ADHD Symptoms and Substance Use Among Adolescents in Ontario: A Cross-Sectional Study Examining Sex Differences and Covariates

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Abstract

Objective: 1) Estimate the prevalence of self-reported ADHD symptoms in sample of youth (grades 9-12) in Ontario schools, by sex; and 2) Assess the relationship between ADHD symptoms and substance use (alcohol, tobacco cigarettes, cannabis, stimulants) by sex, controlling for socio-economic status, internalizing and externalizing problems.

Methods: Data from 2015 and 2017 (n = 6,923) Centre for Addiction and Mental Health Ontario Student Drug Use and Health Survey, included self-reports of ADHD symptomatology and substance use. Statistical analyses included bivariate tables and multinomial regressions.

Results: Prevalence for ADHD symptoms was 20.22%, 95% CI [18.52, 22.03] (males = 16.42%, 95% CI [14.66, 18.34]; females = 24.06%, 95% CI [21.79, 26.49]). Females reporting ADHD symptoms showed increased risk of tobacco cigarette use and cannabis use when accounting for covariates.

Conclusion: The ADHD symptom screener found a large proportion of self-reported ADHD symptoms, especially in females. ADHD symptoms were associated with few substances.

Keywords
ADHD, Adolescent, Ontario, Centre for Addiction and Mental Health, Ontario Student Drug Use and Health Survey, Prevalence, Sex, Alcohol, Tobacco Cigarettes, Cannabis, Stimulants, Substance Use, Socio-economic Status, Internalizing Problem, Externalizing problem
Summary for Lay Audience

The goal of this current study was to present the prevalence of ADHD symptoms in a sample of youth in Ontario and to assess the relationship between ADHD symptoms and substance use. Substances that were examined include alcohol, tobacco cigarettes, cannabis and stimulants. Stimulants included cocaine, crack-cocaine, ecstasy, and methamphetamine. It is posited that socio-economic status and social, emotional, and behavioural problems play a part in the relationship between ADHD symptoms and substance use. Social, emotional, and behavioural problems include internalizing problems (refers to the internal psyche and include depression, anxiety, etc.) and externalizing problems (distress that results in outward behaviour and include aggressive and delinquent behaviours).

Methods include the use of two cycles of survey data from schools across Ontario. The age group of interest includes students that were in grade 9 through 12 at the time of the survey. Sampling weights insured that results from the study reflected students that make up the Ontario population. Importantly, the measurement used to assess ADHD symptoms was a self-report symptom checklist, not a full diagnostic assessment administered by a physician.

The overall prevalence for self-reported ADHD symptoms was 20.22%, with 16.42% of males self-reporting ADHD symptoms and 24.06% of females self-reporting ADHD symptoms. These percentages are high compared to studies that used actual diagnostic measurements; however, these percentages are comparable to studies that used the same symptom checklist that was used in this current study. Without the consideration of socio-economic status and social, emotional, and behavioural problems, it would seem as if ADHD symptoms were a risk factor for alcohol use, tobacco cigarette use, cannabis use, and stimulant use for females. For males, the findings suggest that ADHD symptoms were a risk factor for tobacco cigarette use and stimulant use. However, after controlling for socio-economic status and social, emotional, and behavioural problems, it is evident that ADHD symptoms only presented an increased risk for tobacco cigarette use and cannabis use for females. Due to the limitations, findings should be interpreted cautiously. Future studies should explore what is being captured by the self-report symptom checklist used in this current study.
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For Kevin C.
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Chapter 1

1 Summary

1.1 Background

Attention-deficit/hyperactivity disorder (ADHD) is a chronic neurodevelopmental disorder that significantly influences executive functioning and development (APA, 2013). According to the Diagnostic and Statistical Manual of Mental Disorders Fifth Edition (DSM-5), a diagnosis of ADHD includes six (or five for people over 17 years) of the nine symptoms of inattention and six (or five for people over 17 years) of the nine symptoms of hyperactivity-impulsivity (APA, 2013). ADHD is among the most frequently diagnosed mental health disorders during childhood and adolescence (Simon et al., 2009). In Canada, seven studies have assessed the prevalence of ADHD or ADHD symptoms (age range 1 to 24 years) (Brault & Lacourse, 2012; Brownell & Yogendran, 2001; Georgiades et al., 2019; Hauck, Lau, Wing, Kurdyak, & Tu, 2017; McMartin, Kingsbury, Dykxhoorn, & Colman, 2014; Szatmari, Boyle, & Offord, 1989; Vasiiliadis et al., 2017). Of the seven studies, general prevalence estimates have ranged from 1.5% (Brownell & Yogendran, 2001) to 10.49% (Georgiades et al., 2019). International studies using symptom checklists have found much higher prevalence of self-reported ADHD symptoms, with prevalence as high as 20.90% (Sonnby, Åslund, Leppert, & Nilsson, 2011). This variation in ADHD estimates may be due to differences in measures (use of symptom checklists rather than assessment of administrative medical claims for actual ADHD diagnoses), who provided the information (clinician, parent, teacher, or youth), and sociodemographic information (age) of the children and youth being assessed for ADHD (Skounti, Philalithis, & Galanakis, 2007).

Additionally, the literature indicates that ADHD symptoms may be expressed differently by males and females. Disruptive behaviours, such as aggression, disciplinary violations, and other behaviours violating social norms (which are easily observed by parents and teachers) may be a reason why males with ADHD are more likely to be identified than females with ADHD (Wang et al., 2017). Conversely, females with ADHD are less likely to have disruptive behaviour disorders and are more likely to report higher prevalence of symptoms of inattention, which are more covert than those of hyperactivity and impulsivity (Biederman & Faraone, 2004).
ADHD is associated with health risk behaviours, such as substance use (Klassen, Bilkey, Katzman, & Chokka, 2012). Literature has shown different relationships between ADHD and substance use depending on the substance. For example, the literature indicates conflicting results for the relationships between ADHD symptoms and alcohol (Elkins et al., 2018; Fergusson, Horwood, & Ridder, 2007; Flory, Milich, Lynam, Leukefeld, & Clayton, 2003; Galéra, Bouvard, Messiah, & Fombonne, 2008; Sihvola et al., 2011; Upadhyaya & Carpenter, 2008), and ADHD symptoms and cannabis use (Elkins et al., 2018; Fergusson et al., 2007; Flory et al., 2003; Galéra et al., 2008; Upadhyaya & Carpenter, 2008), although the majority of studies indicate that ADHD symptoms are significantly associated with tobacco cigarette use (Fergusson et al., 2007; Flory et al., 2003; Galéra et al., 2013; Kollins, McClernon, & Fuemmeler, 2005; Sihvola et al., 2011; Upadhyaya & Carpenter, 2008). Additionally, some studies have found that the relationships between ADHD and substance use may vary by sex. For example, some research has found a significant relationship between ADHD symptoms and alcohol use (Elkins et al., 2018; Sihvola et al., 2011) and daily tobacco cigarette use (Galéra, Fombonne, Chastang, & Bouvard, 2005) in females but not in males. Yet another study found a relationship between ADHD symptoms and regular use of cannabis in males but not regular use of cannabis in females or lifetime cannabis use (Galéra et al., 2008). Hence, the literature provides conflicting evidence on the relationship between ADHD and different substances and on differences in use of different substances by males and females with ADHD symptoms.

Moreover, the majority of studies examining the relationship between ADHD symptoms and substance use have examined the commonly popular substances that children and youth use: alcohol (Elkins et al., 2018; Fergusson et al., 2007; Flory et al., 2003; Galéra et al., 2008; Sihvola et al., 2011; Upadhyaya & Carpenter, 2008), tobacco cigarettes (Fergusson et al., 2007; Flory et al., 2003; Galéra et al., 2005; Galéra, 2013; Kollins et al., 2005; Sihvola et al., 2011; Upadhyaya & Carpenter, 2008) and cannabis (Elkins et al., 2018; Fergusson et al., 2007; Flory et al., 2003; Galéra et al., 2008; Upadhyaya & Carpenter, 2008). Few have examined cocaine (Galéra et al., 2013; Lambert & Hartsough, 1998) and no studies using youth samples have examined increased risk of crack-cocaine, methamphetamine, or ecstasy in relation to ADHD symptoms.

Socioeconomic status (SES) is thought to be related to both ADHD and substance use. According to a national health interview survey (data from 2011-2013) in the United States,
children and youth living in poverty have the highest rate of ADHD (CDC/NCHS, 2013). Other studies have suggested that research is inconsistent on whether the direction of the relationship between SES and substance use is positive or negative (Hamilton, Maas, Boak, & Mann, 2014). For these reasons, it is important to examine SES when assessing the relationship between ADHD and substance use, to observe if controlling for SES changes the relationship between ADHD and substance use.

An examination of ADHD and substance use should not be conducted without considering internalizing problems (i.e., depression, anxiety) and externalizing problems (i.e., oppositional defiant disorder, conduct disorder (CD)) since internalizing and externalizing problems have been identified as co-occurring problems with both ADHD and substance use (Jacob, et al., 2014; Lee, Humphreys, Flory, Liu, & Glass, 2011). Because of the co-occurrence of internalizing and externalizing problems with ADHD and substance use, Lee et al. (2011) strongly recommends that internalizing and externalizing problems be included in analyses examining ADHD and substance use.

1.2 Objectives

To address the current knowledge gaps, this study will use population-based data of Ontario youth to: 1) estimate the prevalence of self-reported ADHD symptoms in a representative sample of youth (grades 9-12) in Ontario schools, separately for males and females; and 2) assess the relationship between self-reported ADHD symptoms and substance use among males and females, while controlling for SES, internalizing problems, and externalizing problems.

1.3 Thesis Structure

This thesis includes five chapters. Chapter 2 provides an overview of the current literature on ADHD in children and youth and on the relationships between ADHD and substance use. This literature review provides the study rationale and informs the objectives. Chapter 3 provides information on the methods, including the data source, the study population, measures and the data analytic strategy. Chapter 4 presents the results of the study and Chapter 5 provides a discussion of the findings, the strengths and weaknesses of the study, and suggestions for future research.
Chapter 2

2 Literature Review

2.1 Definition of ADHD

Attention-deficit/hyperactivity disorder (ADHD) is a chronic neurodevelopmental disorder that significantly influences executive functioning and development (APA, 2013). People with ADHD show a persistent pattern of inattention and/or hyperactivity-impulsivity. Since its clinical emergence in 1902 (Still, 1902), ADHD has been designated by a myriad of terms including: minimal brain damage, hyperkinetic syndrome, hyperactivity and attention-deficit disorder (ADD) among others. In DSM-II, ADHD was termed Hyperkinetic Reaction of Childhood, which focused primarily on symptoms of excessive motor activity (APA, 1968). In DSM-III, ADHD was markedly re-conceptualized with a focus on problems with attention, impulsivity, and hyperactivity; in this version, the disorder was renamed attention deficit disorder (ADD) (with and without hyperactivity) (APA, 1980). The term ADHD was finally introduced in DSM-III-R with the elimination of ADD without hyperactivity (APA, 1987). With DSM-IV, the term ADHD was retained, along with the introduction of the three subtypes: combined presentation, predominantly inattentive presentation, and predominantly hyperactive-impulsive presentation (APA, 1994). However, because symptoms can change over time, the presentation of ADHD may be subject to change. Previous adaptations of ADHD stressed a narrower focus on motor activity; however, the current conceptualization emphasizes difficulty with sustained attention and deficits in the regulation of cognitive functioning (Faraone et al., 2000).

The current diagnostic criteria for ADHD in North America are outlined by the Diagnostic and Statistical Manual of Mental Disorders Version 5 (DSM-5). To be diagnosed, six or more of the symptoms of inattention or hyperactivity-impulsivity must cause impairment for children and youth up to age 16 years, or five or more symptoms for youth age 17 years and older. These symptoms must have been present for at least six months. Symptoms of inattention include examples such as, often fails to give close attention to details or makes careless mistakes, often has trouble holding attention on tasks or play activities, often does not seem to listen when talked to directly, and often has trouble organizing tasks and activities. Symptoms of hyperactivity and
impulsivity include examples such as, often fidgets with or taps hands or feet, or squirms around, often leaves seat in situations when remaining seated is expected, often talks excessively, and often has trouble waiting their turn. These symptoms must not be better explained by another mental disorder such as a mood disorder. In addition, several inattentive or hyperactive-impulsive symptoms must be present before the age of 12 and several symptoms must be present in two or more settings such as at home and school. Lastly, there must be clear evidence that these symptoms reduce the quality of school or social functioning (APA, 2013).

The evolution of the nomenclature for the disorder from DSM-II to DSM-5 has broadened the case definition, resulting in more individuals being diagnosed with ADHD. For example, criterion A (ADHD symptoms) changed with a reduction from six to five in the minimum number of symptoms in either symptom domain required for older adolescents and adults (Epstein & Loren, 2013). Criterion B (age of onset) changed from onset of symptoms and impairments before age seven to onset of symptoms before age 12. Criterion C (pervasiveness) was changed from evidence of impairment to evidence of symptoms in two or more settings. Criterion D (impairment) now requires that functional impairments only need to “reduce the quality of social, academic or occupational functioning” instead of requiring that they be “clinically significant.” With changes in each criterion, it is evident that ADHD and the requirements for diagnosis of this disorder has evolved over time.

2.2 Prevalence Estimates of ADHD and ADHD Symptoms in Canada

In order to assess the prevalence of ADHD in Canada, PubMed was searched through December 2019. The following keywords were searched: ADHD prevalence, Canada, and youth. Keywords were combined using the Boolean variables “AND”. The search for humans was specified under the species category. This search stream yielded a total of 293 results on PubMed. Titles and abstracts were read and compared with inclusion and exclusion criteria to determine eligibility. Inclusion criteria are as follows: prevalence of ADHD (or any of the previous definitions of ADHD including hyperactivity or ADD), included the analysis of Canadian data, and included children or youth in the sample. Papers were excluded if they were examining ADHD in adults, included data of non-Canadian populations, included qualitative data, or described methodology. After applying these exclusions, six studies were identified. Reference lists of these studies were
hand-searched which revealed another study meeting the inclusion criteria (Hauck et al., 2017). All other papers were rejected because they described methodology, and/or did not analyze Canadian data, and/or the target population was adults. Results were assessed by summarizing objectives, population, definition of ADHD, method of measuring ADHD, estimates of ADHD, and estimates by sex. After, results were organized by synthesizing studies based on whether symptom checklists or actual ADHD diagnoses (either through survey indication or administrative medical claims) were used.

Seven studies that have examined the prevalence of ADHD or ADHD symptoms (age range 1 to 24 years) in Canada are available (Brault & Lacourse, 2012; Brownell & Yogendran, 2001; Georgiades et al., 2019; Hauck et al., 2017; McMartin et al., 2014; Szatmari et al., 1989; Vasiliadis et al., 2017). Of the seven studies that have been reviewed, general prevalence estimates have ranged from 1.5% (Brownell & Yogendran, 2001) to 10.49% (Georgiades et al., 2019). The differences in prevalence of ADHD may be attributed to time of data collection (which is impacted by the change of definition deemed by DSM criteria), age range of subjects included in each study, self-report vs. objective measures, and differences in measures (survey (includes use of symptom checklists based on DSM criteria or indication from parent of diagnosis from a clinician) or assessment of administrative medical claims for actual ADHD diagnoses). Prevalence studies examining ADHD symptoms have used symptom checklists, typically based on DSM criteria to be filled out by parents, teachers and/or children/youth (Georgiades et al., 2019; McMartin et al., 2014; Szatmari et al., 1989). Whereas prevalence studies examining ADHD have required an indication from parents that their child was diagnosed with ADHD by a clinician (Brault & Lacourse, 2012) or assessed administrative medical claims for actual ADHD diagnoses and/or prescriptions with population denominators of age appropriate regional populations (Brownell et al., 2011; Hauck et al., 2017; Vasiliadis et al., 2017). Of the three studies that used symptom checklists (Georgiades et al., 2019; McMartin et al., 2014; Szatmari et al., 1989), only two produced actual prevalence of ADHD symptoms stratified by sex (Georgiades et al., 2019; Szatmari et al., 1989) while the remaining recorded time trends. When comparing prevalence estimates by sex, Szatmari et al. (1989) produced the largest prevalence of ADHD symptoms estimate for males compared to the other studies that used actual ADHD diagnoses and Georgiades et al. (2019) produced the largest prevalence of
ADHD symptoms estimate for females compared to other studies that used actual ADHD diagnoses.

The following three studies utilized prevalence statistics based on symptom checklists; all were from the Ontario Child Health Study (OCHS) except the study by McMartin et al. (2014), where scales were adapted from the OCHS. McMartin et al. (2014) investigated trends in prevalence of symptoms of ADHD based on hyperactivity scores from 1994/95 through to 2008/09 in Canada. They examined data from Statistics Canada’s, National Longitudinal Survey of Children and Youth (NLSCY), which is a longitudinal study of Canadian youth that follows their development and well-being from birth to early adulthood. McMartin et al. (2014) utilized NLSCY data from those aged 10 years or older. The sample size included of 11,725 participants. The case definition of ADHD symptoms was based on hyperactivity scores to identify youth who would likely qualify for psychiatric diagnosis from symptom criteria based on the DSM-III. This scale was adapted from questionnaires used in the Montreal Longitudinal Survey and the OCHS. Questionnaires were completed on paper at home or in a private setting and hyperactivity symptoms were self-reported. McMartin et al. (2014) found that the mean hyperactivity score significantly increased over time in participants aged 10-11 years (change per 2-year cycle, 0.16, 95% confidence interval [CI] [0.02-0.12]), participants aged 12-13 years (0.13, 95% CI [0.09-0.18]), but not among those aged 14-15 years (0.04, 95% CI [-0.01-0.09]). Unfortunately, specific rates were not reported, only change in mean score were reported. No sex specific prevalence estimates were recorded.

Szatmari et al. (1989) examined ADD with hyperactivity symptoms (known as “ADDH” symptoms) and “ADD” based on a symptom checklist from the OCHS. Szatmari and colleagues (1989) studied the six-month prevalence for symptoms of the historical diagnosis of “ADDH”, in Ontario children and youth (4 to 16 years of age). This was an interviewer-administered population-based survey of 2,052 households with eligible children or youth (whose usual place of residence was a household dwelling in Ontario); 91% (n = 1869) participated in the survey. Problem checklists based on DSM-III criteria for ADD with and without hyperactivity were completed by parents, teachers and also youth 12-16 years of age to measure “ADDH” and ADD, although such checklists did not provide thresholds for approximating individual psychiatric disorders (Boyle, et al., 2019). The findings indicated that the prevalence of “ADDH”
symptoms was 9.4% for males age 4-11 and 2.9% for males age 12-16, while prevalence was 2.8% for females age 4-11 and 1.4% for females age 12-16. However, for ADD, prevalence was 1.4% for males age 4-11 and 1.4% for males age 12-16, while prevalence was 1.3% for females age 4-11 and 1.0% for females age 12-16, indicating a much higher prevalence of hyperactivity symptoms for males than females (Szatmari et al., 1989).

Another paper used the 2014 data by OCHS (Georgiades et al., 2019). The 2014 OCHS assessed families with children and youth aged 4 to 17 years (n = 6,537). The survey design included area and household stratification by income and a 3-stage cluster sampling of areas and households in order to yield a probability sample of families (Boyle et al., 2019). The OCHS assessed common mental symptoms (including ADHD symptoms) occurring in the past 6 months based on the DSM-IV (text revision) using the modified version of the Mini International Neuropsychiatric Interview for Children and Adolescents (MINI-KID) (Georgiades et al., 2019). The parent report of ADHD symptoms in children and youth (4-11 years) was 10.49% (14.77% in males and 6.00% in females). The parent report of ADHD symptoms in youth (12-17 years) was 5.19% (7.51% in males and 2.73% in females), whereas the youth report of ADHD symptoms in youth (12-17 years) was 6.19% (7.78% in males and 4.53% in females). It is important to note that parents reported higher ADHD symptoms in males compared to self-reported symptoms, while, parents reported lower ADHD symptoms in females compared to self-reported symptoms.

One Canadian population-based study examined actual ADHD diagnoses through a self-report survey that asked parents for an indication of diagnosis of ADHD by a clinician (Brault & Lacourse, 2012). Brault and Lacourse (2012) compared trends in prevalence of ADHD diagnosis between 1994 and 2007 of Canadian preschoolers and school-aged children (specifically, children aged 3-9 years). Brault and Lacourse (2012) used the same data (NLSCY) as McMartin et al. (2014) but had different objectives; McMartin et al. (2014) sought to investigate trends in the prevalence of ADHD symptoms whereas Brault and Lacourse (2012) reported actual prevalence estimates of ADHD. Brault and Lacourse (2012) compared data of three cross-sectional samples (n = 12,595 (1994/95), n = 13,904 (2000/01), and n = 14,655 (2006/07)) of non-referred children from the NLSCY. ADHD diagnosis was reported by each child’s parent or guardian. The prevalence of ADHD was 1.7% in 2000/01 and 2.6% in 2006/07. From 2000 to 2007, the prevalence of ADHD increased by 1.5-fold (Brault & Lacourse, 2012). Males’
prevalence for ADHD was higher than that of females’ prevalence for ADHD, but females showed a steeper increase over time. Males’ prevalence for ADHD was 2.6% in 2000/01 and 3.7% in 2006/07. Females’ prevalence for ADHD was 0.9% in 2000/01, and 1.5% in 2006/07. Information regarding ADHD diagnosis is limited to the 2000s, as this information was not collected in 1994/95.

Three Canadian population-based studies examined actual ADHD diagnoses by assessing administrative medical claims for ADHD diagnoses and/or prescriptions with population denominators of age appropriate regional populations (Brownell et al., 2001; Hauck et al., 2017; Vasiliadis et al., 2017). Brownell and Yogendran (2001) examined physicians’ diagnosis rates for ADHD for 4,787 children and youth (up to the age of 19 years) in the province of Manitoba in 1995/96. In 1999, the prevalence of childhood ADHD was 1.5% and the diagnoses were made primarily by paediatricians (47%) and general practitioners (36%) followed by psychiatrists (17%) in 1999. In 2011/12, diagnoses were made primarily by general practitioners (52%), followed by psychiatrists (24%), and paediatricians (23%). There were higher prevalence estimates reported for males (2.4%) than for females (0.6%). Hauck et al. (2017) assessed the prevalence and characteristics of children and youth (n = 29, 256) aged 1-24 years, with ADHD in Ontario. Definite cases of ADHD were defined by family physician recording a diagnosis of ADHD. The prevalence of ADHD was 5.4%; prevalence of ADHD among males was 7.9% and 2.7% among females. Vasiliadis et al. (2017) aimed to evaluate trends and to assess and report over a decade of prevalence of children and youth (1-17 and 18-24) in outpatient and inpatient settings with diagnosed ADHD in Canada (provinces included Manitoba, Ontario, Quebec, and Nova Scotia). The prevalence of ADHD for those between 1-17 years of age increased from 1999 to 2011/2012 for all provinces. For Ontario specifically, the prevalence of ADHD for those between 1-17 years of age increased from 1.06% to 1.10%. The prevalence of ADHD for those 18-24 years of age (0.15% in 1999; 0.53% in 2011/12) was lower than the prevalence of ADHD for those 1-17 years of age. When stratified by sex, prevalence estimates were significantly higher in males than in females in the four provinces in 1999 to 2011. The age-standardized prevalence of ADHD by sex in 1999/2000 in Ontario was 1.65 for males and 0.45 for females. The age-standardized prevalence of ADHD by sex in 2011/12 in Ontario was 1.60% for males and 0.58% for females. Although males consistently have higher ADHD prevalence than
females, the gap in ADHD diagnosis between males and females has been getting smaller (Vasiliadis et al., 2017).

To sum, a number of studies on prevalence of ADHD and ADHD symptoms have been conducted in Canada. These studies have found variation with the prevalence estimates from 1.5% (Brownell & Yogendran, 2001) to 6.2% (Georgiades et al., 2019), a range from 2.4% (Brownell & Yogendran, 2001) to 14.77% (Georgiades et al., 2019) for males, and a range from 0.6% (Brownell & Yogendran, 2001) to 6% (Georgiades et al., 2019) for females. These variations with ADHD estimates may be due to differences in measures (survey (includes use of symptom checklists based on DSM criteria or indication from parent of diagnosis from a clinician) or assessment of administrative medical claims for actual ADHD diagnoses), self-report vs. objective measures, who provided the information (clinician, parent, teacher, or youth), time of data collection (which is impacted by the change of definition deemed by DSM criteria), and sociodemographic information (age) of the children and youth being assessed for ADHD (Skounti et al., 2007). Studies measuring prevalence of ADHD symptoms have used checklists of symptoms (McMartin et al., 2014; Szatmari et al., 1989) whereas studies measuring prevalence of ADHD have used clinical diagnoses through surveys asking for parents to indicate diagnosis of child or youth from a clinician (Brault & Lacourse, 2012) or administrative medical claims (Brownell et al., 2001; Hauck et al., 2017; Vasiliadis et al., 2017). Symptom checklists are generally based on DSM criteria that typically measure the symptoms of a disorder, but without the professional diagnosis and breadth and depth of evidence needed for a formal diagnosis. The symptom checklists can be a lengthy scale or a short screener. Clinical diagnosis by a physician or psychologist is based on DSM criteria that include behavioural or psychological syndromes that occur in an individual. The underlying psychobiological dysfunctions reflected by these syndromes result in functional impairments that “reduce the quality of social, academic or occupational functioning” (Diagnostic and Statistical Manual of Mental Disorders, 2014). These data can be collected from clinical assessments, medical charts or electronic databases or based on parents’ reports of their child having received a diagnosis and/or prescription for an ADHD medication. These different approaches to measure ADHD prevalence and different data collection designs can affect prevalence estimates across these studies. Based on the studies summarized in this section, the lower prevalence estimates came from actual diagnoses from a study that used administrative medical records (Brownell & Yogendran, 2001) and the higher
prevalence estimates came from a study using a symptom checklist (Georgiades et al., 2019; Szatmari et al., 1989). It is possible that studies that used a symptom checklist to measure ADHD produced larger prevalence statistics compared to studies that used administrative medical records because symptom checklists are possibly more inclusive (could be capturing broader spectrum of psychological symptoms but not actually reflecting a true disorder), whereas diagnoses based on DSM criteria by physicians or psychologists are more exclusive (as these ADHD symptoms must not be better explained by another mental disorder such as a mood disorder).

On the other hand, not all children and youth with ADHD have been diagnosed, so relying only on diagnoses could provide a lower prevalence. Hence, one strength of utilizing symptom checklists is that they capture children and youth with ADHD who have not been diagnosed. Therefore, it is a tradeoff, in particular, as mentioned before; females tend to exhibit less disruptive behaviours so they are less likely to be pushed by schools to be assessed. This leads to fewer females being seen by health care professionals which results in a smaller number who actually receive a diagnosis of ADHD.

2.3 International Prevalence Estimates of ADHD and ADHD Symptoms

A number of international papers are available on the prevalence of ADHD and ADHD symptoms in children and youth (age range of 19 and under) (Catalá-López et al., 2012; Green et al., 2019; Madruga et al., 2012; Polanczyk et al., 2010; Polanczyk, Willcutt, Salum, Kieling, & Rohde, 2014; Polanczyk, Salum, Sugaya, Caye, & Rohde, 2015; Reale & Bonati, 2018; Sonnby et al., 2011; Thomas, Sanders, Doust, Beller, & Glasziou, 2015; Wang et al., 2017; Xu, Strathearn, Liu, Yang, & Bao, 2018). International studies, compared to Canadian studies, however, have found larger variation in ADHD/ADHD symptoms prevalence rates among children and youth from 3.4% (Polanczyk et al., 2015) to 20.90% (Sonnby et al., 2011). International studies that reported sex differences generally indicated higher prevalence of ADHD in males than in females (Catalá-López et al., 2012; Reale & Bonati, 2018) although some studies have reported higher prevalence of ADHD symptoms in females than in males (Gritti et al., 2014; Madruga et al., 2012; Polanczyk et al., 2010; Sonnby et al., 2011).
International studies that have used diagnostic measures of ADHD (Polanczyk et al., 2014; Polanczyk et al., 2015; Xu et al., 2018) have similar prevalence rates overall, including for males and females compared to Canadian studies. In a meta-analysis of 135 studies, Polanczyk et al. (2014) reviewed research using original surveys published between 1978 and 2006 from across the world (i.e., North America, Europe, Asia). The meta-analysis assessed community and school samples of children and youth (18 years of age or under) to generate a point prevalence statistic, with diagnoses of ADHD based on the DSM (III, III-R, or IV). The percentage of children and youth (18 years of age or younger) with a diagnosis of ADHD increased between 2003 and 2007 from 7.8% to 9.5%; however, no separate prevalence estimates for males and females were provided (Polanczyk et al., 2014).

A year later, Polanczyk et al. (2015) conducted another systematic review for prevalence studies of mental disorders investigating probabilistic community samples of children and youth with standardized assessment methods that derived diagnoses according to the DSM or ICD. Papers were selected based on consensus if they satisfied the following criteria: 1) original prevalence studies assessing community samples; 2) probabilistic sampling strategy; 3) use of a standardized assessment procedure deriving diagnosis according to DSM-III, DSM-III-R, DSM-IV, ICD-9, or ICD-10; and 4) inclusion of children and youth up to age 18. Forty-one studies conducted in 27 countries from every world region were included (North America, Europe, Asia, Africa, South America and the Caribbean, Middle East, and Oceania). Studies meeting inclusion criteria were published from 1985 to 2012. Informants included: 1) parent, child, and teacher; 2) parent and teacher; 3) parent and child; 4) parent; or 5) child. The worldwide-pooled prevalence of ADHD was 3.4%; however, no separate prevalence estimates for males and females were provided.

Lastly, in the United States, according to analysis of data collected by the National Health Interview Survey, the prevalence rates of diagnosed ADHD among children and youth (age 4-17) in the past twenty years has progressively increased from 6.1% in 1997/1998 to 10.2% in 2015/2016 (Xu et al., 2018).

Other international studies have used symptom checklists; these studies have found much higher prevalence rates of ADHD symptoms than Canadian studies that used symptom checklists (Green et al., 2019; Madruga et al., 2012; Sonnby et al., 2011). Furthermore, no Canadian studies
presented higher prevalence of ADHD symptoms among females than males; however, most of these international studies that used symptom checklists have found higher prevalence rates of ADHD symptoms in females rather than in males (Madruga et al., 2012; Polanczyk et al., 2010; Sonnby et al., 2011). For example, Madruga et al. (2012) used the Brazilian National Alcohol Survey to select 3,007 participants aged 14-19 years old (males = 49.7%). The questionnaire used was the Brazilian adaptation of the Hispanic Americans Base Line Alcohol Survey questionnaire. ADHD symptoms were assessed using the reduced version of the commonly used Adult ADHD Self-Report Scale (ASRS-v1.1) Screener adapted to the Portuguese language using the score 4 as the cutoff point. Nearly one out of ten adolescents recorded ADHD symptoms (9.7%) and females were significantly more likely to meet criteria for ADHD than were males (13.02% and 8.75% respectively).

Sonnby et al. (2011) examined the Survey of Adolescent Life in Vestmanland 2006 data in Sweden of all secondary school students (age 15-18 years old). A total of 4,910 participants (male = 50.37%; overall response rate of 80.3%) were in this study. ADHD symptoms were measured using the ASRS Screener. Of this sample, a total of 20.90% reported ADHD symptoms. Interestingly, 18.4% of males reported ADHD symptoms and 23.5% of females reported ADHD symptoms.

Polanczyk et al. (2010) assessed a representative household sample of the Brazilian population for symptoms of ADHD with the ASRS Screener (Brazilian-Portuguese version) using the first Brazilian National Alcohol Survey in 2005-2006 (survey response rate = 66.4%). The sample was weighted to correct for the probability of selection of responses into the sample and non-response rates. The sample was comprised by 3,007 participants, with an overall prevalence of symptoms of ADHD of 5.8%. The prevalence of symptoms of ADHD by age range was 7.6% (14-17 years of age), 5.2% (18-44 years of age), and 6.1% (45+ years of age). Females presented a higher prevalence for ADHD symptoms than males (Odds Ratio (OR) = 2.03, 95% CI [1.3-3.2]. Among those 18-44 years of age, females had a higher prevalence of ADHD symptoms than males (OR = 2.04, 95% CI [1.0-4.1]).

Green et al. (2019) administered a short symptom checklist (ASRS Screener) in an adolescent community sample in the US. Two school districts with state test passage rates substantially
higher than state or national averages (approximately 90%) administered anonymous assessments of mental health and school functioning. Middle and high school students (grades 6-12; ages 11-18 years old) for a total of 2,472 students (46.6% male; 94% white) completed the assessments (response rate = 94.4%). The overall prevalence of ADHD symptoms was 14.6%. Males reported slightly higher scores than females, although this difference was not significant. The ASRS-v1.1 Screener scores increased significantly with age (from a mean of 5.4 among 6th graders to 9.6 among 11th graders, p < .001); similarly, where 9.6% of middle school students reported symptoms of ADHD, 19.6% of high school students reported symptoms of ADHD. 12.5% of those in grade 9 reported symptoms of ADHD, 17.1% of those in grade 10 reported symptoms of ADHD, 26.0% of those in grade 11 reported symptoms of ADHD, and 23.5% of those in grade 12 reported symptoms of ADHD.

To sum, a number of studies on prevalence of ADHD have been conducted internationally. These studies have found wider variation with the estimates compared to Canadian studies. However, international studies that used diagnostic measures of ADHD have similar prevalence rates overall and for males and females compared to Canadian studies. Some international studies that have used symptom checklists have found much higher prevalence rates of ADHD symptoms than Canadian studies that used symptom checklists (Green et al., 2019; Madruga et al., 2012; Sonnby et al., 2011) and in particular significantly higher prevalence rates of ADHD symptoms in females rather than in males (Madruga et al., 2012; Polanczyk et al., 2010; Sonnby et al., 2011). These variations with ADHD estimates may be due to differences in measurement style (i.e., self-report compared to objective measures, who provided the information) or time of data collection and sociodemographic information of the children and youth being assessed for ADHD (Skounti et al., 2007). These different approaches to measure ADHD or ADHD symptoms prevalence and different data collection methods can influence prevalence estimates across these studies. Similar to Canadian studies, all international studies that reported an overall prevalence estimate based on symptom checklists showed higher estimates than prevalence statistics based on actual DSM diagnosis.

2.4 ADHD and Sex

Research shows that ADHD is a disorder of polygenic inheritance with symptoms of hyperactivity and impulsivity predominantly more apparent in males with ADHD than in females
with ADHD (Wang et al., 2017). Disruptive behaviours, such as aggression, disciplinary violations, and other behaviours violating social norms (which are easily observed by parents and teachers) may be a reason why males with ADHD are more likely to be identified than females with ADHD (Wang et al., 2017). Conversely, females with ADHD are less likely to have disruptive behaviour disorders and are more likely to report higher prevalence of symptoms of inattention, which are more covert than those of hyperactivity and impulsivity (Biederman & Faraone, 2004). Although females are more likely to have the primarily inattentive subtype of ADHD, its consequences are less often studied (Elkins, et al., 2018). Gaub and Carlson (1997) suggested in their meta-analysis that differences in the phenotypic expression of the disorder may be driving diagnostic referrals of more males than females. However, Vasiliadis et al. (2017) believes that the gap in ADHD diagnosis between males and females is getting smaller and may reflect increased identification of ADHD in females, who more often exhibit symptoms of inattention, which may be more difficult to detect than hyperactivity. For example, Brault and Lacourse (2012) reported that the steepest increase over time in ADHD occurred in females and this trend could reflect either the greater attention females are now receiving or the acknowledgment that sex differences may result from referral bias. Furthermore, several international studies have reported higher ADHD symptoms among females than males (Gritti et al., 2014; Madruga et al., 2012; Polanczyk et al., 2010; Sonnby et al., 2011).

Most studies regarding ADHD use clinical samples. Prior clinical studies of sex and ADHD are limited by small sample sizes (Rooney, Chronis-Tuscano, & Yoon, 2011; Egan, Dawson, & Wymbs, 2017), impeding an adequate understanding of sex differences. It is imperative that future studies have large enough sample size to examine sex differences, as the greater the sample size, the greater the power of the test, and there have been instances where there was insufficient power to examine sex differences (Rooney et al., 2011; Egan et al., 2017). Prior clinical studies of sex and ADHD are also limited by the absence of gender matched comparisons. One of the reasons for this limitation is because many clinical studies contain all male samples which limits the ability to make inferences to females (Szatmari et al., 1989). Although there are ADHD studies by sex (Brault & Lacourse, 2012; Brownell & Yogendran, 2001; Hauck et al., 2017; Szatmari et al., 1989; Vasiliadis et al., 2017), there are also ADHD studies that did not record sex specific prevalence statistics (Polanczyk et al., 2014; Polanczyk et al., 2015). Hence, despite the importance of examining sex differences, not all studies that have
examined ADHD have further analyzed sex differences, or if they have, many did not record results specific to males and females (Polanczyk et al., 2014; Polanczyk et al., 2015; Thomas et al., 2015). Therefore, there is a need to understand sex differences related to ADHD for Canadian youth.

2.5 ADHD Symptoms and Substance Use

There has been growing research showing that those with ADHD symptoms are at increased risks of adverse outcomes (Fergusson et al., 2007). These outcomes span substance use (Flory et al., 2003). Substance use refers to the ingestion of drugs of abuse, inhalants, or medications for the intent of intoxication (APA, 1994). Substance use constitutes a substantial clinical, public health, and economic concern (Demyttenaere et al., 2004). Youth with ADHD symptoms are especially susceptible to engaging in substance use as they have difficulties with impulse control, which increases susceptibility for developing addictive behaviour (Faregh & Derevensky, 2011). Furthermore, substance use may share a common genetic vulnerability with ADHD because the dopamine transporter gene (DAT1) and the dopamine receptor D4 gene (DRD4) have been involved in the etiology of both ADHD (Todd et al., 2005) and substance use pathways (Guindalini et al., 2006; Shao et al., 2006).

The majority of studies examining the relationship between ADHD symptoms and substance use examined the commonly popular substances that children and youth use: alcohol (Elkins et al., 2018; Fergusson et al., 2007; Flory et al., 2003; Galéra et al., 2008; Sihvola et al., 2011; Upadhyaya & Carpenter, 2008), tobacco cigarettes (Fergusson et al., 2007; Flory et al., 2003; Galéra et al., 2005; Galéra, 2013; Kollins et al., 2005; Sihvola et al., 2011; Upadhyaya & Carpenter, 2008) and cannabis (Elkins et al., 2018; Fergusson et al., 2007; Flory et al., 2003; Galéra et al., 2008; Upadhyaya & Carpenter, 2008). One has examined cocaine (Galéra et al., 2013) and no studies using youth samples have examined the increased risk of crack-cocaine, methamphetamine, or ecstasy among those with ADHD symptoms.

Examining substance use categories separately is important because there is evidence of different patterns of use; for example, alcohol and cannabis use may differ from tobacco cigarette use because the former two are depressants and the latter is a stimulant. There is evidence that the rate of substance use for those with ADHD was significantly higher for tobacco use and cocaine
use than for alcohol use or cannabis use (Lambert & Hartsough, 1998). Furthermore, it is posited that people with ADHD symptoms are more likely to use stimulants than depressants because stimulants share chemical and mechanistic similarities to methylphenidate, a common ADHD medication (Arnsten, 2006).

2.5.1 Alcohol

Alcohol is the most commonly used substance among children and youth (Barnes, Welte, Hoffman, & Tidwell, 2009; Johnston, O’Malley, Bachman, & Schulenberg, 2007) and remains the substance with the highest prevalence of use by Canadian students in grades 7 through 12 (Government of Canada, 2019). The prevalence of use of alcohol in the past 12 months by students (grades 7-12) was 44%, and remains unchanged from 2016-2017 (Government of Canada, 2019). Youth who are influenced by older people of legal age are more likely to use alcohol (Mezzich et al., 1999). When students were asked how difficult they thought it would be to obtain alcohol if they desired, 66% responded that they thought it would be “fairly easy” or “very easy” (Government of Canada, 2019). Identification of vulnerable subgroups of the population has been an important research agenda in the effort to understand risk and to develop targeted interventions. Given that alcohol use lies along the continuum of externalizing psychopathology (Krueger, Markon, Patrick, & Iacono, 2005; Markon & Krueger, 2005), it may be associated with other externalizing symptomatology (such as ADHD symptoms). However, results from literature indicates conflicting results with the relationship between ADHD and alcohol use.

Some of the research examining the relationship between ADHD symptoms and alcohol use indicates that children and youth with ADHD symptoms are not more likely to use alcohol than children and youth without ADHD symptoms (Flory et al., 2003; Galéra et al., 2008; Upadhyaya & Carpenter, 2008). Flory et al. (2003) examined the relationship between ADHD symptoms and other childhood disruptive behaviours with substance use in young adulthood as part of a 10-12 year longitudinal examination of substance use and psychopathology. Youth (n = 481; male = 50.1%) from multiple schools from a midwestern metropolitan area in the United States were assessed by means of a written questionnaire in the 1987-1988 school year before they started 6th grade. Follow up data were collected from participants over a 5-year period from 6th-10th grade. Participants completed questionnaires on at least three of these five occasions and took part in a
mailed survey at age 19-21. After, participants were contacted by telephone and participated in a 3-4 hour laboratory study. Childhood ADHD symptoms were assessed retrospectively during laboratory protocol using an 18-item questionnaire with items corresponding to APA DSM-IV criteria for ADHD (APA, 1994). Past-month reporting of alcohol use was taken from the mailed survey. Bivariate correlation revealed that ADHD symptoms were not significantly related to alcohol use ($r = -.01, p = NS$). However, CD symptoms, that measured delinquent behaviours, were significantly related to alcohol use ($r = .17, p < .01$). In the regression analysis for alcohol use, CD symptoms made a significant and unique contribution, beyond that of ADHD symptoms; however, ADHD symptoms (OR = 0.92) did not make a significant and unique contribution beyond that of CD symptoms for alcohol use. It is important to note that researchers used a significance level of $p < .01$ to minimize the possibility of Type I error. ADHD symptomology was unrelated to sex of participants.

Galéra et al. (2008) examined ADHD symptoms in childhood and alcohol use in adolescence among the youth gazel cohort (an open and general-purpose epidemiological laboratory that examines the long-term follow-up of a cohort). Participants included 916 children and youth (males = 45.96%) aged 7 to 18 and data were extracted from 1991 to 1999. Youth and the parents or guardians of the children/youth were given questionnaires. ADHD symptoms were measured in 1991 with the 11-item Child Behavior Checklist (CBCL) (a validated and widely used tool in clinical and epidemiological studies) scale for attention problems. An example of some of the symptoms include: “acts young”, “can not concentrate”, “can not sit still”, “daydreams”, “impulsive”, “stares blankly”; CBCL was also used to measure covariates (anxious/depressed, CD symptoms, etc.). The youth questionnaire asked detailed questions about substance use (adapted from the Monitoring the Future (MTF) study). For alcohol use, two variables were created: 1) a binge drinking variable (had five or more drinks in a row at least twice in the last two weeks versus had five or more drinks in a row at most once versus did not have five or more drinks in a row in the last two weeks); and 2) a regular drinking variable (has drunk at least 10 times during the last 30 days versus has drunk less than 10 times or has not drunk during the last 30 days). ADHD symptoms were not significant in the bivariate analysis with alcohol binge drinking or for regular drinking. ADHD symptoms had an OR of 0.73 (95% CI [0.29-1.85]) for binge drinking and an OR of 0.80 (95% CI [0.36-1.78]) for regular drinking.
Irrespective of binge or regular drinking, no association was found between alcohol use and ADHD symptoms in the bivariate analysis or multivariate modelling of the data, for both males and females. CD symptoms were not significantly related to alcohol use for males and females. In females, the environmental risk factor of low SES was predictive of regular alcohol use.

Upadhyaya and Carpenter (2008) aimed to understand the relationship between ADHD symptoms and past-year alcohol use in a convenience sample (n = 334; response rate of 56%; mean 20.6 years; male = 39%) of college students in the states. Past year alcohol use was measured ordinaly (i.e., once per year, six times per year, once per month, twice per month, once per week, three times per week, five times per week, every day). The Current Symptom Scale-Self Report is a rating scale and was used for the assessment of ADHD symptoms in the past six months by subscales (nine items each). Each item was scored from 0-3 (never/rarely, sometimes, often, or very often) and was counted as a symptom of ADHD only if endorsed as often or very often. All analyses controlled for both lifetime CD symptoms and antisocial personality disorder (ASPD) symptoms, with both entered as covariates in the regression model; however, the influence of these covariates in the relationship between ADHD symptoms and alcohol use was never discussed. The number of ADHD symptoms was not significantly related to past year alcohol use (OR = 1.1; 95% CI [0.98–1.16]). ADHD symptomatology was unrelated to sex.

Other studies suggest that there is a relationship between ADHD symptoms and alcohol use among youth (Elkins et al., 2018; Fergusson et al., 2007; Sihvola et al., 2011), specifically that risk of alcohol use may be more apparent in females with ADHD symptoms (Elkins et al., 2018; Sihvola et al., 2011) and ADHD symptoms decrease the risk of alcohol use (Fergusson et al., 2007). It is important to note that these are contradictory findings. Elkins and colleagues (2018) used population-based twin samples recruited for the Minnesota Twin Family Study (n = 3762 individual twins; male = 48%) to examine if childhood inattentive or hyperactive-impulsive symptoms predicted alcohol use by age 17. Primary caregiver reports of twins, including lifetime ADHD symptoms (consistent with DSM-5) and CD symptoms at baseline were obtained with the Diagnostic Interview for Children and Adolescents-Revised (Elkins et al., 2018). Frequency of use was coded to reflect typical escalation during adolescence; for alcohol frequency: 0 = never, 1 = less than once a month, 2 = once a month/nearly weekly, 3 = weekly/daily. Overall
effects were adjusted for covariates (age, parental SES, and sex). When co-occurring use of other substances and conduct/oppositional defiant symptoms were considered, hyperactivity-impulsivity remained significantly associated to alcohol use \((p < .05)\), but inattention became non-significant. When sex differences were significant, ORs were presented separately. ADHD symptoms, specifically inattentive symptoms were significantly related to weekly/daily drinking \((\text{OR} = 1.08 \ (95\% \text{ CI} \ [1.03-1.13]), \ p < .001)\) and maximum number of drinks in 24 hours \((\text{OR} = 1.07, \ p < .001)\). ADHD symptoms, specifically hyperactivity-impulsivity symptoms were significantly related to weekly/daily drinking \((\text{OR} = 1.20 \ (95\% \text{ CI} \ [1.14-1.27]), \ p < .001)\) and maximum number of drinks in 24 hours \((\text{OR} = 1.16, \ p < .001)\) in females significantly more than maximum number of drinks in 24 hours for males \((\text{OR} = 1.08, \ p < .001)\). The risk of alcohol use was more apparent in females (Elkins et al., 2018); reasons for this could be that females experience greater social and academic consequences than males (Elkins, Malone, Keyes, Iacono, & McGue, 2011) leading them to use alcohol as a way to cope with these consequences.

Sihvola and colleagues (2011) aimed to examine the relationship between ADHD symptoms and alcohol use. They conducted a population-based study in Finland \((n = 1545; \ 83\% \text{ completion rate}; \ males = 51\%; \ age 14-17)\) and assessed for DSM-IV based ADHD symptoms using the Multidimensional Peer Nomination inventory. Assessment for ADHD symptoms included four inattentive symptoms and seven hyperactivity-impulsivity symptoms; sum scores of each symptom were constructed as the mean of the items. ADHD symptoms were reported by parents and teachers; however, data reported between the two groups were similar. Alcohol use was reported by youth and was measured as frequent use \((\text{daily or a couple of times a week}), \ \text{once a week, couple times a month, once a month, once a couple of months, 2-4 times a year, once a year or more rarely, or no use. By the age of 17.5 years, 15.4\% of females exhibiting high inattentiveness reported weekly alcohol use while 8.8\% of males exhibiting high inattentiveness reported weekly alcohol use. Young females with core symptoms of ADHD, such as inattentiveness, may be at higher risk of substance use than young males. Larger effects of ADHD symptoms on alcohol consumption in females were found, consistent with Elkins et al. (2018). Alcohol use was not entered as a main interest variable in the multinomial logistical regression but rather it was controlled for when examining tobacco cigarette use.}
Fergusson et al. (2007) used data gathered during the Christchurch Health and Development Study, which is a longitudinal study of 1,265 children (~50% male) born in the Christchurch (New Zealand) urban region during a 4-month period in mid-1977. This cohort has been studied at birth and at annual intervals to age 16 years, 18, 21, and 25 years. Data have been gathered from parental interviews, self-reports, psychometric tests, teacher reports, medical and other official records. The child’s tendencies to ADHD symptoms were recorded from parent and teacher questionnaires at the ages 7-9. All items were scored on a three-point scale from “not at all” to “a great deal”. These measures were then averaged over the 3-year period to provide an overall scale score ranking. Parents and teenagers were questioned in separate interviews on measures of ADHD symptoms based on the Revised Behaviour Problems Checklist at the ages of 14-16. Parent and self-report assessments were combined to classify the individual as having ADHD symptoms if s/he met DSM-III-R diagnostic criteria on the basis of either parental or self-report over the interval from 14–16 years. At age 18, 21, and 25, participants were asked about alcohol use. At each assessment participants were questioned about their use of alcohol in the previous 12 months, including the frequency of alcohol consumption and the amounts consumed. Participants recorded the use of alcohol if they consumed any alcoholic drink in the preceding 12 months. Family SES and CD symptoms were covariates controlled for in the following analyses. Increasing ADHD symptoms in middle childhood were associated with decreasing rates of alcohol use and rates of use tended to decline significantly with increasing ADHD symptoms. Early CD symptoms and ADHD symptoms proved to be correlated ($r = .68; p < .0001$). Alcohol use was unrelated to early CD symptoms and negatively related to ADHD symptoms. Risk Ratio (RR) or OR were not produced. No sex differences were discussed. Researchers assessed based on rates of alcohol use by symptoms (1 low, 2 symptoms, 3 symptoms, 4 symptoms, and 5 high symptoms). The report indicates that rates of use decline significantly with increasing ADHD symptoms.

In summary, some studies did not find any relationship between ADHD symptoms and alcohol use for both frequency of alcohol use (e.g., past month of alcohol use, past year use) (Flory et al., 2003; Upadhya & Carpenter, 2008) and binge drinking (e.g., five or more drinks in a row at least twice a week in the last two weeks) (Galéra et al., 2008). Other studies suggest that there is a relationship between ADHD symptoms and alcohol use among youth (Elkins et al., 2018;
Fergusson et al., 2007; Sihvola et al., 2011). Some found that ADHD symptoms increases the risk of alcohol use (Elkins et al., 2018; Sihvola et al., 2011) while others found that ADHD symptoms decrease the rates of alcohol use (Fergusson et al., 2007). Furthermore, both Elkins et al. (2018) and Sihvola et al. (2011) found larger effects of ADHD symptoms on alcohol in females than in males. Elkins et al. (2018) found that ADHD symptoms (specifically hyperactivity-impulsivity symptoms) were significantly related to alcohol use in females, significantly more than in males. Sihvola et al. (2011) found that significantly more females exhibiting high inattentiveness reported alcohol use compared to males exhibiting high inattentiveness.

### 2.5.2 Tobacco Cigarettes

Tobacco cigarettes is one of the most commonly used substance by children and youth (Barnes et al., 2009). In 2018/19, 19% of students in grades 7 through 12 had ever tried smoking a cigarette (even just a puff) (Government of Canada, 2019). The majority (84%) of students who smoked in the past 30 days obtained their tobacco cigarettes from social sources (rather than retail sources) (Government of Canada, 2019). Social sources include friends and family. Tobacco cigarette use could be used as self-medication among ADHD individuals since nicotine has been shown to improve general attention, learning, and memory, and to have positive effects on cognitive/behavioural inhibition in youth with ADHD (Levin, 1992; Potter & Newhouse, 2004). Furthermore, tobacco cigarettes is hypothesized to modulate dopaminergic pathways possibly implicated in the pathophysiology of ADHD (Swanson et al., 2000). The majority of studies indicate that ADHD symptoms are significantly associated with tobacco cigarette use (Fergusson et al., 2007; Flory et al., 2003; Galéra et al., 2013; Kollins et al., 2005; Sihvola et al., 2011; Upadhyaya & Carpenter, 2008), although sex differences may exist. For example, a study found a significant relationship between ADHD symptoms and daily tobacco cigarette use in females but not in males (Galéra et al., 2005).

Fergusson et al. (2007) measured tobacco cigarette use at age 18, 21, and 25. Those who reported smoking a cigarette at any time in the previous month were classified as using tobacco cigarettes. Increasing ADHD symptoms in middle childhood were associated with increasing rates of tobacco cigarette use. Early CD symptoms and ADHD symptoms proved to be correlated ($r =$
.68; \( p < .0001 \)). RR or OR were not produced. No sex differences were discussed. Researchers assessed based on rates of tobacco cigarette use by ADHD symptoms (1 low, 2 symptoms, 3 symptoms, 4 symptoms, and 5 high symptoms). The report indicates that rates of use increased significantly with increasing ADHD symptoms.

Flory et al. (2003), described previously, also examined the relationship between ADHD symptoms and other childhood disruptive behaviours with tobacco cigarette use in young adulthood. Researchers analyzed past-month reporting of tobacco cigarette use. Sex did not influence results in the multiple regression analysis. In the regression analyses for tobacco cigarette use, CD symptoms made a significant and unique contribution, beyond that of ADHD symptoms. Likewise, ADHD symptoms made a significant and unique contribution beyond that of CD symptoms for tobacco cigarette use (OR = 1.09). It is interesting to note that the only substance to which ADHD symptoms were uniquely related after the inclusion of the ADHD-CD symptoms interaction term was tobacco cigarettes. This finding is consistent with prior research that has demonstrated that ADHD symptoms are related to tobacco use even after the overlap between ADHD symptoms and CD symptoms are taken into account (e.g., Disney, Elkins, McGue, & Iacono, 1999).

Galéra et al. (2013) assessed the link between ADHD symptoms and tobacco cigarette use in 1,103 French youth (male: 41.2%) followed from 1991 to 2009, using the same measures as Galéra et al. (2008). In 2009, youth reported their past 12-month use of tobacco cigarettes. Past 12-month regular tobacco smoking was defined as greater than or equal to one cigarette per day/less than one cigarette per day. After accounting for covariates (anxious/depressed symptoms, CD symptoms, and SES), ADHD symptoms were significantly related to regular tobacco smoking 18 years later. Those who scored high \( \geq 90^{th} \) percentile for ADHD symptoms had higher odds for using regular tobacco cigarettes (OR = 2.74 (95% CI [1.79-4.21]), \( p < .05 \) (adjusted for only age and sex) and OR = 2.19 (95% CI [1.31-3.68]), \( p < .05 \) (fully adjusted)). There were no sex differences in this study (the tests for effect modification by sex were non-significant).
Kollins et al. (2005) studied 15,197 participants (male = 49.5%; average age = 21.94 years) from wave III of the National Longitudinal Study of Adolescent Health (of adolescents followed from 1995 to 2002) to examine the relation between self-reported ADHD symptoms and the lifetime likelihood of being a regular smoker (defined by having smoked at least 1 cigarette a day for 30 days) while controlling for CD symptoms and SES. Participants were asked to retrospectively report ADHD symptoms (analysis included nine inattention symptoms and eight hyperactive/impulsive symptoms) experienced between the ages of 5 and 12 years. A symptom was considered present if it was experienced “often” or “very often” and the total number of symptoms reported was used as a measure of ADHD symptoms severity to assess the relation between symptoms and smoking outcomes. For descriptive and bivariate analyses, individuals were classified into one of four groups based on the number of reported symptoms: 1) six or more inattentive symptoms, fewer than six hyperactivity symptoms; 2) six or more hyperactivity symptoms, fewer than six inattention symptoms; 3) six or more inattentive symptoms and six or more hyperactivity impulsivity symptoms; and 4) fewer than six hyperactivity impulsivity symptoms and fewer than six inattention symptoms. Reporting higher numbers of CD symptoms and reporting six or more inattention and/or hyperactivity-impulsivity symptoms were all significantly associated with higher likelihood of ever regular smoking. In the controlled model, each reported inattention and hyperactivity-impulsivity symptom significantly increased the likelihood of ever regular smoking (OR= 1.11; 95% CI [1.08-1.14] and OR, 1.16; 95% CI [1.13-1.19], respectively). The unadjusted model for likelihood of ever regular smoking was significant for inattentive symptoms (OR = 1.14 (95% CI [1.11-1.17])) and significant for hyperactivity-impulsivity symptoms (OR = 1.20 (95% CI [1.17-1.23])). The addition of demographic variables and CD symptoms resulted in decreased ORs for both hyperactivity-impulsivity and inattention symptoms, though both remained significant. To assess ORs for more clinically relevant variables, the same models mentioned earlier were calculated using symptom cut-off variables as predictors. The odds of becoming a lifetime regular smoker were 1.23 and 2.13 times greater for those individuals with six or more inattention and hyperactivity-impulsivity symptoms, respectively. There were no sex differences found in this study ($p = .67$).

Sihvola and colleagues (2011) assessed ADHD symptoms of adolescents aged 14-17. Their aim was to examine ADHD symptoms and its contribution in predicting tobacco cigarette use after
controlling for CD symptoms with multinomial analyses; importantly, sex differences were evaluated. Tobacco cigarette use was measured as daily smokers, occasional smokers (not daily smoking but smoking either less than once a week or once a week or more often), and experimenters (“I have experimented with tobacco cigarettes but I don’t smoke”). In this prospective three-wave data, high inattentiveness, hyperactivity and impulsivity rated by parents and teachers were of importance regarding daily smoking behaviour among both sexes at age 14 (on average, 24% of females v. 21% of males with high symptoms smoked daily) and at age 17.5 (44% of females v. 39% of males smoked daily). Controlling for CD symptoms, both teachers’ and parents’ ratings of ADHD symptoms consistently predicted daily smoking at ages 14 and 17.5 among males and females.

Model 1 was a multinomial logistic regression model to examine the unadjusted association with the outcomes (Sihvola et al., 2011). Model 2 included potential confounding covariates of daily smoking behaviour, illicit drug use, alcohol use, co-existing symptoms of psychiatric disorders, and interaction terms with sex. Models were also fit separately for males and females. Sex differences were further tested with likelihood ratio tests to confirm significance of the differences between coefficients in models separately fit for males and females.

In the multinomial logistic regressions, all risk ratios were lower after controlling for the covariates, but still strongly significant (Sihvola et al., 2011). Young females with core symptoms of ADHD, such as inattentiveness and hyperactivity, may be at higher risk of tobacco cigarette use than young males, because females’ risk may not be mediated by CD symptoms, a strong predictor of substance use. For example, when adjusted for covariates, females with inattentiveness symptoms had a 2.9, 95% CI [1.7-5.0], \(p < .001\) increased risk of smoking at age 17 (relative to not smoking at age 17), compared to females without inattentiveness symptoms. Males with inattentiveness symptoms had a 2.5, 95% CI [1.6-3.9], \(p < .001\) increased risk of smoking at age 17 (relative to not smoking at age 17), compared to males without inattentiveness symptoms. For hyperactivity symptoms, when adjusted for covariates, females with hyperactivity symptoms had a 4.2, 95% CI [1.9-9.1], \(p < .001\) increased risk of smoking at age 17 (relative to not smoking at age 17), compared to females without hyperactivity symptoms. Males
with hyperactivity symptoms had a 4.1 95% CI [2.3-7.3], \( p < .001 \) increased risk of smoking at age 17 (relative to not smoking at age 17), compared to males without hyperactivity symptoms.

Upadhyaya and Carpenter (2008) assessed frequency of use in the past year for tobacco cigarette. The number of ADHD symptoms was significantly related to past year smoking (OR = 1.1; 95% CI [1.03–1.18]). For every one symptom increase in ADHD, the odds of using tobacco 5+ times per week increased by 10%. For every one symptom increase in both hyperactive and inattentive behaviours, the odds of using tobacco 5+ times per week increased by at least 17% (OR = 1.17; 95% CI [1.03–1.33]) and 18% (OR = 1.18; 95% CI [1.06–1.33]), respectively. Upadhyaya and Carpenter (2008) found that ADHD symptoms were linked to greater tobacco cigarette use even after controlling for conduct problems and ADHD symptomatology was unrelated to sex.

Galéra et al. (2005), on the other hand, did not find a significant relationship between ADHD symptoms and tobacco cigarette use for both sexes. Galéra et al. (2005) examined 916 children and youth (males = 45.96%) aged 7 to 18 and data were extracted from 1991 to 1999 using the same sample and measures as Galéra et al. (2008). Prevalence of smoking was estimated according to three periods: lifetime, last 12 months, and last 30 days. Two dichotomous smoking variables were created: 1) lifetime smoking variable (has ever used tobacco versus never used tobacco; and 2) daily smoking variable (has smoked at least one cigarette per day over the last year versus non-smoker). ADHD symptoms were not significant in the bivariate analysis with lifetime smoking (Wald \( \chi^2 = 3.31, p = .07 \)) or for daily smoking (Wald \( \chi^2 = 3.83, p = .05 \)) for males and were not significant in the adjusted model for lifetime smoking (OR = 1.50, \( p = .25 \)) or for daily smoking OR = 1.51, \( p = .27 \) for males. CD symptoms were not significantly related to lifetime smoking (OR = 2.00, \( p = .06 \)) but were significantly predicting daily smoking (OR = 2.95, \( p < .01 \)) for males. ADHD symptoms were not significant in the bivariate analysis with lifetime smoking (Wald \( \chi^2 = 1.15, p = .28 \)) but were significantly related to daily smoking (Wald \( \chi^2 = 9.25, p < .01 \)) for females. ADHD symptoms were not significant in the adjusted model (OR = 0.89, \( p = .74 \)) for lifetime smoking but remained significant in the adjusted model for daily smoking (OR = 1.98, \( p = .04 \)) for females. CD symptoms significantly predicted lifetime smoking (OR = 3.27, \( p < .01 \)) but not daily smoking (OR = 1.75, \( p = .09 \)) for females. ADHD symptoms in childhood did not predict lifetime smoking in bivariate relationships for both males
and females. ADHD symptoms contributed independently to subsequent daily smoking (OR = 1.98, \( p = .04 \)) only for females. This sex difference is consistent with a population-based study that analyzed ADHD and substance abuse (Disney et al., 1999). Reasons for results could be that tobacco experimentation can be regarded as a normative experience rather than a deviant behaviour. Thus, any association between ADHD symptoms and lifetime smoking is likely to have been diluted in analyses taking into account the broad definition of smoking, and those results were correspondingly biased toward the null hypothesis. A different picture emerged when a more comprehensive definition of smoking was employed. For this reason, it is important to use a more comprehensive definition of smoking, not just lifetime smoking.

In summary, most studies found a relationship between ADHD symptoms and tobacco cigarette use, specifically regular tobacco cigarette use (Fergusson et al., 2007; Flory et al., 2003; Galéra et al., 2013; Kollins et al., 2005; Sihvola et al., 2011; Upadhyaya & Carpenter, 2008). Fergusson et al. (2007) found that rates of tobacco cigarette use increase significantly with increasing ADHD symptoms. Flory et al. (2003), Galéra et al. (2013), Kollins et al. (2005), and Upadhyaya and Carpenter (2008) found that ADHD symptoms made a significant and unique contribution beyond that of covariates for increasing the odds of tobacco cigarette use. Furthermore, both Galéra et al. (2005) and Sihvola et al. (2011) found that the relationship between ADHD symptoms and tobacco cigarettes yielded sex specific results. Sihvola et al. (2011) found that the risk of tobacco cigarette use in females with ADHD symptoms were higher than the risk in males with ADHD symptoms. Galéra et al. (2005) found a significant relationship between ADHD symptoms and daily tobacco cigarette use in females, but not in males. However, when Galéra et al. (2005) also used a less stringent definition of smoking (lifetime smoking variable: has ever used tobacco versus never used tobacco), they found that ADHD symptoms had no relationship with lifetime smoking, for both males and females. Therefore, it is important to consider the use of frequency measures as opposed to lifetime measures for this specific type of research.

2.5.3 Cannabis

Cannabis is one of the three substances most commonly used by youth (Barnes et al., 2009), and has the highest prevalence of use after alcohol (Government of Canada, 2019). In 2018/19, 18% of students in grades 7 through 12 reported using cannabis in the past 12 months (Government of Canada, 2019). Students in grades 7 to 9 reported an increase in the use of cannabis (7%
compared to 6% in 2016/17); cannabis use among those in grades 10 to 12 remained unchanged at 29% (Government of Canada, 2019). Some with ADHD report a preference for cannabis (Mitchell et al., 2019), perhaps due to its anxiolytic properties (Bonn-Miller, Zvolensky, & Bernstein, 2007). Similar to tobacco cigarette use, results from the literature regarding the relationship between ADHD and cannabis use indicate that those with ADHD symptoms are more likely to use cannabis than those with no ADHD symptoms.

Some studies indicate that ADHD symptoms are significantly associated with cannabis use (Fergusson et al., 2007; Upadhyaya & Carpenter, 2008). Other studies did not find a significant relationship between ADHD symptoms and cannabis use (Flory et al., 2003). Moreover, other studies have found a relationship between ADHD symptoms and regular use of cannabis in males (Galéra et al., 2008) but not regular use for cannabis in females or lifetime cannabis use (Galéra et al., 2008) as well as a more apparent risk of cannabis use in females with ADHD symptoms (Elkins et al., 2018).

Fergusson et al. (2007) examined the relationship between ADHD symptoms (measured using the Attention Problem scale) and cannabis use. At age 18, 21, and 25, participants were asked about cannabis use. Participants were classified as using cannabis if they reported using cannabis at any time during the interval. Increasing attentional problems in middle childhood were associated with increasing rates of cannabis use. Early CD symptoms and ADHD symptoms proved to be correlated \( r = .68; \ p < .0001 \). RR or OR were not produced. No sex differences were discussed. Researchers assessed based on rates of cannabis use by symptoms (1 low, 2 symptoms, 3 symptoms, 4 symptoms, and 5 high symptoms). The report indicates that rates of use increased significantly with increasing ADHD symptoms.

Upadhyaya and Carpenter (2008) assessed frequency of use in the past year for cannabis. The number of ADHD symptoms were significantly related to past year cannabis use \( (OR = 1.14; 95\% \ CI [1.06–1.24]) \). For every one symptom increase in ADHD, the odds of using cannabis at least 5 times per week increased by 14%. For every one symptom increase in both hyperactive and inattentive behaviours, the odds of using cannabis at least 5 times per week increased by 21% \( (OR = 1.21; 95\% \ CI [1.03–1.42]) \) and 29% \( (OR = 1.29; 95\% \ CI [1.13–1.47]) \), respectively.
They found that ADHD symptoms were linked to greater cannabis use even after controlling for CD symptoms. Lastly, ADHD symptomatology was unrelated to sex.

Flory et al. (2003) examined the relationship between ADHD symptoms and other childhood disruptive behaviours with substance use in young adulthood and found that ADHD symptoms did not make a significant and unique contribution beyond the addition of covariates for cannabis use. Participants were asked questions regarding past year use of cannabis. Bivariate correlation revealed that ADHD symptoms were significantly related to cannabis use ($r = .17, p < .01$) and that CD symptoms were significantly related to cannabis use ($r = .38, p < .01$). ADHD symptoms and CD symptoms were moderately correlated ($r = .42, p < .01$). Sex did not influence results in the multiple regression analysis (sex did not modify the association between ADHD symptoms and cannabis use). In the regression analyses for cannabis use, CD symptoms made a significant and unique contribution, beyond that of ADHD symptoms. However, ADHD symptoms (OR = 1.01) did not make a significant and unique contribution beyond that of CD symptoms for cannabis use. It is important to note that researchers used a significance level of $p < .01$ to minimize the possibility of Type I error.

Elkins et al. (2018) and Galéra et al. (2008) found that the relationship between ADHD symptoms and cannabis use yielded sex specific results. Elkins and colleagues (2018) examined if childhood inattentive or hyperactive-impulsive symptoms predicted cannabis outcomes by age 17. Frequency of use was coded to reflect typical escalation during adolescence; for cannabis frequency: 0 = never, 1 = less than once a month, 2 = once a month/nearly weekly, 3 = weekly/daily. Adolescents with more ADHD symptoms were more likely to have higher frequency of use. Overall effects were covariate-adjusted for age, parental SES, and sex. There was evidence of effect modification by sex. When co-occurring use of other substances and conduct/oppositional defiant symptoms were considered, hyperactivity-impulsivity and inattention remained significant ($p < .05$). When sex differences were significant, ORs were presented separately. ADHD inattentive symptoms were significantly related to the progression toward daily cannabis use (OR = 1.20 (95% CI [1.13-1.28]), $p < .001$) and for lifetime cannabis use (OR = 1.08, $p < .001$). ADHD hyperactivity-impulsivity symptoms were significantly related to the progression toward daily cannabis use and this was significantly greater in females (OR =
1.40 (95% CI [1.27-1.55]), \( p < .001 \) than males (1.19 (95% CI [1.08-1.31]), \( p < .001 \)) (a result of effect modification). ADHD hyperactivity-impulsivity symptoms were also significantly related to lifetime cannabis use (OR = 1.08, \( p < .001 \)). Hyperactivity-impulsivity effects were associated more strongly with cannabis frequency (\( p = .02 \)) for females than males. Each hyperactive-impulsive symptom was associated with a 40% increase in odds for females (19% for males) of progressing in cannabis frequency (e.g., weekly to daily). The risk of cannabis use was more apparent in females (Elkins et al., 2018); reasons for this could be that females experience greater social and academic consequences from ADHD symptoms than males (Elkins et al., 2011) leading them to use cannabis as a way to cope with these consequences.

Galéra et al. (2008) examined cannabis use. For cannabis use, two variables were created: 1) a lifetime cannabis smoking variable (has ever used cannabis versus never used cannabis); and 2) a regular cannabis smoking variable (has smoked cannabis at least 10 times during the last 30 days versus has smoked cannabis less than 10 times or has not smoked cannabis during the last 30 days). ADHD symptoms were not significant in the bivariate analysis with lifetime cannabis use or in the regression analysis (OR = 1.54 95% CI [0.76-3.11]). ADHD symptoms were significant in the bivariate analysis for regular cannabis use (\( p < .01 \)). In males, ADHD symptoms had an OR of 3.14 (95% CI [1.14-8.63], \( p = .03 \)) for regular cannabis use even after controlling for covariates (age, CD symptoms). In females, ADHD symptoms did not independently increase the likelihood for regular cannabis use, whereas, low SES was predictive of regular cannabis use. ADHD symptoms did not account for the risk of lifetime cannabis use. Owing to its relatively high prevalence, cannabis experimentation cannot be considered as deviant behaviour. Conversely, ADHD symptoms appeared to be a predictor of regular cannabis smoking in males before and after adjusting for relevant covariates that included CD symptoms.

Studies have used lifetime measures for cannabis use (Elkins et al. 2018; Galéra et al. 2008); however, lifetime measures do not differentiate those who used a substance once (i.e., due to experimentation, which is defined as the mild initial use of a substance) from individuals who use substances daily or frequently. A large proportion of youth have experimented with cannabis; however, when lifetime measures are used, these youth are lumped into the same category as those who use cannabis frequently or regularly. For example, according to an Australian survey,
most teenagers seem to use cannabis infrequently: more than 50% used fewer than 10 times in their life and 13% used 100 times or more in their life (Rey, Sawyer, Raphael, Patton, & Lynskey, 2002). The National Drug Strategy Household Survey indicated that many youth who have used cannabis (54% of those reporting lifetime use) appear to have stopped using it, or have been using the substance infrequently (1-2 times per year) (Reid, Lynskey, & Copeland, 2000). This suggests that a high rate of lifetime cannabis use reflects a large amount of experimental and irregular use that does not necessarily progress to regular or heavy use (Reid et al., 2000). It is likely that this is not just the case for cannabis use as the utilization of lifetime substance use measures does not capture the frequency of substance use. Hence, using a more descriptive measure is necessary, given that when participants are categorized into one of two response groups (i.e., those who use vs. those who do not use), there is likely to be significant variability in substance use that is not reflected in the results (Lee et al., 2011) as there is likely to be a significant difference between someone who has used a substance once in their lifetime and someone who uses that substance every day. Thus, a more comprehensive measure is needed when assessing the relationship between ADHD symptoms and any substance.

In summary, like tobacco cigarettes, most studies have found a relationship between ADHD symptoms and cannabis use (Elkins et al. 2018; Fergusson et al., 2007; Galéra et al. 2008; Upadhyaya & Carpenter, 2008). Additionally, Elkins et al. (2018) and Galéra et al. (2008) found that the relationship between ADHD symptoms and cannabis yielded sex specific results. Elkins et al. (2018) found that ADHD hyperactivity-impulsivity symptoms were significantly related to the progression toward daily cannabis use and this was significantly greater in females than in males; however, ADHD inattentive symptoms were significantly related to daily cannabis use and lifetime cannabis use for both males and females and ADHD hyperactivity-impulsivity symptoms were significantly related to lifetime cannabis use (Elkins et al., 2018). Conversely, Galéra et al. (2008) found a relationship between ADHD symptoms and regular cannabis use in males but not in females and no relationship between ADHD symptoms and lifetime cannabis use regardless of sex. Finally, other studies did not find a relationship between ADHD symptoms and cannabis use once CD symptoms were controlled for in the regression analysis (Flory et al., 2003).
2.5.4 Stimulants

In this study, the term “stimulants” refers to cocaine, crack-cocaine, ecstasy, and methamphetamine use, unless stated otherwise. Scholars have debated whether youth with ADHD would be more inclined to use stimulants as a form of self-medication to reduce ADHD symptoms (Galéra et al., 2009) compared to other classes of substances, such as depressants, because stimulant medications, such as methylphenidate, have shown positive therapeutic effects on persons with ADHD (Arnsten, 2006). The strong clinical response of ADHD to dopaminergic psychostimulant medication have raised questions about vulnerability to other dopaminergic drugs (Lambert & Hartsough, 1998), including cocaine (McCabe, Veliz, Wilens, & Schulenberg, 2017).

When reviewing the literature, there is extensive research in this field on non-human samples (such as gerbils, mice, and rats), studies on pregnancy and the effects of stimulant use during pregnancy, and literature on pharmacological treatment for childhood ADHD; information regarding ADHD symptoms and stimulant use among adolescents remains limited (Levin & Kleber, 1995). When specifying the search key to exclude the examination of adults, all but a couple of studies described non-human samples, studies on prenatal effects of stimulants, and ADHD medical use of stimulants. The remaining studies had different key outcome variables (e.g., excess mortality) or included stimulants as a risk factor to more popular substance use (e.g., alcohol and tobacco cigarettes).

Although not ideal, this literature review on stimulants includes childhood ADHD and subsequent adult use of cocaine (because of the lack of literature on childhood ADHD and childhood cocaine use). Only one paper examined the relationship between ADHD symptoms and cocaine use and whether those with ADHD symptoms are more likely to use cocaine than those without ADHD symptoms (Galéra et al., 2013). Other studies have examined ADHD and cocaine dependence (Lambert & Hartsough, 1998).

Galéra et al. (2013) assessed the link between childhood ADHD symptoms based on the Attention Problem scale and cocaine use 18 years later in 1,103 French youth from 1991 to 2009. In 2009, study participants were asked to report on their cocaine use. Lifetime cocaine use was defined as one or more occasions. Galéra et al. (2013) found a significant relationship (OR =
2.73) between ADHD symptoms and lifetime cocaine use in the adjusted model while controlling for anxiety/depression symptoms, CD symptoms, and other demographic variables (e.g., SES). Galéra et al. (2013) did not find an interaction of sex. Those who scored high ≥ 90th percentile for ADHD symptoms had a significant relationship with lifetime cocaine use (OR = 3.10 (95% CI [1.56-6.17]), p < .05 (adjusted for only age and sex)) even after fully adjusting for covariates (OR = 2.73 (95% CI [1.16-6.45]), p < .05).

There is a lack of research on stimulants in youth probably due to the small percentage of youth who engage in stimulants that are not popular substances (e.g., tobacco cigarettes). For example, Loeber, Stouthamer-Loeber, and White (1999) examined alcohol, tobacco cigarettes, cannabis, and other substances; however, because use rates were moderately low for these other substances, analyses of these other substances were omitted. Since cell sizes are often too small to analyze non-popular substances, scholars have integrated non-popular substances into “illicit substances” without the consideration of substance class and how those with ADHD may be more inclined to use stimulants than substances from another substance class. These results should be interpreted cautiously as the robust relations of substances from one class may show the opposite effect of the relations of substances from another class.

From this short review, it is evident that there is limited research on ADHD and stimulants. From this one study that was assessed, there is a relationship between ADHD symptoms and lifetime cocaine use. Galéra et al. (2013) found a significant relationship (OR = 2.73) between ADHD symptoms and lifetime cocaine use in the adjusted model while controlling for CD and anxiety/depression symptoms. Because there are so few studies on this subject matter, it is evident that more research should be done in this area.

### 2.6 Socio-economic Status

Socioeconomic status (SES) is defined as the social standing or class of an individual or group and is often measured as a combination of education, income, and occupation (APA, n.d.). SES is thought to be related to both ADHD and substance use; hence it is necessary to consider SES in any examination of the relationship between ADHD and substance use.
According to a national health interview survey (data from 2011-2013) in the United States, children and youth living in poverty have the highest rate of ADHD (CDC/NCHS, 2013). Studies have suggested a correlation of variously defined measures of SES with ADHD, and a recent systematic review and meta-analysis confirmed a small but reliable association (Russell, Ford, Williams, & Russell, 2016). This systematic review examined 42 studies in their associations between parental socioeconomic disadvantage and childhood ADHD. SES was measured by parental income, education, occupation, and marital status. Of the 42 studies, 35 found a significant univariate association between socioeconomic disadvantage and ADHD; on average, children in families of low SES are 1.85-2.21 more likely to have ADHD than their peers in high SES families. Furthermore, low SES increases the risk of child mental health problems (which they divided between internalizing and externalizing disorders) by 1.18-3.34 times. Furthermore, a study that included in the systematic review found that financial difficulties and a brief housing tenure were significantly associated with ADHD, such that families either living in financial difficulty or living in subsidized housing, were more likely to have a child with a diagnosis of ADHD at age seven (Russell et al., 2015). Additionally, financial difficulties were the strongest predictor of ADHD (OR 2.23 95% CI [1.57-3.16]) (Russell et al., 2015). Lastly, parent report of financial difficulties was regressed on ADHD with adjustment for sex. Males comprised of 83.9% of the ADHD group (compared to females) and only 50.5% of the non-ADHD diagnosis group.

Through the analysis of secondary data, studies have found that SES has also been associated with substance use. A longitudinal population-based study (n=1,203; females 51.5%) from the United States examined the associations of indicators of family SES (including income and parental education) with smoking, alcohol use, and lifetime cannabis use in youth, utilizing data from a household survey of families (Patrick, Wightman, Schoeni, & Schulenberg, 2012). Lower SES was associated with subsequent smoking, and higher SES was associated with alcohol and cannabis use in youth (Patrick et al., 2012). Another study used longitudinal, population-based nationally-representative survey from the United States (National Longitudinal Survey of Adolescent Health) with a total of 20,745 (males constituted 50.84%) students and their parents who participated in-home interviews (Humensky, 2010) to conduct secondary analysis of the relationship between SES and substance use. Substances were coded into lifetime use, and SES was measured by parental education and income. Higher SES was associated with higher rates of
binge drinking and cannabis use; however, no statistically significant results were found for crystal methamphetamine or other substances (Humensky, 2010).

These two population-based studies suggest that research is inconsistent on whether the direction of the relationship between SES and substance use is positive or negative (Hamilton et al., 2014); however, most previous studies focused on lower SES populations (Humensky, 2010). Overall, it is still important to examine SES when assessing the relationship between ADHD and substance use, to observe if an adjusted model controlling for SES changes the relationship between ADHD and substance use.

2.7 Social, Emotional, and Behavioural Problems

In the literature review section 2.5, researchers controlled for co-existing problems when examining the relationship between ADHD symptoms and substance use by including social, emotional, and behavioural problems as covariates in their analyses. Co-existing problems are typically sorted into two groups, internalizing problems and externalizing problems. Internalizing and externalizing problems are well-known concepts in the field of child psychology used to describe two groupings of social, emotional, and behavioural problems (Jacob et al., 2014). Internalizing problems refer to the internal psychological environment rather than the external world in which distress manifests itself inward, and includes depression, anxiety, social withdrawal, and emotional distress (Shin, Sung, Lim, Park, & Cho, 2012). Externalizing problems refer to distress that manifests in outward behaviour (Jacob, et al., 2014), and consists of aggressive and delinquent behaviours such as CD (Shin et al., 2012).

Studies indicate that youth with ADHD report higher levels of both internalizing problems (such as anxiety and depression) and externalizing problems (such as aggression, delinquency, and risk-taking) compared to their counterparts with typical development (McNamara, Willoughby, & Chalmers, 2005; Wehmeier, Schacht, & Barkley, 2010). For example, Galéra et al. (2005) found that those who reported ADHD symptoms were more likely to report CD symptoms than those who did not report ADHD symptoms, as ADHD symptoms were highly correlated with CD symptoms. Galéra et al. (2013) found that ADHD symptoms were significantly related to both CD symptoms (r = 0.44, p < .05) and internalizing problems (such as being anxious or depressed) (r = 0.36, p < .05). Furthermore, both Fergusson et al. (2007) and Flory et al. (2003)
found that CD symptoms and ADHD symptoms proved to be correlated ($r = .68$, $p < .0001$; $r = .42$, $p < .01$, respectively).

There is also research documenting strong associations between both internalizing and externalizing problems and substance use (Winters, Stinchfield, Latimer, & Stone, 2009). Externalizing problems, for example, were strongly associated with alcohol, tobacco cigarette, and cannabis use among youth ($n = 2,212$; ages between 15 and 18 years) in a population-based study conducted in Nordic countries (Pedersen et al., 2018). Studies utilizing population-based samples have demonstrated that substance use such as alcohol is associated with both internalizing and externalizing problems (Dawson, Goldstein, Moss, Li, & Grant, 2011). Galéra et al. (2013) found that being anxious or depressed decreased the likelihood of using cocaine ($r = -0.08$, $p < .05$) and that being anxious or depressed was significantly related to regular tobacco cigarette use (OR = 0.85, 95% CI [0.73-0.99], $p < .05$) and lifetime cocaine use (OR = 0.48, 95% CI [0.33-0.68], $p < .05$). Conversely, externalizing problems increased the chance of substance use. Galéra et al. (2013) found that CD symptoms were significantly related to regular tobacco cigarette use (OR = 1.35, 95% CI [1.19-1.54], $p < .05$) and lifetime cocaine use (OR = 1.39, 95% CI [1.17-1.65], $p < .05$). Galéra et al. (2005) also found that CD symptoms were a significant predictor for daily smoking ($p < .01$). Kollins et al. (2005) indicated that reporting higher numbers of CD symptoms were significantly associated with the higher likelihood of regular tobacco cigarette use. Lastly, Flory et al. (2003) found that CD symptoms were significantly correlated with all substance use categories (alcohol use, tobacco cigarette use, and cannabis use).

Some studies suggest that ADHD is associated with substance use through its comorbidity with CD symptoms (Fergusson et al., 2007); the high interrelation between ADHD symptoms and CD symptoms raises issues about the ways in which these domains of behaviour combine to influence developmental outcomes (Fergusson et al., 2007). For example, Flory et al. (2003) found that ADHD symptoms were no longer significantly related to daily cannabis use after accounting for CD symptoms. Other studies have indicated that ADHD is associated independently with substance abuse, in the adjusted model even after controlling for internalizing problems and externalizing problems, and this was evident through the modelling of covariates (Elkins, McGue, & Iacono, 2007; Galéra et al., 2008; Kollins et al., 2005;
upadhyaya & carpenter, 2008). for example, upadhyaya and carpenter (2008) found that
adhd symptoms were linked to greater substance use even after controlling for cd symptoms.
sihvola et al. (2011) found that even after controlling for cd symptoms, adhd symptoms
predicted frequent alcohol use. kollins et al. (2005) found that the addition of cd symptoms
resulted in decreased ors for adhd symptoms, though both adhd symptoms and cd
symptoms remained significant in the relationship with regular tobacco cigarette use. likewise,
galéra et al. (2008) found that adhd symptoms appeared to be a predictor of regular cannabis
use in males even after adjusting for cd symptoms. lastly, galéra et al. (2013) found that after
controlling for both cd symptoms and anxious-depressed symptoms, adhd symptoms
remained significantly related to both regular tobacco cigarette smoking (or = 1.34, 95% ci
[1.13-1.58], p < .05) and lifetime cocaine use (or = 1.47, 95% ci [1.10-1.97], p < .05).

lee et al. (2011) concluded that internalizing problems and externalizing problems complicate
inferences about the specificity of adhd effects on substance use outcomes. lee et al. (2011)
strongly contended that these relationships be addressed by controlling for possible covariates.
given the substantial correlation between adhd symptoms and social, emotional, and
behavioural problems such as cd symptoms (barkley, 2006) and anxious or depressed
symptoms (r = 0.36, p < .05) (galéra et al., 2013), as well as the robust relations between
externalizing problems (flory et al., 2003) and internalizing problem with substance use
(dawson et al., 2011; galéra et al., 2013), any conclusions regarding adhd and substance use
suggested from studies that do not control for social, emotional, and behavioural problems
should be interpreted cautiously. failure to analyze an adjusted model to control for internalizing
and externalizing problems can lead to erroneous conclusions about the relationship between
adhd and substance use. therefore, it is important to address the possibility of covariates
within the relationship of adhd and substance use in youth.

2.8 study objectives
the overall goal of the current study was to better understand the relationship between adhd
symptoms and substance use by assessing the relationship between these two variables in a
population-based sample of ontario students (grades 9-12). the specific objectives of this thesis
were:
1. to estimate the prevalence of ADHD symptoms in a representative sample of students in Ontario schools, including the prevalence for both males and females separately;

2. to assess the relationship between ADHD symptoms and substance use (alcohol, tobacco cigarettes, cannabis, and stimulants\(^1\)), running two separate models for males and females:

   a. Model 1: unadjusted model - to estimate effect of ADHD symptoms on the risk of substance use. This model aims to provide a baseline understanding of the relationship between ADHD symptoms and substance use without adjusting for any covariates.

   b. Model 2: adjusted model - to examine the effect of ADHD symptoms on the risk of substance use accounting for SES, internalizing problem, and externalizing problem. This model aims to assess if (and how) the relationship between ADHD symptoms and substance use changes after adjusting for covariates.

2.8.1 Hypotheses

It is hypothesized that the estimates of prevalence of ADHD symptoms from this study will be higher than all the prevalence estimates of ADHD that are based on actual diagnoses from a clinician; these estimates in Canada range from 1.5% (Brownell & Yogendran, 2001) to 5.4% (Hauck et al., 2017).

In the literature, the lower prevalence estimates came from studies that used administrative medical records (Brault & Lacourse, 2012; Brownell & Yogendran, 2001; Vasiliadis et al., 2017) and the higher prevalence estimates came from studies using a symptom checklist (Green et al., 2019; Madruga et al., 2012; Polanczyk et al., 2010; Sonnby et al., 2011; Szatmari et al., 1989). It is possible that studies that used a symptom checklist to measure ADHD produced larger prevalence statistics compared to studies that used administrative medical records because symptom checklists are more inclusive (could be capturing broader spectrum of psychological symptoms), whereas diagnoses based on DSM criteria by physicians or psychologists are more exclusive (as these ADHD symptoms should not be better explained by another mental disorder

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\(^1\)In this study, the term “stimulants” refers to cocaine, crack-cocaine, ecstasy, and methamphetamine use, unless stated otherwise.
such as a mood disorder). Furthermore, clinicians, such as physicians, and psychologists try to eliminate other disorders that could account for the symptoms and assess functional impairment in two or more domains that are not typically captured in survey symptom checklists. Finally, studies of ADHD based on clinician diagnoses suffer from referral bias.

In terms of the second objective, it is difficult to hypothesize potential outcomes since the literature has produced conflicting evidence on the relationship between ADHD and substance use (with alcohol, tobacco cigarettes, cannabis, and stimulants), especially when accounting for covariates. When covariates are accounted for in the model, it is hypothesized that ADHD will be related to some substances but not others, similar to the results that Flory et al. (2003) found when controlling for covariates. Based on the literature, it is hypothesized that the relationship between ADHD symptoms and substance use will present differently for the two sexes (Elkins et al., 2018; Galéra et al., 2005; Galéra et al., 2008; Sihvola et al., 2001) and based on the papers reviewed, it is hypothesized that ADHD symptoms will be statistically significantly related to substance use in females, but not in males.

This study offers a unique contribution to the literature by providing recent Canadian prevalence estimates of self-reported ADHD symptoms by sex from a population-based school study in Ontario and by examining the relationship between self-reported ADHD symptoms and substance use of both popular substances and stimulants by sex, as most research has been conducted on the most popular substances (alcohol, tobacco cigarettes, and cannabis). Lastly, SES and social, emotional, and behavioural problems are thought to be related to both ADHD and substance use. Thus, it is important to control for sociodemographic factors including SES, as well as for possible co-occurring problems such as internalizing and externalizing problems so that it is evident if ADHD symptoms are in fact related to substance use or if the relationship we see is confounded by covariates. Therefore, this study provides a unique contribution to the literature by controlling for factors associated with both ADHD and substance use.
Chapter 3

3 Methods

3.1 Study Design

This study was a secondary data analysis conducted using cross-sectional data from the Centre for Addiction and Mental Health (CAMH). The data included two cycles/waves of the Ontario Student Drug Use and Health Survey (OSDUHS): the 2015 and 2017 OSDUHS public datasets. The OSDUHS is a large ongoing population-based survey of Ontario adolescents.

3.2 Data Source

All measures were derived from the OSDUHS. The OSDUHS is a biennial survey that first started in 1977. The survey focuses on reporting substance use, and physical and mental health outcomes of students in Ontario. For the 2015 dataset, questionnaires were collected from November 2014 to June 2015 (Boak, Hamilton, Adlaf, Henderson, & Mann, 2016). For the 2017 dataset, questionnaires were collected from November 2016 to June 2017 (Boak, Hamilton, Adlaf, Henderson, & Mann, 2018). The data were self-reported, derived from anonymous questionnaires administered in classrooms via a paper-and-pencil instrument, to students who consented and whose parents provided active parental consent. There were four split ballot versions of the questionnaire (Form A-ES, Form B-ES, Form A-SS, Form B-SS), which each averaged 30 minutes to complete and were administered by trained staff from the Institute for Social Research (York University, Ontario). Form A and Form B were randomly distributed to students such that one-half of students completed Form A and the other half completed Form B. Forms ending in “ES” were for those in grade 7 and 8 to complete, while forms ending in “SS” were for those in grade 9 to 12 to complete.

Survey respondents were selected by a stratified (region by school level), two-stage cluster sampling design. Region refers to the way that Ontario was divided; there are four base regions and seven regions deemed fit to oversample by Ontario Public Health. So, in total there are 11 mutually exclusive regions in Ontario and seven of these regions were oversampled. Schools within each of these regions were selected by probability-proportionate-to-school size while
classes were selected with equal probability. Both stages employed sampling without replacement. This disproportionally stratified method involved the oversampling of those in northern Ontario in order to provide a more precise estimate for that less populous region. This design ensured that the regional comparison tests have sufficient statistical power and that numbers generated from this study (including prevalence statistics and relative risk ratios) were representative through complex weighting of the sample and using census data (Boak et al., 2016). For the 2015 questionnaire, 63% of selected schools, 88% of selected classes, and 59% of students in participating classes participated in the survey. The 2015 total sample of 10,426 students is representative of the 961,500 grade 7 to 12 students enrolled in Ontario’s publicly funded public and Catholic schools. For the 2017 questionnaire, sixty-one percent (61%) of randomly selected schools, 94% of selected classes, and 61% of eligible students in those classes completed the survey. The 2017 total sample of 11,435 students represents just under one million students in grades 7 to 12 enrolled in Ontario’s publicly funded schools (Boak et al., 2016).

The population of the current study was students enrolled in Ontario’s four publicly funded school systems (English language public, English language Catholic, French language public, and French language Catholic). Students were not included if they were enrolled in private schools, were home-schooled, were on military bases, lived in First Nations communities, were institutionalized for correctional or health reasons, or lived in remote northern regions of Ontario (Boak et al., 2016). Those excluded from the survey’s target population represented a small proportion of roughly 8% of the Ontario student population; therefore, the vast majority of Ontario children and adolescents were captured in the survey (Boak et al., 2016).

### 3.3 Study Sample

Based on the adopted inclusion criteria, the current study included all respondents who provided valid responses to Form A-SS (grade 9-12) from the 2015 and 2017 cycle of the CAMH OSDUHS (only secondary students (grades 9 through 12) were asked questions regarding cocaine, crack-cocaine, ecstasy, and methamphetamine use). Also, the A-SS Form was the only form that included all questions relevant to this study, such as the Adult ADHD Self-Report Scale Version 1.1 (ASRS-v1.1 Screener), the Kessler 6-Item Psychological Distress Scale (K6 Screener), the Antisocial Behaviour Index, and stimulant use questions. Data from the 2015 and 2017 datasets were pooled to increase the sample sizes, as use of stimulants were rare. A total of
7,724 adolescent Ontarians filled out Form A-SS from the 2015 and 2017 cycle; however, 801 participants were removed due to missing data pertaining to the variables of interest for this current study, resulting in a final sample size of 6,923 (see figure 1).

**Fig. 1: Flowchart of Sample Selection**

3.4 Measures

The OSDUHS questionnaire utilizes some standard measures and methods that have gone through rigorous testing to ensure the demonstration of validity and reliability (Boak et al., 2016). Additionally, for studies that include sensitive and taboo topics such as substance use, data collected through anonymous, self-reported, school-based surveys demonstrate higher credibility than other data collecting methods (such as surveys completed at home), since perceived anonymity in the absence of parental company may lead these adolescents to be more honest with their responses (Brener et al., 2006). Lastly, the readability of the 2015 questionnaire indicated a grade 7 reading level according to the Flesch-Kincaid reading score (Boak et al., 2016). Table 1 displays all variables of interest in the present study. In the text below variables were referred to by their variable name (*in brackets*) in the 2017 dataset (however, bridged variable names were created for 2015 and 2017 datasets for the analysis).
<table>
<thead>
<tr>
<th>Variable and Type</th>
<th>Measurement</th>
<th>Missing Data (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Exposure Variable</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ADHD Symptoms (<em>J3a-J3f</em>)&lt;br&gt;Dichotomous</td>
<td>Scores of 14 or higher on the ASRS-v1.1 Screener&lt;br&gt;1 = Yes&lt;br&gt;0 = No</td>
<td>193 (2.50%)</td>
</tr>
<tr>
<td><strong>Outcome Variables</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alcohol Use (<em>b3</em>)&lt;br&gt;Trichotomous</td>
<td>1 = “No use”&lt;br&gt;2 = “Occasional use”&lt;br&gt;3 = “Regular use”</td>
<td>15 (0.19%)</td>
</tr>
<tr>
<td>Tobacco Cigarette Use (<em>b1</em>)&lt;br&gt;Trichotomous</td>
<td>1 = “No use”&lt;br&gt;2 = “Occasional use”&lt;br&gt;3 = “Regular use”</td>
<td>13 (0.17%)</td>
</tr>
<tr>
<td>Cannabis Use (<em>b4</em>)&lt;br&gt;Trichotomous</td>
<td>1 = “No use”&lt;br&gt;2 = “Occasional use”&lt;br&gt;3 = “Regular use”</td>
<td>48 (0.62%)</td>
</tr>
<tr>
<td>Stimulant Use (aggregation of <em>b10-s, b11-s, b12-s, and b13-s</em>)&lt;br&gt;Trichotomous</td>
<td>1 = “No use”&lt;br&gt;2 = “Occasional use”&lt;br&gt;3 = “Regular use”</td>
<td>37 (0.48%)</td>
</tr>
<tr>
<td><strong>Covariates</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sex (<em>a2</em>)&lt;br&gt;Dichotomous</td>
<td>1 = Male&lt;br&gt;0 = Female</td>
<td>No Missing Values</td>
</tr>
<tr>
<td>SES (<em>a20</em>)&lt;br&gt;Trichotomous Nominal</td>
<td>1 = low&lt;br&gt;2 = middle&lt;br&gt;3 = high</td>
<td>121 (1.57%)</td>
</tr>
<tr>
<td>Internalizing Problem (<em>j2a-j2f</em>)&lt;br&gt;Dichotomous</td>
<td>Scores of 13 or higher on K6 Screener&lt;br&gt;1 = Yes&lt;br&gt;0 = No</td>
<td>181 (2.34%)</td>
</tr>
<tr>
<td>Externalizing Problem (<em>m1a-m1j</em>)&lt;br&gt;Dichotomous</td>
<td>Three or more behaviours on the Antisocial Behaviour Index&lt;br&gt;1 = Yes&lt;br&gt;0 = No</td>
<td>334 (4.32%)</td>
</tr>
</tbody>
</table>
3.4.1 ADHD Symptom Measure

ADHD symptoms were measured using the validated WHO’s ASRS-v1.1 Screener. The ASRS-v1.1 Screener (refer to Appendix 1) is a six-item checklist (J3a-J3f) used to assess ADHD symptoms based on DSM-IV criteria for ADHD. The first four questions pertain to inattention, whereas the last two questions pertain to hyperactivity-impulsivity. Each item is scored on a 5-point frequency Likert-type scale (0= never; 4= very often). Assessment of the six screener items indicated good internal consistency (α=0.79); however, a high internal consistency was unlikely, as a stepwise logistic regression analysis was used to select all six screener questions. This method optimized inconsistency among items so that there was no overlap or repetition in a single screener. Kessler et al. (2007) also assessed test-retest reliability by administering the ASRS-v1.1 Screener at baseline, six months to one year after baseline, and again one to three months after the second screening. The ASRS-v1.1 Screener had a test-rest reliability ranging from .58-.77 (Kessler et al., 2007). The 0-24 scoring approach demonstrated high concurrent validity, as the ASRS-v1.1 Screener had a strong concordance with clinical diagnosis, achieving an area under the receiver operating characteristic curve (AUC) of 0.90 (Kessler et al., 2007). Furthermore, Kessler et al. (2007) indicated that this screener had a sensitivity of 0.65, specificity of 0.94, a positive predictive value (PPV) of .50, and a negative predictive value (NPV) of .97. The screener had a total classification accuracy of 0.92 (SE = 0.38) (Kessler et al., 2007).

The ASRS-v1.1 Screener was first developed for population health surveys involving adults (Kessler et al., 2007); however, the screener has also been used in research with adolescents (Green et al., 2019; Madruga et al., 2012; Polanczyk et al., 2010; Sonnby et al., 2011). Though the screener has been used with adolescents, the questions involved in this screener were more applicable to adults than adolescents. Lastly, it is important to remember that this instrument is a screener and should not be considered as a clinical diagnosis (Boak et al., 2018).

Two validation studies were conducted on the ASRS-v1.1 Screener in adolescents (Adler et al., 2012; Green et al., 2019). Adler et al. (2012) conducted a preliminary examination of reliability and concurrent validity of the ASRS-v1.1 Screener in adolescents with ADHD, whereas, Green et al. (2019) examined reliability and validity of the ASRS-v1.1 Screener among community samples of adolescents. Internal consistency for the total sample and in subsamples stratified by
sex and grade level using Cronbach’s alpha were assessed to gauge reliability. To determine convergent and divergent validity, correlation coefficients were compared to the screener sum score to each subscale of the Strengths and Difficulties Questionnaire (SDQ). The SDQ is a 25-item measure of student social-emotional strengths and challenges producing five subscales: hyperactivity/inattention, emotional problems (i.e., anxiety and depression), conduct problems, peer problems, and prosocial behaviours. Prior studies documented reliability of the SDQ and validity in comparison with structured diagnostic interviews (Goodman, 2001). The ASRS-v1.1 Screener demonstrated good internal consistency in the total sample (α=0.80). Reliability was also good in subsamples stratified by gender and grade. The model also fit the data well for both males and females separately and for both middle and high school students separately. The ASRS-v1.1 Screener scores were more strongly associated with the SDQ subscales measuring hyperactivity/inattention (r = 0.58) than all other subscales, which measured emotional problems (r = 0.41, p < .001), conduct problems (r = 0.35, p < .001), etc.

There are several proposed approaches to score the ASRS-v1.1 Screener. Kessler recommended utilizing the four-stratum classification approach based on psychometric analyses (Kessler et al., 2007), as opposed to the 0-6 scoring approach which was found to be less discriminative. For the purpose of this study, a summated score (with a range of 0 to 24) was computed for those who answered all six items. Reported ADHD symptoms were measured as a binary variable based on the cut off score of 13 (0-13=0; 14-24=1) (Kessler et al., 2007).

### 3.4.2 Substance Use Measures

The key outcome variables used to assess the second objective were based on questions related to self-reported frequency of substance use. The standard frequency of use question was used to measure all substances of interest. The substance use questions of interest on the OSDUHS were taken from the National Survey on Drug Use and Health (NSDUH). The NSDUH was one of the primary sources of data for population-based prevalence estimates of mental health and substance use indicators in the United States (Hedden et al., 2012). The reliability statistics among persons aged 12 or older can be found in the 2006 NSDUH Reliability Study (tables on page 58-64) (Substance Abuse and Mental Health Services Administration, 2010). Diagnostic and validation studies have been conducted on substance use measures from the NSDUH (Centre for Behavioral Health Statistics and Quality, 2014). The kappa values for the standard frequency
of substance use questions were for how often one used substances in the “past year”. These “past year” substance use variables showed good reliability and all kappa’s were greater than .60, which indicates substantial agreement among raters (Substance Abuse and Mental Health Services Administration, 2010).

Based on the results of the preliminary analysis, it was noted that not every substance could be examined on its own due to small cell sizes. For instance, the examination of heroine use could not be done, as preliminary data suggested that only 24 (0.35%) of the 6,923 participants in this sample used heroin. Furthermore, few of those participants who reported using heroin reported symptoms of ADHD. Thus, all stimulants with large enough cell sizes (cells with at least 10 cases) were aggregated into one class: stimulants (cocaine, crack-cocaine, ecstasy, and methamphetamine). It was important that these measures reflected the distinct pharma-behavioural features of this class of substance, by labelling and including only stimulants in the “stimulant” category. In addition, popular substances were examined individually (alcohol, tobacco cigarettes, cannabis) as there were sufficient data to carry out these analyses.

3.4.2.1 Popular Substances

3.4.2.1.1 Alcohol Use

Alcohol use (variable b3) was measured with the following question: “In the last 12 months, how often did you drink alcohol-liquor (rum, whiskey, etc.), wine, beer, coolers?”. Frequency of alcohol use was measured on a 10-point scale: “had a sip of alcohol to see what it’s like” (coded 1), “drank only at special events (for example, holidays or at weddings)” (coded 2), “once a month or less often” (coded 3), “2 or 3 times a month” (coded 4), “once a week” (coded 5), “2 or 3 times a week” (coded 6), “4 or 5 times a week” (coded 7), “almost every day- 6 or 7 times a week” (coded 8), “drank, but not in the last 12 months” (coded 9), and “never drank alcohol in lifetime” (coded 10). The standard question for alcohol use was taken from the NSDUH. The inter-rater reliability statistic (kappa) for past year use of alcohol was .85 (SE = .02) (Substance Abuse and Mental Health Services Administration, 2010).

For the purpose of this study, alcohol use was recoded into three categories: (1) “no use” (aggregating “had a sip of alcohol to see what it’s like”, “drank, but not in the last 12 months” and “never drank alcohol in lifetime”); (2) “occasional use” (aggregating “drank only at special
events (for example, holidays or at weddings)” and “once a month or less often”); and (3) “regular use” (aggregating “2 or 3 times a month”, “once a week”, “2 or 3 times a week”, “4 or 5 times a week”, and “almost every day - 6 or 7 times a week”) (Hamilton et al., 2014).

### 3.4.2.1.2 Tobacco Cigarette Use

Tobacco cigarette use (variable $b1$) was measured with the following question: “In the last 12 months, how often did you smoke tobacco cigarettes?”. Frequency of tobacco cigarette use was measured on a 11-point scale, including: “smoked a few puffs to a whole cigarette in the last 12 months” (coded 1), “smoked more than one cigarette, but not every day” (coded 2), “1 or 2 cigarettes a day” (coded 3), “3 to 5 cigarettes a day” (coded 4), “6 to 10 cigarettes a day” (coded 5), “11 to 15 cigarettes a day” (coded 6), “16 to 20 cigarettes a day” (coded 7), “21 to 29 cigarettes a day” (coded 8), “30 or more cigarettes a day” (coded 9), “smoked, but not in the last 12 months” (coded 10), and “never smoked cigarettes in lifetime” (coded 11). The standard question for frequency of tobacco cigarette use was from the NSDUH. The inter-rater reliability statistic (kappa) for past year use of cigarettes was .90 ($SE = .02$) (Substance Abuse and Mental Health Services Administration, 2010).

To be consistent with the measure of alcohol use, tobacco cigarette use was recoded into three categories: (1) “no use” (aggregating “smoked a few puffs to a whole cigarette in the last 12 months”, “smoked, but not in the last 12 months”, and “never smoked cigarettes in lifetime”); (2) “occasional use” (“smoked more than one cigarette, but not every day”); and (3) “regular use” (aggregating “1 or 2 cigarettes a day”, “3 to 5 cigarettes a day”, “6 to 10 cigarettes a day”, “11 to 15 cigarettes a day”, “16 to 20 cigarettes a day”, “21 to 29 cigarettes a day”, and “30 or more cigarettes a day”).

### 3.4.2.1.3 Cannabis Use

Cannabis use (variable $b4$) was measured with the following question: “In the last 12 months, how often did you use cannabis (also known as marijuana, “weed”, “pot”, “grass”, hashish, “hash”, hash oil, etc.)?”. Frequency of cannabis use was measured on a 9-point scale: “1 or 2 times” (coded 1), “3 to 5 times” (coded 2), “6 to 9 times” (coded 3), “10 to 19 times” (coded 4), “20 to 39 times” (coded 5), “40 or more times” (coded 6), “used, but not in the last 12 months” (coded 7), “never used in lifetime” (coded 8), and “don’t know what cannabis is” (coded 9). The
standard question for frequency of cannabis use was from the NSDUH. The inter-rater reliability statistic (kappa’s) for past year use of cannabis was \( .75 (SE = .04) \) (Substance Abuse and Mental Health Services Administration, 2010).

Cannabis use was recoded into three categories: (1) “no use” (aggregating “used, but not in the last 12 months”, “never used in lifetime”, and “don’t know what cannabis is”); (2) “occasional use” (“1 or 2 times”); and (3) “regular use” (aggregating “3 to 5 times”, “6 to 9 times”, “10 to 19 times”, “20 to 39 times”, and “40 or more times”).

3.4.2.2 Stimulants

Stimulants speed up activity in the body by improving alertness and energy, although when abused, stimulants cause a “high” feeling (The Department of Health, 2004). Hence, stimulants may have positive cognitive effects on persons with ADHD. Stimulants include cocaine, crack-cocaine, ecstasy, and methamphetamine. Crack-cocaine is a highly addictive and powerful stimulant derived from powdered cocaine and is inexpensive, and thus accessible; ingesting crack-cocaine will cause an intense euphoric effect. Ecstasy (also known as MDMA) is primarily considered a stimulant, although it is a substance with both stimulant and hallucinogenic properties; symptoms include mild hallucinogenic effects, increased tactile sensitivity, dehydration, and impaired memory. Methamphetamine (also known as speed, crystal meth, or ice) is a stimulant that produces powerful “highs” similar to cocaine, but it can last much longer.

A limited amount of research regarding the different ways to categorize stimulant use exists. For the sake of consistency, stimulant use was recoded into three categories: (1) “no use” (aggregating “used, but not in the last 12 months”, “never used in lifetime” and “don’t know what these drugs are”); (2) “occasional use” which consists of 1 or 2 times in the last 12 months; and (3) “regular use” (aggregating “3 to 5 times”, “6 to 9 times”, “10 to 19 times”, “20 to 39 times”, and “40 or more times”). The empirical distribution was examined after selecting a theoretical distribution that were trichotomized into no uses, occasional use, and regular use. Although most participants fall into the (1) “no use” category, the distribution between (2) “occasional use” and (3) “regular use” were comparably similar.
New variables were generated by aggregating the stimulants by class, as the OSDUHS does not identify stimulant use by class. There are primarily two issues with previous research on stimulants. Most prior research grouped all types of illicit substances under one general umbrella term, thereby including stimulants, depressants, etc. in the same category. Next, most prior research used binary measures, most likely due to small cell sizes. Fischer et al. (2013), for example, aggregated eight substances (mushrooms, LSD, cocaine, crack, methamphetamine, ecstasy, prescription stimulant drugs used non-medically, and prescription tranquilizers/sedatives used non-medically) under one general substance term, even though these substances included a mix of stimulants, hallucinogens, and depressants; this was re-coded as: use of any one of the eight substances at least once during the past 12 months (1), no use (0). Similarly, other papers conceptualized substance use as: “use of at least one of the 24 substances in the past 12 months” (1) and “no use” (0), and this included “illicit substances” across the three substance classes (stimulants, hallucinogens, and depressants) as well as non-medical prescription substance use (Isaranuwatchai et al., 2014). One paper, however, examined stimulant and tranquilizer medication as two separate classes (Pulver, Davison, & Pickett, 2014). Those who reported past-year recreational use of one or more medications, 3 or more times were further categorized as “regular use”, while those reporting using 1-2 times were categorized as “occasional use”. This method of categorization has been previously used in OSDUHS and this is the same method that was employed in this current study.

Since whether a greater percentage of those with reported ADHD symptoms use stimulants regularly or occasionally, compared to those with no reported ADHD symptoms is of interest for this current study, binary measures (no use [0] vs. used at least once [1]) would be an insufficient method, as the saliency of use would not be captured. Data on aggregating stimulant use variables according to substance class is sparse and justification for categorization of response variables is even more sparse. To be consistent with Pulver et al. (2014) and with the measure of alcohol use, tobacco cigarette use, and cannabis use in this current study, stimulant use was measured by frequency.

The following four stimulants (cocaine, crack-cocaine, ecstasy, and methamphetamine) were aggregated under the substance class “stimulants”. It was assumed that all stimulants in this class were equal, so the weight on all stimulants within “stimulant use” was equal. Each participant’s
response was aggregated across the four stimulants to create a new dependent variable. The highest-level ranking score was assigned for each participant. For example, if a participant recorded occasional use of cocaine, crack-cocaine, and methamphetamine, but recorded regular use of ecstasy, this participant was assigned with an overall regular use of stimulants. Preliminary analyses to examine the distribution of stimulants across all three categories by sex were run; cell sizes were above the recommended cell size of 30 and the absolute minimum case of 10 per independent variable.

3.4.2.2.1 Cocaine Use

Cocaine use (variable \textit{b10-s}) was measured with the following question: “In the last 12 months, how often did you use cocaine (also known as “coke”, “blow”, “snow”, “powder”, “snort”, etc.)?”. All stimulants were measured on the same 9-point scale: “1 or 2 times” (coded 1), “3 to 5 times” (coded 2), “6 to 9 times” (coded 3), “10 to 19 times” (coded 4), “20 to 39 times” (coded 5), “40 or more times” (coded 6), “used, but not in the last 12 months” (coded 7), “never used in lifetime” (coded 8), and “don’t know what drug is” (coded 9). The standard question for the frequency of cocaine use was taken from the NSDUH. The inter-rater reliability statistic (kappa) for past year use of cocaine was .78 ($SE = .06$) (Substance Abuse and Mental Health Services Administration, 2010).

3.4.2.2.2 Crack-cocaine Use

Crack-cocaine use (variable \textit{b11-s}) was measured with the following question: “In the last 12 months, how often did you use cocaine in the form of “crack”?” There are a total of 9 response options, including: “1 or 2 times” (coded 1), “3 to 5 times” (coded 2), “6 to 9 times” (coded 3), “10 to 19 times” (coded 4), “20 to 39 times” (coded 5), “40 or more times” (coded 6), “used, but not in the last 12 months” (coded 7), “never used in lifetime” (coded 8), and “don’t know what “crack” is” (coded 9). The standard question for frequency of crack-cocaine use was from the NSDUH. The inter-rater reliability statistic (kappa) for past year use of stimulants was .72 ($SE = .09$) (Substance Abuse and Mental Health Services Administration, 2010). The inter-rater reliability statistic for past year use of crack-cocaine use was not available.
3.4.2.2.3 Ecstasy Use

Ecstasy (b12-s) use was measured with the following question: “In the last 12 months, how often did you use MDMA or “Ecstasy” (also known as “molly”, “E”, “X”)?”. There were a total of 9 response options, including: “1 or 2 times” (coded 1), “3 to 5 times” (coded 2), “6 to 9 times” (coded 3), “10 to 19 times” (coded 4), “20 to 39 times” (coded 5), “40 or more times” (coded 6), “used, but not in the last 12 months” (coded 7), “never used in lifetime” (coded 8), and “don’t know what “ecstasy” is” (coded 9). The standard question for frequency of ecstasy use was from the NSDUH. The inter-rater reliability statistic (kappa) for past year use of stimulants was .72 (SE = .09) (Substance Abuse and Mental Health Services Administration, 2010). The inter-rater reliability statistic for past year use of ecstasy use was not available.

3.4.2.2.4 Methamphetamine Use

Methamphetamine use (variable b13-s) was measured with the following question: “In the last 12 months, how often did you use methamphetamine or crystal methamphetamine (also known as “speed”, “crystal meth”, “crank”, “ice”, etc.”)?”. There were a total of 9 response options, including: “1 or 2 times” (coded 1), “3 to 5 times” (coded 2), “6 to 9 times” (coded 3), “10 to 19 times” (coded 4), “20 to 39 times” (coded 5), “40 or more times” (coded 6), “used, but not in the last 12 months” (coded 7), “never used in lifetime” (coded 8), and “don’t know what these drugs are” (coded 9). The standard question for frequency of methamphetamine use was from the NSDUH. The inter-rater reliability statistic (kappa) for past year use of stimulants was .72 (SE = .09) (Substance Abuse and Mental Health Services Administration, 2010). The inter-rater reliability statistic for past year use of methamphetamine use was not available.

3.4.3 Sex

Sex at birth (variable a2) was measured with the following question: “Were you born male or female?”. There were 2 response options, including: “male” (coded 1) and “female” (coded 0).

3.4.4 Socio-economic Status Measure

For the purpose of this study, subjective SES was measured by the MacArthur Scale of Subjective Social Status (SSS) (Goodman et al., 2001; Goodman, Huang, Schafer-Kalkhoff, & Adler, 2007; McLaughlin, Costello, Leblanc, Sampson, & Kessler, 2012). The questionnaire
showed a 10-rung ladder to symbolize the social hierarchy of Canadian society. Students were asked to choose which rung most represented their family’s place in society with respect to money, education, and occupation. The higher the rung, the higher the perceived family SES—more money, higher education, and highly respected occupations. Rungs 1-5 represented low family SSS (Boak et al., 2018). Rungs 6-8 represented average SES. Rungs 9-10 represented high SES. SES was measured as a categorical variable using the same three categories (low SES: rungs 1-5; middle SES: rungs 6-8; and high SES: rungs 9-10) used in analysis in the CAMH 2017 mental health report (Boak et al., 2018).

3.4.5 Internalizing Problem Measure

The Kessler 6-Item Psychological Distress Scale (K6 Screener) (refer to Appendix 2) is a self-report screening instrument that contains questions pertaining to recent symptoms of anxiety, such as feeling nervous, hopeless, restless or fidgety and recent symptoms of depression, such as feeling depressed (sad) that nothing could cheer you up, that everything was an effort, and feeling worthless. Each of the six items in the K6 Screener began with the wording “In the last 4 weeks, about how often did you…” This screening instrument (j2a-j2f) was designed to detect non-specific psychological distress (symptoms of anxiety and depression) (Kessler et al., 2003), which provided a measure of internalizing problem. The K6 Screener was originally developed and calibrated for population health surveys of adults; however, it has also been used in research with adolescents (Chan & Fung, 2014; Green, Gruber, Sampson, Zaslavsky, & Kessler, 2010; Peiper, Clayton, Wilson, & Illback, 2015). Assessment of the six scale items indicated excellent internal consistency (α=0.88) (Kessler et al., 2002).

The K6 Screener has been compared to the K10, the WHO Disability Assessment Schedule, and the composite international diagnostic interview short-form scale (Kessler et al., 2003). Of these scales, the K6 Screener was the most efficient screening scale, with a sensitivity of 0.36 (0.08) and a specificity of 0.96 (0.02) in predicting serious distress and total classification accuracy of 0.92 (0.02); this pertains to the cut-off point of 13 or higher (Kessler et al., 2003). Studies have examined the psychometric properties of the K6 Screener in large general population samples of adolescents (N= 4,434; mean age =13.5 years; 44.6% male) (Mewton et al., 2016). Here, the K6 Screener demonstrated high levels of internal consistency, with the 6 items loading primarily on 1 factor. In summary, the K6 Screener is brief, easy to administer, and has shown excellent
accuracy and specificity in samples from the general population (Swartz & Lurigio, 2006). Validation studies have shown that the screener’s validity (ROC-AUC) was about .86, which is quite high as compared to longer diagnostic screening and assessment instruments (Andrews & Slade, 2001; Furukawa, Kessler, Slade, & Andrews, 2003; Kessler et al., 2003).

Each item was scored on a 5-point frequency Likert-type scale (0= none of the time; 4= all of the time). Then, a summed score (with a range of 0 to 24) was computed for those who answered all six items. Higher scores indicated higher levels of psychological distress. The use of severity scoring allowed greater specificity as compared to yes/no dichotomized response options. Kessler and colleagues (2002) suggestion for K6 Screener cut-off score of 13 or higher was adopted for this study to estimate the percentage experiencing severe psychological distress (0-12=0; 13-24=1), meaning those who scored 13 or higher were considered as having “internalizing problem” and those who scored below 13 were considered as not having internalizing problem.

3.4.6 Externalizing Problem Measure

The measure of externalizing problem (refer to appendix 3) was obtained from the MTF study (Monitoring the Future, n.d.). This included 10 questions (m1a-m1j) on recent delinquent activity such as “damage something on purpose that wasn’t yours” and “beat up/hurt anyone (not counting sibling).” These 10 questions involved both nonviolent behaviours and violent behaviours. This measure encompassed an open-ended format to indicate the number of occasions during the past 12-month period in which students engaged in these activities. Response options were re-coded into ordinal categories. Psychometrics for this measure do not exist and no tests regarding validity or reliability have been conducted thus far. This is a limitation, but a strength of the MTF is the development of a standardized scoring method (the antisocial behaviour index).

The antisocial behaviour index was created in 1991 (index excludes setting something on fire (m1j) which results in a total of nine behaviours instead of 10). Delinquent behaviour was defined as participating in three or more of the nine behaviours at least once during the past year (Boak et al., 2018). Isaranuwatchai et al. (2014) analyzed this measure as a binary variable: less than three behaviours are not indicative of delinquent behaviour (0), three or more behaviours
are indicative of delinquent behaviour (1). The externalizing problem variable was coded in the same manner as Isaranuwatchai et al. (2014). All nine behaviours were re-coded into binary variables: (0) not done it, (1) done it at least once. Then, all nine behaviours were aggregated into a new variable (called “externalizing problem”) and re-coded (1/2=0, 3-9=1), which means that three or more of the nine behaviours occurred for participants to be considered as having externalizing problem.

3.4.7 Supplementary Variables

In this section, variables that were described in this paper but were not part of the objectives were reported.

3.4.7.1 Age

Age (variable a1) was measured with the following question: “How old are you?”. There were 11 response options, including: “10 years of age or younger” (coded 10), “11 years” (coded 11), “12 years” (coded 12), “13 years” (coded 13), “14 years” (coded 14), “15 years” (coded 15), “16 years” (coded 16), “17 years” (coded 17), “18 years” (coded 18), “19 years” (coded 19), and “20 years or older” (coded 20).

3.4.7.2 Ethnoracial Background

Ethnoracial background (variable a8) was measured with the following question: “Which of the following best describes your background? (You may choose more than one category.) Are you…?”. There were 12 response options, including: “White (for example, British, French, Italian, Portuguese, Ukrainian, Russian, Israeli”, “Chinese”, “South Asian (for example, East Indian, Pakistani, Bangladeshi, Sri Lankan”, “Black (African, Caribbean, North American)”, “Aboriginal (First Nations, Inuit, Métis, non-status Indian)”, “Filipino”, “Latin American, Central American, South American (for example, Mexican, Brazilian, Chilean, Guatemalan, Venezuelan, Colombian, Argentinian, Salvadoran, Costa Rican)”, “Southeast Asian (for example, Vietnamese, Cambodian, Indonesian, Malaysian, Laotian)”, “West Asian or Arab (for example, Egyptian, Saudi Arabian, Syrian, Iranian, Iraqi, Lebanese, Afghan, Palestinian)”, “Korean”, “Japanese”, and “Not sure”. Each response option was dichotomized as yes (coded 1) or no (coded 0).
3.4.7.3 ADHD Medication

ADHD medication (variable \(c2a\)) was measured with the following question: “In the last 12 months, how often did you use medicine to treat ADHD (such as Ritalin, Concerta, Adderall, Dexedrine) with a prescription or because a doctor told you to take it?”. There were 7 response options, including: “once a day” (coded 1), “twice a day” (coded 2), “3 times a day” (coded 3), “4 or more times a day” (coded 4), “used with a prescription, but not in the last 12 months” (coded 5), “never used with a prescription in lifetime” (coded 6), and “don’t know what this medicine is” (coded 7). ADHD medication was later dichotomized as taken at least once a day in the last 12 months (coded 1) or not taken in the last 12 months (coded 2).

3.5 Statistical Analysis

Descriptive statistics were used to summarize the participants in the study. Specifically, frequencies and proportions for the key study variables, as well as the other descriptive variables (such as ethnoracial background and age) were reported. Sample size totals \((n)\) were not weighted in order to provide information on available data; whereas, column proportions with population estimates were derived from the weighted data in order to satisfy survey data design.

For the first objective, in order to estimate the overall prevalence of ADHD symptoms and the prevalence for both males and females separately, cross-tabulations were performed. To examine if prevalence significantly differed between males and females, a proportions test to see if two subsamples (males vs. females) had the same proportion of those with ADHD symptoms was run. For the second objective, in order to assess the relationship between ADHD symptoms and substance use (i.e., alcohol, tobacco cigarettes, cannabis and stimulants), multinomial logistic regression analyses were conducted. Though the categories created for the dependent variables were ordered (never, occasional, and regular), with higher values reflecting greater use, ordered logistic regression could not be used because of violations of the proportional odds assumption. Instead, the dependent variables were treated as nominal. Preliminary tests to examine if the proportional odds assumption would hold for an ordinal regression for alcohol use were run. From the model, the \(p\) value was \(0.0004\) for the likelihood-ratio test that the proportional odds assumption holds. Thus, the assumption was rejected as the proportionality of odds assumption was violated with a significant \(p\) value.
To address the second objective, two sets of models were run. First, the overall relationships between ADHD symptoms and substance use (alcohol, tobacco cigarettes, cannabis, and stimulants) in separate models for males and females were assessed. Then, the relationships between ADHD symptoms and substance use (alcohol, tobacco cigarettes, cannabis, and stimulants), adjusting for SES and social, emotional, and behavioural problems were assessed; as in all previous models, these relationships were estimated separately for males and females. Relative risk ratios with 95% confidence intervals ([CIs] assessed at the $p < .05$ level of significance), were generated from these multinomial regression analyses.

Data screening was carried out prior to all statistical analysis. Data screening for non-continuous variables included analyzing missing data and checking for duplicates. All estimates for both objectives utilized weighted data. Post-stratification weights were calculated for the sex-by-grade distributions within each regional stratum separately to restore each regions structure and ensure that each region is proportionate to the population structure. Furthermore, since the sampling design employs complex sampling methods and unequal probabilities for selection, all 95% CIs for relative risk ratios in the regression and descriptive statistics were corrected for characteristics of the sampling design, using and applying Taylor series methods, specifically used for analyzing survey data; design-based survey commands allowed for unbiased variances and point estimates. All data were analyzed using STATA, version 13.0.
Chapter 4

4 Results

4.1 Description of the Study Sample

A total of 6,923 (42.67% male unweighted; 50.28% male weighted) adolescent Ontarians met the eligibility criteria (filled out form A-SS and were in grade 9-12) and had no missing data for variables of interest for this study. All analyses for the two objectives were conducted on this sample. Ethnoracial background was only used to describe the sample (Table 2); however, ethnoracial background has a different sample size from all the other variables. All other variables (alcohol use, tobacco cigarette use, cannabis use, stimulant use, age, SES, internalizing problem, and externalizing problem) have the same sample size of 6,923. Table 2 provides both unweighted values (frequency (n)) and weighted values (percentage (%)).

More than half the students (54.97%) reported using alcohol (35.55% occasional level; 19.42% regular level). For males, 44.04% reported non-use of alcohol, 34.72% reported occasional use of alcohol, and 21.23% reported regular use of alcohol. For females, 46.02% reported non-use of alcohol, 36.39% reported occasional use of alcohol, and 17.59% reported regular use of alcohol.

Most respondents (89.72%) reported non-use of tobacco cigarettes. For males, 87.84% reported non-use of tobacco cigarettes, 8.01% reported occasional use of tobacco cigarettes, and 4.15% reported regular use of tobacco cigarettes. For females, 91.61% reported non-use of tobacco cigarettes, 6.01% reported occasional use of tobacco cigarettes, and 2.38% reported regular use of tobacco cigarettes.

Almost three-quarters of the students (73.92%) reported non-use of cannabis. For males, 72.34% reported non-use of cannabis, 6.99% reported occasional use of cannabis, and 20.66% reported regular use of cannabis. For females, 75.50% reported non-use of cannabis, 7.58% reported occasional use of cannabis, and 16.91% reported regular use of cannabis.

Most of the students (94.77%) reported non-use of stimulants. For males, 93.91% reported non-use of stimulants, 3.65% reported occasional use of stimulants, and 2.44% reported regular use
of stimulants. For females, 95.65% reported non-use of stimulants, 1.96% reported occasional use of stimulants, and 2.40% reported regular use of stimulants.

For the purpose of describing the demographics of this sample, age as well as ethnoracial background of the sample were recorded in Table 2. The mean age of participants was 15.66 (SD = 1.26, range 13-20 years), with most participants falling into ages 14-17 (92.54% of the sample). Mean age for males and females were similar (males = 15.70; females = 15.62). The majority of the respondents (63.88%) identified their family status (SES) in society as falling in the “middle”, 20.81% of the respondents identified family status in society as “low”, and 15.32% of the respondents identified family status in society as “high”. The majority of the respondents (64.42%) identified their ethnoracial background as “white”. For males, 9.27% reported internalizing problem and 7.81% reported externalizing problem. For females, 26.23% reported internalizing problem and 5.19% reported externalizing problem.
<table>
<thead>
<tr>
<th>Substance Use</th>
<th>Male (n = 2,954)</th>
<th>Female (n = 3,969)</th>
<th>Total (n = 6,923; wn = 669,303)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency (n)</td>
<td>Percentage (%)</td>
<td>Frequency (n)</td>
</tr>
<tr>
<td>Alcohol Use</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>“No use”</td>
<td>1,297</td>
<td>44.04</td>
<td>1,815</td>
</tr>
<tr>
<td>“Occasional use”</td>
<td>1,074</td>
<td>34.72</td>
<td>1,467</td>
</tr>
<tr>
<td>“Regular use”</td>
<td>583</td>
<td>21.23</td>
<td>687</td>
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<tr>
<td>Tobacco Cigarette Use</td>
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<td></td>
<td></td>
</tr>
<tr>
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<td>2,640</td>
<td>87.84</td>
<td>3,632</td>
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<tr>
<td>“Occasional use”</td>
<td>199</td>
<td>8.01</td>
<td>239</td>
</tr>
<tr>
<td>“Regular use”</td>
<td>115</td>
<td>4.15</td>
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</tr>
<tr>
<td>Cannabis Use</td>
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<td></td>
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<td>“No use”</td>
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<td>72.34</td>
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<td>205</td>
<td>6.99</td>
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<tr>
<td>“Regular use”</td>
<td>596</td>
<td>20.66</td>
<td>656</td>
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<td>Stimulant Use</td>
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<tr>
<td>“No use”</td>
<td>2,793</td>
<td>93.91</td>
<td>3,796</td>
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</tr>
<tr>
<td>“Occasional use”</td>
<td>83</td>
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<td>89</td>
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<tr>
<td>“Regular use”</td>
<td>78</td>
<td>2.44</td>
<td>84</td>
</tr>
<tr>
<td>Male (n = 2,954)</td>
<td>Female (n = 3,969)</td>
<td>Total (n = 6,923; wn = 669,303)</td>
<td></td>
</tr>
<tr>
<td>Demographic Variables</td>
<td>Frequency (n)</td>
<td>Percentage (%)</td>
<td>Frequency (n)</td>
</tr>
<tr>
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<tr>
<td>Age</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>13 years</td>
<td>15</td>
<td>0.37</td>
<td>18</td>
</tr>
<tr>
<td>14 years</td>
<td>581</td>
<td>14.69</td>
<td>874</td>
</tr>
<tr>
<td>15 years</td>
<td>733</td>
<td>20.98</td>
<td>1,021</td>
</tr>
<tr>
<td>16 years</td>
<td>706</td>
<td>22.61</td>
<td>932</td>
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<tr>
<td>17 years</td>
<td>680</td>
<td>28.11</td>
<td>869</td>
</tr>
<tr>
<td>18 years</td>
<td>218</td>
<td>12.13</td>
<td>241</td>
</tr>
<tr>
<td>19 years</td>
<td>19</td>
<td>0.90</td>
<td>12</td>
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<tr>
<td>20 years or older</td>
<td>Suppress</td>
<td>0.21</td>
<td>Suppress</td>
</tr>
<tr>
<td>SES</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Low</td>
<td>493</td>
<td>20.17</td>
<td>759</td>
</tr>
<tr>
<td>Ethnoracial Background</td>
<td>Frequency (n)</td>
<td>Percentage (%)</td>
<td>Frequency (n)</td>
</tr>
<tr>
<td>------------------------</td>
<td>--------------</td>
<td>----------------</td>
<td>--------------</td>
</tr>
<tr>
<td>White/Caucasian</td>
<td>2,055</td>
<td>65.51</td>
<td>2,718</td>
</tr>
<tr>
<td>Non-white/other</td>
<td>893</td>
<td>34.49</td>
<td>1,240</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Social, Emotional, and Behavioural Problems</th>
<th>Frequency (n)</th>
<th>Percentage (%)</th>
<th>Frequency (n)</th>
<th>Percentage (%)</th>
<th>Frequency (n)</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internalizing Problem</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>2,683</td>
<td>90.73</td>
<td>2,969</td>
<td>73.77</td>
<td>5,652</td>
<td>82.30</td>
</tr>
<tr>
<td>Yes</td>
<td>271</td>
<td>9.27</td>
<td>1,000</td>
<td>26.23</td>
<td>1,271</td>
<td>17.70</td>
</tr>
</tbody>
</table>

Male (n = 2,948)  Female (n = 3,958)  Total (n = 6,906; wn = 668,089)
4.2 Internal Consistency Reliability of Measures: Cronbach’s Alphas

The alpha coefficients for the ASRS-v1.1 Screener, the K6 Screener, and the Antisocial Behaviour Index are presented in Table 3 below. The level of acceptability of an alpha value is commonly debated, yet it remains common practice to consider alpha reaching the somewhat arbitrary value of 0.70 as a sufficient measure of internal consistency reliability of an instrument (Taber, 2018). Therefore, in accordance to common practice, the ASRS-v1.1 Screener, the K6 Screener, and the Antisocial Behaviour Index display internal consistency reliability.

Table 3: Cronbach’s Alphas and Inter-Item Correlations of the ASRS-v1.1 Screener, the K6 Screener, and the Antisocial Behaviour Index

<table>
<thead>
<tr>
<th>Measure</th>
<th>Alpha</th>
<th>Inter-item correlations</th>
<th>Number of Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASRS-v1.1 Screener</td>
<td>0.782</td>
<td>0.374</td>
<td>6</td>
</tr>
<tr>
<td>K6 Screener</td>
<td>0.887</td>
<td>0.568</td>
<td>6</td>
</tr>
<tr>
<td>Antisocial Behaviour Index</td>
<td>0.732</td>
<td>0.233</td>
<td>9</td>
</tr>
</tbody>
</table>

4.3 Results of Objective 1

Among Ontario adolescents, the prevalence of self-reported ADHD symptoms was 20.22%, 95% CI [18.52, 22.03], with 16.42%, 95% CI [14.66, 18.34] of males self-reporting ADHD symptoms and 24.06%, 95% CI [21.79, 26.49] of females self-reporting ADHD symptoms (Table 4). ADHD symptoms were found to differ significantly by sex (p < .0001), suggesting that females were significantly more likely than males to report ADHD symptoms.
Table 4: Prevalence Estimates for ADHD Symptom Screener Status by Sex

<table>
<thead>
<tr>
<th></th>
<th>Male (n = 2,954)</th>
<th>Female (n = 3,969)</th>
<th>Total (n = 6,923)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% (95% CI)</td>
<td>% (95% CI)</td>
<td>% (95% CI)</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>No ADHD (n = 5551)</td>
<td>83.58 (81.66, 85.34)</td>
<td>75.94 (73.51, 78.21)</td>
<td>79.78 (77.97, 81.48)</td>
<td></td>
</tr>
<tr>
<td>ADHD (n = 1372)</td>
<td>16.42 (14.66, 18.34)</td>
<td>24.06 (21.79, 26.49)</td>
<td>20.22 (18.52, 22.03)</td>
<td></td>
</tr>
</tbody>
</table>

Note. Percentages are weighted; data are shown as column %; n = subpopulation sample size (unweighted); Pearson chi-square (p value) adjusted for the survey design and transformed into an F statistic; p value results from cross-tabulations.

4.3.1 Post Hoc Analysis

For the ASRS-v1.1 Screener, four of the six questions capture symptoms of inattention. Post hoc analyses of the data revealed significant sex differences in response to all questions pertaining to inattention as well as one of the two questions pertaining to hyperactivity-impulsivity (“often fidget or squirm with hands or feet”). Two sample t-tests were run for all six symptoms by sex to examine if there were statistically significant difference in means (higher mean indicated that more adolescents endorsed “often” or “very often” compared to “never” or “rarely”). Females were significantly more likely than males to record symptoms of inattention as well as one symptom of hyperactivity-impulsivity. A post hoc t-test on these scores revealed significant variation among the two sexes for “often have trouble wrapping up the final details of a project” (t value of 7.13, p < .001), for “often have difficulty getting things in order when you have a task” (t value of 3.69, p < .001), for “often have problems remembering appointments” (t value of 5.43, p < .001), for “task that requires thought, often avoid getting started” (t value of 7.87, p < .001), and for “often fidget or squirm with hands or feet” (t value of 8.57, p < .001). Whereas, there was no significant sex difference in the way these adolescents recorded the remaining
symptom of hyperactivity-impulsivity (“often overly active and compelled to do things”, t value of -0.84, NS).

Although ADHD medication was not a variable of interest in this study, the variable was used later in the discussion to help explain these results. Post hoc analyses in this study revealed that 3.23% of males reported taking ADHD medication at least once a day, whereas, 2.20% of females reported taking ADHD medication at least once a day.

4.4 Results of Objective 2

Table 5 to Table 13 presents the results of the second objective. The results were presented by substance (alcohol, tobacco cigarettes, cannabis, and stimulants) and by sex. Within each substance, results for all models (unadjusted model and adjusted model) were combined within a single table by sex. All the Relative Risk Ratio (RRR) for all models for all substances were combined within one table by sex (Table 13).
4.4.1 Alcohol

4.4.1.1 Alcohol Results for Males

Table 5: Weighted Multinomial Logistic Regression for Alcohol Use for Males

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model 1: unadjusted model</th>
<th>Model 2: adjusted model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RRR (95% CI)</td>
<td>Wald Test</td>
</tr>
<tr>
<td></td>
<td>OU</td>
<td>RU</td>
</tr>
<tr>
<td>ADHD symptoms</td>
<td>1.43 (0.99, 2.06)</td>
<td>1.40 (0.95, 2.06)</td>
</tr>
<tr>
<td>SES</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Middle vs. Low</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High vs. Low</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social, Emotional, and Behavioural Problems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internalizing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Externalizing</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. The reference group for the outcome is non-use of alcohol. OU: Occasional Use. RU: Regular Use. Cells indicate relative risk ratio with 95% confidence interval in brackets. Data are from the 2015 and 2017 Ontario Student Drug Use and Health Survey, Ontario, Canada. Results are weighted and adjusted for survey design. Overall F statistics obtained through testparm. “Low” is the reference category for SES. *p < .05. **p < .01. ***p < .001.

Table 5 presents the results to address the second objective: to assess the overall relationship between ADHD symptoms and alcohol use for males. The F statistic from the unadjusted regression model indicates that ADHD symptoms were not statistically significantly correlated with alcohol use for males.

Results from Model 2 address the following objective: to assess the relationship between ADHD symptoms and alcohol use while controlling for SES and social, emotional, and behavioural problems among males. In Model 2 (objective 2, part b), after the addition of both SES and social, emotional, and behavioural problems, the relationship between ADHD symptoms and alcohol use remained statistically non-significant. ADHD symptoms were not significantly related to alcohol use in either model. The only difference between both models is that the
addition of covariates caused the RRR of ADHD symptoms to become closer to the null (null = 1).

### 4.4.1.2 Alcohol Results for Females

**Table 6: Weighted Multinomial Logistic Regression for Alcohol Use for Females**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model 1: unadjusted model</th>
<th>Model 2: adjusted model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RRR (95% CI)</td>
<td>Wald Test</td>
</tr>
<tr>
<td></td>
<td>OU</td>
<td>RU</td>
</tr>
<tr>
<td>ADHD symptoms</td>
<td>1.38</td>
<td>1.79</td>
</tr>
<tr>
<td>SES Middle vs. Low</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SES High vs. Low</td>
<td>0.94</td>
<td>0.54</td>
</tr>
<tr>
<td>Social, Emotional, and Behavioural Problems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internalizing</td>
<td>1.33</td>
<td>1.18</td>
</tr>
<tr>
<td>Externalizing</td>
<td>5.34</td>
<td>15.35</td>
</tr>
</tbody>
</table>

*Note.* The reference group for the outcome is non-use of alcohol. OU: Occasional Use. RU: Regular Use. Cells indicate relative risk ratio with 95% confidence interval in brackets. Data are from the 2015 and 2017 Ontario Student Drug Use and Health Survey, Ontario, Canada. Results are weighted and adjusted for survey design. Overall F statistics obtained through testparm. “Low” is the reference category for SES. *p < .05. **p < .01. ***p < .001.

Table 6 presents the results to address the second objective: to assess the overall relationship between ADHD symptoms and alcohol use for females. The F statistic from the unadjusted regression model for alcohol use for females indicates that ADHD symptoms were statistically significantly correlated with alcohol use. On average, females with ADHD symptoms had a 1.38, [95% CI: 1.12, 1.69] increased risk of occasionally using alcohol (relative to non-drinkers), compared to females without ADHD symptoms. Similarly, on average, females with ADHD symptoms had a 1.79, [95% CI: 1.19, 2.67] increased risk of regularly using alcohol (relative to non-drinkers), compared to females without ADHD symptoms.
Results from Model 2 address the following objective: to assess the relationship between ADHD symptoms and alcohol use, while accounting for SES and social, emotional, and behavioural problems. With the addition of covariates in Model 2, the relationship between ADHD symptoms and alcohol use for females became non-significant compared to Model 1.

4.4.2 Tobacco Cigarettes

4.4.2.1 Tobacco Cigarette Results for Males

Table 7: Weighted Multinomial Logistic Regression of Tobacco Cigarettes Use for Males

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model 1: unadjusted model</th>
<th></th>
<th>Model 2: adjusted model</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RRR (95% CI)</td>
<td>Wald Test</td>
<td>RRR (95% CI)</td>
<td>Wald Test</td>
</tr>
<tr>
<td></td>
<td>OU</td>
<td>RU</td>
<td>F Test</td>
<td>OU</td>
</tr>
<tr>
<td>ADHD symptoms</td>
<td>1.15 (0.61, 2.17)</td>
<td>5.44**</td>
<td>0.76 (0.34, 1.68)</td>
<td>1.52 (0.70, 3.33)</td>
</tr>
<tr>
<td>SES</td>
<td>1.03 (0.61, 1.73)</td>
<td>0.63 (0.31, 1.27)</td>
<td>0.93</td>
<td></td>
</tr>
<tr>
<td>Middle vs. Low</td>
<td>0.60 (0.30, 1.22)</td>
<td>0.63 (0.21, 1.87)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High vs. Low</td>
<td>1.71 (0.87, 3.37)</td>
<td>2.33 (1.05, 5.18)*</td>
<td>3.88*</td>
<td></td>
</tr>
<tr>
<td>Social, Emotional, and Behavioural Problems</td>
<td>4.03 (2.22, 7.30)***</td>
<td>8.31 (4.09, 16.88)***</td>
<td>26.19***</td>
<td></td>
</tr>
</tbody>
</table>

Note. The reference group for the outcome is non-use of tobacco cigarettes. OU: Occasional Use. RU: Regular Use. Cells indicate relative risk ratio with 95% confidence interval in brackets. Data are from the 2015 and 2017 Ontario Student Drug Use and Health Survey, Ontario, Canada. Results are weighted and adjusted for survey design. Overall F statistics obtained through testparm. “Low” is the reference category for SES. *p < .05. **p < .01. ***p < .001.

Table 7 presents the results to address the second objective: assess the overall relationship between ADHD symptoms and substance use (tobacco cigarettes), for males. The F statistic from the unadjusted regression model for males indicates that ADHD symptoms were statistically significantly correlated with tobacco cigarette use. However, not all across-group differences were statistically significant. On average, males with ADHD symptoms had a 3.49 [95% CI:
1.57, 7.74] increased risk of regularly using tobacco cigarettes (relative to those who did not use tobacco cigarettes), compared to males without ADHD symptoms.

Results from Model 2 address the following objective: to assess the relationship between ADHD symptoms and substance use (tobacco cigarettes) while accounting for SES and social, emotional, and behavioural problems, for males. So, with the addition of covariates in Model 2, the relationship between ADHD symptoms and tobacco cigarette use for males became non-significant compared to Model 1.

### 4.4.2.2 Tobacco Cigarette Results for Females

Table 8: Weighted Multinomial Logistic Regression of Tobacco Cigarettes Use for Females

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model 1: unadjusted model</th>
<th>Model 2: adjusted model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RRR (95% CI)</td>
<td>Wald Test</td>
</tr>
<tr>
<td></td>
<td>OU</td>
<td>RU</td>
</tr>
<tr>
<td>ADHD symptoms</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.72 (1.87, 3.98)**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.91 (1.92, 7.97)**</td>
<td></td>
</tr>
<tr>
<td>SES</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Middle vs. Low</td>
<td>1.44 (0.84, 2.45)</td>
<td></td>
</tr>
<tr>
<td>High vs. Low</td>
<td>1.69 (1.01, 2.83)*</td>
<td></td>
</tr>
<tr>
<td>Social, Emotional, and Behavioural Problems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internalizing</td>
<td>1.54 (0.95, 2.50)</td>
<td></td>
</tr>
<tr>
<td>Externalizing</td>
<td>5.73 (3.13, 10.49)***</td>
<td></td>
</tr>
</tbody>
</table>

*Note. The reference group for the outcome is non-use of tobacco cigarettes. OU: Occasional Use. RU: Regular Use. Cells indicate relative risk ratio with 95% confidence interval in brackets. Data are from the 2015 and 2017 Ontario Student Drug Use and Health Survey, Ontario, Canada. Results are weighted and adjusted for survey design. Overall F statistics obtained through testparm. “Low” is the reference category for SES. *p < .05. **p < .01. ***p < .001.

Table 8 presents the results to address the second objective: assess the overall relationship between ADHD symptoms and tobacco cigarettes for females. The F statistic from the unadjusted regression model for tobacco cigarette use for females indicates that ADHD symptoms were statistically significantly correlated with tobacco cigarette use for females. On
average, females with ADHD symptoms had a 2.72 [95% CI: 1.87, 3.98] increased risk of occasionally using tobacco cigarettes (relative to those who did not use tobacco cigarettes), compared to females without ADHD symptoms. Similarly, on average, females with ADHD symptoms had a 3.91 [95% CI: 1.92, 7.97] increased risk of regularly using tobacco cigarettes (relative to those who did not use tobacco cigarettes), compared to females without ADHD symptoms.

Results from Model 2 address the following objective: to assess the relationship between ADHD symptoms and substance use (tobacco cigarettes) while accounting for SES and social, emotional, and behavioural problems, for females. In Model 2 (objective 2, part b), after the addition of both SES and social, emotional, and behavioural problems, the overall relationship between ADHD symptoms and tobacco cigarette use for females, remained statistically significant. The adjusted model with SES and social, emotional, and behavioural problems indicates that ADHD symptoms were statistically significantly correlated with tobacco cigarette use for females; however, not all across-group differences remained statistically significant.

In summary, ADHD symptoms were statistically significantly related to tobacco cigarette use in both the overall unadjusted and overall adjusted models. The only difference is that the addition of covariates caused the RRR of ADHD symptoms to become closer to the null (null = 1) from Model 1 to Model 2.
4.4.3 Cannabis

4.4.3.1 Cannabis Results for Males

Table 9: Weighted Multinomial Logistic Regression of Cannabis Use for Males

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model 1: unadjusted model</th>
<th></th>
<th>Model 2: adjusted model</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RRR (95% CI)</td>
<td>Wald Test</td>
<td>RRR (95% CI)</td>
<td>Wald Test</td>
</tr>
<tr>
<td></td>
<td>OU</td>
<td>RU</td>
<td></td>
<td>OU</td>
</tr>
<tr>
<td>ADHD symptoms</td>
<td>0.92</td>
<td>1.52</td>
<td>1.63</td>
<td>0.70</td>
</tr>
<tr>
<td></td>
<td>(0.52, 1.60)</td>
<td>(0.96, 2.40)</td>
<td></td>
<td>(0.40, 1.25)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.91</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.57, 1.44)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.77</td>
</tr>
<tr>
<td>SES</td>
<td>1.04</td>
<td>0.91</td>
<td>0.89</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.48, 2.25)</td>
<td>(0.63, 1.30)</td>
<td></td>
<td>0.11</td>
</tr>
<tr>
<td>SES</td>
<td>0.97</td>
<td>0.82</td>
<td>0.89</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.41, 2.32)</td>
<td>(0.43, 1.55)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social, Emotional, and Behavioural Problems</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internalizing</td>
<td>1.51</td>
<td>1.32</td>
<td>0.89</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.73, 3.09)</td>
<td>(0.81, 2.15)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Externalizing</td>
<td>3.55</td>
<td>9.91</td>
<td>45.04**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1.49, 8.43)**</td>
<td>(6.15, 15.98)*****</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note.* The reference group for the outcome is non-use of cannabis. OU: Occasional Use. RU: Regular Use. Cells indicate relative risk ratio with 95% confidence interval in brackets. Data are from the 2015 and 2017 Ontario Student Drug Use and Health Survey, Ontario, Canada. Results are weighted and adjusted for survey design. Overall F statistics obtained through testparm. “Low” is the reference category for SES. *p < .05. **p < .01. ***p < .001.

Table 9 presents the results to address the second objective: assess the relationship between ADHD symptoms and substance use (cannabis), for males. The results of the unadjusted regression model for males indicates that ADHD symptoms were not statistically significantly correlated with cannabis use for males.

Results from Model 2 address the following objective: to assess the relationship between ADHD symptoms and substance use (cannabis) while accounting for SES and social, emotional, and behavioural problems, for males. In Model 2 (objective 2, part b), after the addition of both SES and social, emotional, and behavioural problems, the relationship between ADHD symptoms and cannabis use remained statistically non-significant for males, in comparison to the unadjusted model. The adjusted model for males with SES and social, emotional, and behavioural problems indicates that ADHD symptoms were not statistically significantly correlated with cannabis use.
ADHD symptoms were not statistically significantly related to cannabis use in either model. The only difference is that the addition of covariates caused the RRR of ADHD symptoms to become closer to the null (null = 1) for regular cannabis use and further from the null for occasional cannabis use; however, the covariates did not significantly change the relationship of ADHD symptoms to cannabis use for males from Model 1 to Model 2.

### 4.4.3.2 Cannabis Results for Females

**Table 10: Weighted Multinomial Logistic Regression of Cannabis Use for Females**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model 1: unadjusted model</th>
<th>Model 2: adjusted model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RRR (95% CI)</td>
<td>Wald Test</td>
</tr>
<tr>
<td></td>
<td>OU RU F Test</td>
<td>OU RU F Test</td>
</tr>
<tr>
<td>ADHD symptoms</td>
<td>1.58 (0.99, 2.53)</td>
<td>2.21 (1.55, 3.15)***</td>
</tr>
<tr>
<td>SES</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Middle vs. Low</td>
<td>1.18 (0.62, 2.27)</td>
<td>1.17 (0.74, 1.86)</td>
</tr>
<tr>
<td>High vs. Low</td>
<td>1.14 (0.68, 1.90)</td>
<td>1.17 (0.64, 2.16)</td>
</tr>
<tr>
<td>Social, Emotional, and Behavioural</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Problems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internalizing</td>
<td>0.84 (0.51, 1.39)</td>
<td>1.67 (1.23, 2.26)**</td>
</tr>
<tr>
<td>Externalizing</td>
<td>4.24 (1.93, 9.31)***</td>
<td>14.92 (8.73, 25.51)***</td>
</tr>
</tbody>
</table>

**Note.** The reference group for the outcome is non-use of cannabis. OU: Occasional Use. RU: Regular Use. Cells indicate relative risk ratio with 95% confidence interval in brackets. Data are from the 2015 and 2017 Ontario Student Drug Use and Health Survey, Ontario, Canada. Results are weighted and adjusted for survey design. Overall F statistics obtained through testparm. “Low” is the reference category for SES. *p < .05. **p < .01. ***p < .001.

Table 10 presents the results to address the second objective: assess the overall relationship between ADHD symptoms and substance use (cannabis), for females. The results of the unadjusted regression model (F statistic) indicates that ADHD symptoms were statistically significantly correlated with cannabis use for females; however not all across-group differences were statistically significant. On average, females with symptoms of ADHD had a 2.21 [1.55, 3.15] increased risk of regularly using cannabis (relative to those who did not use cannabis), compared to females without ADHD symptoms.
Results from Model 2 address the following objective: to assess the relationship between ADHD symptoms and substance use (cannabis) while accounting for SES and social, emotional, and behavioural problems, for females. In Model 2 *(objective 2, part b)*, after the addition of both SES and social, emotional, and behavioural problems, the relationship between ADHD symptoms and cannabis use for females, remained statistically significant, when comparing results to the unadjusted model. The adjusted model with SES and social, emotional, and behavioural problems indicates that ADHD symptoms were statistically significantly correlated with cannabis use for females. On average, females with ADHD symptoms were at 1.63 [95% CI: 1.01, 2.62] times the risk of occasionally using cannabis (relative to those who did not use cannabis) compared to females without ADHD symptoms, when SES and social, emotional, and behavioural problems were adjusted. On average, females with ADHD symptoms were at 1.49 [95% CI: 1.10, 2.00] times the risk of regularly using cannabis (relative to those who did not use cannabis) compared to females with ADHD symptoms, when SES and social, emotional, and behavioural problems were adjusted.

ADHD symptoms were statistically significantly related to cannabis use in both models, for females. The only difference is that the addition of covariates caused the RRR of ADHD symptoms to become closer to the null (null = 1) for regular cannabis use and further away from the null for occasional cannabis use, from Model 1 to Model 2.
4.4.4 Stimulants

4.4.4.1 Stimulants Results for Males

Table 11: Weighted Multinomial Logistic Regression of Stimulant Use for Males

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model 1: unadjusted model</th>
<th>Model 2: adjusted model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RRR (95% CI)</td>
<td>Wald Test</td>
</tr>
<tr>
<td></td>
<td>OU</td>
<td>RU</td>
</tr>
<tr>
<td>ADHD symptoms</td>
<td>3.39</td>
<td>2.29</td>
</tr>
<tr>
<td></td>
<td>(1.04, 11.03)*</td>
<td>(1.03, 5.13)*</td>
</tr>
<tr>
<td>SES</td>
<td>1.06</td>
<td>0.76</td>
</tr>
<tr>
<td>Middle vs. Low</td>
<td>(0.46, 2.42)</td>
<td>(0.33, 1.75)</td>
</tr>
<tr>
<td>High vs. Low</td>
<td>1.05</td>
<td>0.78</td>
</tr>
<tr>
<td>Social, Emotional, and Behavioural Problems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internalizing</td>
<td>1.40</td>
<td>0.43</td>
</tr>
<tr>
<td></td>
<td>(0.73, 2.67)</td>
<td>(0.16, 1.19)</td>
</tr>
</tbody>
</table>

Note. The reference group for the outcome is non-use of stimulants. OU: Occasional Use. RU: Regular Use. Cells indicate relative risk ratio with 95% confidence interval in brackets. Data are from the 2015 and 2017 Ontario Student Drug Use and Health Survey, Ontario, Canada. Results are weighted and adjusted for survey design. Overall F statistics obtained through testparm. “Low” is the reference category for SES. *p < .05. **p < .01. ***p < .001.

Table 11 presents the results to address the second objective: assess the overall relationship between ADHD symptoms and substance use (stimulants), for males. The F statistic from the unadjusted regression model for males indicates that ADHD symptoms were statistically significantly correlated with stimulant use for males. On average, males with ADHD symptoms had a 3.39 [95% CI: 1.04, 11.03] increased risk of occasionally using stimulants (relative to those who did not use stimulants), compared to males without ADHD symptoms. Similarly, on average, males with ADHD symptoms had a 2.29 [95% CI: 1.03, 5.13] increased risk of regularly using stimulants (relative to those who did not use stimulants), compared to males without ADHD symptoms.

Results from Model 2 address the following objective: to assess the relationship between ADHD symptoms and substance use (stimulants) while accounting for SES and social, emotional, and
behavioural problems, for males. With the addition of covariates in Model 2, the relationship between ADHD symptoms and stimulants use for males became non-significant compared to Model 1.

4.4.4.2 Stimulants Results for Females

Table 12: Weighted Multinomial Logistic Regression of Stimulant Use for Females

<table>
<thead>
<tr>
<th>Variable</th>
<th>Variable</th>
<th>Model 1: unadjusted model</th>
<th>Model 2: adjusted model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>RRR (95% CI)</td>
<td>Wald Test</td>
</tr>
<tr>
<td></td>
<td></td>
<td>OU</td>
<td>RU</td>
</tr>
<tr>
<td>ADHD symptoms</td>
<td></td>
<td>2.40</td>
<td>3.22</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(1.27, 4.55)**</td>
<td>(1.51, 6.85)**</td>
</tr>
<tr>
<td>SES</td>
<td>Middle vs. Low</td>
<td>0.91</td>
<td>1.08</td>
</tr>
<tr>
<td></td>
<td>High vs. Low</td>
<td>0.89</td>
<td>1.29</td>
</tr>
<tr>
<td>Social, Emotional, and Behavioural Problems</td>
<td>Internalizing</td>
<td>1.44</td>
<td>4.29</td>
</tr>
<tr>
<td></td>
<td>Externalizing</td>
<td>14.57</td>
<td>14.25</td>
</tr>
</tbody>
</table>

Note. The reference group for the outcome is non-use of stimulants. OU: Occasional Use. RU: Regular Use. Cells indicate relative risk ratio with 95% confidence interval in brackets. Data are from the 2015 and 2017 Ontario Student Drug Use and Health Survey, Ontario, Canada. Results are weighted and adjusted for survey design. Overall F statistics obtained through testparm. “Low” is the reference category for SES. *p < .05. **p < .01. ***p < .001.

Table 12 presents the results to address the second objective: assess the overall relationship between ADHD symptoms and substance use (stimulants), for females. The F statistic from the unadjusted regression model for females indicates that ADHD symptoms were statistically significantly correlated with stimulant use for females. On average, females with ADHD symptoms had a 2.40 [95% CI: 1.27, 4.55] increased risk of occasionally using stimulants (relative to those who did not use stimulants), compared to females without ADHD symptoms. Similarly, on average, females with ADHD symptoms had a 3.22 [95% CI: 1.51, 6.85] increased risk of regularly using stimulants (relative to those who did not use stimulants), compared to females without ADHD symptoms.
Results from Model 2 address the following objective: to assess the relationship between ADHD symptoms and substance use (stimulants) while accounting for SES and social, emotional, and behavioural problems, for females. With the addition of covariates in Model 2, the relationship between ADHD symptoms and stimulant use for females became non-significant compared to Model 1.

4.4.5 Summary of Results for All Substances

Table 13: Weighted Multinomial Logistic Regression Relative Risk Ratio Summary of Substance Use by Sex

<table>
<thead>
<tr>
<th></th>
<th>Male - Alcohol</th>
<th>Female - Alcohol</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OU</td>
<td>RU</td>
</tr>
<tr>
<td>ADHD symptoms – Model 1: unadjusted model</td>
<td>1.43</td>
<td>1.4</td>
</tr>
<tr>
<td>ADHD symptoms – Model 2: adjusted model</td>
<td>1.22</td>
<td>0.95</td>
</tr>
<tr>
<td>Male – Tobacco Cigarettes</td>
<td>OU</td>
<td>RU</td>
</tr>
<tr>
<td>ADHD symptoms – Model 1: unadjusted model</td>
<td>1.15</td>
<td>3.49**</td>
</tr>
<tr>
<td>ADHD symptoms – Model 2: adjusted model</td>
<td>0.76</td>
<td>1.52</td>
</tr>
<tr>
<td>Male – Cannabis</td>
<td>OU</td>
<td>RU</td>
</tr>
<tr>
<td>ADHD symptoms – Model 1: unadjusted model</td>
<td>0.92</td>
<td>1.52</td>
</tr>
<tr>
<td>ADHD symptoms – Model 2: adjusted model</td>
<td>0.7</td>
<td>0.91</td>
</tr>
<tr>
<td>Male – Stimulants</td>
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<td>RU</td>
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<tr>
<td>ADHD symptoms – Model 1: unadjusted model</td>
<td>3.39*</td>
<td>2.29*</td>
</tr>
<tr>
<td>ADHD symptoms – Model 2: adjusted model</td>
<td>1.81</td>
<td>1.5</td>
</tr>
</tbody>
</table>

Note. The reference group for the outcome is non-use of substance. OC: Occasional Use. R: Regular Use. Data are from the 2015 and 2017 Ontario Student Drug Use and Health Survey, Ontario, Canada. Results are weighted and adjusted for survey design. Overall F statistics obtained through testparm. *p < .05. **p < .01. ***p < .001.

All RRR accompanied with the level of significance can be found in Table 13. Table 13 is sectioned by sex (results for males on the left of the table), and substance use is displayed by rows from alcohol to stimulants. This table will ease the process of comparing substance to substance in the discussion portion of this thesis.
Chapter 5

5 Discussion

The purpose of this population-based study was to estimate the prevalence of self-reported ADHD symptoms by sex and to assess the relationship between ADHD symptoms and substance use by sex.

5.1 Prevalence of ADHD Symptoms Among Ontario Youth

The overall prevalence of self-reported ADHD symptoms in Ontario among youth, using the ASRS-v1.1 Screener was found to be 20.22%. As hypothesized, this estimate is much higher than in previous Canadian studies that have used actual ADHD diagnoses which ranged from 1.5% (Brownell & Yogendran, 2001) to 10.49% (Georgiades et al., 2019). In general, studies that used a survey symptom checklist to measure ADHD, including this study, produced larger prevalence statistics compared to studies that used administrative medical records. In addition, symptom checklists are possibly more inclusive whereas actual diagnoses by physicians or psychologists are more exclusive as clinicians try to identify other disorders that could account for the symptoms and assess functional impairment in two or more domains that are not typically captured in survey symptom checklists. In fact, the current estimate of 20.22% is in accordance with the estimates of Green et al. (2019) (study from the United States) and Sonnby et al. (2011) (study from Sweden) of 19.6% and 20.90%, respectively. Both Green et al. (2019) and Sonnby et al. (2011) used the ASRS-v1.1 Screener with adolescents to estimate the prevalence of self-reported ADHD symptoms.

Furthermore, females self-reported ADHD symptoms significantly more than males (24.06% vs. 16.42%, respectively). Studies using the same ASRS measure that was used in this study found that more females self-reported symptoms of ADHD than males (Madruga et al., 2012; Polanczyk et al., 2010; Sonnby et al., 2011). For example, Sonnby et al. (2011) found that 18.4% of males self-reported ADHD symptoms and 23.5% of females self-reported ADHD symptoms.

It is possible that the ASRS-v1.1 Screener is capturing more than ADHD, particularly since the post-hoc analysis conducted for this study indicates that of this entire sample, 3.23% of males
and 2.20% of females reported taking ADHD medication at least once a day in this current study. The number of participants who actually have ADHD is likely to be higher than the percentage who take ADHD medication because not all of those with ADHD take ADHD medication. Some parents are reluctant to have their children take medication due to medication side effects (Cascade, Kalali, & Wigal, 2010; Toomey, Sox, Rusinak, & Finkelstein, 2012), medication ineffectiveness, and the availability of other therapies besides medication (Barkley, 2004; Zylowska et al., 2008). Therapies besides medication include behavioural parent training, behavioural classroom management, behavioural peer interventions, and organization training programs; unfortunately, there is a significant gap between research and practice, such that these treatments are often not implemented in community and school settings (DuPaul, Evans, Mautone, Owens, & Power, 2019). Furthermore, there is evidence that it is more effective to begin with behavioural treatment and add medication as a secondary treatment to initial behaviour modification, compared to beginning with medication and adding behavioural treatment later (Pelham et al., 2016). That said, the medication use estimates from this survey are more congruent with prevalence estimates of ADHD from studies using measures of clinical diagnosis, suggesting that the ASRS-v1.1 Screener may be capturing a broader range of symptoms and issues in addition to ADHD symptoms.

The prevalence of one in five Ontario high school students reporting symptoms of ADHD may be reflective of overall trends in mental health. In general, youth are experiencing more mental health issues pertaining to internalizing problems; there has been an overall increasing trend of adolescent mental health symptoms globally since the 1980s, especially an increase of internalizing symptoms in females (Blomqvist, Henje Blom, Hägglöf, & Hammarström, 2019). Between 1980/81 and 2004/05, there was an increasing prevalence of self-reported anxiety; the increase was particularly large in young females between ages 16-23 years (Calling, Midlöv, Johansson, Sundquist, & Sundquist, 2017). Blomqvist et al. (2019) found that symptoms of anxiety and depression and functional somatic symptoms increased among males and females from 1981 until 2014 ($p < .001$ for all subscales), and the increase of these symptoms were higher among females. Conversely, conduct problems were significantly higher in males in 1981 and decreased over time so that in 2014, there was no longer a significant difference between males and females regarding conduct problems ($p = .286$) (Blomqvist et al., 2019). Conduct
disorder decreased from 7.2% to 2.5% while emotional disorder increased from 9.2% to 13.2% between 1983 and 2014 in Ontario youth (Comeau et al., 2019).

The increase of mental health issues may be a result of a number of cultural trends (Twenge, Cooper, Joiner, Duffy, & Binau, 2019). Twenge et al. (2019) analyzed data from the National Survey on Drug Use and Health, examining survey responses from more than 200,000 adolescents age 12-17 from 2005-2017 and about 400,000 adults age 18 and over from 2008-2017. The percentage of young Americans experiencing certain types of mental health disorders has risen significantly over the past decade, with no corresponding increase in older adults (Twenge et al., 2019). These cultural trends included an increased use of electronic communication and digital media which may have changed modes of social interaction enough to affect mood disorders (Twenge et al., 2019). Furthermore, youth are not sleeping as much as they did in previous generations, and this could be because digital media can interfere with sleep (e.g., staying up late on phones, using them in the middle of the night) (Twenge et al., 2019). Given that the increase in mental health issues was sharpest after 2011, it is unlikely to be due to genetics or economic problems, but instead how adolescents choose to spend their leisure time (Twenge et al., 2019). Lastly, this spike in mental health issues is happening particularly to female adolescents (Twenge et al., 2019), which could be why the females that respond to the ASRS measure have been self-reporting more ADHD symptoms than males.

To add to reasons why females may have self-reported significantly more ADHD symptoms than males, females are more ready to acknowledge and disclose discomfort than males (Barsky, Peekna, & Borus, 2001; Hill & Stull, 1987; Ubando, 2016). This could be part of the gender-based socializing process in society. Masculinity is a risk factor for male vulnerability (e.g., emotional inexpressiveness, reluctance to seek help) (Möller-Leimkühler, 2003); however, females are more sensitized to bodily sensation and discomfort leading to heightened self-scrutiny which could increase symptom reporting. In this current study, females were significantly more likely than males to self-report symptoms of inattention as well as one symptom of hyperactivity-impulsivity. A post hoc t-test on these scores revealed significant variation among the two sexes for “often have trouble wrapping up the final details of a project” (t value of 7.13, \( p < .001 \)), for “often have difficulty getting things in order when you have a task” (t value of 3.69, \( p < .001 \)), for “often have problems remembering appointments” (t value
of 5.43, \( p < .001 \)), for “task that requires thought, often avoid getting started” (t value of 7.87, \( p < .001 \)). Furthermore, females were significantly more likely than males to record “often fidget or squirm with hands or feet” (t value of 8.57, \( p < .001 \)); whereas, there was no significant sex difference in the way these adolescents recorded the remaining symptom of hyperactivity-impulsivity (“often overly active and compelled to do things”, t value of -0.84, NS). This sex difference could be attributed to differential reporting between the sexes.

Lastly, one important finding from the 2014 OCHS is that prevalence largely depends on whether diagnoses are based on youth versus parent report (Georgiades et al., 2019). The overall prevalence of any symptoms of mental health was 18.2% for youth (12-17 years) based on parent reports and 21.8% based on youth reports. Among youth, the overall prevalence of any disorder was higher for females compared to males based on the youth reports (25.4% versus 18.5%) but generally higher in males compared to females based on the parent reports (20.5% versus 15.8%). Furthermore, the higher prevalence of any disorder in females identified by youth compared to adults was attributable to major depressive episode (10.1% versus 5.1%) and generalized anxiety (13.3% versus 6.3%), while the higher prevalence of any disorder in males identified by parents compared to youth was largely attributable to ADHD (7.5% versus 2.7%). Although prevalence estimates were similar for males and females for mood and anxiety disorders based on parent reports, youth reports revealed rates that were 2 to 3 times higher for females compared to males.

### 5.2 ADHD Symptoms and Substance Use

The use of both unadjusted models and adjusted models provided a better understanding of the association between ADHD symptoms and substance use. The unadjusted models suggest that ADHD symptoms are related to most types of substance use (tobacco cigarette use and stimulant use in males, and alcohol use, tobacco cigarette use, cannabis use, and stimulant use in females). Once adjusting for covariates, it is clearer that internalizing and externalizing problem are highly related to substance use (while SES is only highly related to regular alcohol use in males), and ADHD symptoms are only related to tobacco cigarette use and cannabis use in females, once accounting for covariates.
5.2.1 ADHD Symptoms and Alcohol Use

Consistent with some literature (Flory et al., 2003; Galéra et al., 2008; Upadhyaya & Carpenter, 2008), once controlling for SES and social, emotional, and behavioural problems, there was no relationship between ADHD symptoms and alcohol use for both males and females. However, these findings are dissimilar to other research that found that ADHD symptoms decreased the risk of alcohol use (Fergusson et al., 2007) and that risk of alcohol use may be more apparent in females with ADHD symptoms compared to females without ADHD symptoms (Elkins et al., 2018; Sihvola et al., 2011).

Age of participants could also have affected these results because historically, those who are older are more likely to use or have used alcohol (Boak, Hamilton, Adlaf, & Mann, 2017). For example, Flory et al. (2003) studied participants in 6th-10th grade and did not find a relationship between ADHD symptoms and alcohol use whereas Fergusson et al. (2007) studied participants at age 16, 18, 21, and 25 and did find a relationship between ADHD symptoms and alcohol use. However, both Elkins et al. (2018) and Sihvola et al. (2011) examined a similar age group to the current study (participants aged 17, participants aged 14 and 17, respectively) and found that ADHD symptoms were related to alcohol use.

Perhaps the association between ADHD symptoms and alcohol use is more evident for those who drink more frequently than occasional drinkers. Although for this study, both “occasional” and “regular” labels to categorize level of drinking were used, this definition of regular drinking included drinking “2 or 3 times a month”, “once a week”, “2 or 3 times a week”, “4 or 5 times a week”, and “almost every day- 6 or 7 times a week”. This definition of regular drinking is very broad when compared to studies that used a measurement of weekly/daily drinking (Elkins et al., 2018; Sihvola et al., 2011). Elkins et al. (2018) and Sihvola et al. (2011) used the most comprehensive measure of alcohol use when compared to studies that did not find a relationship between ADHD symptoms and alcohol use (Flory et al., 2003; Galéra et al., 2008; Upadhyaya & Carpenter, 2008). Flory et al. (2003) examined past month use of alcohol. Galéra et al. (2008) examined binge use (five or more drinks in a row at least twice a week in the last two weeks) and regular drinker (10 times in last 30 days). Upadhyaya and Carpenter (2008) examined past year alcohol use (response options included: once per year, six times per year, once per month, twice per month, once per week, three times per week, five times per week, every day). Therefore,
researchers who focused more on weekly/daily drinking (participants that drink more) found an association between ADHD symptoms and alcohol use (Elkins et al., 2018; Sihvola et al., 2011).

5.2.2 ADHD Symptoms and Tobacco Cigarette Use

As hypothesized, ADHD symptoms were statistically significantly related to tobacco cigarette use in females. Consistent with Galéra et al. (2005), females with ADHD symptoms had a significantly increased risk of using tobacco cigarettes than females without ADHD symptoms. Galéra et al. (2005) found that ADHD symptoms contributed independently to subsequent daily smoking (OR = 1.98, \( p = .04 \)) only for females. Reasons for this difference could be that females experience greater social and academic consequences related to inattention symptoms. On average, females are more academically motivated than males, so females with inattention symptoms violate this common gender role thereby further isolating them from peers (Elkins et al., 2011) leading them to use tobacco cigarettes as a way to cope with these consequences. For example, it has been suggested that females with ADHD symptoms may have more difficulty in peer relationships than all other comparison groups (including females without ADHD symptoms, males with ADHD symptoms, and males without ADHD symptoms) (Mikami & Hinshaw, 2003). One population study of 11-year-olds found that females with ADHD symptoms, especially the inattentive subtype, did more poorly with school and peer relationships than females without ADHD symptoms as well as males with and without ADHD symptoms (Elkins et al., 2011). Elkins et al. (2011) found that youth with ADHD symptoms experienced lower popularity and self-concept, fewer positive peers, and increased deviant peers. Females with ADHD symptoms were less popular and more likely to be bullied than females without ADHD, whereas males with ADHD symptoms were not. Specifically, 50% of females with inattention symptoms reported being bullied compared to 29% of males with inattention symptoms. Perhaps since females are more academically motivated than males overall, females with inattention symptoms are in violation of a common gender role expectation and are thereby subjected to greater social stigma (Elkins et al., 2011). Furthermore, inattention may impair the ability to be attuned to subtle social cues and norms, and females may be expected to be aware of and responsive to these cues. Peer adjustment may be of heightened significance at this age, when adaptive peer relationships are central for competency (Masten & Curtis, 2000). The social isolation experienced by many females with ADHD symptoms may lead them to use tobacco
cigarettes as a way to cope. It is speculated that for these reasons, ADHD symptoms were statistically significantly related to tobacco cigarette use in females, only.

5.2.3 ADHD Symptoms and Cannabis Use

Similar to previous research (Elkins et al., 2018; Fergusson et al., 2007; Upadhyaya & Carpenter, 2008), the results from this study indicated that ADHD symptoms were significantly related to cannabis use; however, unlike some previous research (Fergusson et al., 2007; Upadhyaya & Carpenter, 2008), this current study found that this relationship only exists among females with ADHD symptoms and not males with ADHD symptoms. Elkins et al. (2018) also found that the risk of cannabis use was more apparent in females with ADHD symptoms compared to females without ADHD symptoms; each hyperactive-impulsive symptom was associated with a 40% increase in odds for females (19% for males) of progressing in cannabis frequency (e.g., weekly to daily). However, Elkins et al. (2018) found that ADHD symptoms still significantly predicted cannabis frequency for males. Similar to the risk of tobacco cigarette use in females, this current study found the risk of cannabis use only existed for females with ADHD symptoms, but not for males with ADHD symptoms. Again, this could be explained by the greater social and academic consequences that females experience from symptoms of inattention (Elkins et al., 2011) which could lead them to use cannabis as a way to cope with these consequences.

5.2.4 ADHD Symptoms and Stimulant Use

Unlike previous research (Galéra et al., 2013), the current study did not find a significant relationship between ADHD symptoms and stimulant use after controlling for SES, internalizing problem, and externalizing problem. This could be attributed to differences in stimulant use measure. Galéra et al. (2013) measured only lifetime cocaine use whereas this study measured the frequency of stimulant use, including cocaine, crack-cocaine, methamphetamine, and ecstasy. Since Galéra et al. (2005) found a significant relationship between ADHD symptoms and daily tobacco cigarette use but no relationship between ADHD symptoms and lifetime smoking, one would hypothesize that the use of lifetime measurement dilutes any association between ADHD symptoms and lifetime cocaine use. However, perhaps this conclusion regarding lifetime measurement cannot be used for substances that are not as commonly used as tobacco cigarettes; substance use experimentation can be regarded as a normative experience rather than as deviant behaviour for tobacco cigarette use, but this may not extend to cocaine use. However, with such
limited number of studies to use as comparisons and such different methods of measurement, it is understandable that the results obtained from this study are different.

5.2.5 Comparison Across Sexes

Interestingly, there was a significant relationship between ADHD symptoms and tobacco cigarette use and cannabis use for females even after controlling for covariates, but not for males. These results stand in contrast to earlier findings that males with ADHD have a higher frequency of substance use than females with ADHD (Galéra et al., 2008); yet they corroborate earlier work by Elkins et al. (2018), Galéra et al. (2005), and Sihvola et al. (2011), which indicate that females with ADHD symptoms may share a similarly increased risk of substance use compared to their male counterparts.

5.3 Strengths and Limitations

Population-based studies have both strengths and limitations. Population-based studies are the best design to examine the relationship between health-related characteristics and other variables of interest as they exist in a population at one particular time. It is the best study design for quantifying prevalence and risk factors. Although population-based studies cannot capture all members of the population (except for census studies), it is a technique that can capture more cases compared to other types of study designs that include a smaller sample size or rely on clinical diagnosis for case identification. Lastly, poststratification weights can be applied to population data to restore the population gender distribution according to grade. Applying weights addressed the issue of younger female overrepresentation and older male underrepresentation in the OSDUHS.

However, the current results must be interpreted in light of the limitations related to cross-sectional data, measures used (scales and questions included and self-report nature of the survey without corroborating or objective measures), and generalizability of the results to the whole population.

Due to the cross-sectional nature of this study design, the ability to make definitive conclusions about temporality or directionality between the variables in this study were not possible. These findings of associations were correlational and do not imply causation. Therefore, more
longitudinal studies are needed to explore the direction of the relationship between self-reported ADHD symptoms and substance use, specifically tobacco cigarette, and cannabis use in females.

Measures used in this study should also be interpreted cautiously. This study examined prevalence and correlates utilizing screening tools such as the ASRS-v1.1 Screener and K6 Screener instead of psychiatric assessments. It is difficult to ascertain whether ASRS-v1.1 Screener is in fact capturing ADHD symptomatology rather than a broad-spectrum of psychological symptoms. Although the psychometrics of the ASRS-v1.1 Screener in this study are strong, these screeners were not intended to provide diagnosis of disorders (Caci, Morin, & Tran, 2014). Therefore, the use of screening measures such as the ASRS-v1.1 Screener, the K6 Screener, and the Antisocial Behaviour Index, as well as all the single question substance use frequency measures, as opposed to full-length assessments and clinical diagnoses, is a methodological limitation.

The OSDUHS data collection method relied solely on self-report which could lead to social desirability bias, which is the tendency for respondents to answer questions in a fashion that will be viewed favourably by others (Krosnick, 1999). However, reviews of self-report methods for substance use suggest that although surveys typically underestimate true usage, surveys are deemed the best available method to estimate such behaviour (Harrison, Haaga, & Richards, 1993).

Additionally, self-report often leads to a large amount of missing data (Salgado, Azevedo, Proença, & Vieira, 2016). In surveys, missing data can be caused by many reasons: 1) respondents may refuse to answer a question because of privacy issues; 2) respondents may not understand the question posed; 3) respondents may lose interest in the completion of the survey; 4) subject matter may be private or illicit (such as frequency of stimulant use) (SPSS, n.d.). In this study, about 10% of the data were missing, which is a limitation, as imputation methods were not used to correct for this issue. Additionally, recall bias may lead to differential exposure misclassification, so an objective source of information is often better (i.e., registry) than self-reported measures. Furthermore, there may be differential self-reporting based on sex. As stated before, females are historically more ready to acknowledge and disclose discomfort compared to males (Barsky et al., 2001; Hill & Stull, 1987; Ubando, 2016). Masculinity is a risk factor for
vulnerability (Möller-Leimkühler, 2003); whereas, femininity leads to increased vulnerability and subsequently increased symptom reporting.

An important limitation involves the generalizability of the study results. Students not included in the OSDUHS data collection process were those enrolled in private schools, those who were home-schooled, those that were on military bases, those in First Nations communities, those institutionalized for correctional or health reasons, transient populations such as the homeless, and those in remote northern regions of Ontario (Boak et al., 2016). Some of these excluded groups, for example, those institutionalized for correctional reasons and transient populations, such as the homeless, often contain an especially large number of people with mental health issues, such as ADHD (Edidin, Ganim, Hunter, & Karnik, 2012). However, the coverage error depends upon the difference in substance use and mental health status between those surveyed and those not surveyed, and the size of the group not captured due to the design of the study (Boak et al., 2016). The presence of internalizing problem, externalizing problem, ADHD symptoms, and substance use may be significantly higher in the excluded groups than those in the sampled population; yet if the size of the excluded groups is small relative to the total population, the bias is usually minimal (Boak et al., 2016). Those excluded from the survey’s target population represent a small proportion of 8% of the Ontario student population; hence, the vast majority of Ontario adolescents were represented by the OSDUHS (Boak et al., 2016).

5.4 Implications and Directions for Future Research

Despite these limitations, this study has increased understanding of the relationship between self-reported ADHD symptoms and substance use while controlling for SES, internalizing and externalizing problems, which are covariates that have not been controlled for or studied altogether in the past Ontario studies. In addition, this study produced supportive evidence on relatively high prevalence of self-reported ADHD symptoms among youth (Green et al., 2019; Sonnby et al., 2011). Furthermore, this study adds to research that found that females self-reported ADHD symptoms more than males (Madruga et al., 2012; Polanczyk et al., 2010; Sonnby et al., 2011), as well as studies that indicate that females with ADHD symptoms had increased risk of substance use, but not their male counterparts (Elkins et al., 2018; Galéra et al., 2005; Sihvola et al., 2011). Speculations on why females with ADHD symptoms had a higher risk of substance use than females without self-reported ADHD symptoms could be that females
are typically more school and peer oriented than males; therefore, females with inattention symptoms may be outcasts for not conforming to gender norms (Elkins et al., 2011) leading them to use tobacco cigarettes and cannabis as a way to cope. However, more research in this area is needed to understand why females with self-reported ADHD symptoms had a higher risk of substance use.

Future studies could conduct a psychiatric assessment of a similar cohort of participants who self-report for ADHD symptoms on the ASRS-v1.1 Screener, in order to validate the results from this study, as the use of symptom screeners has resulted in a larger proportion of self-reported ADHD symptoms, especially in females. Although both Adler et al. (2012) and Green et al. (2019) presented validation studies on the ASRS-v1.1 Screener in adolescents, Green et al. (2019) noted that this was just initial evidence for reliability and validity of this measurement tool. Furthermore, Green et al. (2019) studied two high achieving school districts with limited racial and ethnic diversity; both districts participating in the study had state test passage rates substantially higher than state or national averages (approximately 90%). Adler et al. (2012) validated the ASRS-v1.1 Screener in outpatients that met the DSM-IV-TR criteria for primary diagnosis of ADHD. It is important to note that they studied a very small sample of 88 adolescents (76.1% male) and 73.9% were receiving medication for ADHD, which limits generalizability of their results (Adler et al., 2012).

Future studies could further test the sensitivity and specificity to measure the degree of overlap between screening tools and actual psychiatric diagnoses. Prospective follow-up studies of those who screened for ADHD symptoms may lend to the validation of ASRS-v1.1 Screener as a predictor of ADHD, as well as ADHD as a co-occurring factor with internalizing and externalizing problems. This process could also be repeated for the other screeners utilized in this study to validate screeners that measure internalizing problem and externalizing problem against clinical diagnoses.

These results warrant future studies to explore the findings of this study. Specifically, knowing what is being captured by the ASRS-v1.1 Screener and why youth are reporting these symptoms at such high rates is important. Furthermore, these future studies should focus on why females are self-reporting such high rates of these symptoms compared to males. Literature indicates that
females are more likely to have the primarily inattentive subtype of ADHD compared to males; however, these consequences are less often studied (Elkins, et al., 2018).

In the context of these limitations, the results of the current study warrant further research measuring risk and resiliency factors of ADHD symptoms and more research on substances such as stimulants within this context are necessary.

### 5.5 Conclusions

Overall, a large proportion (20.22%) of Ontario students in grades 9 through 12 self-reported symptoms of ADHD; 16.42% of males reported ADHD symptoms and 24.06% of females reported ADHD symptoms. A few studies using the same ASRS measure also found that more females recorded symptoms of ADHD than males (Madruga et al., 2012; Polanczyk et al., 2010; Sonnby et al., 2011). Sonnby et al. (2011) found that 18.4% of males self-reported ADHD symptoms and 23.5% of females self-reported ADHD symptoms.

The prevalence of ADHD symptoms uncovered in this study could be much larger than previous reported Canadian ADHD statistics because of the measure used to identify ADHD symptoms. Furthermore, youth are experiencing more mental health issues pertaining to internalizing problems; symptoms of anxiety and depression and functional somatic symptoms have significantly increased from 1981 onward and the increase of these symptoms were higher in females than in males (Blomqvist et al., 2019). Future studies should explore the findings of this study by identifying what is being captured by the ASRS-v1.1 Screener and why youth are reporting these symptoms at such high rates. Moreover, these studies should also focus on why females self-reported these symptoms at higher rates compared to males.

Results from the regression analyses indicated that self-reported ADHD symptoms significantly increased risk of tobacco cigarette use and stimulant use for males and significantly increased risk of alcohol use, tobacco cigarette use, cannabis use, and stimulant use for females in the unadjusted models. However, after accounting for SES, internalizing problem, and externalizing problem, ADHD symptoms only significantly increased the risk of tobacco cigarette use and cannabis use in females. Controlling for covariates and comparing unadjusted to adjusted models, this study provided evidence on the effect of ADHD symptoms on substance use. If only
unadjusted models were examined, conclusions would be that ADHD symptoms leads to most types of substance use in females and that ADHD symptoms leads to some types of substance use in males. However, after adjusting for covariates, it is clearer that internalizing problem and externalizing problem greatly impact substance use (while SES is only highly related to regular alcohol use in males), and ADHD symptoms are only related to tobacco cigarette use and cannabis use in females.

Lastly, due to its limitations, findings from this study have to be interpreted cautiously as the use of symptom screeners may have resulted in a large proportion of self-reported ADHD symptoms, especially in females.
Bibliography


Appendices

Appendix 1: ASRS-v1.1 Screener

<table>
<thead>
<tr>
<th>Questions:</th>
<th>Never</th>
<th>Rarely</th>
<th>Sometimes</th>
<th>Often</th>
<th>Very Often</th>
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<tbody>
<tr>
<td>In the LAST 6 MONTHS, how often did you have trouble wrapping up the final details of a project, once the challenging parts had been done?</td>
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<tr>
<td>In the LAST 6 MONTHS, how often did you have difficulty getting things in order when you had to do a task that required organization?</td>
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<tr>
<td>In the LAST 6 MONTHS, how often did you have problems remembering appointments or obligations (thing you had to do)?</td>
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<tr>
<td>In the LAST 6 MONTHS, when you had a task that required a lot of thought, how often did you avoid or delay getting started?</td>
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<tr>
<td>In the LAST 6 MONTHS, how often did you fidget or squirm with your hands or feet when you had to sit down for a long time?</td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>In the LAST 6 MONTHS, how often did you feel overly active and compelled to do things, like you were driven by a motor?</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>
Appendix 2: K6 Screener

<table>
<thead>
<tr>
<th>In the LAST 4 WEEKS, about how often did you feel…</th>
<th>All of the time</th>
<th>Most of the time</th>
<th>Some of the time</th>
<th>A little of the time</th>
<th>None of the time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nervous</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Hopeless</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Restless or fidgety</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>So depressed (sad) that nothing could cheer you up</td>
<td></td>
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<td></td>
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<tr>
<td>That everything was an effort</td>
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<tr>
<td>Worthless</td>
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<td></td>
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</tr>
</tbody>
</table>
Appendix 3: Antisocial Behaviour Index

How often (if ever) in the **LAST 12 MONTHS** have you done each of the following? (Write “0” if you have not done it.)

a) Taken a car, truck, or SUV for a ride without the owner’s permission? _______ times

b) Banged up or damaged something (on purpose) that did not belong to you? _______ times

c) Sold marijuana or hashish? _______ times

d) Taken things worth **$50 or less** that did not belong to you? _______ times

e) Taken things worth **more than $50** that did not belong to you? _______ times

f) Beat up or hurt anyone (on purpose), not counting fights you may have had with a brother or sister? _______ times

g) Broken into a locked building other than your own home? _______ times

h) Carried a weapon, such as a gun or knife (not for hunting)? _______ times

i) Run away from your home (left home without the permission of one or both of your parents/guardians)? _______ times

j) Set something on fire that you weren’t supposed to? _______ times
Curriculum Vitae

Name: Shannon Wong

Post-secondary Education and Degrees:
Western University
London, Ontario, Canada
2013-2017 Honours Bachelor of Science Specialization in Psychology
Western University
London, Ontario, Canada
2017-2020 Master of Science in Epidemiology and Biostatistics

Honours and Awards:
Deans Honours List
2013-2017

Related Work Experience:
Graduate Research Assistant
Western University
Western Centre for Public Health and Family Medicine
2017-2020

Poster Presentations:
Undergraduate Thesis Presentation Day
Role of Autonomic Signals in Affective Constituents of Familiarity
April 2017