ADHD and Sleep Trouble: How are they Related?

By

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Abstract

Objective: The purpose of the current research was to explore the relationship between ADHD and sleep trouble using a large nation-wide population-based sample. It was hypothesized that (1) people with ADHD would be more likely to report sleep troubles than their non-ADHD peers, and (2) that mental health covariates would contribute to the relationship between ADHD and sleep troubles.

Method: Using the Statistics Canada Canadian Community Health Survey of Mental Health (CCHS-MH) data base, a chi square analysis was used to compare participants with self-reported ADD/ADHD to participants in an age- and gender-matched control group on the frequency they experience sleep trouble. Next, a logistic regression analysis was used to determine whether mental health covariates such as General Anxiety Disorder, Major Depressive Disorder, and Bipolar Disorder I and II contributed to the relationship between ADD/ADHD and sleep trouble.

Results: There was an increased likelihood of sleep troubles among respondents who reported a diagnosis of ADD/ADHD compared to those who did not report a diagnosis. Female respondents with ADHD reported greater sleep troubles than male respondents with ADHD, and increasing age predicted increases in sleep troubles. A comorbid diagnosis of depression also predicted an increase in reported sleep troubles.

Conclusion: The current study indicated that ADHD is related to increased levels of sleep troubles, and that factors such as age, gender and mental health comorbidities contribute to the relationship between ADHD and sleep troubles. Clinicians should target sleep troubles and comorbid depression as part of a comprehensive approach to ADHD treatment.

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ADHD and Sleep Trouble: How are they Related?

Attention Deficit Hyperactivity Disorder (ADHD) is one of the most common psychiatric disorders of childhood and adolescence, characterized by a consistent pattern of symptoms that impedes functioning such as hyperactivity, inattention, and impulsivity (American Psychiatric Association (APA), 2013; Marks, Newcorn & Halperin, 2001; Pliszka, 2007). Approximately 60% of childhood ADHD cases persist into adulthood with 4.4% of the adult population having the diagnosis (Barbaresi, et al., 2013; Sibley, et al., 2017), although, ADHD symptom severity tends to decrease as people with ADHD age. Adolescents and adults with ADHD are usually less hyperactive than they were as children, however, this hyperactivity can manifest into feelings of restlessness (Martel, Von Eye & Nigg, 2012; Targum & Adler, 2014). Adults who struggle with ADHD often experience difficulty with executive functioning, working memory and planning, which can greatly impact important areas of life such as academics and career (Tseng & Gau, 2013). Along with this, ADHD is highly comorbid with psychiatric disorders, such as anxiety, depression and bipolar disorder (Perroud et al., 2014; Van Ameringen et al., 2011). Comorbid mental health disorders exacerbate the already impairing symptoms of ADHD, further confounding diagnosis and management of the disorder (Katzman et al., 2017). In addition to these mental health comorbidities, disrupted sleep may contribute to worsening of ADHD symptoms (Baird et al., 2012). Research examining ADHD and sleep using population-based samples is limited. However, this area of research is important because it will aid in early identification and increase efficacy of ADHD treatments. The current research will fill this gap in the literature by exploring the relationship between ADHD and sleep trouble in a large national community-based sample of adults.

Attention Deficit Hyperactivity Disorder

ADHD is a chronic neurodevelopmental disorder defined by a persistent pattern of symptoms that interferes with an individual's functioning or development (APA, 2013). It is thought that the brains of individuals with ADHD do not develop neurotypically from birth (Vaidya, 2011), which results in differences in brain development and brain activity that can impact attention, hyperactivity and impulsive behaviour. For example, imaging studies have shown that the amygdala and the hippocampus are smaller in the brains of people who have ADHD (Onnink et al., 2013; Tajima-Pozo et al., 2018). The prefrontal cortex of the brain is involved with the executive functions, and is responsible for tasks including planning, organizing, attention, and managing emotional reactions (Koechlin, 2015). Among individuals with ADHD, the prefrontal cortex receives decreased blood flow, which means decreased neurological activity (Kim et al., 2010). These areas play an important role in emotional processing and impulsivity (Hoogman, Bralten, Hibar, et al., 2017). Moreover, dopamine has been identified as a key neurotransmitter related to ADHD, and low levels of the neurotransmitter in the prefrontal cortex has been linked to increased levels of inattention and impulsivity (Volkow et al., 2009).

In terms of diagnoses, there are currently three recognized presentations of ADHD that differ based on the nature of the symptoms reported by the individual (APA, 2013). These presentations include predominantly inattentive presentation, predominantly hyperactive-impulsive presentation, and combined presentation (APA, 2013). Individuals with a predominantly inattentive presentation meet criteria for a diagnosis of ADHD based on symptoms of inattention only, while individuals with the predominantly hyperactive-impulsive presentation meet criteria for diagnosis based on symptoms of hyperactivity and impulsivity.

Individuals with combined presentation experience five or more symptoms of both inattention and hyperactivity-impulsivity and can therefore meet diagnostic criteria across both types of symptoms (APA, 2013). Although ADHD is predominantly thought of as a childhood disorder, the *DSM-5* includes revised diagnostic criteria that reflects the fact that the disorder can persist into adulthood or be newly diagnosed in adulthood and that the symptom presentation may change over time (APA, 2013).

Symptoms of inattention include failing to pay close attention to details or making careless mistakes; difficulty sustaining attention in tasks; appearing to not listen when spoken to directly; failure to follow through on instructions and failing to complete chores or duties in the work place; difficulty organizing tasks and activities; avoiding, disliking or being reluctant to engage in tasks that require sustained mental effort; often losing things necessary for activities; often being distracted by extraneous stimuli (including unrelated thoughts); and being forgetful in daily activities (APA, 2013; Sroubek & Li, 2013). Conversely, symptoms of hyperactivity and impulsivity include fidgeting; feeling restless; inability to engage in leisure activities quietly; being unable to be or being uncomfortable being still for extended periods of time or being seen by others as restless or difficult to keep up with; often talking excessively; often completing other people's sentences or unable to wait for turn in conversations; often having difficulty waiting one's turn; and often interrupting or intruding on others (APA, 2013).

In addition to the different presentations of ADHD, ADHD can present differently across gender (Vildalen et al., 2019). Research examining gender differences among adults with ADHD symptoms found that females reported more severe inattention symptoms when compared to males (Vildalen et al., 2019). However, males tend to receive a diagnosis of ADHD more frequently than females, with the ratio of males to females among adults with ADHD being 3:2

(Van Ameringen et al., 2011). Conversely, males also tend to receive a diagnosis of hyperactive-impulsive presentation more than females (Gershon & Gershon, 2002). This could be due to symptoms of hyperactivity being easier to notice compared to symptoms of inattention (Vildalen, et al., 2019).

Symptoms of ADHD can change as individuals age, the severity of their symptoms decline, while some adults may continue to experience impairments that interfere with their daily functioning (Caye et al., 2016). Adults who struggle with ADHD have difficulty with executive functioning, working memory and planning, which can negatively impact school and work performance (Tseng & Gau, 2013).

In terms of educational outcomes, individuals with ADHD are less likely to enrol in higher education than their ADHD non-peers, and within the individuals who do pursue higher levels of education, fewer will graduate at the same time as their non-ADHD peers (Sedgwick, 2018). Employment rates among adults with ADHD indicate that 24% reported employment compared to 79% of individuals in a population-based control group (Halmøy et al., 2009). In addition to difficulties related to education and employment difficulties, ADHD has also been shown to be highly comorbid with other psychiatric disorders (Kennemer & Goldstein, 2005; Van Ameringen et al., 2011).

ADHD Comorbidities

Individuals with a diagnosis of ADHD have a greater likelihood of experiencing mental health comorbidities than those without ADHD (Kessler et al., 2006). Differentiating the diagnosis of adult ADHD from other mental health conditions can be challenging since certain ADHD symptoms have been shown to be like other comorbid conditions and overlap. Some of

these most common comorbid psychopathologies of ADHD include anxiety, depression, and bipolar disorder (Katzman et al., 2017; Kennemer & Goldstein 2005).

ADHD and Anxiety

According to the *DSM-5* individuals who have an anxiety disorder can experience symptoms such as restlessness, sleep disturbance and being easily fatigued (APA, 2013). ADHD and anxiety are separate conditions that share common symptoms, and for many individuals these disorders can occur comorbidly with the prevalence of adult ADHD being higher in clinical samples of people who have anxiety disorders compared to control samples (Van Ameringen et al., 2011). Moreover, recent studies have suggested that there is a need to address both ADHD and comorbid anxiety symptoms to minimize negative impacts of the combined symptoms such as difficulty with concentration, heightened feelings of stress and restlessness, (Koyuncu et al., 2022; Quenneville et al., 2022; Shen et al., 2020). It is important to consider both disorders since individuals with ADHD have been shown to have higher symptom severity scores when comorbid anxiety disorders are present (Van Ameringen et al., 2011).

There are various factors that connect ADHD and anxiety such as feelings of daily stress, struggles with initiating tasks and experiences of emotional dysregulation (Combs et al., 2015). Experiencing feelings of stress and uncertainty regarding events or daily tasks is characteristic of anxiety. Due to symptoms of hyperactivity and/or inattention, when an individual has ADHD there can be feelings of stress, uncertainty and anxiety surrounding daily tasks and situations (Combs et al., 2015; Marije Boonstra et al., 2005). Individuals with ADHD may experience distrust and uncertainty in oneself while experiencing ADHD symptoms exasperating feelings of anxiety (Newark, Elsässer & Stieglitz, 2016).

Another link between anxiety and ADHD is that individuals with ADHD struggle with initiation of tasks and implementation leading to procrastination (Miller, 2007). Procrastination is a significant factor within the relationship of ADHD and anxiety, particularly in adulthood (Bolden, & Fillauer, 2020). Barriers to implementation of tasks within ADHD can include, self-regulatory efficacy such as the worry of not being able to resist distraction or uphold focus and incautious optimism such as having distorted positive thoughts such as depending on working most efficiently on a task last minute (Knouse, & Mitchell, 2015; Prevatt et al., 2015).

Another component of anxiety and ADHD is emotional dysregulation (Hirsch et al., 2018; Tsypes, Aldao & Mennin, 2013). Individuals who have ADHD can experience great emotional intensity (Skirrow et al., 2014).

A biological link between anxiety and ADHD has also been the subject of research which suggests that anxiety and ADHD share similar brain structure pathologies that characterize the two disorders (Levy, 2004). Deficits in various brain regions such as the amygdala and the prefrontal cortex are involved with impulsive behavior or dysregulatory psychopathology, especially among individuals with ADHD (Nigg & Casey, 2005; Levy, 2004). Moreover, ADHD and anxiety are also highly comorbid with mood disorders (Van Ameringen et al., 2011).

ADHD and Depression

According to the *DSM-5* a diagnosis of depression includes symptoms such as depressed mood for most of the day, significant decrease in engagement in activities and trouble concentrating (APA, 2013). Depression is another disorder which has been shown to be connected to ADHD and can often co-occur with it (Riglin et al., 2021). Symptoms of both depression and ADHD can overlap, which may create difficulty providing an accurate diagnosis and hamper treatment for both conditions. For example, difficulty with focus is one of the signs

of both depression and ADHD (Keller, Leikauf, Holt-Gosselin, et al., 2019; Paucke et al., 2021). An individual who has ADHD may have feelings of lacking motivation resulting in inattentive symptoms while an individual who has depression may experience feelings of hopelessness and therefore not be able to hold their attention on a particular task (Keller, Leikauf, Holt-Gosselin, et al., 2019).

Individuals who have comorbid ADHD and depression experience a lower quality of life then those who have depression alone (McIntyre et al., 2010). Individuals with ADHD have reported experiencing depression at a significantly earlier age in relation to individuals without ADHD (Van Ameringen et al., 2011). For these individuals, depression may be a result of low self-esteem and a poor self-image caused by ongoing feelings of being overwhelmed by life due to ADHD symptoms (Choi et al., 2019). ADHD symptoms can cause problems for individuals in many areas such as relationships, academics and careers which can result in individuals with ADHD having low self-efficacy, further causing them to be prone to having low self-esteem (McIntyre et al., 2010). When individuals experience problems in their daily lives due to symptoms of ADHD this may result in low mood or feelings of hopelessness (Arsandaux et al., 2021).

Individuals who have ADHD can also have difficulty with emotional dysregulation in that they may find it difficult to transition out of and distracting themselves from negative emotions which may also contribute to depression (Hirsch et al., 2018). Another reason ADHD and depression may co-occur is that ADHD is related to dysregulation of dopamine, a neurochemical responsible for motivation and implicated in reward systems and moods (Dailly et al., 2004; Mehta, Monegro, Nene, et al., 2019). Another mood disorder which is highly related to ADHD is bipolar disorder (BP; Perroud et al., 2014).

Bipolar I and II and ADHD

BP I is characterized as a manic depressive disorder and includes symptoms such as intense increases in energy and feelings of euphoria, depressive or hypomanic episodes, followed by periods of neutral mood (APA, 2013). BP II disorder is characterized by episodes of depression and mania, these episodes have been shown to interchange, an individual diagnosed with the disorder usually experiencing at least one major depressive episode and at least one hypomanic episode (APA, 2013).

Research has indicated that over 20% of individuals with bipolar disorder also meet the diagnostic criteria for ADHD (Perroud et al., 2014). People who have both ADHD and BP have been shown to experience higher numbers of depressive episodes, more anxiety disorders, greater alcohol and substance dependence and more borderline personality traits (Perroud et al., 2014). There is an overlap between symptoms of ADHD and mania or hypomania associated with BP which include distractibility, talkativeness, difficulty maintaining attention, and loss of social functioning (O'Connell et al., 2021) Another commonly occurring symptom between ADHD and comorbid disorders is sleep troubles (Baird et al., 2012; Harvey, Talbot & Gershon, 2009).

Sleep

Sleep is an important part of one's health as sleep enables one's body to rest, replenish resources and create the energy required to accomplish daily and necessary tasks (Irwin & Opp, 2017). However, energy becomes depleted throughout the day as work and responsibilities are completed (Barber & Munz, 2011). If there is not enough energy due to lack of rest and sleep debt grows and if not gained through recovery sleep, substantial daytime sleepiness may arise (Owens, 2005).

How one cognitively performs during the day depends significantly on circadian sleep regulation (Garbarino et al., 2021). Sleepiness during the daytime could be the outcome of disturbances in circadian regulation (Owens, 2005). Changes in behaviour impacting social relationships and occupational functioning can also occur when unhealthy sleep patterns take place. These can range from functional inadequacy to higher risks at work or failure to pay attention while driving (Garbarino et al., 2020). Lack of sleep can also impact the regulation of stress (Prather, Bogdan & Hariri, 2013). Studies have also shown that if sleep is persistently improved that it may help to alleviate stress (Barber & Munz, 2011).

Sleep and ADHD

Many of the symptoms associated with ADHD are similar to those of sleep deprivation (Gamble et al., 2013). For example, sleep troubles in adults who have ADHD may include symptoms such as inattention and difficulty concentrating, this overlap of symptoms may cause difficulty in knowing if symptoms are caused by ADHD, sleep troubles or both (Philipsen, Hornyak & Riemann, 2006). Disrupted sleep worsens symptoms of adult ADHD and adults with ADHD have been shown to have a high prevalence of sleep disorders such as a preference for being awake during later times, issues with executive functioning and self-control, and delayed sleep phase disorder (DSPD) (Baird et al., 2012; Bae et al., 2010; Cifre, Walters & Budnick, 2020; Muraven & Baumeister, 2000).

DSPD can be defined as a circadian rhythm sleep disorder causing delayed sleep time in relation to the desired clock time, resulting in difficulty adjusting the patient's sleep onset and wake-up times (Takahashi, Hohjoh, & Matsuura, 2000). Individuals who have ADHD experience adverse changes in circadian rhythm (Baird et al., 2012). A study by Snitselaar, Smits and Spijker (2019), showed significantly more ADHD symptoms and higher percentage of

probable ADHD in DSPD patients when compared to patients without DSPD. Additionally, studies have shown that ADHD appears twice as frequently among those with DSPD when in individuals who have reported sleep issues without DSPD (Snitselaar, Smits & Spijker, 2019).

Another aspect of the relationship between sleep health and ADHD is the concept of eveningness (Bae et al., 2010). Morningness and eveningness can be defined as how alert one feels in the morning and the evening, respectively (Bae et al., 2010). Studies have shown that eveningness is a significant predictor of having problems falling asleep (Vollmer et al., 2016). Eveningness and lack of sleep at night is correlated with adult ADHD and is associated with the severity of symptoms such as inattention, hyperactivity and impulsivity (Bae et al., 2010; Baird et al., 2012).

Issues with executive functioning have been observed in adults who have ADHD, especially if they regularly experience poor sleep (Cifre, Walters & Budnick, 2020). Lack of sleep has a negative impact on executive functioning when one already experiences high impulsivity (Cifre, Walters & Budnick, 2020). Lack of control over initiation of sleep among adults who have ADHD could contribute to poor sleep such as becoming distracted instead of initiating sleep (Muraven & Baumeister, 2000). Self-control is conceptualized as the ability or capacity to overcome or resist impulses and temptations and modify behaviour through active and conscious means (Hagger, 2010). Self-control takes place when an individual tries to alter the way that they may instinctively behave, feel or think (Muraven & Baumeister, 2000). Sleep and self-regulation issues have been shown to emerge as early as approximately 2 to 3 years of age for children with mother-reported ADHD and these differences seem to remain persistent across time (Williams & Sciberras, 2016).

Sleep troubles in ADHD appear to differ depending on the type of ADHD (Gamble et al., 2013). Individuals with predominantly inattentive symptoms are more likely to have a later bedtime, while those predominantly hyperactive-impulsive symptoms are more likely to suffer from insomnia (Philipsen, Hornyak & Riemann, 2006). Individuals who have a combined type of ADHD may experience a poor sleep as well as a later bedtime (Wynchank et al., 2017). Sleep troubles within individuals who have ADHD may be further exasperated as people begin to develop anxiety related to going to sleep (D'Agati, Curatolo & Mazzone, 2019; Grupe & Nitschke, 2013).

Sleep and Anxiety

Anxiety has an established relationship with sleeping problems (Boehm et al., 2016; Mellman, 2006). Experiencing sleep troubles can exasperate symptoms of anxiety and cause greater impairment (Neckelmann, Mykletun & Dahl, 2007). Researchers have found that people who are prone to anxiety are especially sensitive to the effects of insufficient sleep which can provoke symptoms of anxiety (Goldstein et al., 2013).

Symptoms that can come along with anxiety such as feelings of worry may make it difficult to fall asleep and stay asleep for a long period of time. Moreover, sleep deprivation has been shown to make feelings of anxiety worse, creating a cycle of sleep troubles and anxiety disorders (Kalmbach et al., 2018). Sleep disturbances within anxiety disorders can present as trouble falling and staying sleep, poor quality of sleep and nightmares much like individuals who have depression (Mellman, 2006). There are various reasons as to why anxiety causes sleep troubles.

Experiencing stress around falling asleep and experiencing sleep troubles can create further anticipatory anxiety (Grupe & Nitschke, 2013). Moreover, individuals who have anxiety

disorders are more likely to experience high sleep reactivity, experiencing sleeping problems due to feelings of stress (Kalmbach, Anderson & Drake, 2018). This may cause sleep fragmentation, which could impact the duration and quality of sleep (Ohayon, Morselli, & Guilleminault, 1997).

Sleep and Depression

Sleep disturbances are commonly associated with chronic depression (Baglioni et al., 2011; Hoyos et al., 2020; Nota et al., 2020). Depression is associated with sleep troubles such as shortening the amount of restorative slow wave sleep a person gets each night (Thase, 2006). Slow wave sleep is one of the four stages of sleep (along with wake, light sleep, and REM sleep) that your body spends time in on a nightly basis (Landsness et al., 2011). Slow wave sleep is when your body physically restores itself (Léger et al., 2018). Sleep trouble is not just a consequence of depression but additionally, may also worsen symptoms of depression (Scott, Webb & Rowse, 2017). This may create a cycle between depression and sleep troubles such that the worse one's symptoms of depression become, the more difficult it is to sleep.

Another variable involved in the relationship between depression and sleep is emotional dysregulation (Compare et al., 2014). Experiencing sleep troubles could create difficulties regulating emotions which may make symptoms of depression worse (Gruber, & Cassoff, 2014). Dysfunctional emotional regulation in the form of rumination can impact the development of depression (Compare et al., 2014). Sleep troubles can make individuals more emotionally aroused and sensitive to stressful stimuli and events (Vandekerckhove, & Wang, 2018). Moreover, depression and rumination can have a severe negative impact on one's overall health such as impaired ability to process negative information, adrenal axis overactivation and higher rates of cortisol production (Compare et al., 2014). Another disorder associated with sleep troubles is BP (Harvey, Talbot & Gershon, 2009).

Sleep and BP I and II

Sleep disturbance is a common symptom of BP (Harvey, Talbot & Gershon, 2009). Research has shown that insomnia persists in 70% of patients even when their mood is stable, and these sleep problems put them at risk for more episodes of mania and depression (Harvey, Soehner, Kaplan, et al., 2015). According to research, sleep troubles such as insomnia, hypersomnia and delayed sleep phase, are regularly experienced by individuals with bipolar disorders (Colombo et al., 1999; Laskemoen et al., 2019). During periods of mania, individuals who have BP may experience a loss of sleep for multiple days at a time. Sleep deprivation can also trigger manic or hypomanic episodes for some individuals with BP (Ng et al., 2015).

Current Study

Previous research has indicated that individuals with ADHD experience greater levels of mental health difficulties than their non-ADHD peers. The current research will explore the relationship between ADHD and sleep trouble using a large nation-wide population-based sample. It is hypothesized that people reporting a diagnosis of ADD/ADHD will be more likely to report sleep troubles than their non-ADD/ADHD peers, and that mental health covariates will contribute to the relationship between ADD/ADHD and sleep.

Methods

Participants

Data was obtained via the Statistics Canada Canadian Community Health Survey of Mental Health (CCHS-MH) (Statistics Canada, 2013); a survey that sampled individuals living in private dwellings throughout 115 health regions covering all ten provinces. Respondents for the survey were selected in three stages. Geographical areas were selected, followed by households within each geographical area. Finally, one respondent from each household was

randomly selected. The overall national response rate was 68.9%, with the CCHS-MH providing cross-sectional data from 25,113 Canadians aged 15 to 80 residing in private residences from the 10 provinces. The sample did not include individuals living in the three territories, those living on Aboriginal reserves or settlements, full-time members of the Canadian forces, or institutional residents. However, Statistics Canada estimates that the total number of these individuals represents less than 3% of the target population, so as a result the remaining sample is still considered to be nationally representative (CCHS-MH; Statistics Canada, 2013).

The sample size for the current study was 488 participants. Participants who reported a diagnosis of ADHD and were between the ages of 20 and 64 were selected from the database. As the present study is focused on the experiences of adults, data from seniors (those beyond age 64) were excluded from the analysis as those age 65 and older are typically considered to be 'seniors' (Statistics Canada, 2007). The age category 15- 19 was excluded from the analyses. Adults aged 18-19 were not included in the analyses due to the way the database stratifies age in 5-year categories. A randomly selected age and sex matched control sample was created from the remaining participants who did not report a diagnosis of ADHD.

Data Collection

Data obtained via the CCHS-MH was collected from individuals aged 15 to 80 living in private dwellings throughout the ten Canadian provinces. Data collection occurred from January 2012 to December 2012. During the sampling period, 25,113 valid interviews were conducted. Detailed information regarding sampling techniques and data collection is available from Statistics Canada (2013) but are summarized below.

The CCHS-MH used the same area frame as used in the Labor Force Survey (LFS); a complex two-stage stratified design in which clusters make up each stratum. First, clusters are

selected using a sampling method with a probability proportional to size. Next, for each cluster dwelling lists are prepared, and a systematic sample of households is selected from these lists. Afterwards, a single member was randomly selected from each household with the assistance of selection probabilities based on household composition and age.

Prior to the commencement of data collection, introductory letters and brochures were sent to the 43,030 selected households explaining the purpose of the study. The importance of survey participation, along with examples outlining how the CCHS-MH data would be utilized were provided. Participants were made aware that their contributions would be meaningful and important, but completion of the survey was entirely voluntary.

Minimizing non-responding. CAPI interviewers were instructed to make initial personal contact with a randomly selected survey respondent from each dwelling. Every reasonable effort was made to obtain interviews. Respondents were contacted by phone initially to arrange an appointment time for the in-person interview. However, respondents were also offered the opportunity to complete the interview by phone if they were available immediately. Proxy interviews were not permitted for the CCHS-MH.

To further minimize the incidence of non-responding, a letter underscoring the importance of the household's participation in the survey was sent to those respondents who initially refused to complete the survey. This was followed by a second contact with a statistics Canada representative (either in person or by phone) to further stress the importance of participation in the survey.

Use of CAPI by trained interviewers. Data were collected directly from survey respondents by trained individuals from Statistics Canada's collections planning and management division. Most interviews (87%) for the CCHS-MH were conducted in person, with

the remaining completed via telephone. All interviews were completed using the computer assisted personal interviewing method (CAPI). This computer-assisted interviewing system allows for custom interviews for each respondent based on their individual characteristics and survey results, ensuring the interviewers do not ask questions that do not apply to the respondent.

Instrument Description

The CCHS-MH was designed by Statistics Canada in consultation with representatives from various governmental agencies, the Mental Health Commission of Canada, and academic experts in mental health. Subjects covered in the survey include health, health care services, lifestyle and social conditions, mental health and wellbeing, and prevention and detection of disease. The survey is composed of 30 modules. The decision to include an in-depth module assessing for symptoms of a given diagnostic psychiatric disorder was guided by recommendations from the CCHS-MH expert committee. Modules to be incorporated into the CCHS-MH were selected based upon numerous factors, including currently available estimates of prevalence, relevance to current programs/policy, perceived impact on health care costs, and comparability with previous CCHS-MH cycles (CCHS-MH; Statistics Canada, 2013).

Screening Selection

To reduce respondent burden, the survey modules for depression, mania, and generalized anxiety disorder (GAD) in the CCHS-MHC are preceded by a section with screener questions for each disorder. To avoid the occurrence of false negatives and the possibility of participants purposely answering ‘no’ to avoid completing a given module, all screener questions were grouped together in a separate module (Screening Section) near the beginning of the survey. The Screening Section module requires an average of approximately 19 minutes to complete (WHO WMH CIDI, 2018). Participants who responded ‘no’ to screener questions were not asked

questions associated with that disorder and were considered as failing to meet criteria for the given disorder. Respondents who answered 'yes' were flagged for follow-up questioning within disorder-specific modules which include more in-depth questioning regarding specific symptoms of a given psychiatric illness.

Assessment of psychiatric disorders; lifetime and 12-month prevalence. The questions used for the CCHS-MH modules on major depressive disorder (MDD), BP I and II disorders and GAD are based on a recognized World Health Organization version of the Composite International Diagnostic Interview (WHO-CIDI) modified for the needs of CCHS-MH (Statistics Canada, 2013). The WMH-CIDI is a comprehensive and fully standardized instrument for the assessment of mental disorders and conditions according to definitions and criteria of the Diagnostic and Statistical Manual of Mental Disorders (*DSM-IV*) and the International Classification of Diseases and Related Health Problems (ICD-10) (Kessler & Ustun, 2004). The WMH-CIDI was created by the World Health Organization (WHO) in 1998 to be used by trained lay-interviewers for epidemiological, clinical and research purposes. The WMH-CIDI was created as an expansion of its predecessor, the WHO-CIDI (Kessler & Ustun, 2004), which was developed in 1990 (WHO WMH-CIDI, 2018). The WMH-CIDI is similar to the WHO-CIDI, which contains symptom related questions, probes for psycho-social impairments, evaluates symptom severity, and measures other relevant episode-related questions (Wittchen, 1994). Previous research, including a review of multiple reliability studies by Wittchen (1994) suggests that the WHO-CIDI is a reliable and valid measure (Kessler et al., 1998; WHO-CIDI, 1990; Wittchen, 1994;), as it is expanded and updated version, the WMH-CIDI (Haro et al., 2006; Kessler & Usten, 2004), upon which the CCHS-MH modules for depression, BP and general anxiety disorder are based.

Computer-based algorithms were used to calculate lifetime criteria for each disorder based on respondents' answers to the questions within each disorder module. For each disorder, 12-month criteria included meeting the criteria for a lifetime diagnosis of the disorder, experiencing an episode of the disorder within the previous 12 months, and experiencing a marked impairment in occupational and social functioning.

Sociodemographic covariates

A battery of sociodemographic covariates were used within the regression analyses, which included sex (male/female), and age (5-year increments from 20 to 64) (see Table 1 for descriptive statistics).

Mental health covariates

Mental health covariates were also included in the regression analyses. These covariates included diagnoses of GAD, MDD, and/or BP I and II. These mental health variables are included because they are known to be comorbid with ADHD and it is important to account for their effect on the relationships between ADHD and sleep.

To reduce respondent burden, the survey modules for depression, GAD and BP were preceded by a section with screener questions for each disorder. Participants who responded "no" to the screening questions were not asked questions from the module associated with that disorder and were categorized as failing to meet the criteria for that disorder. The questions used for the CCHS-MH modules on GAD, MDD, and BP I and II are based on a recognized World Health Organization version of the Composite International Diagnostic Interview (WHO-CIDI) modified for the needs of CCHS-MH (Statistics Canada, 2013). The WHO-CIDI is a standardized instrument for the assessment of mental disorders and conditions based on the definitions and criteria of Diagnostic and Statistical Manual of Mental Disorders (4th ed.; *DSM-*

IV; APA, 1994) and International Classification of Diseases and Related Health Problems (ICD-10; World Health Organization, 1992). Mental conditions or problems found in the CCHS-MH are partially coded to *DSM-IV* (Statistics Canada, 2013). Computer-based algorithms were used to calculate lifetime criteria for each disorder based on respondents' answers to the questions within each disorder module. For each disorder, 12-month criteria included meeting the criteria for a lifetime diagnosis of the disorder, experiencing an episode of the disorder within the previous 12 months, and experiencing a marked impairment in occupational and social functioning (see Table 1 for descriptive statistics).

Attention Deficit Hyperactivity Disorder (ADHD)

The presence of ADHD was assessed within the section of the questionnaire on chronic health conditions. Respondents were asked to indicate whether or not they had previously been diagnosed by a healthcare professional with a variety of conditions that have lasted or are expected to last at least six months. Participants were asked "Do you have attention deficit disorder"?

Sleep Trouble

The presence of sleep troubles was assessed using the question "How often do you have trouble going to sleep or staying asleep?" Responses were rated on a 5-point scale from 1 (none of the time) to 5 (all of the time). Participants who reported having trouble sleeping "most of the time" or "all of the time" were considered to have poor sleep.

Design & Data Analysis

A chi square analysis was used to compare participants in the ADHD and control groups on the frequency with which they have trouble sleeping. Next, a logistic regression analysis was

used to determine whether mental health covariates were predictive of sleep troubles among a sample of individuals who self-reported a diagnosis of ADD/ADHD.

Results

Chi Square

A chi-square test of independence was used to determine if the frequency of sleep troubles was greater among the sample of individuals reporting a diagnosis of ADD/ADHD compared to the control sample who did not report a diagnosis of ADD/ADHD. The results of the chi-square indicated that the frequency of sleep troubles was significantly greater in the sample of individuals reporting a diagnosis of ADHD $\chi(1) = 48.006$, $p = 0.000$. The prevalence of sleep troubles in the ADHD sample was 33.6% compared to 14.6% in the control sample (see table 2).

Logistic Regression

A hierarchical binary logistic regression was performed to ascertain the effects of age, gender, anxiety, depression, BP I and BP II on the likelihood of experiencing sleep trouble among individuals who reported a diagnosis of ADD/ADHD.

Block 1 regressed age and gender on sleep trouble, and the model was statistically significant, $\chi^2(9) = 36.437$, $p \leq .0005$. The model accounted for 10.2% (Nagelkerke R^2) of the variance in sleep trouble and correctly classified 68.3% of cases. Females were 50.6% more likely to exhibit sleep trouble than males. An overall trend of increasing age was associated with an increased likelihood of exhibiting sleep trouble, apart from the oldest age category which was not significantly related to sleep trouble.

The addition of mental health covariates in Block 2 improved the model, $\chi2(13) = 60.843$, $p \leq .0005$. The model explained 16.6% (Nagelkerke R^2) of the variance in sleep trouble

and correctly classified 71.5% of cases. Females were 54% more likely to exhibit sleep trouble than males. Overall, increasing age was associated with an increased likelihood of exhibiting sleep trouble, except for oldest age category which was not significantly related to sleep trouble. Depression was associated with an increased likelihood of sleep trouble (OR = 2.07, 95% CI [1.227, 3.517]). Anxiety, BP I and BP II did not significantly contribute to the model.

Discussion

The current study examined whether people reporting a diagnosis of ADHD were more likely to report sleep troubles compared to their non-ADHD peers, and whether mental health covariates contributed to the relationship between ADHD and sleep troubles. Results indicated that there was an increased likelihood of sleep troubles among the ADHD sample than their non-ADHD peers. Interestingly, some sociodemographic indicators and co-occurring mental health conditions contributed to the level of sleep troubles reported by those with an ADHD diagnosis.

Results indicated that the level of sleep troubles were greater among female respondents than male respondents, which was consistent with the literature. Among adults with ADHD, women are significantly more likely than men to report a history of sleep problems, including more interrupted sleep and greater daytime sleepiness (Robison et al., 2008).

Considering the role hormones have with ADHD in females is important. Hormones are considered the chemical messengers of the body (Fuentes & Silveyra, 2019). Estrogen is a type of female hormone which is important for reproductive development (Fuentes & Silveyra, 2019). Estrogen can impact neurotransmitters within the brain, neurotransmitters are molecules used by the nervous system to transmit messages between neurons (Marwein, Biswal & Acharya, 2020; Nussbaum, 2012). Serotonin, dopamine, and norepinephrine can be influenced by estrogen, these neurotransmitters have a role in concentration and mood (Hwang et al., 2020). Changes in the

level of estrogen can intensify the symptoms of ADHD (Nussbaum, 2012). Women may have trouble concentrating and memory issues as well as fatigue and problems with sleep when estrogen levels are low (Polo-Kantola, 2008; Scharf, McDannold et al., 1997). Females who have ADHD can be sensitive to low levels of estrogen (Westlund, 2021). One study examining sex differences in adults with ADHD found that women were significantly more likely than men to report a history of sleep problems, including more interrupted sleep and greater daytime sleepiness (Robison et al., 2008).

Regarding age, older age categories reported significant increases in sleep troubles compared to the youngest category of respondents among the sample reporting a diagnosis of ADHD. The current study suggested older adults experience a greater level of sleep trouble. However, one exception was the oldest age category (60-64 years) who reported a more attuned level of sleep trouble than younger adults. According to Statistics Canada, in 2020 the average age of a retiree was approximately 64.5 (Government of Canada, Statistics Canada, 2022), which means that retirement and lifestyle changes could be a contributing factor to this observation. Retirement signifies a shift from regular work and career oriented occupations to parttime, flexible or even volunteer positions (Hong Mao et al., 2019). Moreover, research has shown that retirement can reduce stress in men but conversely can raise stress among women (Chen, & Bärnighausen, 2020). Moreover, research has also shown that retirement is associated with reductions in disturbed sleep among participants who retired before age 65 years who were working full-time, who lacked control over their work hours and who had high psychological demands (Van de Straat et al., 2020).

The presence of mental health disorders can have a detrimental effect on healthy sleep and this relationship was observed in the results from the current study which indicated that a

comorbid diagnosis of depression and ADHD contributed to an increase in reported sleep troubles. The findings in the current study are consistent with research which has found that people with ADHD report increased levels of sleep troubles than their non-ADHD peers (Bjorvatn et al., 2017).

ADHD and depression are conditions that can often co-occur (Knouse, Zvorsky & Safren, 2013). The co-occurrence of depression and ADHD could be the result of low self-esteem, poor self-image and emotional dysregulation (Cook, Knight & Hume, 2014; Hirsch et al., 2018; Mehta et al., 2019). People with ADHD face numerous difficulties as the disorder is linked with increased risk of depression and sleep troubles, both of which amplify one another while also exacerbating the symptoms of ADHD (Bron et al., 2016; Wajszilber, Santiseban, & Gruber, 2018; Knouse, Zvorsky, & Safren, 2013; Díaz-Román, & Cortese, 2018; Riglin et al., 2021). (See figure 1).

The relationship between sleep and depression is bidirectional (Baglioni et al., 2011; Franzen & Buysse, 2008; Sivertsen, et al., 2012). Patients with depression can show sleep changes such as impaired sleep continuity, prolonged sleep latency, increased intermittent awakenings and early morning awakenings (Steiger, & Pawlowski, 2019; Fang et al., 2019). Sleep problems can exacerbate depression, leading to a negative cycle between depression and sleep that can be challenging to break. This means that poor sleep can contribute to the development of depression and that having depression makes a person more likely to develop sleep issues. Sleep disruptions can affect the body's stress system, disrupting circadian rhythms (Daut & Fonken, 2019) and increasing vulnerability for depression (Meerlo, Sgoifo & Suchecki, 2008).

Limitations

Despite the strengths of the current study there are several limitations that should be considered. Firstly, ADD/ADHD was assessed using self-report, which is a limiting factor. Individuals may not have been diagnosed with ADD/ADHD or mental health comorbidities by a health professional. Due to the nature of self-report data, it was not possible to confirm the accuracy of reported diagnoses. This lack of verification of ADD/ADHD diagnosis may have also affected the association between self-reported ADD/ADHD and sleep troubles.

Secondly, information regarding ADHD presentation was not included in the self-report data. Presentation may have contributed additional information and provided more insight into the relationship investigated in the current study as previous studies have found differences in comorbidity patterns between ADHD presentations (Friedrichs et al., 2012; Pineiro-Dieguez et al., 2016; Sobanski et al., 2008).

Thirdly, there was no information available in the data to identify whether subjects had received any form of treatment for ADD/ADHD. Without treatment information, the researchers could not determine if treatment mitigated the observed relationship between ADD/ADHD and sleep trouble.

Fourthly, as the focus of the present study included those aged 20-64, these findings can only be generalized to an adult population. Senior populations should be a focus of future research as child and teen populations have significant research already conducted (Torgersen et al., 2016). It is important to note that due to the nature of how age was classified within the CCHS-MH 2012 (Statistics Canada, 2013) database, participants between the ages of 18 and 19 years were not included in the prevalence estimate. The age band of 15 to 19 years included 143 individuals who reported a diagnosis of ADHD. It may be possible that including adults between

the ages of 18 and 19 years could have altered the study's finding. Additionally, the data utilized within the current study is cross-sectional, this may limit conclusions regarding causality.

Finally, CCHS-MH 2012 (Statistics Canada, 2013) gender data was coded as either male or female, which excludes other identities such as people who are transgender as their gender identity does not match with the sex they were assigned at birth (Pinto et al., 2019). According to the APA, sex is defined as the biological sex assignment of an individual while gender is described as a social identity (APA, 2012). People may have a gender identity and a preferred name that differ from those assigned at birth, or those listed on their current legal identification (Deutsch, & Buchholz, 2015). The Canadian Psychological Association (CPA) confirms that all adolescent and adult persons have the right to define their own gender identity regardless of chromosomal sex, genitalia, assigned birth sex, or initial gender role (CPA, 2010). The CPA states that all adolescent and adult persons have the right to free expression of their self-defined gender identity (CPA, 2010). Gender identity and sexual orientation are key social determinants of health, and therefore should be included in future research (Pinto et al., 2019).

Directions for Future Research

Future research should continue to expand our understanding of the relationship between adult ADHD and sleep troubles. Future research should observe how different presentations of adult ADHD are impacted by sleep troubles and to develop interventions that are targeted towards specific ADHD presentations.

Development of tailored interventions for females should incorporate strategies to help improve sleep. It could also be beneficial to focus on biological models that examine the impact of hormones on sleep among women with ADHD (Haimov-Kochman & Berger, 2014). Focusing on why females who have ADHD experience more sleep troubles when compared to their male

peers is another important goal. Interventions which are tailored towards males or females should be explored (Stibbe et al., 2020).

There is a lack of research that focuses on ADHD in older adult populations including such areas as clinical diagnosis and treatment (Dobrosavljevic et al., 2020). Thus, future research should focus on how to better understand sleep troubles among older adults with ADHD and how sleep troubles impact these individuals as they age.

Furthermore, a component of anxiety and ADHD is emotional dysregulation (Hirsch et al., 2018; Tsypes, Aldao & Mennin, 2013). Individuals who have ADHD can experience great emotional intensity (Skirrow et al., 2014). An inability to manage emotional discomfort may lead to avoidance and procrastination, which can exacerbate anxiety (Abdi Zarrin, Akbarzadeh, Mostafavi, 2019; Zhang et al., 2022). Future research should focus on creating interventions which focus on coping and regulating emotions when treating ADHD and comorbid anxiety.

Conclusion

The findings from the current research contributes to our understanding of ADHD as it relates to sleep trouble. The study established that demographic factors and mental health comorbidities impact the relationships between ADHD and sleep trouble. While these findings are preliminary, they enhance our understanding of ADHD and the deleterious effect of sleep troubles on those with the disorder. These findings can aid practitioners in identifying potential risk factors that can be used to diagnose and treat patients with ADHD who report sleep troubles, ultimately improving mental health outcomes for those with the disorder.

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Figure 1
The relationship between ADHD and the feedback loop between depression and sleep troubles

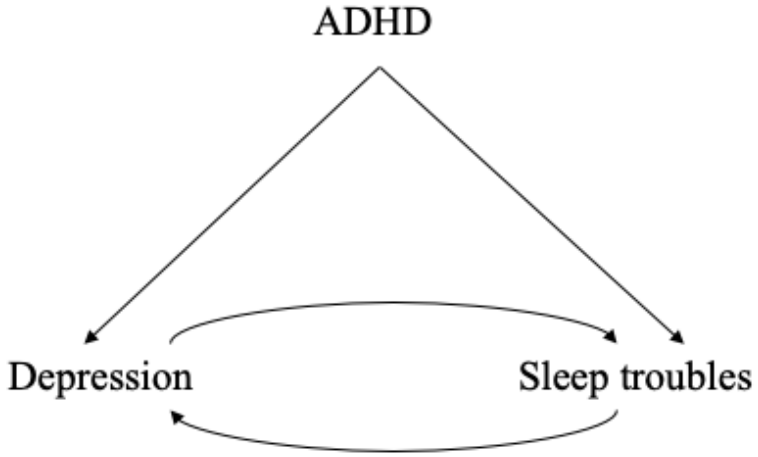

Table 1

Descriptive Statistics for 2012 Canadian Community Health Survey Using a Matched ADHD Sample

	Non – ADHD		ADHD	
	%	*M/SD*	*%*	*M/SD*
Sex (% Female)	41.2%	1.41/0.493	41.2%	1.41/0.493
Age Categories		5.00/2.512		5.00/2.512
20 to 24 Years	20.7%		20.7%	
25 to 29 Years	16.8%		16.8%	
30 to 34 Years	11.3%		11.3%	
35 to 39 Years	11.3%		11.3%	
40 to 44 Years	11.7%		11.7%	
45 to 49 Years	8.4%		8.4%	
50 to 54 Years	7.2%		7.2%	
55 to 59 Years	7.0%		7.0%	
60 to 64 Years	5.7%		5.7%	
Major Depression (Yes%)	3.3%		23.3%	
Bipolar I (Yes%)	0.6%		4.1%	
Bipolar II (Yes%)	0.4%		2.3%	
Generalized Anxiety Disorder (Yes%)	0.8%		15.1%	
Trouble Sleeping (Yes%)	14.6%		33.6%	
N = 962	488		488	

Table 2

Chi-Square: Relationship Between ADHD and Sleep Troubles

Group	Reported Sleep Quality	
	Has Trouble Sleeping "Most" Or "All Of The Time"	Does Not Have Trouble Sleeping "Most" Or "All Of The Time"
Has Attention Deficit Disorder	164 (33.6%)	324 (66.4%)
Does Not Have Attention Deficit Disorder	71 (14.6%)	415 (85.4%)

$\chi^2(1) = 48.006$, $p = .000$

Table 3

Hierarchical Binary Logistic Regression: Influence of Variables on the Relationship Between ADHD and Sleep Troubles.

	Block 1		Block 2	
	OR	95% CI	OR	95% CI
Age (Grouped)				
Age (Grouped)(1)	.658	(.344, 1.299)	.597	(.296, 1.201)
Age (Grouped)(2)	.885	(.401, 1.957)	.842	(.373, 1.899)
Age (Grouped)(3)	.626	(.295, 1.330)	.676	(.310, 1.474)
Age (Grouped)(4)	.472*	(.227, .979)	.535	(.251, 1.138)
Age (Grouped)(5)	.388*	(.177, .854)	.469	(.205, 1.074)
Age (Grouped)(6)	.215***	(.094, .494)	.235***	(.100, .554)
Age (Grouped)(7)	.286**	(.122, .670)	.314**	(.129, .761)
Age (Grouped)(8)	.929	(.343, 2.513)	1.000	(.357, 2.805)
Sex	.506	(.339, .755)	.540**	(.357, .817)
Bipolar I			1.914	(.688, 5.329)
Bipolar II			1.323	(.359, 4.880)
Major Depressive Episode			2.077**	(1.227, 3.517)
Generalized Anxiety Disorder			1.806	(.974, 3.349)
Pseudo R^2	.102***		.166***	

Note: Block 1's covariates included sex and age. Block 2 included Block 1's covariates, as well as bipolar disorder, depression, and generalized anxiety disorder.
* $p < .05$, ** $p < .01$, *** $p < .001$