder and prescribed one sleep medication, 1 participant was diagnosed with one sleep disorder and prescribed two sleep medications, 1 participant was diagnosed with one sleep disorder and prescribed three sleep medications, 2 participants were diagnosed with two sleep disorders and prescribed one sleep medication, and 1 participant was diagnosed with two sleep disorders and prescribed two sleep medications (Table 9).

**Control Sample of Adolescents without ADHD**. Of the 61 adolescents without ADHD diagnosed with a sleep disorder, 96.7% (*n* = 59) were diagnosed with one sleep disorder and 3.30% (*n* = 2) were diagnosed with two sleep disorders (Table 5). Of the 20 adolescents with ADHD also prescribed a sleep medication, 95.50% (*n* = 19) were

prescribed one sleep medication and 5.00% (*n* = 5) were prescribed two sleep medications (Table 5). Regarding the overlap between sleep diagnoses and sleep medications, two participants were diagnosed with one sleep disorder and prescribed one sleep medication and one participant was diagnosed with one sleep disorder and prescribed two sleep medications (Table 10).

**Subsample of Adolescents with ADHD.** Of the 18 adolescents with ADHD randomly selected and also diagnosed with a sleep disorder, 100% (*n* = 18) were diagnosed with one sleep disorder (Table 5). Of the 47 adolescents with ADHD randomly selected and also prescribed a sleep medication, 85.10% (*n* = 40) were prescribed one sleep medication and 14.90% (*n* = 7) were prescribed two sleep medications (Table 5). Of the 41 adolescents with ADHD randomly selected and also reported a sleep problem, 73.20% (*n* = 30) reported one sleep problem, 24.40% (*n* = 10) reported two sleep problems, and 2.40% (*n* = 1) reported three sleep problems (Table 5). Regarding the overlap between sleep diagnoses, sleep medications, and sleep problems, two participants were diagnosed with one sleep disorder and prescribed one sleep medication (Table 11). In addition, five participants were diagnosed with one sleep disorder and reported one sleep problem and three participants were diagnosed with one sleep disorder and reported two sleep problems (Table 11). Finally, eight participants were prescribed one sleep medication and reported one sleep problem, two participants were prescribed one sleep medication and reported two sleep problems, one participant was prescribed two sleep medications and reported one sleep problem, and two participants were prescribed two sleep medications and reported two sleep problems (Table 11).

## Diagnosis of ADHD Process

**Subsample of Children with ADHD.** Of the 280 randomly selected children with ADHD, 28.90% (*n* = 37) were diagnosed with ADHD by a psychiatrist (Table 12). This was followed by an unknown provider (*n* = 72, 25.70%), psychologist (*n* = 46, 16.40%), primary care physician (*n* = 37, 13.2%), neurologist (*n* = 23, 8.2%), and developmental pediatrician (*n* = 21, 7.5%).

Regarding the 37 children diagnosed with ADHD by their primary care physician, 8.10% (*n* = 3) of diagnoses involved the completion of a parent broadband measure, 5.40% (*n* = 2) of diagnoses involved the completion of a teacher broadband measure, 81.10% (*n* = 30) of diagnoses involved the completion of a parent narrowband measure, 78.40% (*n* = 29) of diagnoses involved the completion of a teacher narrowband measure, 0.00% (*n* = 0) of diagnoses involved a parent or teacher structured interview, 83.80% (*n* = 31) of diagnoses involved an unstructured parent interview, and 27.00% (*n* = 10) of diagnoses involved an unstructured teacher interview. Of the 30 parent narrowband measures completed, the most common was the NICHQ Vanderbilt Assessment (*n* = 21, 70.00%), followed by the Conners Rating Scale (*n* = 7, 23.30%), and unknown (*n* = 2, 6.70%). Of the 29 teacher narrowband measures completed, the most common was the NICHQ Vanderbilt Assessment (*n* = 21, 72.40%), followed by the Conners Rating Scale (*n* = 6, 20.70%), and unknown (*n* = 2, 6.90%). A full description of the process by which the diagnosis of ADHD was made by the primary care physician is provided in Table 13.

**Subsample of Adolescents with ADHD.** Of the 276 randomly selected adolescents with ADHD, 45.30% (*n* = 125) were diagnosed with ADHD by an unknown provider (Table 12). This was followed by a psychiatrist (*n* = 78, 28.30%), psychologist

(*n* = 30, 10.90%), primary care physician (*n* = 17, 6.20%), neurologist (*n* = 16, 5.80%), and developmental pediatrician (*n* = 10, 3.60%).

Regarding the 17 adolescents diagnosed with ADHD by their primary care physician, 58.80% (*n* = 10) of diagnoses involved the completion of a parent narrowband measure, 58.80% (*n* = 10) of diagnoses involved the completion of a teacher narrowband measure, 70.60% (*n* = 12) of diagnoses involved an unstructured parent interview, 5.90% (*n* = 1) of diagnoses involved an unstructured teacher interview, 0.00% (*n* = 0) involved the completion of a parent or teacher broadband measure, and 0.00% (*n* = 0) of diagnoses involved a parent or teacher structured interview. Of the 10 parent narrowband measures completed, the most common was the NICHQ Vanderbilt Assessment (*n* = 7, 70.00%), followed by the Conners Rating Scale (*n* = 2, 20.00%), and unknown (*n* = 1, 10.00%). Of the 10 teacher narrowband measures completed, the most common was the NICHQ Vanderbilt Assessment (*n* = 7, 70.00%), followed by the Conners Rating Scale (*n* = 2, 20.00%), and unknown (*n* = 1, 10.00%). A full description of the process by which the diagnosis of ADHD was made by the primary care physician is provided in Table 13.

**Research Question One**

Is ADHD a predictor of sleep disorders and use of sleep medication in children (ages 6-12) and adolescents (ages 13-18)?

**Overall Sample of Children with and without ADHD.** Logistic regression was used to determine whether an ADHD diagnosis is predictive of a sleep disorder diagnosis or prescribed sleep medication in the overall sample of children with and without ADHD. The independent variable entered into the model was ADHD status.

Regarding a sleep disorder diagnosis, analyses revealed that children with ADHD were more likely than those without ADHD to be diagnosed with a sleep disorder. A full description of this model is provided in Table 14.

Regarding prescribed sleep medication, analyses revealed that children with ADHD were more likely to be prescribed a sleep medication. A full description of this model and all independent variables is provided in Table 15.

**Overall Sample of Adolescents with and without ADHD.** Logistic regression was used to determine whether an ADHD diagnosis is predictive of a sleep disorder diagnosis or prescribed sleep medication in the overall sample of adolescents with and without ADHD. The independent variable entered into the model was ADHD status.

Regarding a sleep disorder diagnosis, analyses revealed that adolescents with ADHD were more likely than those without ADHD to be diagnosed with a sleep disorder. A full description of this model is provided in Table 16.

Regarding prescribed sleep medication, analyses revealed that adolescents with ADHD were more likely to be prescribed a sleep medication. A full description of this model and all independent variables is provided in Table 17.

**Research Question Two**

In children (ages 6-12) and adolescents (ages 13-18) with ADHD, to what degree are ADHD medication status, ADHD subtype, and psychiatric comorbidity predictive of sleep disorders, use of sleep medication, and sleep problems?

**Overall Sample of Children with ADHD.** Logistic regression was used to determine risk factors predictive of a sleep disorder diagnosis or prescribed sleep

medication in the overall sample of children with ADHD. Independent variables entered into the model included medication status, ADHD type, and comorbidity.

Regarding a sleep disorder diagnosis, analyses revealed that children with ADHD with hyperactivity and children with an externalizing comorbidity were more likely to be diagnosed with a sleep disorder. The remaining factors were not predictive of a sleep disorder diagnosis. A full description of this model and all independent variables is provided in Table 18.

Regarding prescribed sleep medication, analyses revealed that children prescribed any type of medication used to treat the symptoms of ADHD (including stimulant, non-stimulant, and both stimulant and non-stimulant) were more likely to be prescribed a sleep medication. Similarly, children diagnosed with any type of comorbidity (including externalizing, internalizing, and both externalizing and internalizing) were more likely to be prescribed a sleep medication. Children diagnosed with ADHD with hyperactivity were more likely to be prescribed a sleep medication. A full description of this model and all independent variables is provided in Table 19.

**Subsample of Children with ADHD.** Logistic regression was used to determine risk factors predictive of a reported sleep problem in the subsample of children with ADHD. Independent variables entered into the model included medication status, ADHD type, and comorbidity. Analyses revealed that none of the independent variables were predictive of a reported sleep problem. A full description of this model and all independent variables is provided in Table 20.

**Overall Sample of Adolescents with ADHD.** Logistic regression was used to determine risk factors predictive of a sleep disorder diagnosis or prescribed sleep

medication in the overall sample of adolescents with ADHD. Independent variables entered into the model included medication status, ADHD type, and comorbidity.

Regarding a sleep disorder diagnosis, analyses revealed that adolescents diagnosed with an externalizing or externalizing and internalizing comorbidity were more likely to be diagnosed with a sleep disorder. The remaining factors were not predictive of a sleep disorder diagnosis. A full description of this model and all independent variables is provided in Table 21.

Regarding prescribed sleep medication, analyses revealed that adolescents prescribed stimulant or stimulant and non-stimulant medication were more likely to be prescribed a sleep medication. Similarly, adolescents diagnosed with an externalizing or internalizing comorbidity were more likely to be prescribed a sleep medication. Finally, adolescents diagnosed with ADHD with hyperactivity were more likely to be prescribed a sleep medication. The remaining factors were not predictive of a prescribed sleep medication. A full description of this model and all independent variables is provided in Table 22.

**Subsample of Adolescents with ADHD.** Logistic regression was used to determine risk factors predictive of a reported sleep problem in the subsample of adolescents with ADHD. Independent variables entered into the model included medication status, ADHD type, and comorbidity. Analyses revealed that adolescents diagnosed with both an externalizing and internalizing comorbidity were more likely to report a sleep problem. The remaining factors were not predictive of a reported sleep problem. A full description of this model and all independent variables is provided in Table 23.

# CHAPTER V. DISCUSSION

The purpose of this study was to determine the prevalence of sleep disturbance in children and adolescents with and without ADHD. This was accomplished by examining diagnosed sleep disorders, medications commonly used to treat sleep disturbance, and child and/or caregiver complaint of sleep problems. In addition, this study explored the frequency, type, and significance of sleep disturbance in children and adolescents with ADHD across medications used to treat symptoms of ADHD, subtype of ADHD, and diagnosed comorbidities. This information was obtained through electronic medical record documentation made by primary care providers during annual well-child visits.

## Research Question One

ADHD was found to be a predictor of sleep disorders and use of sleep medication in children (ages 6-12) and adolescents (ages 13-18).

Children and adolescents with ADHD were more likely to have disturbed sleep, as measured by ICD-9 sleep disorder diagnosis and prescribed sleep medication, compared to their counterparts with no ADHD diagnosis. Specifically, children and adolescents with ADHD were two times more likely to be diagnosed with a sleep disorder compared to peers with no ADHD diagnosis. Children with ADHD were 39 times more likely and adolescents with ADHD were 16.4 times more likely to be prescribed a sleep medication. In addition, significantly more children (8.9%) and adolescents (5.0%) with ADHD were also diagnosed with a sleep disorder compared to children (4.5%) and adolescents (2.5%) without ADHD. In addition, the rates of medication used to treat sleep disturbance was significantly elevated in children (16.1%)

and adolescents (12.1%) with ADHD compared to children (0.5%) and adolescents (0.8%) without ADHD.

The prevalence of sleep disorders found in the present study was lower than previous estimates of 25% to 50% in children and adolescents with ADHD (Corkum, Tannock, & Muldofsky, 1998) and 11% to 37% in the general pediatric population (Owens et al., 2000). In previous prevalence studies, rates of sleep disturbance were attained through parent and child completed measures specifically designed to screen for symptoms of sleep disorders and sleep problems. In contrast, the present study only considered the presence of a previously diagnosed sleep disorder. Thus, prevalence rates in the current study may be an underestimate of sleep disturbance in children and adolescents with ADHD and the general pediatric population.

Although systematically lower across this study, the prevalence of sleep disorders across ages is nearly double in the sample of children and adolescents with ADHD compared to their counterparts with no diagnosis of ADHD. This finding indicates an increased risk of a comorbid sleep disorder in this population. At present, the origin of this risk increase is unclear. Individuals diagnosed with ADHD may have intrinsic differences in sleep that is associated with this disorder (Golan et al., 2004; Lecendreux et al., 2000). This possible association between symptoms of ADHD and sleep disturbance could be related to an underlying neurobehavioral abnormality. Individuals with ADHD may present with a hypoarousal state during the day and a hyperarousal state at night (Lecendreux et al., 2000). In other words, these individuals are more like to fall asleep during the day and have increased arousals or waking at night. In contrast, it is possible that sleep disorders may lead to symptoms of ADHD in some children (Chervin, 2001).

For example, sleep loss can result in restlessness, irritability, low frustration tolerance, and difficulties sustaining attention (Anstead, 2000; Owens, 2005).

The most common sleep disorders diagnosed in children with ADHD were nocturnal enuresis (4.1%) and sleep disorder, NOS (2.8%). Similarly, nocturnal enuresis and sleep disorder, NOS were the most common sleep diagnoses in adolescents with ADHD, with prevalence rates of 1.8% and 1.9%, respectively. Although elevated in the sample of individuals with ADHD, the same sleep disorders were the most prevalent in the sample of children and adolescents without ADHD. It is possible that the high prevalence of nocturnal enuresis may be attributed to the significant impact this disorder poses on family functioning resulting in increased caretaker motivation to report and treat this disorder. The relatively high rates of sleep disorder, NOS could be due to this diagnostic code encompassing numerous sleep problems. The specific symptoms that led to this diagnosis are unknown and this diagnosis may serve as a default for primary care providers when symptoms or test results do not yield a more specific sleep diagnosis.

**Research Question Two**

The degree to which ADHD medication status, ADHD subtype, and psychiatric comorbidity were predictive of sleep disorders, use of sleep medication, and sleep problems in children (ages 6-12) and adolescents (ages 13-18) was determined.

**Medication Status.** Children and adolescents with ADHD prescribed any type of medication (stimulant medication, non-stimulant medication, and both stimulant and non-stimulant medication) designed to treat symptoms of ADHD were more likely to be prescribed a medication used to treat sleep disturbance compared to their counterparts not prescribed medication designed to treat symptoms of ADHD. Specifically, children with

ADHD prescribed a stimulant and non-stimulant medication were 2.4 times more likely, prescribed a stimulant medication were 1.5 times more likely, and prescribed a non-stimulant were 1.9 times more likely to also be prescribed a sleep medication than children with ADHD not prescribed any medication designed to treat symptoms of ADHD. Adolescents with ADHD prescribed a stimulant and non-stimulant medication were 2.9 times more likely and prescribed a stimulant medication were 2.6 times more likely to also be prescribed a sleep medication than adolescents with ADHD not prescribed medication designed to treat symptoms of ADHD. There were no differences in sleep disturbance, as measured by sleep diagnoses and sleep problems, between medicated and non-medicated children and adolescents with ADHD.

These findings are consistent with previous results in the literature that have found differences in sleep disturbance as a function of the medication status of children and adolescents with ADHD (Corkum et al., 2007; Galland, Tripp, & Taylor, 2010; Mayes et al., 2009; Schwartz et al., 2004; Stein, 1999). In addition, the present study highlights the link between prescribed medications used to treat ADHD and increased prevalence of prescribed medications used to treat sleep disturbance. These results suggest that children and adolescents prescribed any type of medication used to treat ADHD experience increased risk of sleep disturbance that is likely treated with another prescription medication. This finding is not surprising given that the most common side effect of stimulant medication is a decreased need for sleep and awareness of fatigue (Bricard & Boiden, 2001). It is unclear why this group of participants was not also diagnosed with sleep disorders and/or did not report sleep problems; however, this finding may be due to insufficient screening and diagnostic procedures in the primary

care setting. It is also possible that sleep disturbance in children and adolescents with ADHD treated with a medication is viewed as an adverse side-effect of stimulant medication rather than a sleep disorder that requires further medical or behavioral intervention beyond treatment with an additional sleep medication.

**ADHD Subtype.** This study also investigated sleep disturbance across both ICD-9 ADHD subtypes: ADHD with hyperactivity and ADHD without hyperactivity. Children with ADHD with hyperactivity were 1.7 times more likely to be diagnosed with a sleep disorder; however, there were no differences found between subtypes in adolescents. Both children and adolescents with ADHD with hyperactivity were 2.5 and 1.8 times more likely, respectively, to be prescribed a sleep medication. There were no differences found between subtypes when reporting sleep problems across both age groups. Taking into account the relatively low overall prevalence rates of diagnosed sleep disorders in the current study, these results suggest there is a difference in sleep behavior between subtypes of ADHD with children and adolescents with ADHD with hyperactivity experiencing greater sleep disturbance compared to children and adolescents with ADHD without hyperactivity.

It has been well documented that insufficient and/or poor quality sleep may affect children and adolescents differently than adults (Anstead, 2000). For example, rather than exhibiting daytime sleepiness and lethargy, children deprived of sleep typically demonstrate hyperactivity, restlessness, and difficulty sustaining attention. This may explain why children with ADHD with hyperactivity were more likely to be diagnosed with a sleep disorder and were more likely to be prescribed a sleep medication. As adolescents approach adulthood, there may be a shift in the daytime behavior that is

demonstrated while sleep deprived from hyperactivity to lethargy. This shift in symptom expression may result in fewer sleep disorder diagnoses in adolescents with ADHD with hyperactivity. As previous research findings offer conflicting results regarding specific differences in sleep disturbance across subtype (Corkum et al., 1999; LeBourgeois et al., 2004; Lecendruex et al., 2000; Mayes et al., 2009; Willoughby et al., 2008), future studies should aim to identify the specific sleep disorders and sleep problems that cause insufficient and/or poor quality sleep that children and adolescents with ADHD with hyperactivity are more likely to experience.

**Comorbidity.** Previously, few studies had investigated the effect of psychiatric comorbidity on sleep disturbance. The present study found that children with ADHD and an externalizing comorbidity were 1.5 times more likely and adolescents with ADHD and either an externalizing or internalizing and externalizing comorbidity were 2.5 times and 12.4 times more likely, respectively, to be diagnosed with a sleep disorder. These results are consistent with previous findings indicating that internalizing and externalizing comorbidities are linked to increased rates of sleep disorders (Corkum et al., 1999; Ivanenko et al., 2006). Children with ADHD and either an internalizing, externalizing, or both an internalizing and externalizing comorbidity were more likely to be prescribed a sleep medication. Similarly, adolescents with ADHD and either an internalizing or externalizing comorbidity were 3.6 and 2.8 times more likely, respectively, to be prescribed a sleep medication. Finally, adolescents with both an internalizing and externalizing comorbidity were 12.4 times more likely to report a sleep problem. This finding is somewhat contradictory to Mayes et al. (2009), who concluded that comorbid internalizing disorders increased sleep problems whereas comorbid externalizing

disorders did not. This difference may be due to the current study including multiple externalizing comorbid disorders, such as conduct disorder and oppositional defiant disorder, whereas Mayes et al. (2009) only included oppositional defiant disorder.

Overall, the results of the present study clearly indicated a strong link between both externalizing and internalizing comorbidities and sleep disturbance in this population. The symptoms associated with comorbid disorders may either cause sleep disturbance in this population or exacerbate sleep disturbance that is already present. For example, symptoms of anxiety, including excessive worry, feelings of restlessness, and difficulty with sleep, and symptoms of depression, including hypersomnia, may lead to a sleep disorder diagnosis of insomnia. Symptoms of oppositional defiant disorder, including arguing with adults, defiant behavior, and refusing to comply with demands, and symptoms of conduct disorder, including staying out at night despite parental prohibitions, may lead to a sleep disorder diagnosis of insufficient sleep, poor sleep hygiene, or delayed sleep phase syndrome. Futures studies should control for comorbidity, thereby identifying the relative contribution of ADHD alone to sleep disturbance.

**Other Notable Findings**

It is interesting to note the lack of treatment recommendations made by the primary care provider after a parent and/or patient complaint of a sleep problem. In the subsample of patients with ADHD, 84% of children and 88% of adolescents or their caregivers who reported a sleep problem to their primary care provider and were given no treatment recommendation. The absence of referrals to specialty sleep centers after a complaint of a sleep problem may contribute to the low prevalence of diagnosed sleep

disorders. This finding highlights the need for more comprehensive education for primary care providers regarding the screening, diagnosis, and treatment of pediatric sleep medicine. Additional awareness is particularly needed for children and adolescents with increased risk of sleep disturbance, specifically those patients with ADHD.

There are several advantages to conducting an electronic medical record review within the context of a primary care setting.as it provides a realistic snapshot of current care of children and adolescents. In addition, it identifies under-diagnosing of sleep disorders and mental health disorders within the primary setting. Under-diagnosing of these conditions may be due to lack of training or comfort in the diagnostic procedures necessary for these disorders. In addition, time constraints may prohibit primary care providers from asking about symptoms related to these disorders. Further, even if patients or caregivers view symptoms of these disorders as problematic, these concerns may not be among their top priorities for which to initiate a discussion with the primary care physician.

Sleep disorders, internalizing disorders, and externalizing disorders were under-diagnosed compared to previous prevalence rates. As previously discussed, the prevalence of sleep disorders within this study was 8.9% in children and 5.0% in adolescents, which is well below previous prevalence reports of between 25% and 50% in children and adolescents with ADHD (Corkum, Tannock, & Muldofsky, 1998). Regarding internalizing disorders across all children and adolescents seen for a well-child visit in the 2007 calendar year, 0.09% ($N$ = 70) had a diagnosis of a depressive disorder and 0.35% ($N$ = 279) had a diagnosis of an anxiety disorder. These prevalence rates are well below previous estimates of 7.9% for any depressive disorder and 3.8% for any

anxiety disorder (Mergl, Seidscheck, Allgaier, Moller, Hegerl, & Henkel, 2007). Regarding externalizing disorders, 2.3% (*N* = 1,816) of children and adolescents seen for a well-child visit in the 2007 calendar year were diagnosed with an externalizing disorder. Similarly, the prevalence rates found in the current study are well below previous estimates. Finally, only ADHD diagnoses were found to be greater than previous estimates. Specifically, 7.8% (N = 6,311) of children and adolescents seen for a well-child visit within the 2007 calendar year had a diagnosis of ADHD which is within the range of previous estimates of between 3% to 5% of school age children (American Psychiatric Association, 2000). These results indicate that primary care providers may have difficulty or be less comfortable in identifying sleep disorders, internalizing disorders, and externalizing disorders (other than ADHD) within the general pediatric population.

**Limitations**

This study has several limitations to consider. First, the sample in the present study varied in ADHD diagnostic evaluation and diagnosing provider, it is impossible to rule out the possibility that some individuals were incorrectly diagnosed with ADHD based on falsely elevated symptoms of ADHD caused by a sleep disorder. Similarly, the diagnostic process undertaken to evaluate sleep disorders is unknown and there is no way to ensure that all diagnoses were made correctly. Second, there are currently no medications to treat sleep disturbances in the pediatric population approved by the Food and Drug Administration. As a result, medications commonly used to treat sleep disturbance in adults were used as a proxy method of obtaining prevalence rates. As

such, the current study may have overestimated the rates of prescribed medications to treat sleep disturbance.

There are also several limitation associated with the use of an electronic health record for data collection. Although these procedures are able to provide a realistic picture of sleep disturbance in a large sample of children and adolescents with ADHD seen in the primary care environment, it is impossible to ensure the integrity of the data collection completed by the primary care providers. Specifically, providers are prompted to ask about sleep problems by the well child visit electronic template; however, there are no quality control measures in place to ensure that these questions are asked of patients and their parents. In addition, the electronic template varies between children and adolescents with the adolescent template providing a greater number of prompts for possible sleep problems. In contrast, the child template provides few prompts and relies on the primary care provider to manually type in many sleep problems. These labor-intensive procedures may be cumbersome and providers may be more likely to record sleep problems in adolescents than children as doing so for the latter is time consuming.

Finally, the logistic regression analyses were completed with a *p*-value that was not corrected for potential inflation of experiment-wise Type I error. Although multiple statistical procedures may increase the risk of Type I error, the current study identified possible risk factors of sleep disturbance and less conservative statistical methods will allow providers to identify all possible risk factors. Use of a corrected *p*-value may have resulted in factors that are predictive of sleep disturbance being incorrectly discounted and lead to an increase in Type II error. In sum, given the exploratory nature of this study the use of a *p*-value that was not corrected is justified in that the harm of

discounting truly predictive risk factors is greater than incorrectly identifying variables as risk factors of sleep disturbance.

**Clinical Implications**

ADHD was found to be a predictor of sleep disorders and use of sleep medication in both children and adolescents. As disturbed sleep can result in daytime sleepiness and behavioral difficulties that affect cognitive functions, such as attention and memory, as well as exacerbate symptoms of ADHD, it is imperative that all clinicians screen for sleep disturbance during the assessment for ADHD in order to make the most accurate diagnosis. Further, a comprehensive treatment approach designed to decrease symptoms of ADHD must ensure that sleep disturbance is evaluated and, if present, behavioral and/or medical strategies are included in the overall treatment approach.

In addition, the present study identified specific risk factors of sleep disturbance for children and adolescents with ADHD, including medication status, ADHD subtype, and comorbid status. It is important that clinicians are aware of these specific risk factors and a more intensive assessment for sleep disturbance that goes beyond a screening measure may be warranted with this population. Finally, the prevalence of sleep disorders in the present study was lower than previous estimates. There was also a lack of treatment recommendations made by the primary care provider after a parent and/or patient complaint of a sleep problem. These findings indicate that additional training for primary care providers is needed in the assessment and treatment of sleep disturbance in children and adolescents with ADHD.

**Directions for Future Research**

Identified directions for future research include the development of a screening measure to assess sleep disturbance in the population of children of children and adolescents with ADHD in the primary care setting. In addition, a multi-component treatment strategy that targets symptoms of ADHD at home and school should include the assessment and treatment of sleep disturbance. The effects of this component should be assessed via academic, social, and behavioral outcomes, as well medication status and the dosage of medication needed to obtain therapeutic effects.

Future research should also aim to tease out the predictive contributions of internalizing and externalizing comorbidities to sleep disturbance above and beyond the predictive contributions of a diagnosis of ADHD. In the current study, the percentage of children with a diagnosed sleep disorder was higher compared to the percentage of adolescents diagnosed with a sleep disorder. Future research should investigate if this is a clinically meaningful finding and examine the differences of sleep disturbance between children and adolescents in this population. Finally, the results of this study highlight ADHD as a risk factor for sleep disturbance. This suggests that the association between these two medical conditions may be related to a common underlying brain functioning factor. Future research should attempt to determine if this underlying factor exists and how it may differ between subtypes of ADHD.

**Conclusion**

In conclusion, the present study highlights the need for screening and appropriate treatment recommendations for sleep disturbance in children and adolescents with ADHD in the primary care setting. This is one of the first studies to examine the prevalence of sleep disturbance in children and adolescents with ADHD in the primary care setting.

Particular emphasis should be placed on early identification of sleep disturbance in children and adolescents with ADHD and risk factors identified in the current study, including those patients prescribed any type of medication used to treat symptoms of ADHD (stimulant, non-stimulant, and stimulant and non-stimulant), those patients diagnosed with ADHD with hyperactivity, and those patients with a psychiatric comorbidity (internalizing, externalizing, and internalizing and externalizing). These risk factors and their subsequent effects on the severity of symptoms associated with ADHD must be considered when assessing and treating children and adolescents with ADHD.

Table 1

*Demographic Variables According to Study Group*

| Variable | Children with ADHD Overall Group (*N* = 3478) | Children without ADHD Control Group (*N* = 3478) | Children with ADHD Subgroup (*N* = 280) | Adolescents with ADHD Overall Group (*N* = 2403) | Adolescents without ADHD Control Group (*N* = 2403) | Adolescents with ADHD Subgroup (*N* = 276) |
|---|---|---|---|---|---|---|
| Gender, % | | | | | | |
| Male | 73.60 | 73.60 | 73.60 | 69.20 | 69.20 | 71.40 |
| Female | 26.40 | 26.40 | 26.40 | 30.80 | 30.80 | 28.60 |
| Age, mean (SD), y | 9.44 (1.88) | 9.44 (1.88) | 9.90 (1.87) | 15.01 (1.57) | 15.01 (1.57) | 14.92 (1.65) |
| Race, % | | | | | | |
| Asian | 0.60 | 2.40 | 1.10 | 0.40 | 1.20 | 0.00 |
| Black | 29.10 | 31.90 | 25.40 | 20.40 | 23.40 | 21.70 |
| Hispanic or Latino Black | 0.20 | 0.20 | 0.00 | 0.10 | 0.20 | 0.00 |
| Hispanic or Latino Other | 0.80 | 0.70 | 0.40 | 0.90 | 0.90 | 1.10 |
| Hispanic or Latino White | 0.80 | 0.30 | 0.70 | 0.40 | 0.20 | 0.00 |
| White | 60.80 | 57.60 | 62.50 | 69.10 | 67.20 | 70.30 |
| Other | 7.80 | 7.00 | 10.00 | 8.60 | 6.90 | 6.90 |
| Median income, Mean (SD), $ | 54,142.63 (20,153.12) | 54,048.16 (20,325.25) | 54,031.63 (19,442.18) | 58,293.12 (19,608.91) | 57,806.01 (19,767.93) | 57,387.40 (19,239.46) |
| Individuals below below poverty level, % | 9.98 (9.87) | 10.28 (10.10) | 10.44 (10.50) | 8.12 (8.31) | 8.51 (8.88) | 8.74 (9.37) |

Table 2

*Percent of Sleep Diagnosis*

| Variable | Children with ADHD Overall Group (*N* = 3478) | Children without ADHD Control Group (*N* = 3478) | Children with ADHD Subgroup (*N* = 280) | Adolescents with ADHD Overall Group (*N* = 2403) | Adolescents without ADHD Control Group (*N* = 2403) | Adolescents with ADHD Subgroup (*N* = 276) |
|---|---|---|---|---|---|---|
| Sleep Diagnosis | 8.90 | 4.50 | 8.21 | 5.00 | 2.50 | 6.50 |
| Sleep Disorder | | | | | | |
| Nocturnal Enuresis | 4.10 | 2.60 | 4.28 | 1.80 | 1.00 | 1.80 |
| Sleep Disorder, NOS | 2.80 | 1.10 | 2.86 | 1.90 | 0.80 | 4.00 |
| Sleep Disordered Breathing | 2.10 | 1.10 | 0.71 | 0.70 | 0.50 | 0.70 |
| Insomnia | 0.40 | 0.00 | 1.07 | 0.80 | 0.10 | 0.00 |
| Circadian Rhythm Disorder | 0.00 | 0.00 | 0.00 | 0.10 | 0.00 | 0.00 |
| Narcolepsy | 0.00 | 0.00 | 0.00 | 0.10 | 0.00 | 0.00 |
| RLS/PLMD | 0.10 | 0.00 | 0.00 | 0.00 | 0.10 | 0.00 |
| Parasomnia | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Bruxism | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Table 3

*Percent of Prescribed Sleep Medication*

| Variable | Children with ADHD Overall Group (*N* = 3478) | Children without ADHD Control Group (*N* = 3478) | Children with ADHD Subgroup (*N* = 280) | Adolescents with ADHD Overall Group (*N* = 2403) | Adolescents without ADHD Control Group (*N* = 2403) | Adolescents with ADHD Subgroup (*N* = 276) |
|---|---|---|---|---|---|---|
| Sleep Medication | 16.10 | 0.50 | 17.85 | 12.10 | 0.80 | 17.00 |
| Name of Medication | | | | | | |
| Antihistamines | 7.20 | 0.00 | 4.29 | 4.30 | 0.00 | 6.20 |
| Alpha Agonists | 5.40 | 0.10 | 7.50 | 3.70 | 0.00 | 6.20 |
| Antipsychotics | 4.00 | 0.20 | 4.64 | 3.00 | 0.20 | 3.60 |
| SSRI's | 0.40 | 0.10 | 1.07 | 1.50 | 0.40 | 2.50 |
| Melatonin | 0.60 | 0.00 | 1.79 | 0.40 | 0.00 | 0.00 |
| Benzodiazepines | 0.20 | 0.20 | 0.00 | 0.80 | 0.20 | 1.10 |
| Antidepressants | 0.10 | 0.00 | 0.36 | 0.01 | 0.00 | 0.00 |
| Hypnotic Agents | 0.00 | 0.00 | 0.00 | 0.10 | 0.00 | 0.00 |
| Chloral Hydrate | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Table 4

*Percent of Parent and/or Child Reported Sleep Problem and Treatment Recommendation*

| Variable | Children with ADHD Subgroup ($N$ = 280) | Adolescents with ADHD Subgroup ($N$ = 276) |
|---|---|---|
| Sleep Problem | 17.86 | 14.86 |
| Type of Sleep Problem | | |
| Bedtime Struggles/Limit Setting | 1.07 | 0.00 |
| Change in Sleep Location | 1.07 | 0.00 |
| Daytime Fatigue | 0.71 | 0.00 |
| Daytime Sleepiness | 0.36 | 1.45 |
| Delayed Sleep Schedule | 0.71 | 1.81 |
| Difficulty Falling Asleep | 9.64 | 6.88 |
| Early Morning Waking | 0.36 | 0.00 |
| Insufficient Sleep | 0.00 | 0.36 |
| Symptoms of Nocturnal Enuresis | 1.79 | 0.36 |
| Parasomnia | 1.07 | 1.45 |
| Poor sleep | 1.79 | 1.45 |
| Restless Sleep | 0.36 | 0.36 |
| RLS Symptoms | 0.00 | 0.36 |
| Snoring | 0.36 | 0.00 |
| Use of Medication | 0.36 | 1.09 |
| Waking During the Night | 1.79 | 3.62 |
| Treatment Recommendation | | |
| Behavioral Sleep Rec. | 2.00 | 0.00 |
| Prescribe Medication | 0.00 | 4.88 |
| Suggest Melatonin | 4.00 | 0.00 |
| Referral for PSG | 2.00 | 2.44 |
| Other | 8.00 | 4.88 |
| None | 84.00 | 87.80 |

Table 5

*Frequency of Sleep Diagnosis, Sleep Medication, and Sleep Problems Within Participants*

| Variable | Children with ADHD Overall Group (*N* = 3478) | Children without ADHD Control Group (*N* = 3478) | Children with ADHD Subgroup (*N* = 280) | Adolescents with ADHD Overall Group (*N* = 2403) | Adolescents without ADHD Control Group (*N* = 2403) | Adolescents with ADHD Subgroup (*N* = 276) |
|---|---|---|---|---|---|---|
| Sleep Disorder Diagnosis, *n* | 308 | 158 | 23 | 120 | 61 | 18 |
| One Diagnosis, % | 91.88 | 93.70 | 95.65 | 92.50 | 96.70 | 100.00 |
| Two Diagnoses, % | 7.79 | 5.70 | 4.35 | 7.50 | 3.30 | 0.00 |
| Three Diagnoses, % | 0.32 | 0.60 | 0.00 | 0.00 | 0.00 | 0.00 |
| Prescribed Sleep Medication, *n* | 559 | 17 | 50 | 290 | 20 | 47 |
| One Medication, % | 89.62 | 94.10 | 90.00 | 86.90 | 95.50 | 85.10 |
| Two Medications, % | 10.02 | 5.90 | 10.00 | 12.07 | 5.00 | 14.90 |
| Three Medications, % | 0.36 | 0.00 | 0.00 | 1.03 | 0.00 | 0.00 |
| Reported Sleep Problem, *n* | | | 51 | | | 41 |
| One Problem, % | | | 72.55 | | | 73.20 |
| Two Problems, % | | | 27.45 | | | 24.40 |
| Three Problems, % | | | 0.00 | | | 2.40 |

Table 6

*Frequency of Sleep Diagnosis and Sleep Medication Across Variables in the Overall Sample of Children with ADHD*

| | One Sleep Disorder Diagnosis | Two Sleep Disorder Diagnoses | Total |
|---|---|---|---|
| One Prescribed Sleep Medication | 55 | 5 | 60 |
| Two Prescribed Sleep Medications | 12 | 2 | 14 |
| Total | 67 | 7 | 74 |

Table 7

*Frequency of Sleep Diagnosis and Sleep Medication Across Variables in the Overall Sample of Control Children without ADHD*

| | One Sleep Disorder Diagnosis | Total |
|---|---|---|
| One Prescribed Sleep Medication | 3 | 3 |
| Total | 3 | 3 |

Table 8

*Frequency of Sleep Diagnosis and Sleep Medication Across Variables in the Subsample of Children with ADHD*

| | One Sleep Disorder Diagnosis | Two Sleep Disorder Diagnoses | One Prescribed Sleep Medication | Two Prescribed Sleep Medications | Total |
|---|---|---|---|---|---|
| One Sleep Disorder Diagnosis | X | X | 2 | 1 | 3 |
| Two Sleep Disorder Diagnoses | X | X | 1 | 0 | 1 |
| One Prescribed Sleep Medication | 2 | 1 | X | X | 3 |
| Two Prescribed Sleep Medications | 1 | 0 | X | X | 1 |
| One Reported Sleep Problem | 3 | 0 | 9 | 1 | 13 |
| Two Reported Sleep Problems | 3 | 1 | 3 | 0 | 7 |
| Total | 9 | 2 | 15 | 2 | 28 |

Table 9

*Frequency of Sleep Diagnosis and Sleep Medication Across Variables in the Overall Sample of Adolescents with ADHD*

| | One Sleep Disorder Diagnosis | Two Sleep Disorder Diagnoses | Total |
|---|---|---|---|
| One Prescribed Sleep Medication | 24 | 2 | 26 |
| Two Prescribed Sleep Medications | 1 | 1 | 2 |
| Three Prescribed Sleep Medications | 1 | 0 | 1 |
| Total | 26 | 3 | 29 |

Table 10

*Frequency of Sleep Diagnosis and Sleep Medication Across Variables in the Overall Sample of Control Adolescents without ADHD*

| | One Sleep Disorder Diagnosis | Total |
|---|---|---|
| One Prescribed Sleep Medication | 2 | 2 |
| Two Prescribed Sleep Medications | 1 | 1 |
| Total | 3 | 3 |

Table 11

*Frequency of Sleep Diagnosis and Sleep Medication Across Variables in the Subsample of Adolescents with ADHD*

| | One Sleep Disorder Diagnosis | Two Sleep Disorder Diagnoses | One Prescribed Sleep Medication | Two Prescribed Sleep Medications | Total |
|---|---|---|---|---|---|
| One Sleep Disorder Diagnosis | X | X | 2 | 0 | 2 |
| Two Sleep Disorder Diagnoses | X | X | 0 | 0 | 0 |
| One Prescribed Sleep Medication | 2 | 0 | X | X | 3 |
| Two Prescribed Sleep Medications | 0 | 0 | X | X | 0 |
| One Reported Sleep Problem | 5 | 0 | 8 | 1 | 14 |
| Two Reported Sleep Problems | 3 | 0 | 2 | 2 | 7 |
| Total | 10 | 0 | 12 | 3 | 25 |

Table 12

*Percent of ADHD Diagnoses by Provider Type*

| Variable | Children with ADHD Subgroup ($N$ = 280) | Adolescents with ADHD Subgroup ($N$ = 276) |
|---|---|---|
| Type of Provider | | |
| Developmental Pediatrician | 7.50 | 3.60 |
| Neurologist | 8.20 | 5.80 |
| Primary Care Physician | 13.20 | 6.20 |
| Psychiatrist | 28.90 | 28.30 |
| Psychologist | 16.40 | 10.90 |
| Unknown Provider | 25.70 | 45.30 |

Table 13

*ADHD Diagnosis Process by Primary Care Physicians*

| Variable | Children with ADHD Subgroup, Diagnosed by the PCP (*N* = 37) | Adolescents with ADHD Subgroup, Diagnosed by the PCP (*N* = 17) |
|---|---|---|
| Broadband Measure, % | | |
| Parent | 8.10 | 0.00 |
| Teacher | 5.40 | 0.00 |
| Narrowband Measure, % | | |
| Parent | 81.10 | 58.80 |
| Teacher | 78.40 | 58.80 |
| Name of Narrowband Measure | | |
| Parent, *n* | 30 | 10 |
| Conners Rating Scale, % | 23.30 | 20.00 |
| NICHQ Vanderbilt Assessment, % | 70.00 | 70.00 |
| Unknown, % | 6.70 | 10.00 |
| Teacher, *n* | | |
| Conners Rating Scale, % | 20.70 | 20.00 |
| NICHQ Vanderbilt Assessment, % | 72.40 | 70.00 |
| Unknown, % | 6.90 | 10.00 |
| Structured Interview, % | | |
| Parent | 0.00 | 0.00 |
| Teacher | 0.00 | 0.00 |
| Unstructured Interview, % | | |
| Parent | 83.80 | 70.60 |
| Teacher | 27.00 | 5.90 |

Table 14

*Logistic Regression Model used to Predict Sleep Disorder Diagnoses in the Sample of Children with and without ADHD Overall Group (N = 6956)*

| Predictor Variable | *B*, Estimate ± SE | Odds Ratio (95% Confidence Interval) |
|---|---|---|
| ADHD Status | | |
| ADHD Diagnosis | 0.714 ± 0.101 | 02.042 (1.675-2.488)[a] |

[a] $p<.001$.

Table 15

*Logistic Regression Model used to Predict Prescribed Sleep Medication in the Sample of Children with ADHD Overall Group (N = 3478)*

| Predictor Variable | *B*, Estimate ± SE | Odds Ratio (95% Confidence Interval) |
|---|---|---|
| ADHD Status | | |
| ADHD Diagnosis | 3.663 ± 0.247 | 38.988 (24.004-63.326)[a] |

[a] $p<.001$.

Table 16

*Logistic Regression Model used to Predict Sleep Disorder Diagnoses in the Sample of Adolescents with and without ADHD Overall Group (N = 4806)*

| Predictor Variable | *B*, Estimate ± SE | Odds Ratio (95% Confidence Interval) |
|---|---|---|
| ADHD Status | | |
| ADHD Diagnosis | 0.702 ± 0.160 | 02.018 (1.475-2.761) [a] |

[a] $p<.001$.

Table 17

*Logistic Regression Model used to Predict Prescribed Sleep Medication in the Sample of Adolescents with and without ADHD Overall Group (N = 4806)*

| Predictor Variable | *B*, Estimate ± SE | Odds Ratio (95% Confidence Interval) |
|---|---|---|
| ADHD Status | | |
| ADHD Diagnosis | 2.794 ± 0.233 | 16.353 (10.355-25.824) [a] |

[a] $p<.001$.

Table 18

*Logistic Regression Model used to Predict Sleep Disorder Diagnoses in the Sample of Children with ADHD Overall Group (N = 3478)*

| Predictor Variable | *B*, Estimate ± SE | Odds Ratio (95% Confidence Interval) |
|---|---|---|
| Type of ADHD Medication | | |
| Stimulant and Non-Stimulant | -0.261 ± 0.260 | 0.771 (0.463-1.282) |
| Stimulant | -0.124 ± 0.136 | 0.884 (0.677-1.154) |
| Non-Stimulant | -0.397 ± 0.365 | 0.672 (0.329-1.376) |
| ADHD Diagnosis | | |
| ADHD with Hyperactivity | 0.554± 0.159 | 1.741 (1.276-2.376)[a] |
| Type of Comorbidity | | |
| Externalizing and Internalizing | 0.234 ± 1.060 | 1.264 (0.158-10.088) |
| Externalizing | 0.407 ± 0.159 | 1.502 (1.100-2.052)[b] |
| Internalizing | 0.671 ± 0.418 | 1.956 (0.863-4.434) |

[a] $p$=.001.
[b] $p$<.05.

Table 19

*Logistic Regression Model used to Predict Prescribed Sleep Medication in the Sample of Children with ADHD Overall Group (N = 3478)*

| Predictor Variable | *B*, Estimate ± SE | Odds Ratio (95% Confidence Interval) |
|---|---|---|
| Type of ADHD Medication | | |
| Stimulant and Non-Stimulant | 0.904 ± 0.183 | 2.470 (1.727-3.535)[a] |
| Stimulant | 0.433 ± 0.121 | 1.542 (1.217-1.954)[a] |
| Non-Stimulant | 0.619 ± 0.249 | 1.857 (1.139-3.027)[c] |
| ADHD Diagnosis | | |
| ADHD with Hyperactivity | 0.925 ± 0.133 | 2.523 (1.944-3.274)[a] |
| Type of Comorbidity | | |
| Externalizing and Internalizing | 1.547 ± 0.645 | 4.697 (1.326-16.639)[c] |
| Externalizing | 0.848 ± 0.119 | 2.335 (1.847-2.951)[a] |
| Internalizing | 0.975 ± 0.331 | 2.650 (1.386-5.068)[b] |

[a] $p<.001$.
[b] $p<.01$.
[c] $p<.05$.

Table 20

*Logistic Regression Model used to Predict Sleep Problems in the Sample of Children with ADHD Subgroup (N = 280)*

| Predictor Variable | *B*, Estimate ± SE | Odds Ratio (95% Confidence Interval) |
|---|---|---|
| Type of ADHD Medication | | |
| Stimulant and Non-Stimulant | 0.021 ± 0.491 | 1.021 (0.390-2.671) |
| Stimulant | 0.271 ± 0.382 | 1.311 (0.620-2.772) |
| Non-Stimulant | -0.900 ± 0.672 | 0.407 (0.109-1.516) |
| ADHD Diagnosis | | |
| ADHD with Hyperactivity | -0.197 ± 0.323 | 0.821 (0.436-1.547) |
| Type of Comorbidity | | |
| Externalizing and Internalizing | -0.650 ± 1.085 | 0.522 (0.062-4.375) |
| Externalizing | 0.232 ± 0.436 | 1.262 (0.537-2.964) |
| Internalizing | 0.082 ± 0.497 | 1.085 (0.410-2.872) |

Table 21

*Logistic Regression Model used to Predict Sleep Disorder Diagnoses in the Sample of Adolescents with ADHD Overall Group (N = 2403)*

| Predictor Variable | *B*, Estimate ± SE | Odds Ratio (95% Confidence Interval) |
|---|---|---|
| Type of ADHD Medication | | |
| Stimulant and Non-Stimulant | 0.410 ± 0.351 | 1.507 (0.757-3.000) |
| Stimulant | 0.093 ± 0.232 | 1.098 (0.697-1.729) |
| Non-Stimulant | -0.577 ± 0.556 | 0.562 (0.189-1.670) |
| ADHD Diagnosis | | |
| ADHD with Hyperactivity | 0.358 ± 0.213 | 1.431 (0.942-2.173) |
| Type of Comorbidity | | |
| Externalizing and Internalizing | 2.520 ± 0.895 | 12.432 (2.153-71.789)[b] |
| Externalizing | 0.929 ± 0.261 | 2.531 (1.518-4.219)[a] |
| Internalizing | 0.135 ± 0.734 | 1.144 (0.271-4.825) |

[a] $p<.001$.
[b] $p<.01$.

Table 22

*Logistic Regression Model used to Predict Prescribed Sleep Medication in the Sample of Adolescents with ADHD Overall Group (N = 2403)*

| Predictor Variable | *B*, Estimate ± SE | Odds Ratio (95% Confidence Interval) |
|---|---|---|
| Type of ADHD Medication | | |
| Stimulant and Non-Stimulant | 1.077 ± 0.266 | 2.937 (1.745-4.944)[a] |
| Stimulant | 0.942 ± 0.191 | 2.565 (1.765-3.729)[a] |
| Non-Stimulant | 0.504 ± 0.337 | 1.655 (0.855-3.201) |
| ADHD Diagnosis | | |
| ADHD with Hyperactivity | 0.589 ± 0.146 | 1.802 (1.354-2.400)[a] |
| Type of Comorbidity | | |
| Externalizing and Internalizing | 1.430 ± 0.890 | 4.179 (0.731-23.898) |
| Externalizing | 1.035 ± 0.188 | 2.814 (1.947-4.067)[a] |
| Internalizing | 1.291 ± 0.360 | 3.638 (1.796-7.368)[a] |

[a] $p<.001$.

Table 23

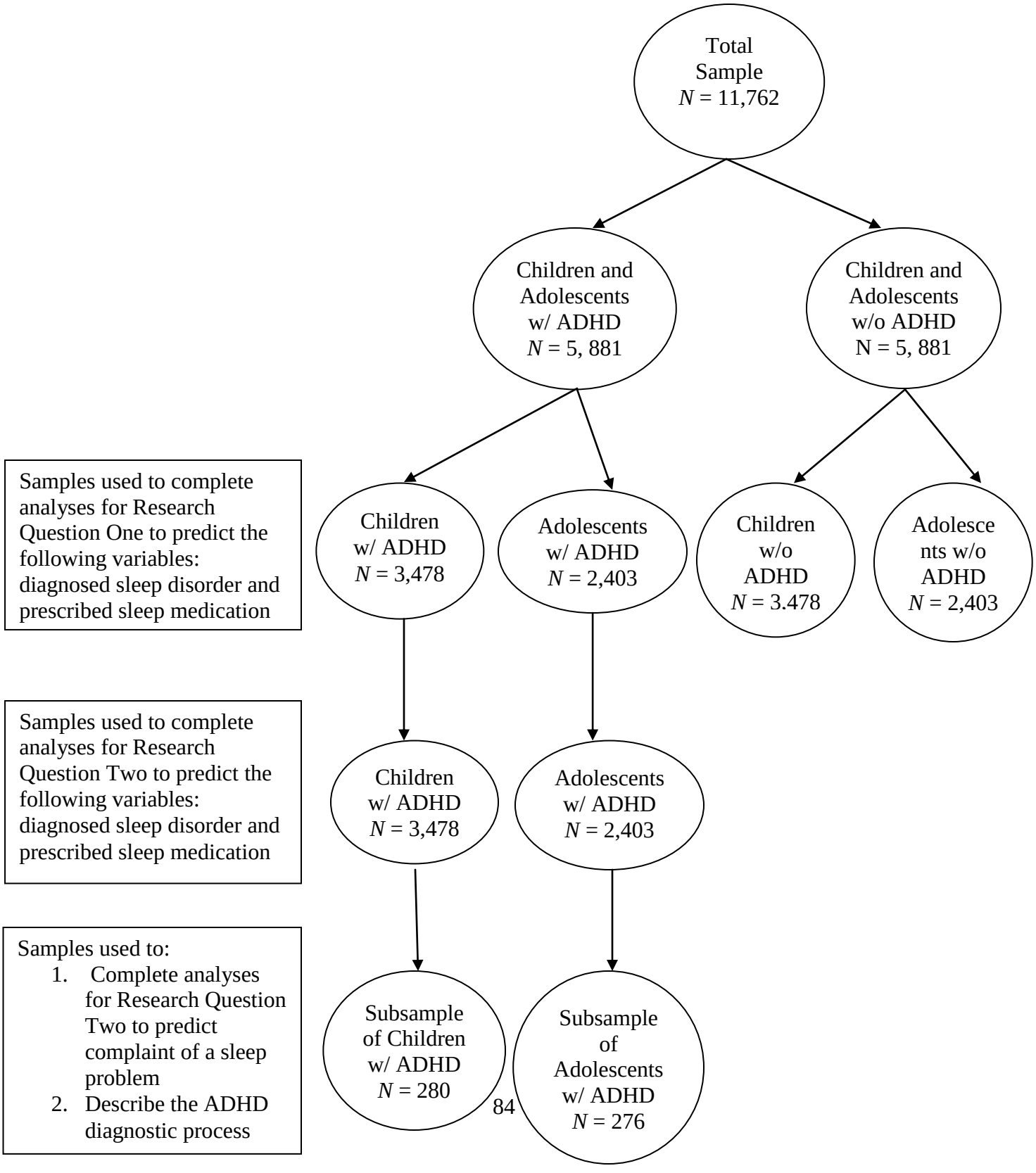
*Logistic Regression Model used to Predict Sleep Problems in the Sample of Adolescents with ADHD Subgroup (N = 276)*

| Predictor Variable | *B*, Estimate ± SE | Odds Ratio (95% Confidence Interval) |
|---|---|---|
| Type of ADHD Medication | | |
| Stimulant and Non-Stimulant | 0.254 ± 0.615 | 1.289 (0.386-4.306) |
| Stimulant | 0.398 ± 0.481 | 1.488 (0.580-3.818) |
| Non-Stimulant | 0.780 ± 0.540 | 2.182 (0.757-6.288) |
| ADHD Diagnosis | | |
| ADHD with Hyperactivity | -0.140 ± 0.348 | 0.869 (0.440-1.719) |
| Type of Comorbidity | | |
| Externalizing and Internalizing | 2.515 ± 0.918 | 12.365 (2.046-74.721)[a] |
| Externalizing | 0.075 ± 0.457 | 1.078 (0.440-2.640) |
| Internalizing | -0.021 ± 0.590 | 0.979 (0.308-3.114) |

[a] $p<.01$.

Figure 1

*Visual Depiction of the Samples Used in Each Statistical Analysis*



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# BIOGRAPHY

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