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Rates of Diagnosis and Treatment of Attention Deficit/Hyperactivity Disorder in Manitoba Children: Considering the Socioeconomic Gradient

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December 17, 2007

THESIS DEFENSE IN PARTIAL FULFILLMENT OF THE REQUIREMENTS OF THE DEGREE

OF

MASTER OF ARTS

Abstract

This project investigated the diagnosis and psychostimulant treatment rates of Attention Deficit/Hyperactivity Disorder (ADHD) in Manitoba children. These rates were considered according to sex, age, socioeconomic status (SES), geographical region, and comorbidity with learning disabilities (LD) and behavioral disturbances (BD). Data came from the Manitoba Population Health Research Data Repository, a comprehensive collection of administrative, registry, survey and other databases. The research population included all children aged 0 to 19 years in Manitoba (n = 319,506) with a diagnosis of ADHD (n= 9,233), during two Fiscal years (2003/2004 and 2004/2005). The term "gradient" refers to the relationship between SES and health and emphasizes the idea that the change in outcomes is gradual and occurs across the full range of SES. Results from this study indicate that region of residence (urban versus rural) and comorbid BD moderate the SES gradient, as low income, urban dwelling children with a comorbid diagnosis of BD had the highest rates of ADHD diagnoses and prescriptions. Furthermore, whereas age did not moderate the SES gradient, the crude rates indicated that the SES gradient for ADHD diagnoses and prescriptions was most pronounced in urban children 0 to 13 years of age. Otherwise, all main effects tested (sex, age, socioeconomic status, geographical region, and comorbid BD and LD) were significant in both the diagnosis and prescription models for ADHD. Policy considerations that arise out of this study include more stringent diagnostic and prescription treatment practices, additional support resources for children who are most at risk of having ADHD, and increased information about alternate treatment implementation for ADHD.

Acknowledgements

I would like to begin by expressing great gratitude to my research advisor on this project, Dr. Marni Brownell. Her constant support and mentorship throughout this project have not only fostered learning specific to the research, but her encouragement of critical and creative thinking have also facilitated my professional and personal growth on many levels. Furthermore, I am deeply thankful to the other members of my research committee, Dr. Mike LeBow (academic advisor, who has consistently offered his guidance throughout my M.A.), Dr. Lisa Lix (external member, whose statistical expertise has been immensely appreciated), and Dr. Dan Bailis (internal member, who provided me with education and support from the social psychology perspective on health).

With respect to funding, I would like to acknowledge the Faculty of Graduate Studies, University of Manitoba, for awarding me the Graduate Student Thesis Research Award in the Area of Child Development. I would also like to thank the Faculty of Graduate Studies, the Faculty of Arts, the Department of Psychology and the Graduate Students Association for the travel funding that supported me in presenting a poster on my thesis at the 115th Annual Convention of the American Psychological Association in San Francisco, California. Finally, an operating grant from the Canadian Institute of Health Research held by Dr. Marni Brownell, covered the cost of printing two research posters as well as some of the technical support required for this project.

Additionally, several of the statisticians and programmers from the Manitoba Centre for Health Policy (MCHP) have generously offered me their incredible expertise throughout my journey in learning SAS programming and executing my analysis plan. Warmest thanks to Charles Burchill (my primary instructor of SAS and the person who made sure I was on track with my dataset), Shelley Derksen (an undeniably wise and kind statistician & programmer), Wendy Au (programmer-analyst), Heather Prior (programmer-analyst), and Oke Ekuma (a very talented statistician who helped make sense of the theory and programming behind my regression contrast estimates).

Finally, I would like to acknowledge the unconditional love and support provided by my family and their continued encouragement in my journey to become a clinical health psychologist. Special thanks to my fiancé Blair Van Camp, whose daily support and thoughtful presence always reminds me to keep up with my own wellness.

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Introduction

Attention-Deficit/Hyperactivity Disorder (ADHD):

Attention-Deficit/Hyperactivity Disorder (ADHD) is characterized by persistent and developmentally inappropriate problems with inattention and/ or impulsivity and hyperactivity that commence prior to the age of seven (American Psychiatric Association, 2000). In a review on ADHD diagnosis, Barkley (2003) describes inattention as the "inability to sustain responding to tasks or other activities, to remember and follow through on rules and instructions, and to resist distractions while doing so" (p.78). The hyperactivity-impulsivity dimension refers to the inability to inhibit predominant responses, such as reward seeking (Barkley, 2003).

According to the *Diagnostic and Statistical Manual of Mental Disorders, Tenth Edition, Text Revision* (DSM-IV-TR), ADHD has three major diagnostic subtypes, ADHD Combined Type, ADHD Predominantly Inattentive Type, and ADHD Predominantly Hyperactive-Impulsive Type (American Psychiatric Association, 2000). Combined Type is diagnosed if six or more symptoms (see Appendix A) of both inattention and hyperactivity-impulsivity have persisted for a period of six months or more (American Psychiatric Association, 2000). The majority of children and adolescents with ADHD have Combined Type (American Psychiatric Association, 2000). Predominantly Inattentive Type is diagnosed if six or more symptoms of inattention (but fewer than six symptoms of hyperactivity-impulsivity) are present for six months or more, and Predominantly Hyperactive-Impulsive Type is diagnosed if six or more symptoms of hyperactivity-impulsivity (but fewer than six symptoms of inattention) are present for six months or more (American Psychiatric Association, 2000).

An additional category in the DSM-IV-TR, termed Attention-Deficit/Hyperactivity Disorder Not Otherwise Specified, encompasses symptoms of hyperactivity-impulsivity and inattention that do not meet the criteria for ADHD. An example of this given in the DSM-IV-TR is: "individuals whose symptoms and impairment meet the criteria for Attention-Deficit/Hyperactivity Disorder, Predominantly Inattentive Type but whose age at onset is 7 years or after" (American Psychiatric Association, 2000). Another example given is "individuals with clinically significant impairment who present with inattention and whose symptom pattern does not meet the full criteria for the disorder but have a behavioral pattern marked by sluggishness, daydreaming, and hypoactivity" (American Psychiatric Association, 2000).

When health practitioners are assessing for ADHD, it is important for them to examine the possibility of alternative explanations for the presenting symptoms. For example, other psychiatric, medical, educational, or cultural factors may affect the individual in a way that causes behaviors that mimic ADHD. Notable differential diagnoses listed in the DSM-IV-TR that should be considered include: mental retardation, learning disabilities, age-appropriate behaviors in active children, oppositional behavior, understimulating environments, pervasive developmental disorder, psychotic disorder, and substance-related disorder not otherwise specified (American Psychiatric Association, 2000).

In addition, several conditions commonly occur along with ADHD. Specific Learning Disabilities (LD) are present in about 20% to 30% of children with ADHD and as many as 30% to 50% of all children with ADHD also have Oppositional Defiant Disorder (National Institute of Mental Health [NIMH], 2003). Furthermore, about 20% to 40% of children with ADHD also have a co-occurring Conduct Disorder (NIMH, 2003). Comorbid anxiety, depression, and bipolar disorder are also common in children with ADHD, often diagnosed as secondary disorders (NIMH, 2003). A small percentage of children with ADHD also have Tourette syndrome, although about 50% of children diagnosed with Tourette syndrome have comorbid ADHD (NIMH, 2003).

The exact cause of ADHD is still not known. Brain imaging studies suggest that there may be some specific neurological basis to the disorder. According to research conducted by the National Institute of Health's Child Psychiatry Branch, as a group, children with ADHD have 3% to 4% smaller brain volumes compared to children without ADHD (Castellanos et al., 2002). Furthermore, this decreased volume is found in most regions of the brain, including the temporal gray matter, frontal lobes, cerebellum, and caudate nucleus (Castellanos et al., 2002). Another interesting finding from this same study is that the children with ADHD who had never taken medication for treatment had an abnormally reduced amount of white brain matter compared to controls, whereas the white matter volume in children with ADHD who were receiving medication did not differ from that of controls. The authors explain that white matter consists of fibers that allow for long-distance associations between brain regions and that these fibers normally thicken with age and maturation of the brain (Castellanos et al., 2002).

Other studies have examined a genetic contribution to ADHD. It has been found that if a child's parent or sibling has ADHD, the likelihood that he or she will also have ADHD is about 25% to 30% (Acosta, Arcos-Burgos, & Muenke, 2004). Comparatively, the prevalence of ADHD in the general population is about 5% (National Institute of Mental Health, 2003). A review of genetic studies in relation to ADHD indicates that specific dopamine transporter and dopamine receptor genes have been linked to the presence of ADHD (Cook, 1999). However, Cook also states that our most accurate model of the disorder should include both genetic and environmental components. He describes this phenomenon by explaining that there are likely several genes that contribute to both protection and susceptibility. Furthermore, Cook explains that both genetic variation as well as environmental variation may contribute to positive outcomes in a substantial proportion of children with ADHD (1999).

Several non-genetic factors have also been linked to ADHD. Some of these include premature birth, brain injuries (particularly those involving the prefrontal cortex), and exposure to high levels of lead in early childhood (Barkley, 1998). However, even when taken together these factors only account for about 20% to 30% of ADHD cases among boys and an even smaller margin among girls (Barkley, 1998). Dietary factors, such as the amount of sugar consumption, and particular methods of child-rearing do not seem to play a major role in the development of ADHD (Barkley, 1998).

ADHD tends to have a global impact on the lives of those who live with it. Common areas of difficulty include nonverbal and verbal working memory, mental computation, and application of organizational strategies (Mariani & Barkley, 1997; Clark, Prior, Kinsella, 2000). Children with ADHD are reported to have significant social, emotional, and academic problems at school and at home (Klassen, Miller, & Fine, 2004). The longer a person with ADHD goes without diagnosis, the more probable it is that secondary symptoms, such as low self-esteem, frustration and boredom in school or work, depression, impaired social relationships, substance use, criminal activity, or violent behavior will develop (Hallowell & Ratey, 1995, p.52).

Historically, ADHD was believed to be a disorder of childhood, with symptoms generally having diminished by adolescence (Willoughby, 2003). Currently, ADHD is recognized as a disorder that is typically diagnosed in elementary school years, yet is a chronic condition that often persists into adulthood (American Psychiatric Association, 2000; Willoughby, 2003). The DSM-IV-TR notes that symptoms of ADHD are often observed by parents in preschool years, but a diagnosis is not usually made until school years, as many overactive toddlers do not develop ADHD (American Psychiatric Association, 2000). Furthermore, children with ADHD Predominantly Inattentive Type are often diagnosed later in childhood in part because symptoms of inattentiveness may be less recognizable than symptoms of hyperactivity (American Psychiatric Association, 2000).

In most individuals, symptoms appear to diminish with age (Willoughby, 2003), although a review paper on outcome studies states that 50% to 65% of adults with ADHD continue to experience deficits (Ingram, Hechtman, & Morgenstern, 1999). The symptoms that were noted as commonly continuing into adulthood include depression, impaired social relationships, low self concept, drug use, antisocial behavior, and occupational disadvantages (Ingram, Hechtman, & Morgenstern, 1999). McGough and Barkley have also pointed out that the symptom checklist for core ADHD symptoms was validated with children and that many of the symptoms may be inappropriate for an adult population (2004). In other words, McGough and Barkley are questioning whether adults outgrow ADHD or if they outgrow the empirical symptoms (2004). The DSM-IV-TR states that only a minority of individuals with ADHD have symptoms that persist into mid-adulthood and that those who retain only some of the symptoms are given the diagnosis of ADHD, In Partial Remission (American Psychiatric Association, 2000). With consideration to McGough and Barkley's (2004) point about using diagnostic criteria that were validated on children, the number of adults with ADHD may be much higher if the diagnostic criteria for adults were to change.

In terms of prevalence, ADHD is often cited as one of the most commonly diagnosed mental health disorder in children (Nietzel, Bernstein, Kramer, & Milich, 2003). The DSM-IV-TR reports prevalence rates of 3 to 7% in school aged children, with boys being three times more likely than girls to be diagnosed with ADHD (American Psychiatric Association, 2000; Barkley, 1998). However, the gender ratio is more equal for the Predominantly Inattentive Type (American Psychiatric Association, 2000).

Using the Manitoba Population Health Research Data Repository (a wide-ranging collection of databases that includes records for virtually all contacts with provincial health care services, which will subsequently be referred to as the Repository), researchers at the Manitoba Centre for Health Policy have investigated rates of diagnosis and treatment for ADHD in Manitoban children. The provincial diagnostic prevalence for ADHD in children was 1.52% (2.4% for males and 0.6% for females) and psychostimulant prescription prevalence was 0.89% (1.5% for males and 0.3% for females) in Fiscal Year 1995/1996 (Brownell & Yogendran, 2001). In a later study that used data from 1997 through 2001 (Martens et al., 2004), the diagnostic prevalence in Manitoba was reported as 3.0% (4.6% for males and 1.3% for females). Based on these two studies, it is clear that increasing numbers of children in Manitoba are getting diagnosed with and treated for ADHD.

Psychostimulant Treatment:

A great deal of the research on ADHD focuses on treatment using psychostimulant medications (Harpin, 2005; Steer, 2005). Psychostimulants work by inhibiting the dopamine transporters located on certain neurons, which then increases the time that dopamine takes to bind to the associated receptors on other neurons (Barkley, 1998). These medications have been found to improve the behavior of about 70% to 90% percent of children who have ADHD and are older than five years of age (Barkley, 1998). Behaviors that are said to be improved by psychostimulants include impulsivity, distractibility, restlessness, academic performance, working memory, internalized speech, and self control (Barkley, 1998).

A large-scale study, titled the Multimodal Treatment Study of Children with Attention-Deficit/Hyperactivity Disorder (MTA), conducted by the National Institute of Mental Health measured the outcomes of four treatment modalities (MTA Cooperative Group, 1999). These modalities included a medication management intervention, a behavioral treatment intervention, a combination of medication management and behavioral treatment intervention and a routine community care group.

This study included 579 elementary school boys and girls with ADHD, 95-98 at each of 6 treatment sites (MTA Cooperative Group, 1999). Children in each of the groups were reassessed regularly throughout the 14-month study period by teachers and parents on presence of hyperactivity, impulsivity, and inattention, and symptoms of anxiety and depression, as well as social skills. The children in the medication management and combined groups were seen monthly for a half hour by a physician, who would also seek input from the teachers on a monthly basis. Children in the behavioral group met up to 35 times with a behavior therapist, mostly in group sessions with their families. Behavior therapists also made repeated visits to schools to consult with children's teachers. Furthermore, the children in the behavioral group attended an 8-week summer treatment program that addressed academic, social, and sports skills, and provided intensive behavioral therapy. The combined group of children received both the medication management and behavioral treatments as described above and the children in routine community care saw a doctor 1-2 times per year. It should be noted that individuals in the community care group may or may not have received medications or behavior therapy, as they were not asked to restrict treatment choices that were beyond the study conditions.

In terms of results, the MTA Group (1999) found that all treatment resulted in ADHD symptom reduction over time. However, they report that at 14 months after the study commenced, combined and medication management groups were superior to intensive behavioral and routine community treatment. Additionally, the combined group was superior for reducing symptoms of anxiety and oppositionality, and improving academic performance, parent-child relations, and social skills. Furthermore, they found that children in the combined group could be successfully treated with lower doses of medicine compared to the medication management group (MTA Group, 1999).

Unfortunately, a more recent follow-up study from the MTA group found that these results were not maintained at the 36 month outcome point (Jensen et al., 2007). Instead, they found that there were no differences in symptom outcomes between treatment groups, although all treatment groups had successfully reduced ADHD and oppositionality symptoms (2007). They also found that their original randomized treatment group assignments began to dissipate after the initial 14 month period, with many members of the behavioral group deciding to begin a medication regime, as well as the number of medication visits for some of the children in the medication only and combined groups being reduced (presumably due to reduced symptoms; 2007). In line with this limited evidence on the long term success of available treatments, it is believed that addressing problems in functioning at an early age will lessen some of the secondary symptoms of ADHD (e.g. low self-esteem, frustration and boredom in school or work, depression, impaired social relationships, substance use, criminal activity, or violent behavior) that may otherwise develop in later life (Ingram, Hechtman, & Morgenstern, 1999; Hallowell & Ratey, 1995, p.52).

Furthermore, there is growing concern about how frequently such medications are prescribed for children (Vitiello, 2001). Previous research indicates that the psychostimulants that are frequently used in treating ADHD are relatively safe, with side effects that are typically mild and short lived (Subcommittee on Attention-Deficit/Hyperactivity Disorder and Committee on Quality Improvement, 2001; Ingram, Hechtman, & Morgenstern, 1999). The Subcommittee on Attention-Deficit/Hyperactivity Disorder and Committee on Quality Improvement reported that the side effects that do occur commonly are reduced appetite, stomach or head aches, problems with sleep onset, jitteriness, and social withdrawal (2001). Additionally, they found that about 15% to 30% of children taking stimulant medication experience motor tics, mostly of the transient type (Subcommittee on Attention-Deficit/Hyperactivity Disorder and Committee on Quality Improvement, 2001).

However, while most of these symptoms can be managed successfully by adjusting the dosages or schedule of medication (Subcommittee on Attention-Deficit/Hyperactivity Disorder and Committee on Quality Improvement, 2001), current research has identified that psychostimulants are leading to a more serious side effect that cannot be managed. A recent 3-year follow-up study from the MTA group has confirmed that psychostimulant use is related to reduced growth rates in children (Swanson et al., 2007). Furthermore, this study did not find evidence of growth rebound (2007).

Moreover, even with careful adjustments to dosage, medication still proves to be ineffective in some children. Steer (2005) estimates that for about 30% of children, medication either does not work or produces side effects that lead to withdrawal from treatment. Specific behavioral techniques recommended for use with children who have ADHD include positive and negative reinforcement, strategies to simplify, shorten, and draw attention to tasks, and the use of token economies, ‘‘time outs,’’ and home/school diaries (Steer, 2005). Barkley (1998) summarizes this by describing the importance of implementing structured environments where rules, consequences and time management are managed externally by care givers in order to compensate for the weaker internal capacities for rule following and information management that are typically found in children with ADHD. In conjunction with the finding that a combined treatment program that includes medication and behavior therapy has the most favorable short-term outcome overall, the reality that medication does not work for many children demands consideration of more diverse treatment options for ADHD from health care providers.

Socioeconomic Gradient:

Another major concern around medication prescriptions for ADHD relates to research findings that certain population groups tend to receive higher rates of such prescriptions. For example, a British Columbia study found that psychostimulant prescriptions for children within that province varied by socioeconomic status quintiles (Miller, Lalonde, McGrail, & Armstrong, 2001). Specifically, they found that in the two least privileged quintiles, 21.6 per 1000 children received methylphenidate, compared with 18.4 per 1000 in the three most privileged quintiles (Miller et al., 2001). However, since Miller et al. did not investigate ADHD diagnosis rates, it is not possible to discern whether these prescription rates are in accordance with the number of diagnoses in the study population.

Similarly, an analysis using population-based health care utilization data in Manitoba revealed that while no differences in ADHD diagnosis and prescription rates across income were observed in 1996, an inverse gradient in rates was found in 2003, with higher rates of ADHD in lower income areas (Brownell & Yogendran, 2005). This analysis also found that rates of

ADHD increased for all income areas across time, but the greatest increase was for the lowest income group (81.6% increase for diagnoses; 103.7% increase for stimulants prescribed).

Researchers have pointed out that a large majority of ADHD research has been conducted with young, middle-class, caucasian males (Rowland, Lesesne, & Abramowitz, 2002; Gingerich, Turnock, Litfin, & Rosén, 1998). In a review of ADHD and diversity issues, Gingerich, Turncock, Litfin, and Rosén (1998) state that research on the interaction between ADHD and variables such as ethnicity, gender, age, and differing socioeconomic status (SES) groups, has been relatively scarce. Additionally, in an epidemiological review of ADHD, Rowland, Lesesne, & Abramowitz (2002) state that there is no reliable information on the prevalence of socioeconomic variables in ADHD. One study by Rieppi et al. (2002) did find that SES appears to moderate treatment outcomes in children with ADHD. Their results indicate that for children with ADHD and oppositional-aggressive symptoms, those with lower SES benefited the most from combined medication and behavior therapy treatments, whereas children with higher SES had no differential treatment response (Rieppi et al., 2002). With so little literature in this area, more information on ADHD diagnosis and treatment rates with respect to SES is needed. Therefore, conducting population-based research that elucidates more information about the relationship between ADHD and SES could provide important direction for practitioners and policy makers.

Research focusing on other health outcomes has generally found not only that lower SES is associated with poorer health, but that the relationship between SES and health forms a gradient, with increases in health with each increase in SES (Marmot et al., 1991, Adler et al., 1994). Understanding whether such a gradient exists for children with ADHD could have important treatment implications. For example, if children from lower SES backgrounds are more likely to receive ADHD diagnoses, education or health programs could be implemented in lower SES regions in order to promote environments that improve the management of this disorder. This in turn could lead to better outcomes for children diagnosed with ADHD.

In terms of other research that has investigated the relationship between SES, age, and gradients in health status, a recent study on acute conditions of respiratory illness and injury found that the relationship between poor child health and low SES appeared most consistently during adolescence (Chen, Martin, & Matthews, 2006). In addition, they found that respiratory illness had a reverse SES gradient in early childhood (Chen, Martin, & Matthews, 2006). While this relationship has yet to be studied with an ADHD population, such findings support the investigation of how diagnosis and treatment of ADHD vary according to SES and age.

Furthermore, age is an important variable in ADHD research because there appears to be distinct patterns in the timing of diagnosis and treatment for males and females. Martens et al. (2004) stated that the ADHD treatment prevalence for Manitoba children peaks between 10 and 13 years of age for males and from 8 to 12 years of age for females. However, there is little known about whether an SES gradient for diagnosis and treatment of ADHD exists for particular age groups. One study did find that earlier estimated age of onset of ADHD symptoms in children is associated with a greater degree of comorbid aggressive, delinquent, and anxious/depressive symptoms in a clinically referred sample of children with ADHD (Connor et al., 2003).

Region of residence is also an important variable in ADHD research. Rowland, Lesesne, & Abramowitz (2002) indicate that prevalence rates for ADHD are higher in children in urban areas compared to children in rural areas. Brownell & Yogendran's Manitoba study (2001), also found that children in urban areas were more likely to be diagnosed with ADHD than children from rural areas, although ADHD-diagnosed children from rural locations were more likely to receive medications, particularly if they were from higher income levels. This finding supports further investigation into the relationship between region of residence and SES for diagnosis and treatment rates of ADHD. However, the authors suggested that this finding may be in part caused by the lack of data on health care received in nursing stations in certain northern remote rural locations (Brownell & Yogendran, 2001).

As mentioned earlier, Oppositional Defiant Disorder (ODD), Conduct Disorder (CD), and specific Learning Disabilities are very commonly comorbid with ADHD (National Institute of Mental Health, 2003). However little is known about the relationship between SES and comorbid diagnosis and treatment for ADHD. An American study by August, Realmuto, MacDonald, Nugent, & Crosby (1996) found lower SES to be associated with a greater likelihood of having a diagnosis of ADHD on its own or of having a diagnosis of ADHD as well as another comorbid mental disorder. In particular they found that children with ADHD and a comorbid externalizing disorder (i.e. ODD or CD) had the greatest likelihood of having the lowest SES (August et al., 1996).

Rationale and Objectives:

The proposed study investigated both diagnosis and treatment prevalence of ADHD in various sub-groupings of Manitoba children. Subsequently, this analysis has added to the literature on ADHD with relation to diagnosis, psychostimulant prescriptions, SES, sex, age, region of residence, and co-occurrence with learning disabilities and behavioral disturbances. It has furthered Manitoba research in this area by considering SES within varying age groups and within two types of comorbid categories and by analyzing more recent data (from 2003-2005) than previous studies using this population-based data resource.

It should be noted that the Repository is a comprehensive collection of administrative, registry, survey and other databases primarily comprising residents of Manitoba. It was developed to describe and explain patterns of health care and profiles of health and illness, facilitating inter-sectoral research in areas such as health care, education, and social services. The administrative health database, for example, holds records for virtually all contacts with the provincial health care system, the *Manitoba Health Services Insurance Plan* (including physicians, hospitals, personal care homes, home care, and pharmaceutical prescriptions) of all registered individuals. With data derived from a multitude of sources, the Repository is a unique and valuable resource that has received world-wide recognition (Evans, Mustard, & Fraser, 1999).

The specific research objectives for the proposed study were:

1) To determine the prevalence rates of ADHD diagnosis and psychostimulant prescriptions for Manitoba children (0 to 19 years of age) in two Fiscal Years 2003/2004 and 2004/2005. These rates were calculated according to:
    - Sex
    - Age groups
    - Region of Residence (Rural and Urban)
    - SES
    - Comorbid diagnosis with learning disabilities and/or for behavioral disturbances

2) To investigate whether an SES gradient for the diagnosis and treatment of ADHD exists within:
   - The entire population of Manitoba
   - Urban and rural areas of Manitoba
   - Particular age groups (i.e. 0 to 3, 4 to 6, 7 to 9, 10 to 13, and 14 to 19)
   - The subset of children who receive a diagnosis of ADHD as well as a comorbid diagnosis for learning disabilities and/or for behavioral disturbances

Hypotheses

Based on previous findings (Brownell & Yogendran, 2001; Martens et al., 2004; Brownell & Yogendran, 2005), it was hypothesized that more boys than girls would be diagnosed with and treated for ADHD, with an approximate ratio of 3 or 4 to 1. In addition, it was hypothesized that both diagnosis and treatment rates would be highest in children aged 10 to 13, next highest at 7 to 9, then 14 to 19, 4 to 6, and 0 to 3. The basis for this hypothesis was the analysis conducted by Brownell and Yogendran (2005).

In terms of SES, children with lower SES were expected to have higher rates of diagnosis and treatment compared to children with higher SES and this relationship was predicted to occur in an inverse gradient form (i.e. increasing rates of ADHD with decreasing SES). This hypothesis is supported by the findings of Miller, Lalonde, McGrail, and Armstrong (2001) and Brownell and Yogendran (2001, 2005). It was also hypothesized that there would be higher rates of diagnosis and treatment of ADHD for children in urban areas compared to children in rural locations. This hypothesis is based on findings from Rowland, Lesesne, & Abramowitz (2002) as well as the Manitoba studies by Brownell & Yogendran (2001) and Martens et al. (2004). However it was also hypothesized that for children living in rural areas, higher diagnosis and treatment rates would be found in children with higher SES. This hypothesis is based on results from Brownell & Yogendran (2001).

As mentioned earlier, little is known about whether an SES gradient for diagnosis and treatment of ADHD exists for particular age groups. However, since Chen, Martin, and Matthews (2006) found that the relationship between poor child health and low SES appeared most consistently during adolescence for acute conditions of respiratory illness and injury and that respiratory illness had a reverse SES gradient in early childhood, it was believed that a similar pattern would be found in Manitoba children with ADHD. In other words, children ages 14 to 19 were expected to have an inverse SES gradient (i.e. increasing rates of ADHD with decreasing SES) and children ages 0 to 13 were hypothesized to have a direct SES gradient (i.e. decreasing rates of ADHD with decreasing SES). Part of the rationale for this hypothesis was that children with higher SES may get diagnosed sooner in life than children with lower SES, perhaps due to parents having lower thresholds for noticing symptoms and taking their child to the doctor (Chen, Martin, and Matthews, 2006) or a greater awareness of the disorder on the part of parents with higher education levels.

Since very little research has been conducted on the relationship between SES and comorbid diagnoses in children with ADHD, it is difficult to provide strong support for a hypothesis. However, since Oppositional Defiant Disorder, Conduct Disorder, and specific Learning Disabilities are very commonly comorbid with ADHD (National Institute of Mental Health, 2003) and higher overall rates of mental disorders are generally found in members of lower SES groups (Cockerham, 2003), it was an important investigation. Furthermore, August, Realmuto, MacDonald, Nugent, & Crosby (1996) did find that lower SES is associated with a greater likelihood of having a diagnosis of ADHD as well as another comorbid mental disorder and that children with ADHD and a comorbid externalizing disorder (i.e. ODD or CD) had the greatest likelihood of having the lowest SES. Therefore, it was hypothesized that children with ADHD and lower SES would be more likely to have a comorbid diagnosis relating to behavioral disturbances or learning disabilities. Please see Table 1 for an overview of the hypotheses.

Table 1

Overview of Study Hypotheses

	Diagnosis Rate	**Treatment Rate**
1. Sex	Higher in Boys than in Girls	Higher in Boys than in Girls
2. Age	In decreasing order: 10 to 13, 7 to 9, 14 to 19, 4 to 6, and 0 to 3	In decreasing order: 10 to 13, 7 to 9, 14 to 19, 4 to 6, and 0 to 3
3. SES	Increases with decreasing SES	Increases with decreasing SES
4. Region of Residence	Higher in Urban areas compared to Rural areas	Higher in Urban areas compared to Rural areas
5. Age and SES	Children 0 to 13: decreases with decreasing SES, Children 14 to 19: increases with decreasing SES	Children 0 to 13: decreases with decreasing SES, Children 14 to 19: increases with decreasing SES
6. Region of Residence and SES	Rural areas: Higher in children with higher SES, Urban Areas: Higher in children with lower SES	Rural areas: Higher in children with higher SES, Urban Areas: Higher in children with lower SES

7. Comorbid Diagnoses and SES	Higher in children with lower SES	Higher in children with lower SES

Methods

Data Sources:

Using the Manitoba Population Health Research Data Repository (henceforward referred to as the Repository), population-based information on the diagnosis and psychostimulant treatment of ADHD within a two year period (2003/04-2004/05) was examined. Manitoba Health, the government department which administers the health insurance program for the province, provides these data for use at the Manitoba Centre for Health Policy (MCHP). The data are transferred in the form of anonymized records of Manitoban residents' interactions with the health care system. Due to the fact that Manitoba has a health care system that offers universal coverage, health services reported in this database include the large majority of services received by virtually all Manitobans who have made contacts with the health care system.

Most health data for Manitobans are available in the Repository from 1984 onward. All records in the Repository are anonymous, as they contain no names or addresses. Instead, an encrypted identifier allows for linkages across databases and years of data. The health data in the Repository have been studied extensively and validated for research purposes (Roos et al., 1993; Roos & Nicol, 1999).

Physician claims files were used to determine diagnosis rates of ADHD in Manitoban children. The data originates from the Manitoba Health Services Insurance Plan (MHSIP) records, which is the agency that facilitates health care coverage for Manitoba residents. Most physicians in Manitoba are reimbursed for their services on a fee-for-service basis.

Consequently, almost all physician visits are captured in this database, with the exception of emergency visits and services from certain sessional physicians. Visits to nurses at nursing stations, which occur mostly in northern remote communities, are also not captured in the Repository, which could lead to undercounting of ADHD diagnosis and psychostimulant treatment for children residing in these communities. Each claim contains a unique numerical family identifier and a numeric patient identifier. Additionally, all claims include an ICD-9-CM or ICD-10 diagnosis code (recorded to the third digit).

Hospital files were used in the same manner, as some diagnoses and treatment for ADHD may occur while a child is in hospital. These files contain abstracts (summaries) of demographic (including PHIN) and clinical information for all hospital discharges as part of the global operating budget funding process. The information contained in hospital discharge databases is generally considered very accurate as abstracts missing information are returned to the hospital (by the Canadian Institute for Health Information) for completion. Psychostimulant prescription information was taken from the Drug Program Information Network (DPIN), which contains administrative data with records of prescriptions given to Manitoba residents for use out of hospital. In other words, all prescriptions filled in pharmacies or hospitals (for outpatients) are recorded in the DPIN. These claims are also coded using numeric patient identifiers and they also include drug identification numbers (DIN) and information on quantity and date given.

Study population, study period, and definitions:

For this study, diagnosis rates were determined using the *International Classification of Diseases, Ninth Edition, Clinical Modification* (ICD-9-CM; Hart, Schmidt, & Aaron, 1999) and the *International Classification of Diseases, Tenth Edition* (ICD-10; World Health Organization, 2006), classification systems. ADHD is represented by the ICD-9-CM code of 314 (termed hyperkinetic syndrome of childhood) and the ICD-10 code of F90 (termed hyperkinetic disorders). In addition, children who had two or more prescriptions for a psychostimulant and no diagnosis for Conduct disorder, Narcolepsy or Catalepsy (which are also sometimes treated with psychostimulants) were classified as having a diagnosis of ADHD. Treatment rates were based on the prescription for a psychostimulant (including Ritalin, Dupram, Vivarin, or Dexedrine) occurring during the study period. Physician claims, hospital discharge, and Drug Program Information Network (DPIN) files informed diagnosis rates and treatment was defined by prescriptions made in Manitoba health drug claims records (from DPIN). These methods of determining ADHD prevalence and treatment were defined for use with Repository data by Brownell and Yogendran (2001) and Martens et al. (2004).

While other forms of treatment for ADHD, such as behavior therapy, are also employed by some Manitoba health practitioners (e.g. psychiatrists and psychologists), this study only considered treatment with respect to psychostimulant use. This decision was based on the lack of comprehensiveness of information on other treatment types as well as the pervasiveness of psychotropic treatment for ADHD.

This cross-sectional analysis used two fiscal years of data (2003/2004 and 2004/05), including all children aged 0 to 19 years in the province of Manitoba (n = 319,506) with a diagnosis of ADHD (n= 9,233). Two fiscal years of data are used because previous research with this dataset indicates that given the persistent nature of ADHD, one year often does not capture all current diagnosis and treatment cases (Brownell & Yogendran, 2001). Rates of diagnosis and treatment for ADHD were analyzed according to the following categories: sex, age at the first visit during the study period, urban and rural provincial regions of residence (determined by municipal and postal codes, with *urban* referring to residents of Winnipeg and Brandon and *rural* referring to all other residents of Manitoba), SES, income, and comorbidity with learning disabilities or behavioral disturbances (as measured by ICD-9-CM and ICD-10 codes).

For learning disabilities, the ICD-9-CM codes that were used were 315 (specific delays in development) and 317-319 (mental retardation). Specific delays in development includes specific reading disorders, arithmetical disorders, other learning difficulties, developmental speech or language disorders, coordination disorders (not due to a neurological disorder), mixed development disorder, and other specified or unspecified delays in development. The ICD-10 codes that were used were F80-F83 and F88-89 (disorders of psychological development) and F70-F79 (mental retardation). The disorders of psychological development include specific developmental disorders of speech and language, specific developmental disorders of scholastic skills, specific developmental disorder of motor function, mixed specific developmental disorders, other disorders of psychological development, and unspecified disorder of psychological development.

The ICD-9-CM codes used for behavioral disturbances were 312 and 313 (disturbance of conduct, not elsewhere classified and disturbance of emotions specific to childhood and adolescence, respectively). Disturbance of conduct, not elsewhere classified includes the sub-categories of undersocialized conduct disorder, socialized conduct disorder, disorders of impulse control not elsewhere classified, mixed disturbance of conduct and emotions, and other specified or unspecified disturbances of conduct. Disturbance of emotions specific to childhood and adolescence includes the sub-categories of overanxious disorder, misery and unhappiness disorder, sensitivity, shyness and social withdrawal disorder, relationship problems, other mixed emotional disturbances of childhood or adolescence (including oppositional disorder, identity disorder, academic underachievement disorder, and other), and unspecified emotional disturbance of childhood or adolescence.

The ICD-10 codes used for behavioral disturbances were F91-F94 and F98. The specific categories for these codes are conduct disorders, mixed disorders of conduct and emotions, emotional disorders with onset specific to childhood, disorders of social functioning with onset specific to childhood and adolescence, other behavioral and emotional disorders with onset usually occurring in childhood and adolescence.

To measure SES, this study used an area-level average household income (grouped into quintiles) derived from 2001 Census data. The reasoning for using this construct for SES is that past research on ADHD in Manitoban children has used income quintiles as the variable for SES (Brownell & Yogendran, 2001; Martens et al., 2004), which allows for more interpretable cross-year comparisons. Furthermore, some researchers suggest that asset-based measures of SES, such as income, may be more sensitive to detecting gradients over time because they are more prone to fluctuate (Chen, Martin, & Matthews, 2006).

Crude rates are reported for prevalence of diagnosis and treatment by sex, age, income quintiles, SES, region of residence (i.e. urban versus rural), comorbid learning disabilities, and comorbid behavioral disturbances. The crude rate was calculated as the number of diagnoses or prescriptions divided by the total population relevant for the measure. For this study, crude rates were calculated by dividing the number of children with an ADHD diagnosis or prescription by the total population and then multiplying by 100, which then gives the crude rate per 100. The benefits of using crude rates are that they use a relatively simple calculation and that they provide a broad picture of rates during a particular period of time. However, it should be noted that crude rates cannot account for confounding variables that are not included in the calculation (e.g. the impact of age distribution when comparing regions of residence).

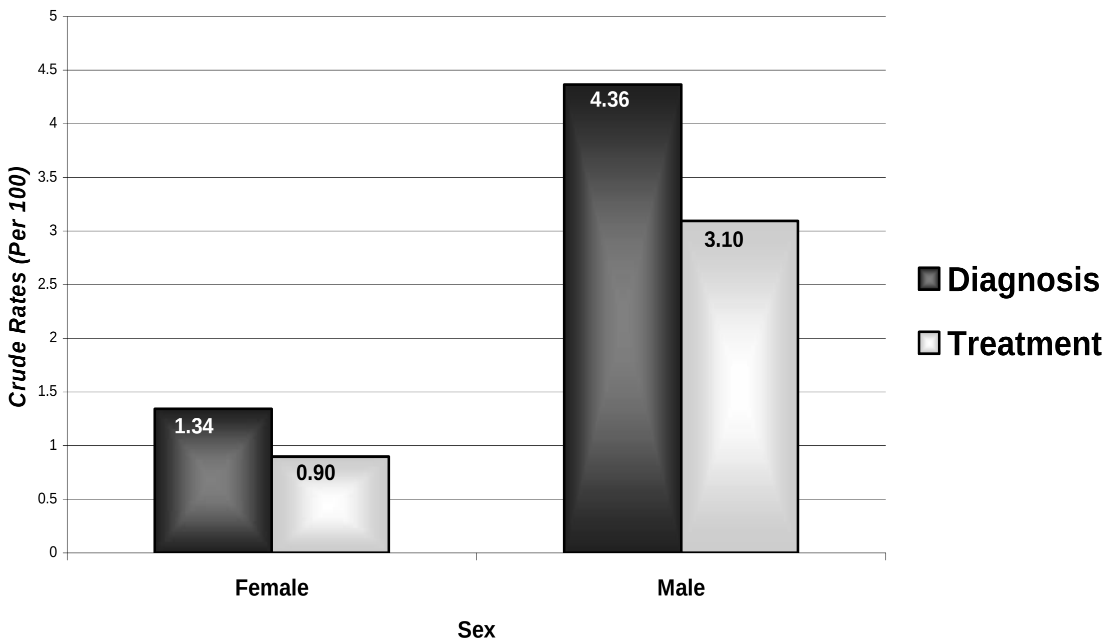
Subsequently, the relationships between the dependent and independent variables were explored using a negative binomial distribution. A multiple Poisson regression analysis, which counts the number of events in a population stratum as a function of explanatory variables such as sex, age, income quintile, region of residence, and comorbid conditions, was attempted first. However, Poisson regression is an appropriate analysis technique for rare events that are homogeneously distributed across the population and variance heterogeneity was observed across the population strata. Consequently, a negative binomial distribution was selected instead of a Poisson distribution to model the data (Littell, Stroup, & Freund, 2002). Two-way interactions among the explanatory variables were also investigated. Data analyses were performed using SAS® statistical analysis software, version 9.1 (2002).

Results

Crude Rate Analysis:

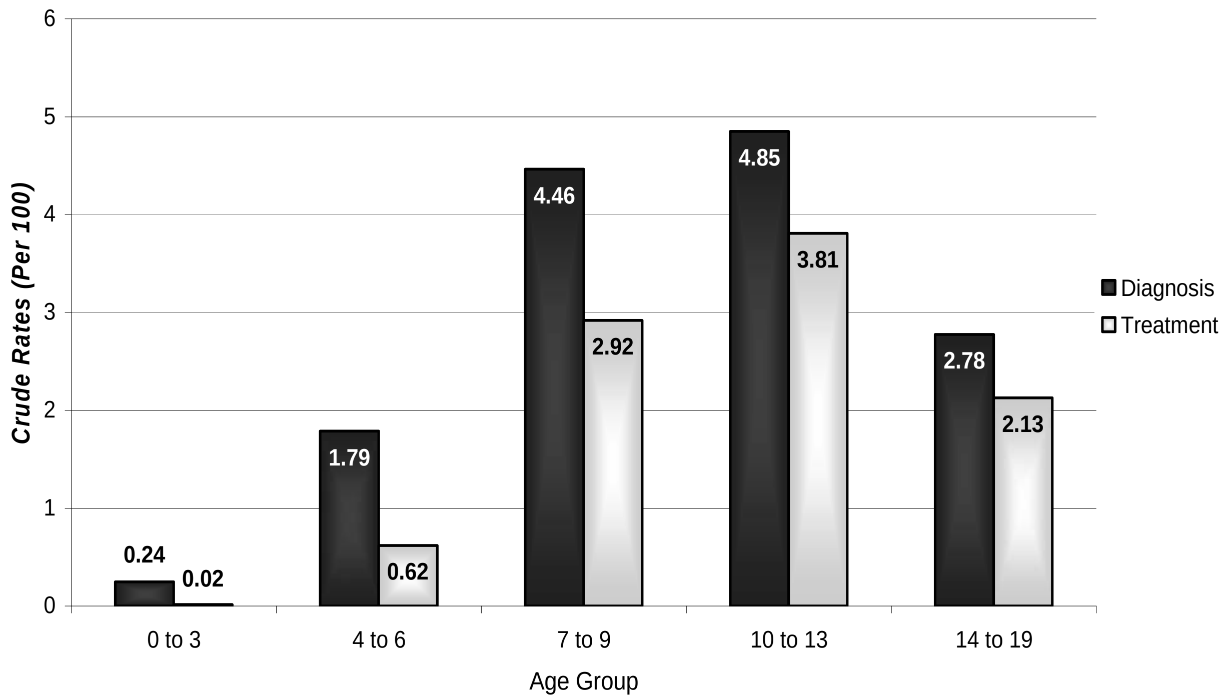
The overall crude rate of ADHD diagnosis for Manitoba children (aged 0 to 19) in the 2004/2005 fiscal year was 2.89%, with 9,233 children having an ADHD diagnosis as defined in this project out of a total provincial child population of 319,506. Furthermore, the crude rate for treatment during this time period was 2.02%, with 6,463 Manitoba children receiving two or more prescriptions for a psychostimulant medication out of the total provincial child population of 319,506. The results for crude rates according to sex give the expected ratio of 3 or 4 to 1 for both diagnosis and treatment. Out of the total male child population of 163,698, 7,144 (4.36%) had a diagnosis for ADHD and 5,067 (3.10%) received treatment for ADHD (see Figure 1). In regard to the total female child population of 155,808, 2,089 (1.34%) had a diagnosis for ADHD and 1,396 (0.90%) received treatment for ADHD (see Figure 1).

Figure 1. Crude rates of ADHD diagnosis and treatment by sex in 2004/05.



Crude rates for age also followed expected patterns. The crude diagnostic rate for Manitoba children in the 2004/2005 fiscal year was highest in children aged 10 to 13 years (4.85%, or 3,320 of 68,475 children), next highest at 7 to 9 years (4.46%, or 2,184 of 48,937 children), then 14 to 19 years (2.78%, or 2,791 of 100,552 children), 4 to 6 years (1.79%, or 799 of 44,694 children), and finally 0 to 3 years (0.24%, or 139 of 56,848 children) [see Figure 2]. Similar in pattern, the crude treatment rate for Manitoba children in the 2004/2005 fiscal year was highest in children aged 10 to 13 years (3.81%, or 2,608 of 68,475 children), next highest at 7 to 9 (2.92%, or 1,429 of 48,937 children), then 14 to 19 (2.13%, or 2,140 of 100,552 children), 4 to 6 (0.62%, or 277 of 44,694 children), and finally 0 to 3 years (0.02%, or 9 of 56,848 children) [see Figure 2].

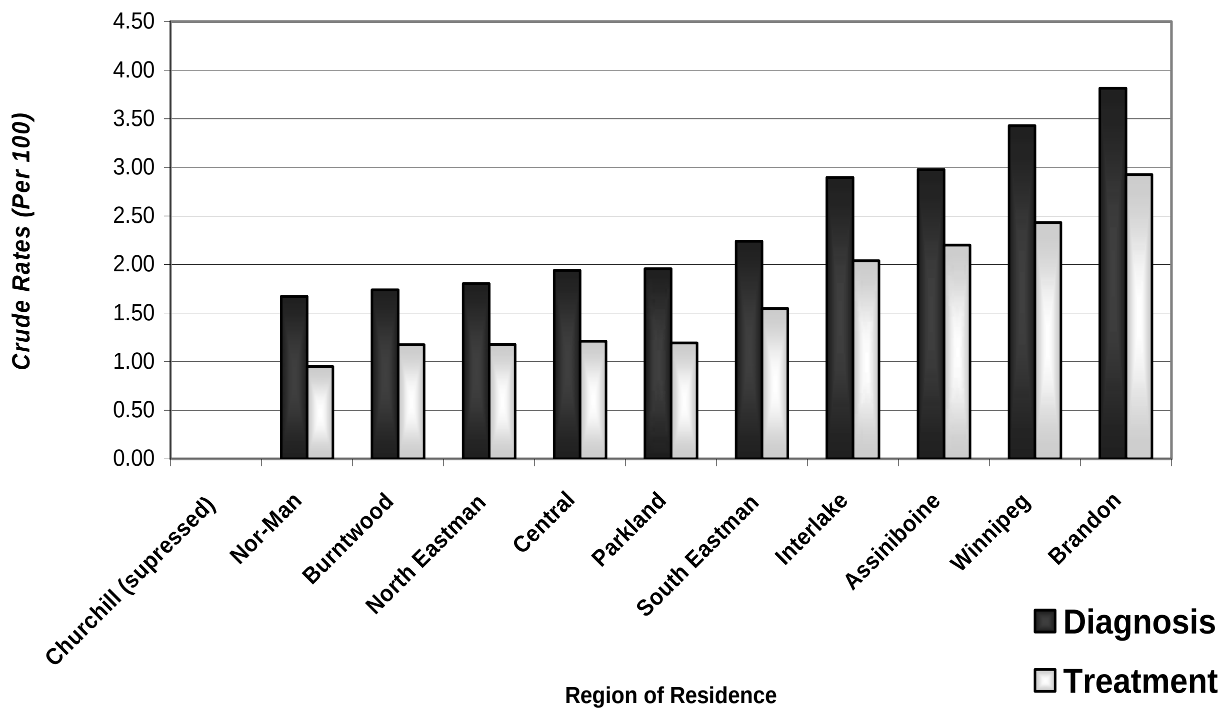
Figure 2. Crude rates of ADHD diagnosis and treatment by age in 2004/05.



In terms of Manitoba region of residence, the general pattern of higher crude rates in urban areas as compared to rural areas was found. The crude diagnostic rate for Manitoba children in the 2004/2005 fiscal year was highest in children who lived in Brandon (3.81%, or 497 of 13,029 children), followed by Winnipeg (3.43%, or 5,662 of 165,151 children), then Assiniboine (2.98%, or 544 of 18,273 children), Interlake (2.90%, or 605 of 20,880 children), South Eastman (2.24%, or 259 of 11,564 children), Parkland (1.96%, or 228 of 11,653 children), Central (1.94%, or 611 of 31,512 children), North Eastman (1.80%, or 341 of 18,925 children), Burntwood-Churchill (1.72%, 342 of 19,895 children), and finally Nor-Man (1.67%, or 144 of

8624 children) [see Figure 3]. In terms of treatment prevalence, crude rates were: highest in children who live in Brandon (2.92%, or 381 of 13,029 children), followed by Winnipeg (2.43%, or 4018 of 165,151 children), then Assiniboine (2.20%, or 402 of 18,273 children), Interlake (2.04%, or 426 of 20,880 children), South Eastman (1.55%, or 179 of 11,564 children), Central (1.21%, or 382 of 31,512 children), Parkland (1.19%, or 139 of 11,653 children), North Eastman (1.18%, or 223 of 18,925 children), Burntwood-Churchill (1.16%, 231 of 19,895 children), and finally Nor-Man (0.95%, or 82 of 8624 children) [see Figure 3].

Figure 3. Crude rates of ADHD diagnosis and treatment by geographical region in 2004/05.



Prevalence rates of ADHD diagnosis and treatment by income quintile were first considered within the entire population of Manitoba children 0 to 19 years of age. As can be observed in Figure 4, no distinct patterns emerged at this level of analysis. Crude rates for diagnosis were 2.80%, 2.93%, 2.95%, 2.67%, and 2.78% for Q1 through Q5, respectively, and crude rates for treatment were 0.95%, 1.00%, 1.03%, 0.93%, and 1.06% for Q1 through Q5, respectively. Income quintiles were then split into urban and rural geographical location and crude rates were determined separately for each. The crude diagnostic rate for urban Manitoba children in the 2004/2005 fiscal year was highest in children in the lowest income quintile (U1; 4.11%, or 1,456 of 35,453 children), followed by the second lowest quintile (U2; 3.53%, or 1,154 of 32,664 children), then the middle quintile (U3; 3.41%, or 1,134 of 33,269 children), the second highest quintile (U4; 3.05%, or 1,100 of 36,048 children), and finally the highest quintile (U5; 3.00%, or 1,167 of 38,893 children) [see Figure 5]. Similarly, the prescription crude rate for Urban Manitoba children in the 2004/2005 fiscal year was highest in children in the lowest income quintile (U1; 2.93%, or 1,040 of 35,453 children), followed by the second lowest quintile (U2; 2.43%, or 794 of 32,664 children), then the middle quintile (U3; 2.38%, or 793 of 33,269 children), the highest quintile (U5; 2.33%, or 908 of 38,893 children), and finally the second highest quintile (U4; 2.14%, or 771 of 36,048 children) [see Figure 5].

Figure 4. Crude rates of ADHD diagnosis and treatment in Manitoba children by income quintile in 2004/05.

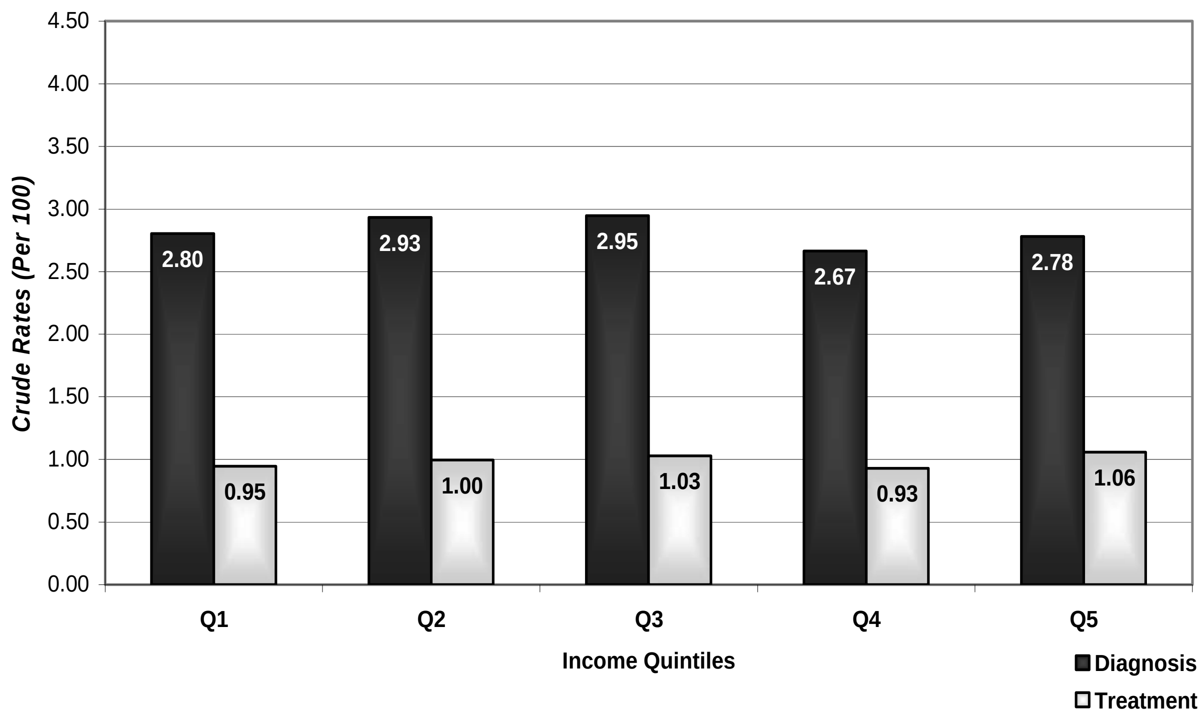
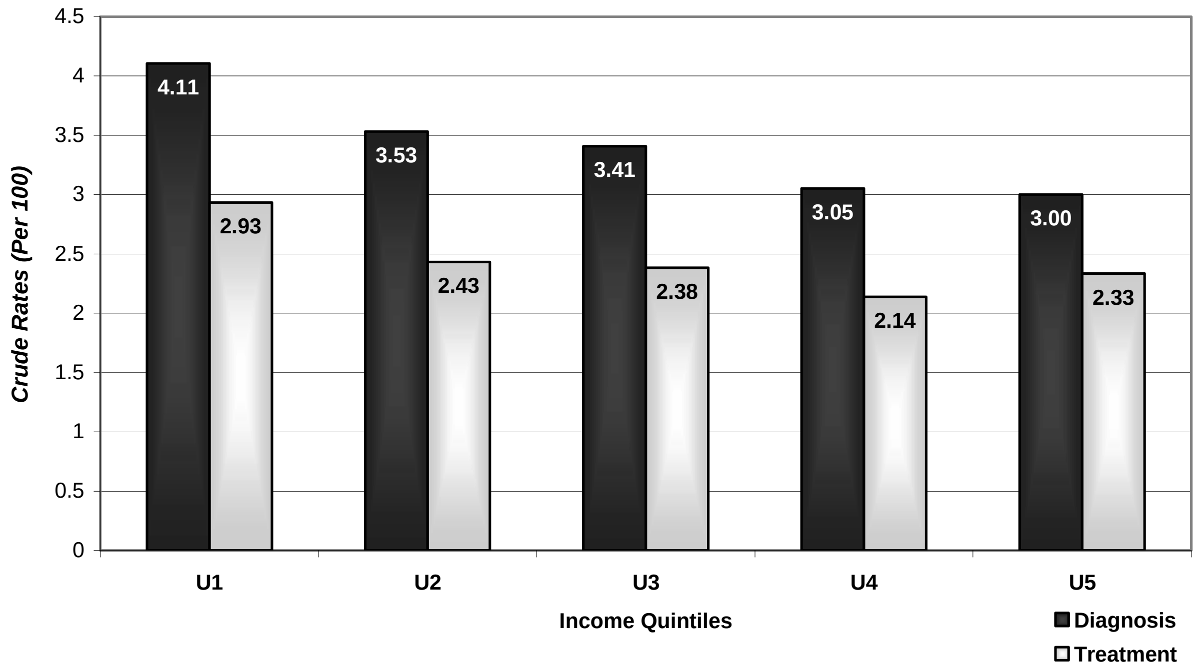
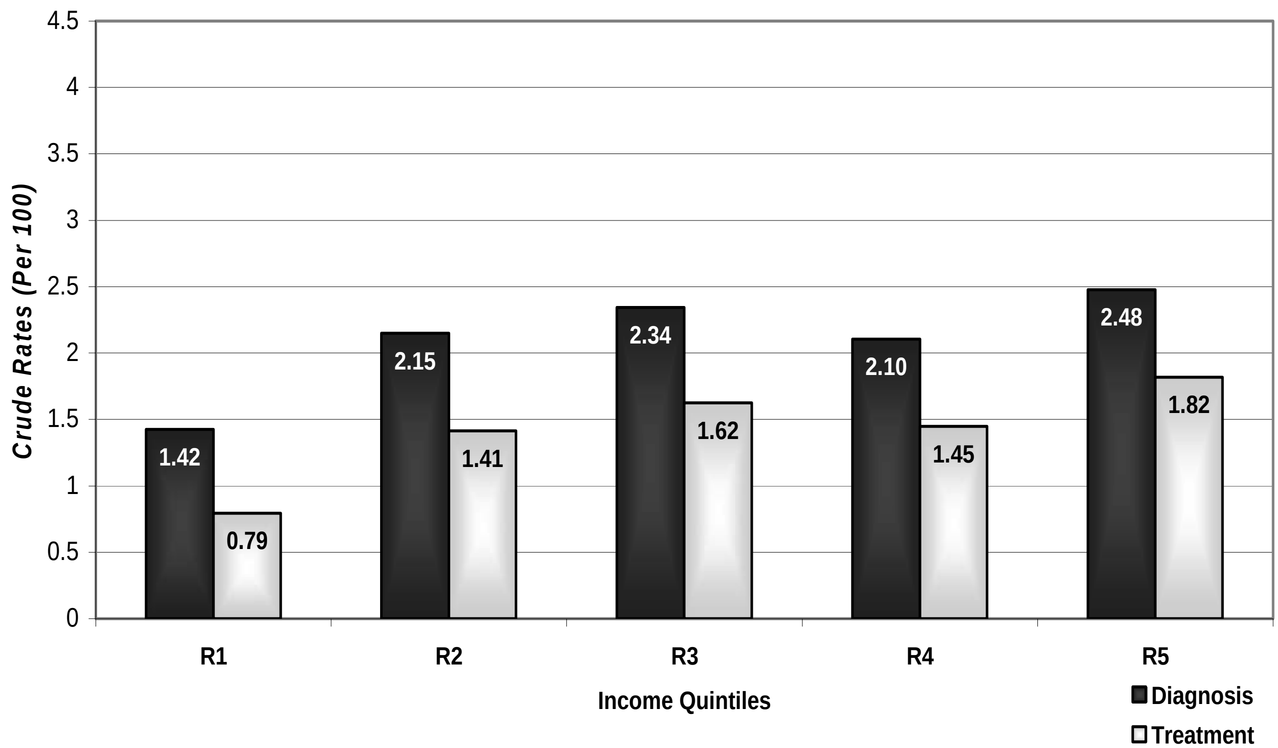


Figure 5. Crude rates of ADHD diagnosis and treatment in urban Manitoba children by income quintile in 2004/05.



Following a somewhat reverse pattern, the crude diagnostic rate for Rural Manitoba children in the 2004/2005 fiscal year was highest in children in the highest income quintile (R5; 2.48%, or 707 of 28,533 children), followed by the middle quintile (R3; 2.34%, or 597 of 25,481 children), then the second lowest quintile (R2; 2.15%, or 536 of 24,950 children), the second highest quintile (R4; 2.10%, or 520 of 24,720 children), and finally the lowest quintile (R1; 1.42%, or 479 of 33,616 children) [see Figure 6]. Finally, the crude prescription rate for Rural Manitoba children in the 2004/2005 fiscal year was highest in children in the highest income quintile (R5; 1.82%, or 519 of 28,533 children), followed by the middle quintile (R3; 1.62%, or 414 of 25,481 children), then the second highest quintile (R4; 1.45%, or 358 of 24,720 children), the second lowest quintile (R2; 1.41%, or 353 of 24,950 children), and finally the lowest quintile (R1; 0.79%, or 267 of 33,616 children) [see Figure 6].

Figure 6. Crude rates of ADHD diagnosis and treatment in rural Manitoba children by income quintile in 2004/05.



Crude rates were also determined for age groups according to income quintiles. Data from the 0 to 3 age category were suppressed due to small numbers. These rates were also split into urban and rural populations, as these populations follow distinctly different patterns. As can be seen in Figures 7 and 8, crude rates for both diagnoses and prescriptions for urban children in all age groups, with the exception of 14 to 19 year olds, decreased with increasing income quintiles. Interestingly, the 14 to 19 year old age group did not follow a pattern for either diagnostic or prescription rates. In addition, crude rates for diagnoses and prescriptions for rural children in all age groups did not follow any distinct trends (see Figures 9 and 10). Data for crude rates for both diagnoses and prescriptions for Manitoba children in the 2004/2005 fiscal year can be found in Appendix B.

Figure 7. Crude rates of ADHD diagnosis in urban Manitoba children by age and income quintile in 2004/05.

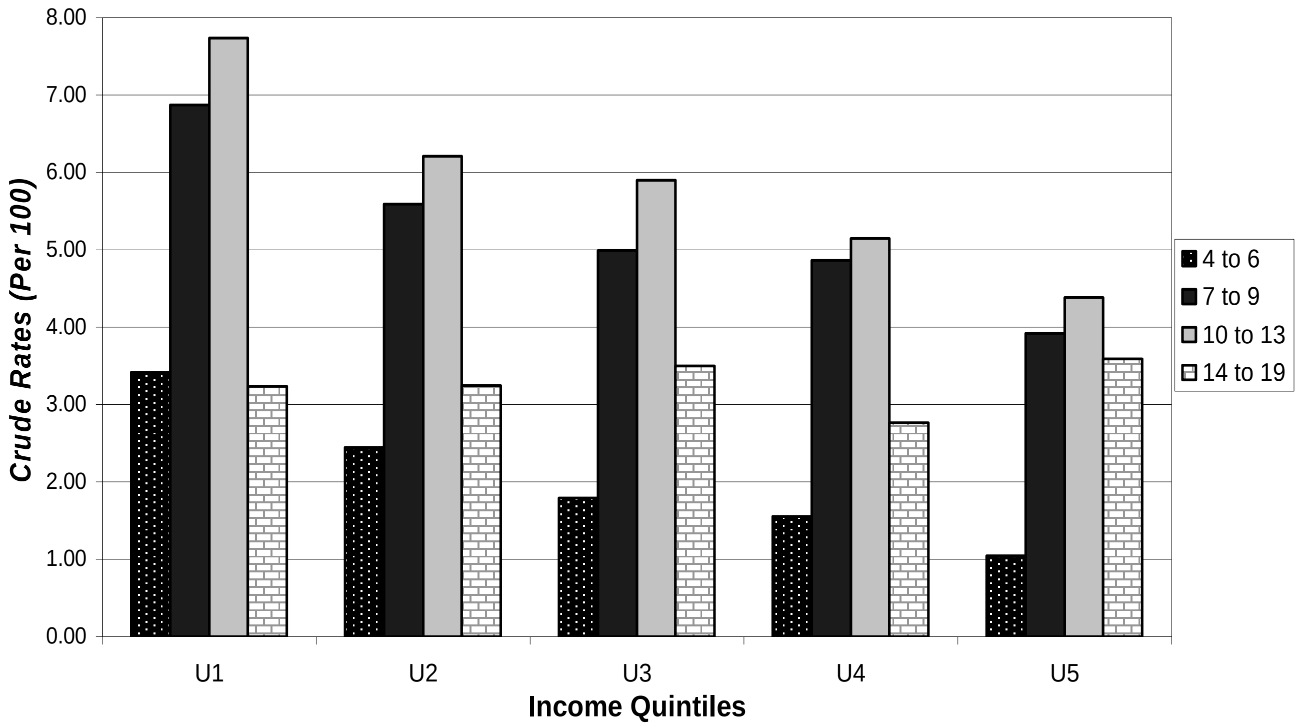


Figure 8. Crude rates of ADHD prescriptions in urban Manitoba children by age and income quintile in 2004/05.

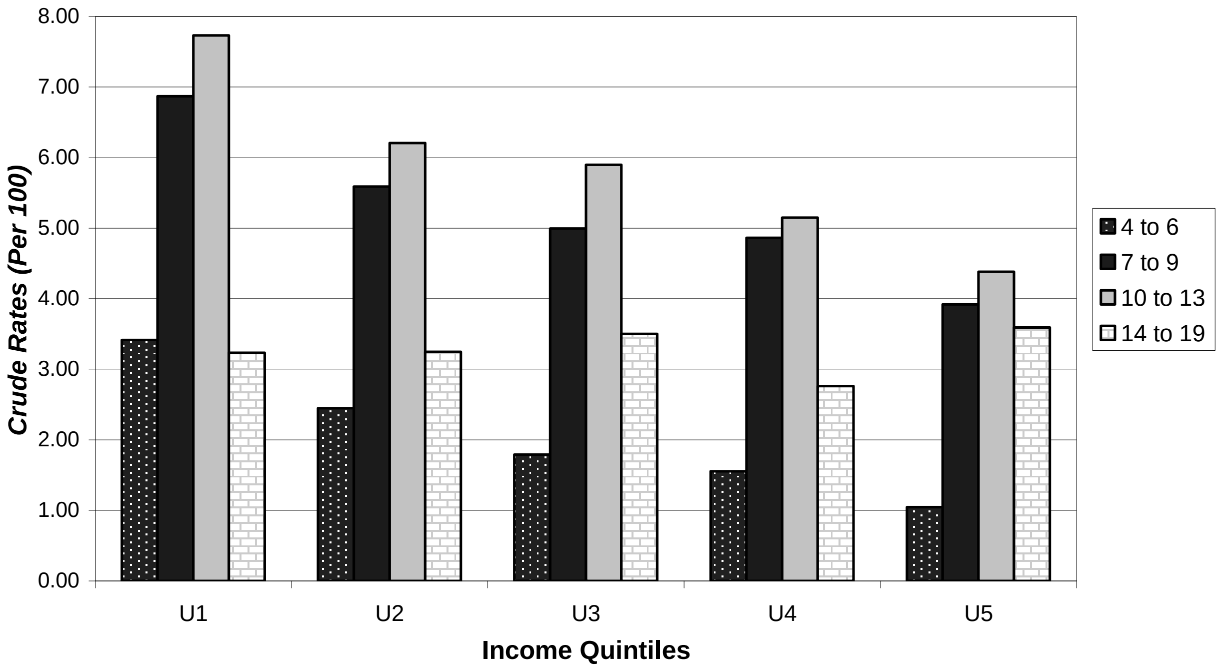


Figure 9. Crude rates of ADHD diagnosis in rural Manitoba children by age and income quintile in 2004/05.

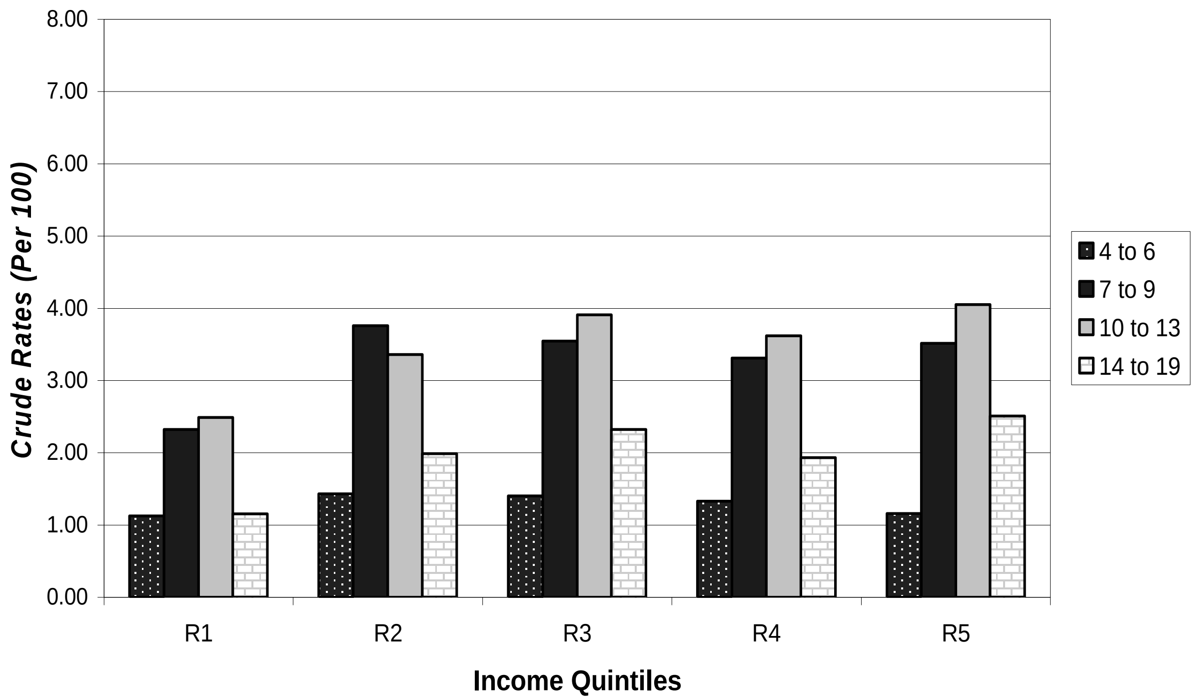
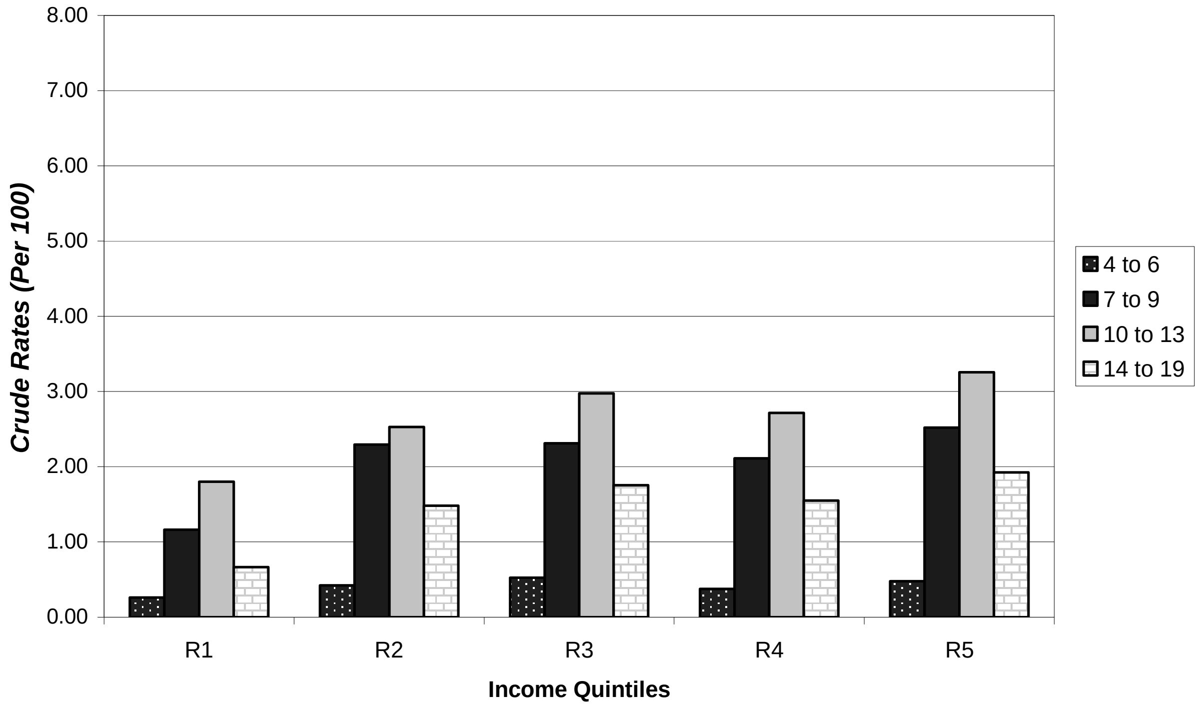


Figure 10. Crude rates of ADHD prescriptions in rural Manitoba children by age and income quintile in 2004/05.



This study also considered crude rates for ADHD with both Behavioral Disturbances (BD) and Learning Disabilities (LD). A few descriptive statistics of these variables in and of themselves have been included in this section, as they may provide some helpful information for interpretation. Of the 3,201 BD diagnoses made in the 2004/2005 fiscal year, 1,173 (36.64%) were female and 2,028 (63.36%) were male. With respect to age groups and BD diagnoses, 424 (13.25%) were 0 to 3 years old, 716 (22.37%) were 4 to 6 years old, 554 (17.31%) were 7 to 9 years old, 688 (21.49%) were 10 to 13 years old and 819 (25.59%) were 14 to 19 years old. Finally, 2,324 (72.60%) of BD diagnoses were given to children living in urban areas and 877 (27.40%) were given to children from rural areas.

Furthermore, there were 2,524 LD diagnoses during the same time period, 818 (32.41%) female and 1,706 (67.59%) male. In terms of age groups and LD diagnoses, 848 (33.60%) were 0 to 3 years old, 882 (34.94%) were 4 to 6 years old, 331 (13.11%) were 7 to 9 years old, 222 (8.80%) were 10 to 13 years old, and 241 (9.55%) were 14 to 19 years old. Lastly, 1,590 (63.0%) of LD diagnoses were given to urban children and 934 (37.0%) were given to children from rural areas. Of particular interest are the somewhat opposite trends between BD and LD diagnosis rates by age, with BD rates tending to increase slightly with age and LD rates tending to decrease dramatically with age.

For Manitoba children aged 0 to 19 in the 2004/2005 fiscal year diagnosed with ADHD, 10.39% have a comorbid diagnosis of BD and 3.85% have a comorbid diagnosis of LD (see Figures 11 and 12). Furthermore, the crude rate for comorbid psychostimulant prescriptions and BD was 8.11% and the crude rate for psychostimulant prescriptions and LD was 2.43% for Manitoba children aged 0 to 19 in the 2004/2005 fiscal year.

Figure 11. Crude Rate of Comorbid ADHD and Behavioral Disturbances (BD) in 2004/05.

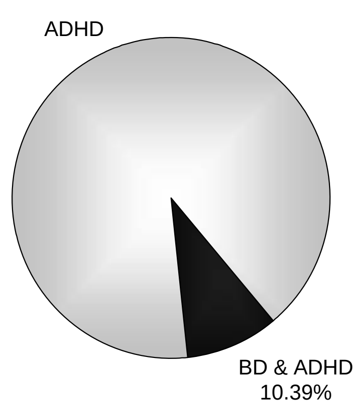
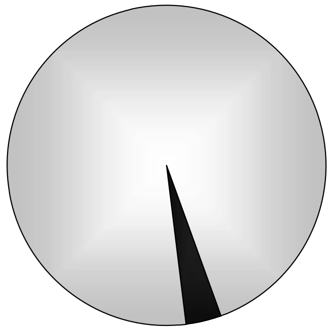
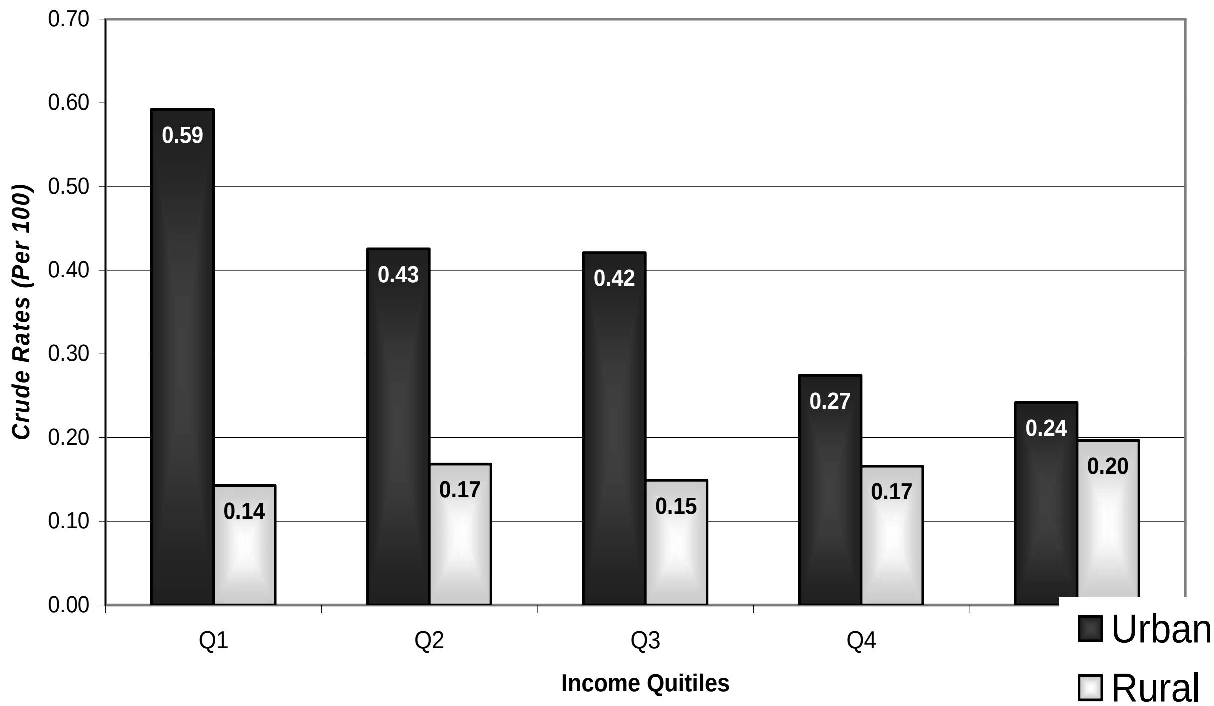


Figure 12. Crude Rate of Comorbid ADHD and Learning Disabilities (LD) in 2004/05.



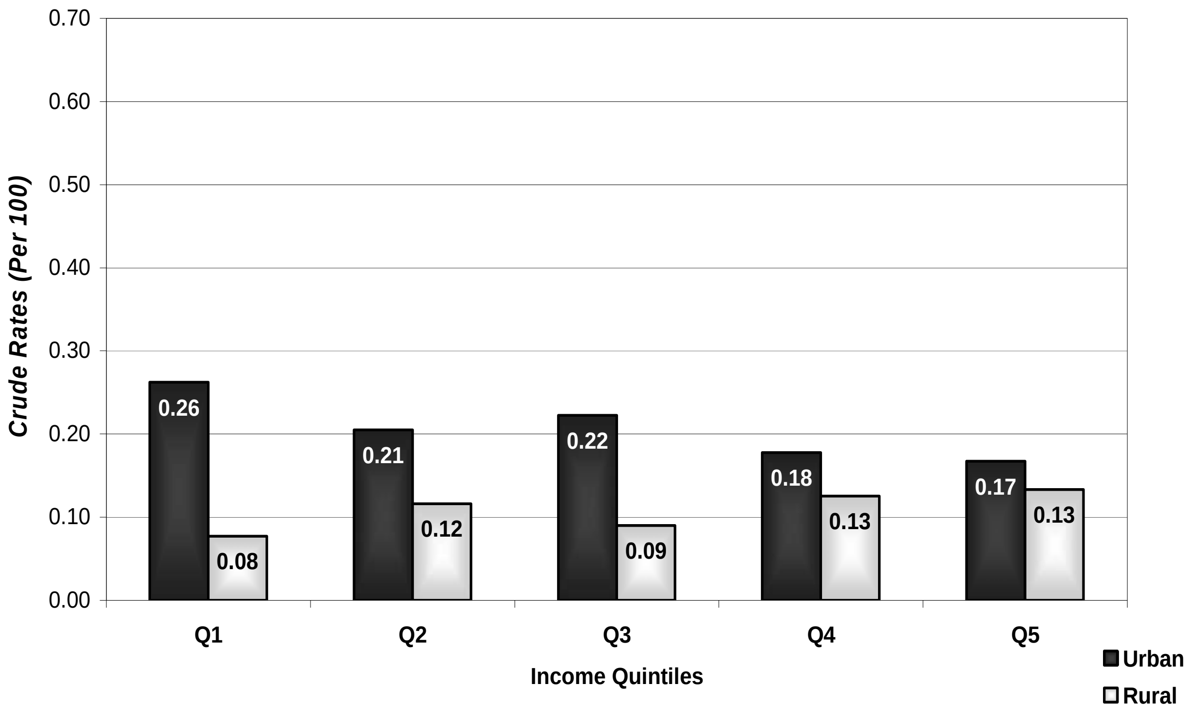
These comorbid disorders were also considered according to income quintiles within the entire population of Manitoba children aged 0 to 19 in the 2004/2005 fiscal year. The crude rate for comorbid ADHD and BD in urban Manitoba children in the 2004/2005 fiscal year was highest in children in the lowest income quintile (U1; 0.59%, or 210 of 35,453 children), followed by the second lowest quintile (U2; 0.43%, or 139 of 32,664 children), then the middle quintile (U3; 0.42%, or 140 of 33,269 children), the second highest quintile (U4; 0.27%, or 99 of 36,048 children), and finally the highest quintile (U5; 0.24%, or 94 of 38,893 children) [see Figure 13]. Not following a clear pattern, the crude rate for comorbid ADHD and BD in rural Manitoba children in the 2004/2005 fiscal year was highest in children in the highest income quintile (R5; 0.20%, or 56 of 28,533 children), followed by second highest quintile (R4; 0.17%, or 41 of 24,720 children), then the second lowest quintile (R2; 0.17%, or 42 of 24,950 children), the middle quintile (R3; 0.15%, or 38 of 25,481 children), and finally the lowest quintile (R1; 0.14%, or 48 of 33,616 children) [see Figure 13].

Figure 13. Crude rates of comorbid ADHD and BD by the total Manitoba child population, by income quintile in 2004/05.



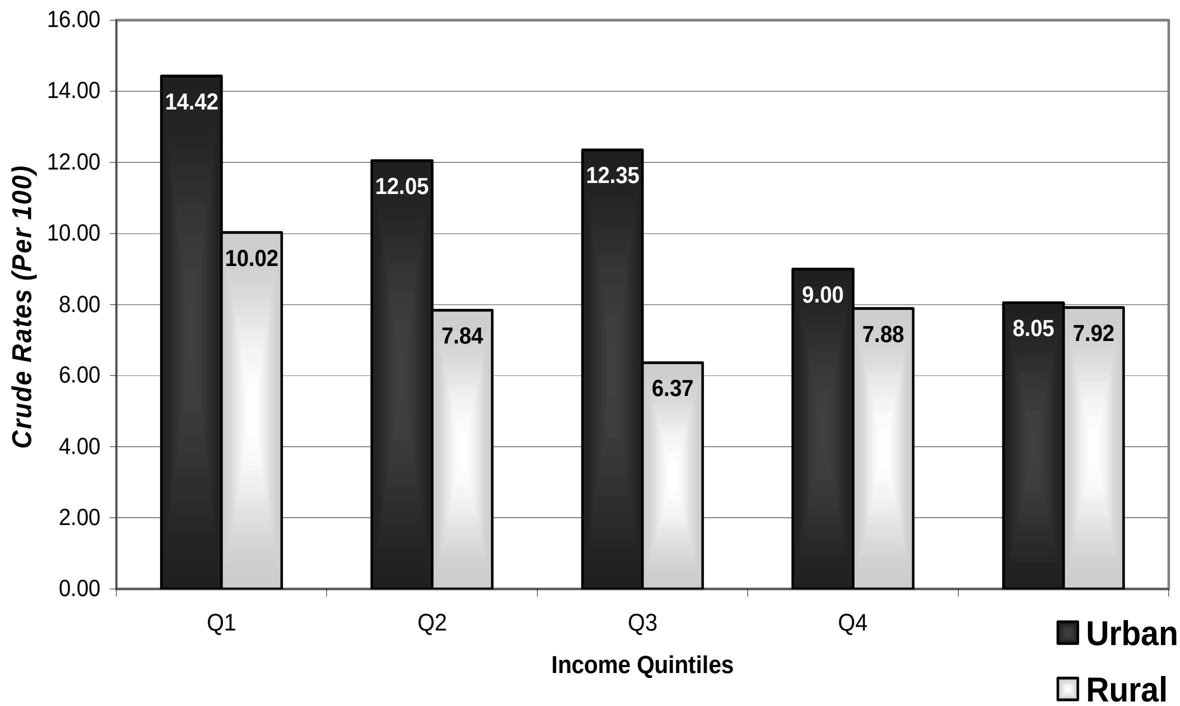
Crude rates with comorbid BD and psychostimulant prescriptions follow a similar pattern. The crude rate for comorbid psychostimulant prescriptions and BD in urban Manitoba children in the 2004/2005 fiscal year was highest in children in the lowest income quintile (U1; 0.26%, or 93 of 35,453 children), followed by the middle quintile (U3; 0.22%, or 74 of 33,269 children), then the second lowest quintile (U2; 0.21%, or 67 of 32,664 children), the second highest quintile (U4; 0.18%, or 64 of 36,048 children), and finally the highest quintile (U5; 0.17%, or 65 of 38,893 children) [see Figure 14]. Not following a clear pattern, the crude rate for comorbid psychostimulant prescriptions and BD in rural Manitoba children in the 2004/2005 fiscal year was highest in children in the highest income quintile (R5; 0.13%, or 38 of 28,533 children), followed by second highest quintile (R4; 0.13%, or 31 of 24,720 children), then the second lowest quintile (R2; 0.12%, or 29 of 24,950 children), the middle quintile (R3; 0.09%, or 23 of 25,481 children), and finally the lowest quintile (R1; 0.08%, or 26 of 33,616 children) [see Figure 14].

Figure 14. Crude rates of comorbid psychostimulant Prescriptions and BD by the total Manitoba child population, by income quintile in 2004/05.



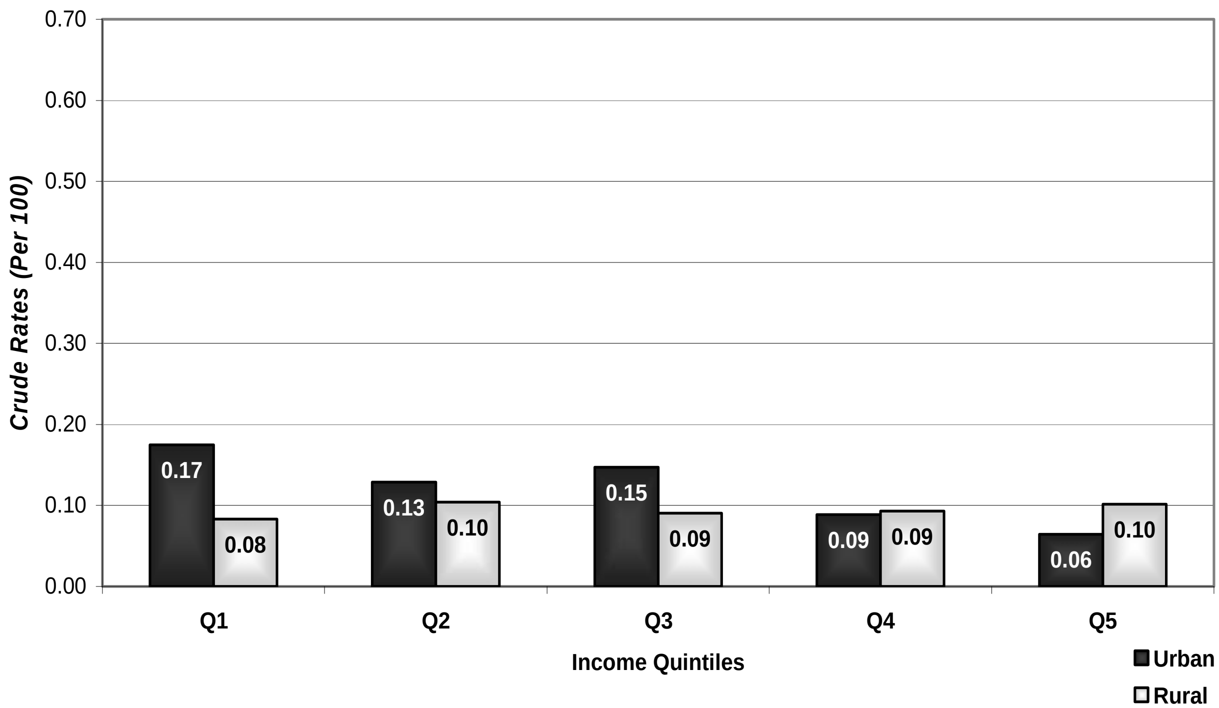
Crude rates for ADHD and BD were also calculated according to income quintile with the respective population of children with ADHD as the denominator. The crude rate for comorbid ADHD and BD in urban Manitoba children with ADHD in the 2004/2005 fiscal year was highest in children in the lowest income quintile (U1; 14.42%, or 210 of 1,456 children), then the middle quintile (U3; 12.35%, or 140 of 1,134 children), followed by the second lowest quintile (U2; 12.05%, or 139 of 1,154 children), the second highest quintile (U4; 9.00%, or 99 of 1,100 children), and finally the highest quintile (U5; 8.05%, or 94 of 1,167 children) [see Figure 15]. While this pattern does not follow an exact gradient pattern, it can be seen that the difference in crude rates between the second and third quintiles is relatively small. With respect to rural Manitoba children in the 2004/2005 fiscal year, the crude rate for comorbid ADHD and BD out of all children with ADHD was highest in children in the lowest quintile (R1; 10.02%, or 48 of 479 children), followed by the highest income quintile (R5; 7.92%, or 56 of 707 children), then second highest quintile (R4; 7.88%, or 41 of 520 children), the second lowest quintile (R2; 7.84%, or 42 of 536 children), and finally the middle quintile (R3; 6.37%, or 38 of 597 children) [see Figure 15]. As can be observed, there is very little difference in crude rates between R2, R4, and R5. A χ^2 test was conducted to investigate the hypothesis that there would be a significant difference in BD rates across income quintile, within the population of Manitoban children aged 0 to 19 with ADHD. The test statistic value of 39.15 ($p < .0001$), in conjunction with the trend shown in Figure 13, supports the hypothesis that children with lower income levels have higher rates of comorbid ADHD and BD compared to children with higher income levels.

Figure 15. Crude rates of comorbid ADHD and BD by the population of Manitoba children with ADHD, by income quintile in 2004/05.



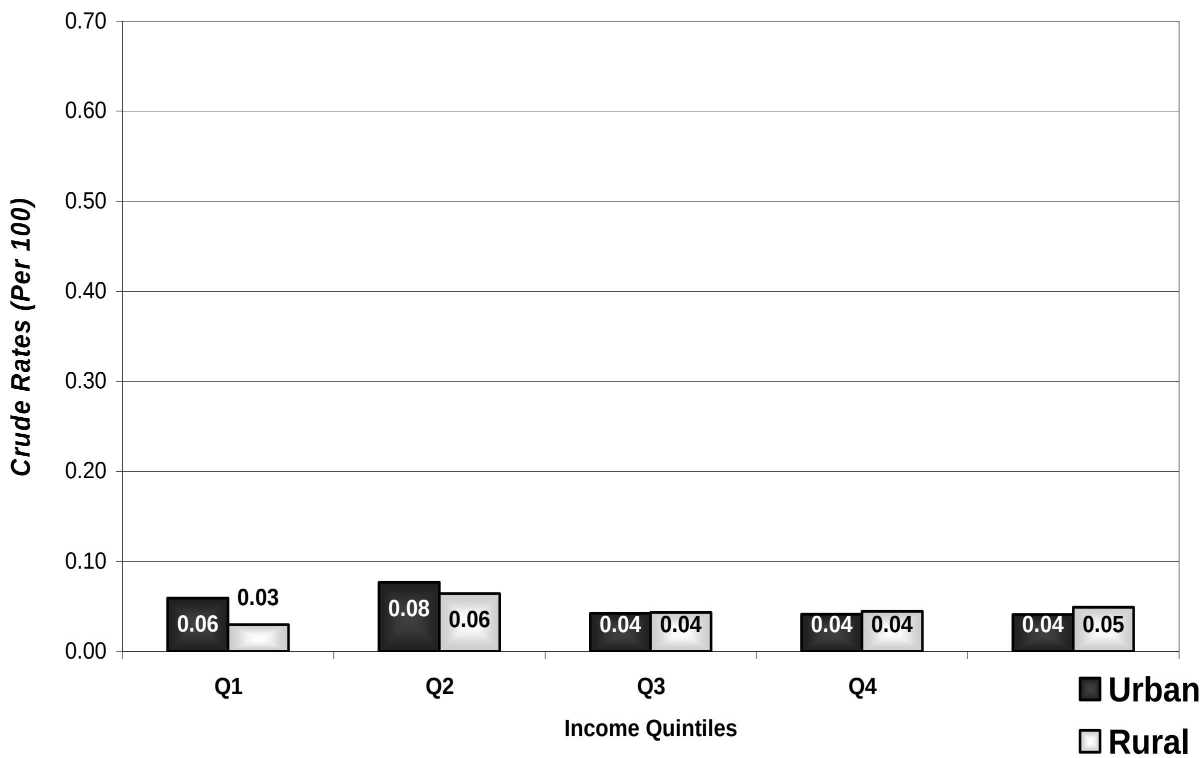
The crude rate for comorbid ADHD and LD in urban Manitoba children in the 2004/2005 fiscal year was highest in children in the lowest income quintile (U1; 0.17%, or 62 of 35,453 children), followed by the middle quintile (U3; 0.15%, or 49 of 33,269 children), then the second lowest quintile (U2; 0.13%, or 42 of 32,664 children), the second highest quintile (U4; 0.09%, or 32 of 36,048 children), and finally the highest quintile (U5; 0.06%, or 25 of 38,893 children) [see Figure 16]. Furthermore, the crude rate for comorbid ADHD and LD in rural Manitoba children in the 2004/2005 fiscal year is highest in children in the highest income quintile (R5; 0.10%, or 29 of 28,533 children), followed by the second lowest quintile (R2; 0.10%, or 26 of 24,950 children), then the second highest quintile (R4; 0.09%, or 23 of 24,720 children), the middle quintile (R3; 0.09%, or 23 of 25,481 children), and finally the lowest quintile (R1; 0.08%, or 28 of 33,616 children) [see Figure 16]. As can be observed, there was very little difference in crude rates for comorbid ADHD and LD across rural Manitoba income quintiles.

Figure 16. Crude rates of comorbid ADHD and LD by the total Manitoba child population, by income quintile in 2004/05.



There was very little difference between the crude rates for comorbid ADHD prescriptions and LD in urban Manitoba children in the 2004/2005 fiscal year across quintile. In order of increasing quintile, the values were: 0.06%, or 21 of 35,453 children for U1, 0.08%, or 25 of 32,664 children for U2, 0.04%, or 14 of 33,269 children for U3, 0.04%, or 15 of 36,048 children for U4, and 0.04%, or 16 of 38,893 children for U5 [see Figure 17]. Similarly, there was very little difference between the crude rates for comorbid ADHD prescriptions and LD in rural Manitoba children in the 2004/2005 fiscal year across income quintile. In order of increasing quintile, the values were: 0.03%, or 10 of 33,616 children for R1, 0.06%, or 16 of 24,950 children for R2, 0.04%, or 11 of 25,481 children for R3, 0.04%, or 11 of 24,720 children for R4, and 0.05%, or 14 of 28,533 children) for R5 [see Figure 17].

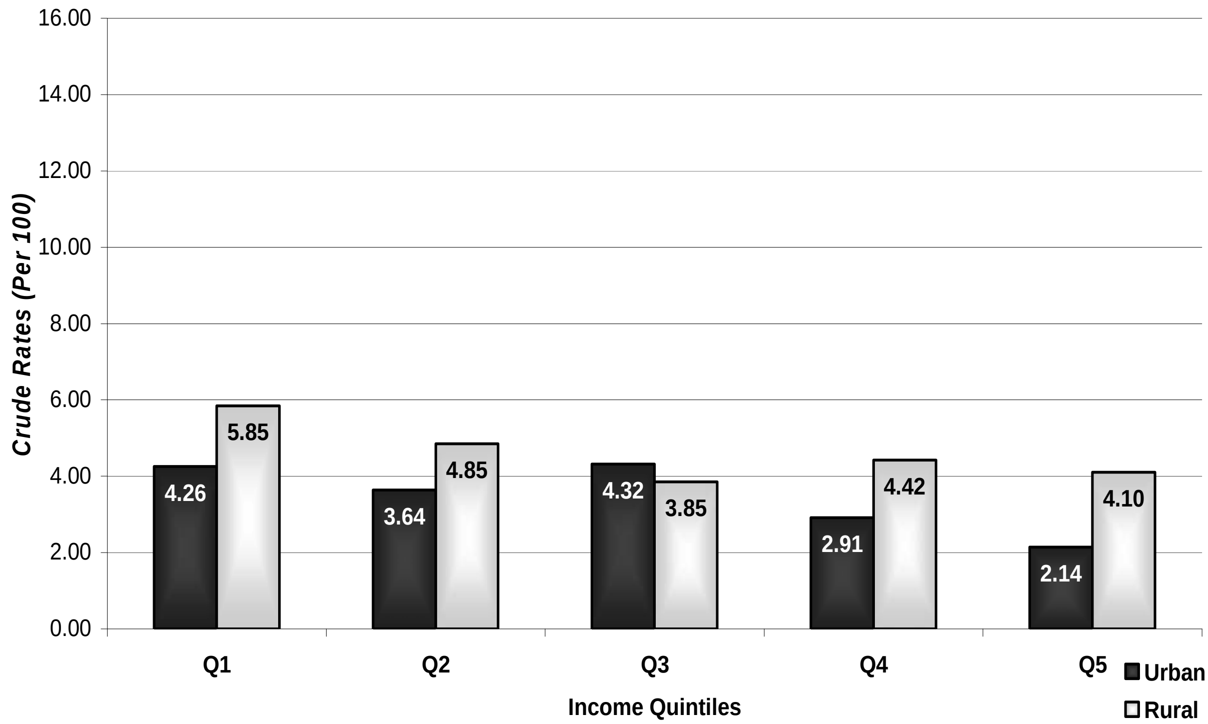
Figure 17. Crude rates of comorbid Psychostimulant prescriptions and LD by the total Manitoba child population, by income quintile in 2004/05.



As was done with BD, crude rates for ADHD and LD were also calculated according to income quintile with the respective population of children with ADHD as the denominator. The crude rate for comorbid ADHD and LD in urban Manitoba children with ADHD in the

2004/2005 fiscal year was highest in children in the lowest income quintile (U1; 4.26%, or 62 of 1,456 children), followed by the middle quintile (U3; 4.32%, or 49 of 1,134 children), then the second lowest quintile (U2; 3.64%, or 42 of 1,154 children), the second highest quintile (U4; 2.91%, or 32 of 1,100 children), and finally the highest quintile (U5; 2.14%, or 25 of 1,167 children) [see Figure 18]. As can be observed, the difference between U1 and U3 is relatively small. Moreover, the crude rate for comorbid ADHD and LD in rural Manitoba children with ADHD in the 2004/2005 fiscal year is highest in children in the lowest quintile (R1; 5.85%, or 28 of 479 children), followed by the second lowest quintile (R2; 4.85%, or 26 of 536 children), then the second highest quintile (R4; 4.42%, or 23 of 520 children), the highest income quintile (R5; 4.10%, or 29 of 707 children), and finally the middle quintile (R3; 3.85%, or 23 of 597 children) [see Figure 18]. A χ^2 test was conducted to investigate the hypothesis that there would be a significant difference in LD rates across income quintile, within the population of Manitoban children aged 0 to 19 with ADHD. The test statistic value of 9.90 ($p = .0422$), supports this hypothesis. However, while these results suggest that children from lower income areas have higher rates of comorbid ADHD and LD compared to children from higher income areas, the descriptive statistics graphed in Figure 18 suggest that with the exception of quintile 3 (which is higher than expected for urban children and lower than expected for rural children) urban and rural areas have somewhat opposite trends with respect to comorbid ADHD and LD with income quintile.

Figure 18. Crude rates of comorbid ADHD and LD by the population of Manitoba children with ADHD in 2004/05.



Regression Analysis:

Negative binomial regression analyses were conducted instead of Poisson regression analyses because preliminary analyses using Poisson models for ADHD diagnosis and prescription rates suggested significant over-dispersion of the data (i.e. variance larger than the mean). A diagnosis of ADHD was the dependent variable in all regression models listed under ADHD diagnosis modeling and a prescription for a psychostimulant was the dependent variable in all models listed under psychostimulant prescription modeling. Goodness of fit was assessed using the ratio of model deviance to degrees of freedom, which tests equality of the mean and the variance (with acceptable fit evidenced by a ratio close to 1). The significance of each of the variables in the model was assessed using likelihood ratio tests and the significance of the estimates for each level within all variables was assessed via χ^2 contrasts. For both diagnosis and prescription modeling, a series of sequential models were used, with interactions added separately to the main effects, because of a priori theoretical findings that support the main effects, in conjunction with fewer past studies supporting all of the interactions. Furthermore, the relatively low numbers of comorbid diagnoses in the data did not support the addition of multiple interaction terms into one model and there was a high likelihood of strong co-linearity between them, as they commonly co-occur.

ADHD Diagnosis Modeling:

The base model included the main effects of sex, age group, geographical location of residence (urban versus rural), and income quintile. The deviance to degrees of freedom ratio for this model was 1.20 and the likelihood ratio statistics indicated that all independent variables were statistically significant (see Table 1).

Table 1

Likelihood Ratio Statistics for Base Model

Source	**DF**	χ^2	**p-value**
Sex	1	182.04	<.0001
Age Group	4	264.56	<.0001
Region of Residence	1	64.42	<.0001
Income Quintile	4	16.62	0.0023

Next, the Behavioral Disturbance variable (BD) was added to the model (Model 1a). The deviance to degrees of freedom ratio with BD added was 1.11 and the likelihood ratio statistics showed that all independent variables were significant (see Table 2). The addition of this variable improved overall model fit and increased the significance of the income quintile variable.

Table 2

Likelihood Ratio Statistics for Model 1a

Source	**DF**	χ^2	**p-value**
Sex	1	226.12	<.0001
Age Group	4	339.38	<.0001
Region of Residence	1	81.25	<.0001
Income Quintile	4	27.1	<.0001
BD	1	412.4	<.0001

The Learning Disabilities variable (LD) was added to the model next (Model 1b). The deviance to degrees of freedom ratio with LD added was 1.19 and the likelihood ratio statistics indicated that all independent variables were statistically significant (see Table 3). While the model fit was slightly reduced with the addition of this variable, it is considered an important variable to include in the model because past research has found it to be so commonly comorbid with ADHD (National Institute of Mental Health, 2003). Furthermore, the low crude rates for LD found in this study offer some explanation for why the addition of LD worsens model fit.

Table 3

Likelihood Ratio Statistics for Model 1b

Source	DF	χ^2	p-value
Sex	1	201.02	<.0001
Age Group	4	305.48	<.0001
Region of Residence	1	51	<.0001
Income Quintile	4	23.2	0.0001
BD	1	347.19	<.0001
LD	1	489.72	<.0001

Thirdly, an interaction of region of residence (urban versus rural geographical location) and income quintile variables was added to the model (Model 1c). The deviance to degrees of freedom ratio with region of residence*income quintile added was 1.22 and the likelihood ratio statistics indicated that all independent variables were significant (see Table 4). Again, model fit was slightly decreased with the addition of this interaction, although previous research on ADHD in the province of Manitoba supports the inclusion of this interaction because diagnosis rates vary so differently according to income in urban versus rural locations (Brownell & Yogendran, 2001). Furthermore, contrast estimates can be found in Table 5. The contrast estimates indicate that there is a significant SES gradient for urban children, but not for rural children, and this difference is driving the interaction.

Table 4

Likelihood Ratio Statistics for Model 1c

Source	DF	χ^2	p-value
Sex	1	210.7	<.0001
Age Group	4	317.94	<.0001
Region of Residence	1	54.47	<.0001
Income Quintile	4	20.26	0.0004
BD	1	362.65	<.0001
LD	1	507.25	<.0001
Region of Residence*Income Quintile	4	21.14	0.0003

Table 5

Regression Coefficient Estimates for Total Population ADHD Diagnosis Model 1c

Model Effect	Estimate	RR	95% CI	χ^2	p-value
Sex					
Female	-1.11	0.33	(0.29, 0.37)	364.48	<.0001
Male	Ref	—	—	—	—
Age Group					
0-3	-2.24	0.11	(0.08, 0.14)	315.98	<.0001
4-6	-0.08	0.93	(0.77, 1.11)	0.65	0.4198
7-9	0.57	1.77	(1.51, 2.08)	50.49	<.0001
10-13	0.50	1.64	(1.41, 1.91)	40.28	<.0001
14-19	Ref	—	—	—	—
Region of Residence					
Rural	-0.46	0.63	(0.56, 0.70)	64.99	<.0001
Urban	Ref	—	—	—	—
Income Quintile					
Q1	0.34	1.41	(1.18, 1.68)	14.65	0.0001
Q2	0.17	1.18	(0.99, 1.42)	3.42	0.0646
Q3	0.16	1.17	(0.98, 1.40)	3.02	0.0821

Q4	-0.01	0.99	(0.83, 1.19)	0.00	0.9511
Q5	Ref	—	—	—	—
Comorbid BD					
Yes	1.97	7.19	(6.34, 8.17)	923.98	<.0001
No	Ref	—	—	—	—
Comorbid LD					
Yes	2.91	18.40	(15.74, 21.51)	1336.90	<.0001
No	Ref	—	—	—	—
Region of Residence* Income Quintile					
Rural: Q1	-0.06	0.95	(0.73, 1.22)	0.18	0.6689
Rural: Q2	-0.07	0.93	(0.72, 1.22)	0.26	0.6121
Rural: Q3	-0.03	0.98	(0.75, 1.27)	0.03	0.8518
Rural: Q4	-0.12	0.89	(0.68, 1.16)	0.79	0.3741
Rural: Q5	Ref	—	—	—	—
Urban: Q1	0.74	2.09	(1.66, 2.65)	38.39	<.0001
Urban: Q2	0.41	1.50	(1.18, 1.90)	11.19	0.0008
Urban: Q3	0.34	1.40	(1.11, 1.78)	7.84	0.0051
Urban: Q4	0.11	1.12	(0.88, 1.42)	0.81	0.3693
Urban: Q5	Ref	—	—	—	—
Linear test	-1.78	0.17	(0.10, 0.29)	43.62	<.0001

**RR refers to Relative Risk; **CI refers to Confidence Interval*

Additional interactions that were proposed included Age Group*income quintile, BD*income quintile, and LD*income quintile. All of these interactions were added separately to model 1b (which included, sex, age group, region of residence, income quintile, BD, and LD) and with the exception of the BD*income quintile interaction, the models with these interactions did not meet goodness of fit criteria and therefore these interactions were dropped. The deviance to degrees of freedom ratio for the model with BD* income quintile (Model 1e) was 1.20 and the likelihood ratio statistics indicated that all independent variables were significant (see Table 6). Contrast estimates for this interaction were non-estimable, likely due to small numbers of events.

Table 6

Likelihood Ratio Statistics for Model 1e

Source	**DF**	χ^2	**p-value**
Sex	1	206.32	<.0001
Age Group	4	310.86	<.0001
Region of Residence	1	53.5	<.0001
Income Quintile	4	31.47	<.0001
BD	1	357	<.0001
LD	1	499.45	<.0001
BD*Income Quintile	4	10.74	0.0297

Urban Only Modeling:

As a result of the trends noticed in the rural versus urban crude rates between various independent variables, a few models were considered with an urban only population (i.e., Winnipeg and Brandon only). Considering just the urban population is also supported by past ADHD research in Manitoba (Brownell & Yogendran, 2005), as a result of rural data being less consistent (due incomplete data from nursing stations, reduced access to particular health professionals, and more within-area heterogeneity in SES). Consequently, the following interactions were also attempted separately with a model that included sex, age group, income quintile, BD, and LD: age group*income quintile, BD*income quintile, and LD*income quintile. However, none of these interactions were statistically significant. The deviance to degrees of freedom ratio for the model with sex, age group, income quintile, BD, and LD in the urban Manitoba child population was 1.21 and the likelihood ratio statistics indicated that all independent variables were significant (see Table 7). Results from this model (Model 2b) are very similar to Model 1b with the entire Manitoba child population.

Table 7

Likelihood Ratio Statistics for Model 2b

Source	DF	χ^2	p-value
Sex	1	107.82	<.0001
Age Group	4	176.82	<.0001
Income Quintile	4	40.14	<.0001
BD	1	181.22	<.0001
LD	1	289.78	<.0001

Psychostimulant Prescription Modeling:

The base model for psychostimulant prescriptions also included sex, age group, region of residence, and income quintile as independent variables. The deviance to degrees of freedom ratio for this model was 1.11 and the likelihood ratio statistics revealed that with the exception of income quintile, all independent variables were significant (see Table 8).

Table 8

Likelihood Ratio Statistics for Base Model

Source	DF	χ^2	p-value
Sex	1	162.59	<.0001
Age Group	4	305.05	<.0001
Region of Residence	1	61.86	<.0001
Income Quintile	4	6.75	0.1496

Next, the Behavioral Disturbance variable (BD) was added to the model (Model 3a). The deviance to degrees of freedom ratio with BD added was 1.09 and the likelihood ratio statistics showed that all independent variables were significant (see Table 9). The addition of this variable increased the significance of the income quintile variable.

Table 9

Likelihood Ratio Statistics for Model 3a

Source	**DF**	χ^2	**p-value**
Sex	1	185.67	<.0001
Age Group	4	391.05	<.0001
Region of Residence	1	73.18	<.0001
Income Quintile	4	12	0.0174
BD	1	304.14	<.0001

Secondly, the Learning Disabilities variable (LD) was added to the model (Model 3b). The deviance to degrees of freedom ratio with LD added was 1.12 and the likelihood ratio statistics indicated that all independent variables were significant (see Table 10). As with the diagnostic modeling, the model fit was slightly reduced with the addition of this variable, although it is considered a viable independent variable because past research has found it to be so commonly comorbid with ADHD (National Institute of Mental Health, 2003) and because the low crude rates in this study suggest that Learning Disabilities are greatly under-represented in this data source.

Table 10

Likelihood Ratio Statistics for Model 3b

Source	**DF**	χ^2	**p-value**
Sex	1	158.95	<.0001
Age Group	4	375.07	<.0001
Region of Residence	1	50.18	<.0001
Income Quintile	4	12.59	0.0134
BD	1	248.65	<.0001
LD	1	393.89	<.0001

Thirdly, an interaction of region of residence and income quintile variables was added to the model (Model 3c). The deviance to degrees of freedom ratio with region of residence*income quintile added was 1.19 and the likelihood ratio statistics revealed that with the exception of income quintile, all independent variables were significant (see Table 11). Once more, model fit was slightly decreased with the addition of this interaction, although previous research on ADHD in the province of Manitoba supports the inclusion of this interaction because prescription rates vary so differently according to income in urban versus rural locations (Brownell & Yogendran, 2001). Furthermore, contrast estimates can be found in Table 12. The contrast estimates indicate that there is a significant SES gradient for urban children, but not for rural children, and this difference is driving the interaction.

Table 11

Likelihood Ratio Statistics for Model 3c

Source	DF	χ^2	p-value
Sex	1	176.55	<.0001
Age Group	4	399.53	<.0001
Region of Residence	1	60.17	<.0001
Income Quintile	4	7.58	0.1083
BD	1	271.53	<.0001
LD	1	418.94	<.0001
Region of Residence*Income Quintile	4	32.38	<.0001

Table 12

Regression Coefficient Estimates for Total Population Psychostimulant ADHD Prescriptions Model 3c

Model Effect	Estimate	RR	95% CI	χ^2	p-value
Sex					
Female	-1.17	0.31	(0.28, 0.35)	356.74	<.0001
Male	Ref	—	—	—	—
Age Group					
0-3	-4.82	0.01	(0.00, 0.02)	192.47	<.0001
4-6	-0.97	0.38	(0.31, 0.47)	76.70	<.0001
7-9	0.45	1.57	(1.34, 1.84)	30.79	<.0001
10-13	0.55	1.73	(1.49, 2.01)	52.17	<.0001
14-19	Ref	—	—	—	—
Region of Residence					
Rural	-0.55	0.58	(0.51, 0.65)	81.39	<.0001
Urban	Ref	—	—	—	—
Income					

Quintile					
Q1	0.18	1.19	(0.99, 1.44)	3.44	0.0638
Q2	0.07	1.07	(0.89, 1.29)	0.53	0.4682
Q3	0.05	1.06	(0.88, 1.27)	0.32	0.5693
Q4	-0.07	0.93	(0.77, 1.12)	0.61	0.4363
Q5	Ref	—	—	—	—
Comorbid BD					
Yes	2.01	7.45	(6.46, 8.60)	761.44	<.0001
No	Ref	—	—	—	—
Comorbid LD					
Yes	3.25	25.90	(21.37, 31.40)	1098.40	<.0001
No	Ref	—	—	—	—
Region of Residence* Income Quintile					
Rural: Q1	-0.33	0.72	(0.54, 0.94)	5.68	0.0171
Rural: Q2	-0.13	0.87	(0.66, 1.16)	0.88	0.3487
Rural: Q3	-0.09	0.91	(0.69, 1.20)	0.45	0.5027
Rural: Q4	-0.13	0.88	(0.66, 1.16)	0.85	0.357
Rural: Q5	Ref	—	—	—	—
Urban: Q1	0.69	1.99	(1.55, 2.55)	29.61	<.0001
Urban: Q2	0.27	1.31	(1.03, 1.68)	4.70	0.0302
Urban: Q3	0.20	1.22	(0.96, 1.56)	2.57	0.109
Urban: Q4	-0.02	0.98	(0.77, 1.26)	0.02	0.8947
Urban: Q5	Ref	—	—	—	—
Linear test	-1.67	0.19	(0.11, 0.33)	33.84	<.0001

**RR refers to Relative Risk; **CI refers to Confidence Interval*

As with ADHD diagnosis, additional interactions that were proposed with psychostimulant prescriptions included age group*income quintile, BD*income quintile, and LD*income quintile. All of these interactions were added separately to model 3b (which included sex, age group, region of residence, income quintile, BD, and LD) and with the exception of the BD*income quintile interaction, they did not meet goodness of fit criteria or were not significant and cannot be considered viable models. The deviance to degrees of freedom ratio for the model with BD* income quintile (Model 3e) was 1.15 and the likelihood ratio statistics indicated that all independent variables were significant (see Table 13). As was the case with the diagnostic model 1e, contrast estimates for this interaction were non-estimable, likely due to small numbers of events.

Table 13

Likelihood Ratio Statistics for Model 3e

Source	**DF**	χ^2	**p-value**
Sex	1	164.96	<.0001
Age Group	4	381.19	<.0001
Region of Residence	1	53.73	<.0001
Income Quintile	4	19.32	0.0007
BD	1	258.05	<.0001
LD	1	404.55	<.0001
BD*Income Quintile	4	11.52	0.0213

Discussion

All of the study hypotheses (see Table 1, page 25) were supported by the results, with the exception of the hypothesis regarding SES taken alone (Hypothesis 3), as well as the hypotheses involving age groups and SES (Hypothesis 5). This discussion will first review the crude rate analysis and the regression analysis according to each of the seven study hypotheses. Finally, the discussion will conclude with a consideration of study limitations, strengths, and implications.

Overall the diagnostic (2.89%) and the treatment (2.02%) crude rates of ADHD for Manitoban children in 2004/2005 were higher than those of 2003/2004 (2.33% and 1.69%, respectively; Brownell & Yogendran, 2005). As crude rates of ADHD for Manitoban children in 1995/96 were reported at 1.44% for diagnosis and 0.93% for prescriptions (Brownell & Yogendran, 2001), it appears that ADHD rates are continuing to increase with time. These increases are likely caused by multiple reasons, such as increased awareness of ADHD, changes in health and/or education policies, and potential over-diagnosis or inaccurate diagnosis of ADHD (Mandell, Thompson, Weintraub, DeStefano, & Blank, 2005). A study by Mandell et al. (2005) indicated that diagnostic rates for several etiologically unrelated mental disorders have increased over time, which provides some support for the increased awareness and changed policies hypotheses. However, with several other mental health diagnoses that are also generally discovered in childhood (e.g. Fetal Alcohol Spectrum Disorder, Conduct Disorder, Oppositional Defiant Disorder, and Learning Disabilities) having such high symptom overlap with ADHD (NIMH, 2003), it is highly possible that inaccurate diagnosis and treatment are also occurring.

Hypothesis 1:

The first hypothesis of this study, that males would have higher diagnosis and prescription rates than females was supported in both the crude rate and the regression analyses. As predicted, the ratio was 3 or 4 to 1 for both diagnosis and treatment. Sex as a main effect was statistically significant in all regression models for both diagnosis of ADHD and psychostimulant prescriptions.

Hypothesis 2:

Similarly, the hypothesis regarding the ordering of crude rates for both diagnosis of ADHD and psychostimulant treatment of ADHD for age groups was also supported. In decreasing order, crude rates for age groups were as follows: 10 to 13, 7 to 9, 14 to 19, 4 to 6, and 0 to 3. Age group as a main effect was statistically significant in all regression models for both diagnosis of ADHD and psychostimulant prescriptions.

Hypothesis 3:

The hypothesis that diagnosis and treatment rates increase with decreasing SES cannot not be interpreted on its own, as SES was found to be significant in two interactions (see Hypotheses 6 & 7). As was illustrated in the Results section, two separate SES gradients appeared when the population was separated into urban and rural cohorts. However, none of the analyses supported an SES gradient when analyzed separately from the other variables. Furthermore, in the base model of the regression analysis for prescriptions, income quintile still was not statistically significant when sex, age group, and region of residence were controlled for. Despite not being significant in the base model, income quintile was left in the other models because of the theoretical support for its inclusion (Rieppi et al., 2002; Marmot et al., 1991; Adler et al., 1994) and because it was needed for the testing of the interactions.

Interestingly, also in the prescription regression modeling, all variables were significant with the addition of BD (Model 3a) and LD (Model 3b) as main effects, including income quintile, and the fit remained good. These results suggest that children from low income areas in this dataset who were identified with ADHD were more likely to get psychostimulant prescriptions compared to their counterparts from higher income areas. Similarly, Brownell, Mayer, & Chateau's study (2006) using data from the National Longitudinal Survey of Children and Youth found that children who were rated high on hyperactivity/impulsivity and inattention were much more likely to be prescribed Ritalin if they were low SES. Furthermore, they found that when behavioral symptoms and individual level income were controlled for, area level SES still had a significant impact, with children from low SES areas being much more likely to have Ritalin prescriptions. Another possible explanation for these results is that children with a BD and/or LD diagnosis, but not an ADHD diagnosis, received more psychostimulant prescriptions if they were from lower incomes, but this possibility was not explored in this study.

Hypothesis 4:

The fourth hypothesis predicted that diagnostic and treatment rates would be higher in urban areas compared to rural areas. Winnipeg and Brandon as well as regions surrounding urban centers (i.e. Assiniboine and Interlake) had higher diagnostic and crude rates compared to rural regions. Furthermore, the region of residence variable (urban versus rural) was consistently significant in all of the regression models for diagnosis and prescriptions. This finding may be caused in part by fact that there are more medical specialists (e.g. pediatricians, psychiatrists, etc.) in urban areas, thus enabling children in these regions to have greater access to such specialists and accordingly, to have a greater likelihood of getting diagnosed and/or treated (Brownell & Yogendran, 2001).

Hypothesis 5:

The next hypothesis to be considered was the interaction between age groups and income quintiles. It was hypothesized that for both diagnosis and treatment, rates would decrease with decreasing SES for children ages 0 to 13 years and would increase with decreasing SES for children ages 14 to 19 years. The crude rates for diagnosis and treatment of urban Manitoba children ages 0 to 13 did not support this hypothesis, as they decreased with increasing SES.

Furthermore, the diagnosis and treatment rates for urban children in the 14 to 19 year old age category did not follow any distinct pattern, which is not congruent with the predicted outcome. Also not congruent with the hypothesis, no SES trends were found for diagnostic or treatment rates in rural Manitoba children of any age group. Furthermore, the age group*income quintile interaction was not significant in the diagnosis nor the prescription regression modeling. To ensure that potential inconsistencies with the rural data were not the sole cause of the non-significant result, the age group*income quintile interaction was also tested with an urban only dataset (along with sex, age group, income quintile, BD, and LD), yet it remained a non-significant variable in that model as well.

The inconsistencies in the rural data may be due to incomplete data from nursing stations, reduced access to particular health professionals, and more within-area heterogeneity in SES (Brownell & Yogendran, 2005). However, the reasoning behind the lack of an SES gradient in the rates for urban 14 to 19 year olds is less clear, as the age group by income quintile interaction was not significant in the urban subset of Manitoba children for this study period. Perhaps it is a result of greater awareness that ADHD often does persist into adolescence and adulthood (McGough & Barkley, 2004), so more youths in that age range were receiving diagnosis and treatment, regardless of SES. Nonetheless, these results indicate a childhood-limited model (Chen, Boyce, & Mathews, 2002) of SES for ADHD diagnosis and treatment, as the relationship between SES and ADHD was strongest in early to mid childhood and weakened with age.

Hypothesis 6:

Hypothesis 6 stated that for both diagnosis and prescriptions of ADHD, rates would be higher in children with higher SES in rural areas, whereas rates would be higher in children with lower SES in urban areas. With respect to the regression analysis for diagnosis and prescriptions of ADHD (Model 1c and 3c, respectively), region of residence*income quintile contrast estimates indicated that there was a significant SES gradient for urban children, but not for rural children, and this difference was driving the interaction. This finding corresponds well with the crude rate analysis, where an inverse SES gradient trend was observed for ADHD diagnosis in urban children, but the SES pattern of ADHD diagnosis followed a somewhat opposite trend for rural children. Consequently, with respect to the hypotheses regarding the interaction between region of residence and SES, these results strongly support the hypothesis that in urban areas rates were higher in children with lower SES, and moderately support the hypothesis that rural area rates were higher in children with higher SES.

Hypothesis 7:

The final hypothesis to be considered according to crude rates stated that comorbid diagnoses (i.e. BD and LD) with ADHD would be higher in children with lower SES. It is important to first note that the overall rates of comorbid BD and ADHD (10.39%) and LD and ADHD (3.85%) were much lower than expected, as the literature indicates that within the population of children with ADHD, 20-40% have a comorbid conduct disorder, 30-50% have a comorbid oppositional defiant disorder, and 20-30% have a comorbid learning disability (NIMH, 2003). Consequently, it is likely that the data used for this study under-report the true prevalence rates of these disorders, particularly in rural areas as the majority of these comorbid cases were identified in children from urban areas.

Despite this likelihood, the crude rate analysis found some distinct SES gradient trends for these comorbid disorders. For BD, not only was there a distinct inverse SES gradient with respect to comorbid BD and ADHD (diagnosis and prescriptions) in the context of the entire urban population of Manitoban children, but there was also a clear inverse SES gradient pattern for comorbid BD and ADHD within the urban population of Manitoban children who have ADHD. In other words, lower SES corresponded with higher rates of comorbid BD and ADHD for all urban Manitoban children. Furthermore, of the urban children who had a diagnosis of ADHD, the children with lower SES had higher rates of also having BD compared to ADHD children with higher SES, which was supported statistically with a χ^2 test. Crude rates for comorbid BD and ADHD in the rural Manitoba child population did not show clear patterns with respect to SES, although this is also likely in part caused by the aforementioned inconsistencies with rural data.

The BD*income quintile interactions in the regression analysis for diagnosis and prescriptions were also significant when added to sex, age group, region of residence, income quintile, BD, and LD, although the numbers were too small to provide contrast estimates. Overall, there was an inverse SES gradient for BD and ADHD in urban Manitoba children and very slight direct SES gradient for BD and ADHD in rural Manitoba children. Consequently, it is likely this difference that was driving the BD*income quintile interaction for both diagnoses and prescriptions. Taken together, these results do support the hypothesis that comorbid diagnoses (for BD) with ADHD were higher in children with lower SES.

For comorbid LD and ADHD, there was also an inverse SES gradient in the context of the entire urban population of Manitoban children, despite the overall LD and ADHD crude rate being at least five times lower than what the literature reports should be expected (NIMH, 2003) and the fact that the LD diagnoses that were picked up in this dataset were greatly skewed towards the two youngest age groups and urban dwellers. The skewed rates may have been a result of a high prevalence of language disorders treated in medical settings during this early developmental period (American Psychiatric Association, 2000). Perhaps as a result of the low numbers, the trend between comorbid LD and ADHD in regard to SES was less defined. Despite the significant result from the χ^2 test and the overall inverse SES gradient trend for this sub-population, the patterns of rates for comorbid LD and ADHD according to SES within the ADHD population did not follow a gradient trend for urban or rural children when income quintiles were divided according to region of residence. As with BD, lack of clear patterns with respect to SES for crude rates of comorbid LD and ADHD in the rural Manitoba child population were likely caused in part by inconsistencies with rural data.

Not surprisingly, the LD*income quintile interactions in the regression modeling for both ADHD diagnosis and prescriptions were not significant and therefore do not support the hypothesis that comorbid LD and ADHD was higher in children with lower SES. However, this is likely due to the fact that the numbers for LD were so low (probably due to missed diagnoses in the dataset) as well as highly skewed towards the two youngest age groups. In other words, the number of LD diagnosis codes in the dataset was insufficient to adequately interpret this interaction.

Limitations

While this study has a number of strong points, a few potential limitations should be considered. Firstly, the ICD categories being used for determining comorbidities with learning disorders and behavioral disturbances have not been validated, so only face validity and comparisons to known rates of these comorbidities may be used to verify these measures. As was discussed, the crude rates for these comorbid disorders were likely under-reported in the dataset. Despite this, the expected hypotheses for ADHD diagnoses and prescriptions with BD were still found.

Additionally, there are moderate differences in how the ICD-9-CM and ICD-10 codes in hospital abstracts were labeled, which created some risk that the two versions would not capture the same population. However, the hospital abstracts only capture about 1 to 2% of the ADHD diagnoses, otherwise most of the rates were calculated using ICD-9-CM codes. Additionally, the researcher observed mostly grade 1 and a few grade 2 congruencies (highly acceptable standards according to World Health Organization conversion tables made available to the author via internal MCHP access) between the rates for each of the ICD editions as a basic check for equivalency.

There is also the possibility that some children with ADHD diagnoses or prescriptions were not captured in the databases used in this study (e.g. residents of some northern remote communities that use nursing stations instead of hospitals or health offices with physicians, or those diagnosed by psychologists). However, administrative data offers the unique opportunity to observe the rates of medical diagnosis and pharmaceutical treatment that occur, which is still interesting and highly worthwhile information.

Finally, this study used an area-level measure of SES, income quintile, instead of an individual-level measure. It is possible that an individual-level measure would have provided greater accuracy in measuring SES, which may have led to SES being more consistently significant. However, previous research has shown that small-area data from the Census are highly correlated with individual-level SES information (Mustard, Derksen, Berthelot, Wolfson, 1999). Furthermore, some researchers suggest that asset-based measures of SES, such as income, may be more sensitive to detecting gradients over time because they are more prone to fluctuate (Chen, Martin, & Matthews, 2006).

Strengths

The design of this study is supported by a number of strong points. One of the biggest strengths is the study population size, which essentially includes the entire population of Manitoba children, including all of those with provincial records that indicate ADHD diagnosis or treatment. Furthermore, having linkage between the multiple databases (i.e. hospital, physician claims, pharmaceutical claims, public access census files, and population registry data) to be used for this study was a real asset because it provided information on all of the variables of interest. Furthermore, the use of previously validated methods for measuring ADHD diagnosis and treatment rates and measures for most of the variables aids in strengthening the results of this study (Brownell & Yogendran, 2001, Martens et al. 2004).

Finally, the inclusion of BD and LD, variables that had not previously been considered as comorbid conditions with ADHD using this dataset, greatly added to this study. Firstly, these variables provided new information about their significance in relation to ADHD diagnosis and treatment, taken both singly and in relation to SES. Additionally, this study provided some important information about how these conditions are represented in this dataset. Most notably, this study highlighted the great likelihood that the true prevalence rates of these conditions are under-reported in these data, especially for LD (NIMH, 2003). Additionally, the results showed that the prevalence rates for LD were highly skewed towards children ages 0 to 6 years of age. This information may assist the interpretation of future research that considers these variables and uses the Repository data.

Study Implications

This study contributes to the literature on ADHD in terms of prevalence rates for diagnoses and treatment, as well as how these rates vary with sex, age, SES, geographical region, and comorbid learning disabilities or behavioral disturbances. Furthermore, the results provide important information regarding the mechanisms that drive the SES gradient for ADHD by furthering our knowledge of when in childhood SES gradients for ADHD occur, the direction of such gradients, and the factors that moderate these differences. Specifically, the results from this study indicate that urban versus rural region of residence and comorbid BD moderate the SES gradient, with low income, urban dwelling children who have a comorbid diagnosis of BD having the highest rates of ADHD diagnoses and psychostimulant prescriptions. Furthermore, while age does not moderate the SES gradient, the crude rates indicate that the SES gradient for ADHD diagnoses and prescriptions appears most pronounced in urban children 0 to 13 years of age.

These understandings are ultimately critical for the development of policies and programs that will flatten this gradient and enhance the health status of all Canadian children with ADHD. In accordance with the findings from this study, such policy changes might include more stringent diagnostic and prescription treatment practices, additional support resources for children who are most at risk of having ADHD, and increased information about alternate treatment implementation for ADHD.

Both the fact that ADHD diagnosis and treatment rates are continuing to increase from previous years, as well as the significant role that comorbid diagnoses play in predicting ADHD diagnosis and treatment support the need to review diagnostic practices. As Barkley (2005) explains, there are a number of health professionals that may diagnosis ADHD, but there can be quite a range in their expertise as well as their methods of assessment for ADHD. For example, psychologists are trained and certified to give psychological, neuropsychological, and learning tests, which are typically standardized with large samples of both normal and clinical populations (2005). Furthermore, as these assessments are so rigorously tested for validity and reliability and because psychologists often administer a full battery of such tests in response to an assessment question, they are more likely to pinpoint the specific type of behavioral or learning difficulty that a child has (2005). While a medical evaluation with a physician or other medical doctor is important for ruling out medical explanations for symptoms, their practices typically do not include such stringent assessment procedures for an ADHD diagnosis.

Unfortunately, with no population data available on psychologist-diagnosed ADHD in Manitoba, it is difficult to know how many children are gaining access to such assessments. However, in their study reviewing ADHD diagnosis and treatment in regard to physician specialty, Brownell and Yogendran (2001) found that the diagnosis and treatment of ADHD in Manitoba are strongly influenced by the practice styles of local physicians (with general practitioners in rural areas varying a great deal in their diagnosing and prescribing behaviors). Consequently, it seems that a policy review of assessment procedures for ADHD in Manitoba is highly advisable. If the methods for diagnosing and treating this disorder were standardized across the province, it would enable a clearer picture as to whether ADHD rates are truly on the rise, as well as greater assurance that the appropriate diagnoses were being given. As discussed previously, there are a number of disorders with similar symptoms to ADHD (i.e. Fetal Alcohol Spectrum Disorder, Conduct Disorder, Oppositional Defiant Disorder, and Learning Disabilities) and many of these disorders also very commonly co-occur with ADHD (NIMH, 2003).

Therefore, a more thorough assessment process is crucial for gaining a complete diagnostic picture for each child and a complete diagnostic picture is essential for effective treatment.

With the findings from the present study in conjunction with findings from past research that low income (Rieppi et al., 2002; Brownell, Mayer & Chateau, 2006), urban dwelling (Brownell & Yogendran, 2001; 2005; Rowland, Lesesne, & Abramowitz, 2002) children who have a comorbid diagnosis of BD and/or LD (August, Realmuto, MacDonald, Nugent, & Crosby, 1996) had the highest rates of ADHD diagnoses and prescriptions, it seems advisable to focus the most resources on children in these categories. Furthermore, with the SES gradient being observed for urban children 0 to 13 years of age only, it is also advisable to focus extra resources for low income urban children in this age group. As was mentioned in the previous paragraphs, these resources should certainly include the best assessments available. Additional resources might include smaller teacher to student ratios, and higher numbers of other education professionals (e.g. school psychologists, resource teachers, teacher's aids, etc.).

With the high prevalence of comorbid diagnoses and ADHD, additional resources specific to these subgroups would also be highly beneficial. Furthermore, it would be helpful to have more information on the prevalence rates of conditions that are commonly comorbid with ADHD or have similar symptom presentation to ADHD, but were not included in this study (i.e. mood disorders, anxiety disorders, substance use disorders, and Fetal Alcohol Spectrum Disorder). In a review of ADHD and comorbid mental health conditions, Spencer stated that "follow-up studies of children with ADHD indicate that subgroups of subjects with ADHD and comorbid disorders have a poorer outcome as evidenced by significantly greater social, emotional, and psychological difficulties" (2006). Consequently, whenever possible, resources for children with ADHD and comorbid conditions should be tailored as much as possible to each child's full range of symptoms.

In light of the recent findings that psychostimulants are related to growth delays that don't seem to rebound over time (Swanson et al., 2007), along with the non-significant differences in ADHD symptom reduction for medication, behavioral treatments, combined (medication and behavioral) treatments and community care treatments (Jensen et al., 2007) found by the MTA studies, increased information about alternate treatment implementation for ADHD is highly warranted. Population-based data on prevalence rates for treatments such as behavioral therapy as well as additional studies that investigate the outcome success of multiple treatment modalities are both important areas of exploration at this time. With this knowledge, policy makers could make informed decisions on what the most efficacious treatment of ADHD is, while avoiding further health problems (i.e. permanent growth stunting).

Results from this study in conjunction with previous research (Brownell & Yogendran) indicate that psychostimulant medication rates in Manitoba children with ADHD have almost doubled since 1995/96. Consequently, it appears that medication is a popular treatment for ADHD in this province, and this popularity is increasing with time. However, if research continues to support the finding that these medications are related to growth delays that do not rebound, Manitoba health policy makers may need to reconsider acceptable ADHD treatment methods as well.

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Appendix A

DSM-IV-TR Diagnostic Criteria for Attention-Deficit/ Hyperactivity Disorder

A. Either (1) or (2):

(1) six (or more) of the following symptoms of **inattention** have persisted for at least 6 months to a degree that is maladaptive and inconsistent with developmental level;

Inattention

- often fails to give close attention to details or makes careless mistakes in schoolwork, work, or other activities
- often has difficulty sustaining attention in tasks or play activities
- often does not seem to listen when spoken to directly
- often does not follow through on instructions and fails to finish schoolwork, chores, or duties in the workplace (not due to oppositional behavior or failure to understand instructions)
- often has difficulty organizing tasks and activities
- often avoids, dislikes, or is reluctant to engage in tasks that require sustained mental effort (such as schoolwork or homework)
- often loses things necessary for tasks or activities (e.g., toys, school assignments, pencils, books, or tools)
- is often easily distracted by extraneous stimuli
- is often forgetful in daily activities

(2) six (or more) of the following symptoms of **hyperactivity-impulsivity** have persisted for at least 6 months to a degree that is maladaptive and inconsistent with developmental level:

Hyperactivity

- often fidgets with hands or feet or squirms in seat
- often leaves seat in classroom or in other situations in which remaining seated is expected
- often runs about or climbs excessively in situations in which it is inappropriate (in adolescents or adults, may be limited to subjective feelings of restlessness)
- often has difficulty playing or engaging in leisure activities quietly
- is often "on the go" or often acts as if "driven by a motor"

- often talks excessively

Impulsivity

- often blurts out answers before questions have been completed
- often has difficulty awaiting turn
- often interrupts or intrudes on others (e.g., butts into conversations or games)

(B) Some hyperactive-impulsive or inattentive symptoms that caused impairment were present before age 7 years.

(C) Some impairment from the symptoms is present in two or more settings (e.g., at school [or work] and at home).

(D) There must be clear evidence of clinically significant impairment in social, academic, or occupational functioning.

(E) The symptoms do not occur exclusively during the course of a Pervasive Developmental Disorder, Schizophrenia, or other Psychotic Disorder and are not better accounted for by another mental disorder (e.g., Mood Disorder, Anxiety Disorder, Dissociative Disorder, or Personality Disorder).

Based on these criteria, three specific subtypes of ADHD are identified:
1. ADHD, Combined Type: if both criteria 1A and 1B are met for the past 6 months

2. ADHD, Predominately Inattentive Type: if criterion 1A is met but criterion 1B is not met for the past six months

3. ADHD, Predominately Hyperactive-Impulsive Type: if Criterion 1B is met but criterion 1A is not met for the past six months

Appendix B

Crude rate data for income quintiles by age groups for Diagnoses and Prescriptions in 2005/05

		Income by Age for Diagnoses			Income by Age for Prescriptions		
Age Group	Income Quintile	Number of Diagnoses	Child Population	Crude Rate	Number of Diagnoses	Child Population	Crude Rate
1	NF	6	1268	0.47	*s*	1268	*s*
1	R1	12	6672	0.18	*s*	6672	*s*
1	R2	9	4437	0.20	*s*	4437	*s*
1	R3	7	4474	0.16	*s*	4474	*s*
1	R4	6	4330	0.14	*s*	4330	*s*
1	R5	12	4506	0.27	*s*	4506	*s*
1	U1	30	7564	0.40	*s*	7564	*s*
1	U2	18	6303	0.29	*s*	6303	*s*
1	U3	15	6020	0.25	*s*	6020	*s*
1	U4	16	5714	0.28	*s*	5714	*s*
1	U5	8	5560	0.14	*s*	5560	*s*
2	NF	45	861	5.23	11	861	1.28
2	R1	56	4972	1.13	13	4972	0.26
2	R2	51	3564	1.43	15	3564	0.42
2	R3	51	3638	1.40	19	3638	0.52
2	R4	46	3464	1.33	13	3464	0.38
2	R5	44	3790	1.16	18	3790	0.47
2	U1	182	5327	3.42	71	5327	1.33
2	U2	115	4703	2.45	35	4703	0.74
2	U3	83	4642	1.79	34	4642	0.73
2	U4	74	4760	1.55	27	4760	0.57
2	U5	52	4973	1.05	21	4973	0.42
3	NF	90	851	10.58	57	851	6.70
3	R1	120	5172	2.32	60	5172	1.16
3	R2	141	3749	3.76	86	3749	2.29
3	R3	138	3895	3.54	90	3895	2.31
3	R4	124	3745	3.31	79	3745	2.11
3	R5	155	4408	3.52	111	4408	2.52
3	U1	374	5445	6.87	254	5445	4.66
3	U2	285	5099	5.59	187	5099	3.67
3	U3	256	5125	5.00	169	5125	3.30
3	U4	270	5551	4.86	175	5551	3.15
3	U5	231	5897	3.92	161	5897	2.73
4	NF	129	1226	10.52	102	1226	8.32
4	R1	181	7281	2.49	131	7281	1.80
4	R2	178	5298	3.36	134	5298	2.53
4	R3	217	5547	3.91	165	5547	2.97
4	R4	192	5308	3.62	144	5308	2.71
4	R5	260	6418	4.05	209	6418	3.26
4	U1	544	7034	7.73	454	7034	6.45
4	U2	416	6701	6.21	322	6701	4.81
4	U3	413	7002	5.90	309	7002	4.41

4	U4	404	7847	5.15	305	7847	3.89
4	U5	386	8813	4.38	333	8813	3.78
5	NF	113	1673	6.75	76	1673	4.54
5	R1	110	9519	1.16	63	9519	0.66
5	R2	157	7902	1.99	117	7902	1.48
5	R3	184	7927	2.32	139	7927	1.75
5	R4	152	7873	1.93	122	7873	1.55
5	R5	236	9411	2.51	181	9411	1.92
5	U1	326	10083	3.23	257	10083	2.55
5	U2	320	9858	3.25	248	9858	2.52
5	U3	367	10480	3.50	280	10480	2.67
5	U4	336	12176	2.76	264	12176	2.17
5	U5	490	13650	3.59	393	13650	2.88

s refers to suppressed data