ASSOCIATION OF PREVALENCE OF AUTISM SPECTRUM DISORDERS AMONG KINDERGARTEN CHILDREN IN RELATION TO DISTANCE TO REGIONAL INTERVENTION SERVICE PROVIDERS IN ONTARIO

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By
ANAHITA HADIOONZADEH, M.Sc.

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AUTHOR: Anahita Hadioonzadeh, M.Sc. (McMaster University)

SUPERVISORS: Dr. Peter Szatmari, Dr. Magdalena Janus

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Abstract

Background and objectives: Recently, more attention has been placed on contributing factors for different prevalence rates of ASDs/PDDs in geographical areas. This study examines the association between diagnosis of ASDs and distance to regional intervention centres using a population-based dataset of children attending Senior Kindergarten classes in Ontario. Demographic and socioeconomic variables were also examined to find significant predictors for diagnosis of ASDs.

Methods: Data from all sites of Ontario with completed Early Development Instrument (EDI) in school years 2009/10 and 2010/11 were included. Individual-level variables were derived based on the data provided by EDI. Neighbourhood-level variables on socioeconomic factors of children's place of residence were obtained through census data.

Results: 708 out of 66,284 children were reported by teachers to have diagnosis of ASDs, which results in a prevalence rate of 1.0% for ASDs. Children living near regional centres were less likely to be in the diagnosed group (OR=0.77). Moreover, children living in neighborhoods with high proportion of adults with high school diplomas and high proportion of single-parent families were more at risk of being reported as diagnosed (OR=1.27 & 0.73; respectively). MCYS region that a child lives in was found to be another significant predictor for teacher-reported diagnosis of ASDs.

Conclusion: Regional centres were not the only centres providing interventions to children with ASDs in Ontario. Therefore, having in-detailed information about the exact place of receiving intervention for each child would be beneficial. Furthermore, having single-parent family

structure as a significant predictor necessitates specific policies for these families to obtain appropriate services, reduce caregiver's stress, and improve family functioning.

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1. Introduction

Autism Spectrum Disorders (ASDs) are known as one of the most challenging disabilities for children. According to the DSM-IV-TR, ASDs include Autistic Disorder (AD), Asperger's disorder (AS), and pervasive developmental disorder- Not Otherwise Specified (PDD-NOS). Pervasive Developmental Disorders are also sometimes considered as ASDs as they usually share similar features. PDD covers autistic disorder, Asperger syndrome, PDD not otherwise specified, Rett's Syndrome, and childhood disintegrative disorder (CDD). However, the prevalence of Rett's Syndrome and CDD are reported to be very low, thus not making any difference in the overall prevalence rates (1 in 10,000 and 0.2 in 10,000, respectively) (Fombonne, 2003a; Fombonne, 2003b; Fombonne, 2009). The average prevalence rates are reported to be 20.6/ 10,000 for AD, 37.1/ 10,000 for PDD-NOS, 6/10,000 for AS by a systematic review of surveys for children with median age of 8 years old (Fombonne, 2009).

A child diagnosed with Autistic Disorder has core symptoms such as impairments in social interaction including the use of non-verbal behaviors, developing friendships, sharing enjoyment or interests, and in social or emotional reciprocity. They may also suffer from impairments in communication which include developmentally delays in speech and language, being unable to initiate/ sustain a conversation, the use of stereotyped and repetitive language, and deficits in social imitative play appropriate to developmental level. Additionally, children with autism may experience restricted, repetitive and stereotyped patterns of behavior and activities that are abnormal (DSM-IV).

Children diagnosed with Asperger's Disorder (AS) have difficulty in social interaction, reciprocity and communication. They may also have restricted interests or unusual obsessions leading to social isolation. To differentiate this diagnosis from autistic disorder, we can consider

the fact that there is no clinically significant general delay in language for diagnosed children with AS. Children use single words and communicative phrases by age two and three, respectively. Also, these children do not have clinically significant delays in cognitive development, self- help skills, and in adaptive behaviour except in social interaction, and environmental curiosity (DSM-IV).

A child is diagnosed with Pervasive Developmental Disorder- Not Otherwise Specified (PDD-NOS) if he/she has a pervasive impairment in the development of reciprocal social interaction. This can be due to shortfalls in either verbal or nonverbal communication skills, or with the presence of stereotyped behavior, interests, and activities. On the other hand, PDD_NOS is a diagnosis of exclusion, which means that the child should not meet the criteria for other developmental disorders such as another Pervasive Developmental Disorder, Schizophrenia, Schizotypal Personality Disorder, or Avoidant Personality Disorder. In a study conducted by Walker et al., children diagnosed under this category were functioning higher compared to the children with autism and had more delayed language than children with AS (Walker et al., 2004). Children categorized with this disorder are reported to have remarkable impairments in social communication and fewer repetitive behaviors than both the autism and AS groups (Walker et al., 2004).

Some of the reliable and valid diagnostic tools used for case identification include Autism Spectrum Screening Questionnaire (ASSQ), Autism Diagnostic Observation Schedule (ADOS), and Autism Diagnostic Interview–Revised (ADI-R) (Ehlers, Gillberg, & Wing, 1999; Lord et al., 1989; Lord, Rutter, & LeCouteur, 1994; Lord, DiLavore, & Risi, 1999; Wing, Leekam, Libby, Gould, & Larcombe, 2002).

2. Literature Review

This section contains a review of the current literature on the reported prevalence rates for ASDs and the associated determinants. The majority of the publications were based on either health care or administrative records and a few of them consist of a combination of both. Therefore, it was essential to report the source of the data as including both might lead to a different prevalence rate.

2.1. Search strategy

A systematic search of the literature was conducted in order to identify studies related to the thesis topic. The following electronic databases were identified as being most relevant to the subject of interest: Medline, Pubmed, Psychinfo, and the Cochrane library. A list of subject headings related to prevalence rate of ASDs and its significant determinants were compiled. These included: 'ASDs', 'PDDs', in combination with 'environmental factors', 'comorbidity of ASDs', 'diagnosis', 'epidemiology', and 'socioeconomic variables'. These subject headings were exploded in order to obtain additional related search terms and categories. The searches were limited to studies published in English between the years 2000 and 2012. Although it is desirable to include only recent studies in order to reflect current practice and knowledge, an initial search revealed that a few important studies were published in the late 1990s, which were included in the search. After combining search terms, a total of 348 papers were found. Titles and abstracts were examined by the author and irrelevant articles were discarded. Finally, a total of 146 relevant studies were selected and retrieved for full text review.

Websites of Health Canada, the Canadian Institute of Health Information (CIHI), Census Canada, and the Ministry of Child and Youth Services (MCYS) were searched for relevant

statistics from the "grey literature" concerning prevalence rates and associated factors in Canadian jurisdictions.

2.2. Findings

During the last two decades, an unprecedented growth is reported for the prevalence rate of ASDs from 3/10,000 in 1980s to 6-7/10,000 (0.6 to 0.7%; or one child out of 150) (American Psychiatric Association, 1980; US Dept of Health and Human Services, 1988; American Psychiatric Association, 1994; World Health Organization, 1992; Burd, Fisher, & Kerbeshian, 1987; Ritvo, Freeman, & Pingree, 1989; Kirby, Brewster, Canino, & Pavin, 1995; Yeargin-Allsopp et al., 2003; Bertrand et al., 2001; Fombonne, 2009; Chakrabarti & Fombonne, 2005; Baird, Chairman, & Baron-Cohen, 2000; Centers for Disease Control and Prevention, 2007; Mandell et al., 2010). Two other studies found a remarkable increase of 57% for children aged eight from 2002 to 2006 and a rise from 2.3% in the school year of 2002/03 to 4.4% in 2007/08 based on administrative data (Centers for Disease Control and Prevention, 2006; Office of Special Education Programs, 2008a; Office of Special Education Programs, 2008b). The most recent report by Centres for Disease, Control, and Prevention (CDC) provided a prevalence rate of 1 out of 88 for children at 8 years of age with collecting data from existing records in 14 Autism and Developmental Disabilities Monitoring Network sites in United States (Centers for Disease Control and Prevention, 2012). However, whether the prevalence rate of autism spectrum is increasing is a highly debated topic. There are lots of underlying reasons in this regard that should be taken into account before making any conclusions.

First, changes in diagnostic criteria and expanding the concept of autism to a spectrum of disorders can be considered as one of the contributing factors (Bishop, Whitehouse, Watt, & Line, 2008; Grether, Rosen, Smith, & Croen, 2009; King & Bearman, 2009; Nassar et al., 2009).

This may also result in switching between diagnosis of this disorder and some other disorders such as mental retardation or language disorders and providing more ability to detect the less severe types of disorder (Croen, Grether, Hoogstrate, & Selvin, 2002; Jick, Kaye, & Black, 2003; Kielinen, Linna, & Moilanen, 2000; Bishop, Whitehouse, Watt, & Line, 2008). In a study by Jick et al. the incidence of language disorders has declined by roughly the same amount that the incidence of ASDs has increased in boys between 1990 to 1997 (Jick, Kaye, & Black, 2003).

Second, case identification methods vary a lot between studies and can play a significant role in explaining differences in ASD prevalence rates (Fombonne, 2002; Fombonne, 2008; Grinker, 2007; Fombonne, 2003a). Chakrabarti assessed prevalence of PDDs among two consecutive birth cohorts of 4-6 years of age born in 1992-1995 and 1996-1998 in the same area while employing the same methodology and suggested a stable incidence (Chakrabarti & Fombonne, 2005). Other related studies showed that availability and accessibility of more data sources are correlated with higher prevalence rates (Centers for Disease Control and Prevention, 2007; Centers for Disease Control and Prevention, 2009; Fombonne, 2001; Laidler, 2005; Newschaffer, Falb, & Gurney, 2005; Pinborough-Zimmerman, Bilder, Satterfield, Hossain, & McMahon, 2010). CDC examined prevalence rates of ASDs when relying on health records and compared it to the rates derived with considering education and health records combined. The former provided an estimate of 0.75%; whereas the latter increased to 1.1% (Centers for Disease Control and Prevention, 2012). This confirms the limitation of records and registry-based approaches for case identification in different studies.

Other important factors in this regard can be considered as increased public awareness (Barbaresi, Katusic, Colligan, Weaver, & Jacobsen, 2005; Fombonne, Zakarian, Bennett, Meng, & McLean-Heywood, 2006; Kogan et al., 2009), more availability of medical and educational

resources, increased media coverage, informed professionals and service providers (National Research Council, 2001; Cowley, 2000; Children's Health Act of 2000, 2000).

One of the previous studies showed that children living within 250 meters of a child diagnosed with ASDs has a four times greater risk for receiving the diagnosis of ASDs, compared to living between 500 to 1,000 meters away (King, Zerubavel, & Bearman, 2010). This may be due to social contagion and becoming familiar with symptoms through conversations with families who have an affected child. Another study provided evidence on increase in prevalence rates as a function of special education services availability, which may lead more parents bringing their children's problems to the attention of health care professionals. This may also result in increased awareness among health care professionals to detect and document ASD related symptoms (Barbaresi, Katusic, Colligan, Weaver, & Jacobsen, 2005). Moreover, better ascertainment especially for the children at the less severe end of the spectrum was reported to account for the increase in prevalence rates compared to previous studies (Kim, Leventhal, Koh, Fombonne, & Laska, 2011; King, Zerubavel, & Bearman, 2010).

2.2.1. Etiology

Genetic factors:

Except for Rett syndrome, which is associated with mutations of the methyl-CpG-binding protein 2 (*MeCP2*) genes, the etiology of ASDs has not been confirmed yet (Amir, Van den Veyver, & Wan, 1999). Heritability accounts for more than 90% of the autism spectrum cases and more than 100 genes are reported as potential candidates (Szatmari & Jones, 2007; Freitag, 2007; Folstein & Rosen-Sheidley, 2001; Ykes & Lamb, 2007).

Environmental factors:

Since heritability explains less than 100% of cases and there is a huge variation for symptoms among identical twins with autism, environmental factors may play a significant role in increasing the risk of autism. Fombonne found no association between autism and inflammatory bowel disease or with a live Measles, Mumps, and Rubella (MMR) vaccination (Fombonne, 1999; Chakrabarti & Fombonne, 2001). Although factors such as advanced age in parents and use of psychiatric drugs by mothers during pregnancy have been studied, still there is uncertainty if pathogenesis in autism is through the mother or the father or both (Gardener, Spiegelman, & Buka, 2009). Some of the previous studies identified older paternal age as a significant risk factor for ASDs (Schubert, 2008; Geschwind, 2009).

2.2.2. Co-morbidities

High rates of comorbidity are reported between ASD and at least one additional psychiatric disorder (70%) (Leyfer et al., 2006; Simonoff et al., 2008). One study in UK included 26 autistic children between 4 to 6 years of age and reported a co- occurrence rate of 70-80% between ASD and Mental Retardation (MR) (Chakrabarti & Fombonne, 2001). Although it is sometimes challenging to decide if symptoms such as compulsivity are part of ASDs or a comorbidity of Anxiety Disorder, it is clear that anxiety is a problem for a large number of individuals with ASD. Autism can also be accompanied by early life epilepsy (Ronen, Buckley, Penney, & Streiner, 2007; Tuchman & Cuccaro, 2011). Diagnosis of common epilepsy and autism has been found for 30% of children (Spence & Schneider, 2009; Jensen, 2011; Brooks-Kayal, 2010). Other comorbid disorders may include attention deficit/ hyperactivity disorder, mood disorders, bipolar disorder, Tuberous Sclerosis, Tourette Syndrome, Oppositional Defiant Disorder, depression, and schizophrenia (Ghaziuddin, Ghaziuddin, & Greden, 2002; McElroy, 2004; Matson & Nebel-Schwalm, 2007; Curatolo, Bombardieri, & Jozwiak, 2008; Jeste, Sahin, Bolton,

Ploubidis, & Humphrey, 2008; Steyaert & De La Marche, 2008; Simonoff et al., 2008; Hofvander et al., 2009; Rapoport, Chavez, Greenstein, Addington, & Gogtay, 2009).

Despite a large number of studies about comorbidity rates of ASD and other medical conditions, only a few studies have been done with the focus of pre-school children with ASDs. In a large-scale study of 3 to 5-year-olds, results for children with ASDs was compared with two other samples of preschoolers. Co- morbidity rates were found to be 41% for ADHD, 51% for anxiety disorder, and less than 10%–15% diagnoses such as depression, dysthymia, oppositional defiant disorders, and conduct disorders (Gadow, DeVincent, Pomeroy, & Azizian, 2004). However, these rates were even higher than those found in a high-risk sample of 1,700 children with ASDs, who were 3 to 5 years of age (average of emotional and behavioral disorders=17%) (Feil, Small, Forness, R Serna, & Hancock, 2005).

Additionally, prevalence rates for emotional/ behavioral disorders in typically developing preschool samples were taken into account. These rates are reported to be 3% to 5% for ADHD, 1% to 2% for depression/ dysthymia, and 6% for anxiety in children younger than six years of age or the ones attending kindergarten classes (Ghuman, Arnold, & Anthony, 2008; Birmaher & Brent, 2007; Connolly & Bernstein, 2007).

2.2.3. Formal diagnosis of ASDs

In prevalence rate studies for different age groups, the timing of receiving a formal diagnosis is also critical. Owing to establishing diagnostic criterion of symptoms for children before age 3, age of diagnosis has decreased from age 5 and 6 years to 3 years of age during the last two decades (Mandell, Listerud, Levy, & Pinto-Martin, 2002; Chakrabarti & Fombonne, 2005; Howlin & Asgharian, 1999; Siegel, Pliner, Eschler, & Elliot, 1988; Lord, Risi, & DiLavore,

2006; Wetherby, Woods, & Allen, 2004; Filipek, Accardo, & Ashwal, 2000). However, still a long period of delay remains between the identification of the first symptoms (usually around 18 to 24 months) and formal diagnosis of ASDs (school age) (Levy, Merhar, Ittenbach, & Pinto-Martin, 2003; Mandell, Listerud, Levy, & Pinto-Martin, 2002; Yeargin-Allsopp et al., 2003). Some of the significant factors that might account for the finding that young children do not have come to the attention of health care professionals earlier are inadequate screening practices, slow response of pediatricians to parental concerns, low sensitivity of screening instruments for autism, lack of awareness of symptoms, or misdiagnosis of autism spectrum due to similarity of features (Sices, Feudtner, McLaughlin, Drotar, & Williams, 2003; Shevell, Majnemer, Rosenbaum, & Abrahamowicz, 2001; Dumont-Mathieu & Fein, 2005; Shah, 2001; Noterdaeme, Amorosa, Mildenberger, Sitter, & Minow, 2001). Other influential factors might be lower availability of services, younger age of mothers, lower educational level of mothers, and mother's ethnic background (Shattuck, Durkin, & Maenner, 2009).

Diversity in geographical regions can be considered as another contributing factor for variations in age of diagnosis of children with ASDs. Ouellette- Kuntz and colleagues used clinical data from 1997 to 2005 in four regions in Canada and found significant difference in age of diagnosis by geographical regions. Included regions were Manitoba, Southeastern Ontario, Prince Edward Island, and Newfoundland and Labrador. Median age of diagnosis in months was reported as 42, 47, 44.5, and 36; respectively. "Zero" waitlist policy for initiating interventions in Newfoundland and Labrador, and availability of interventions only for autistic children or those with severe symptoms in Ontario can be some of the important factors explaining this variation (Ouellette-Kuntz, Coo, & Lam, 2009).

2.2.4. Prevalence rate of ASDs in relation to geographical regions:

Evidence suggests that examining prevalence rates in different geographical regions and assessing associated determinants could provide systematic information regarding existing services and policies in each region as well as the needs and priorities of each community.

In a systematic review, Elsabbagh and colleagues examined the possible impact of geographic, cultural/ethnic, and socioeconomic factors on prevalence estimates (Elsabbagh, Divan, Koh, Kim, & Kauchali, 2012). A median estimate of 17/10,000 for autism disorder and 62/10,000 for all PDDs combined were found. Since the year 2000, prevalence estimates of autism were not significantly different between America, Western Pacific, and Europe, which were reported to be 22, 12, and 19 per 10,000, respectively. PDD estimates were not significantly different among America (65/10,000) and Europe (62/10,000). This study reflected that a large number of studies were conducted in countries with high level of income such as northern Europe, Japan, and the United States; whereas only a few studies were available for mid-income countries and no prevalence estimates were available for low-income regions such as Africa. This paucity of research for mid-income and low-income countries is also reported in some of the other studies, which indicates the urge to increase availability of services and also research in countries/ communities with lower levels of income (Fombonne, 2009; Williams, Thomas, Sidebotham, & Emond, 2008).

Studies conducted by Centers for Disease Control and Prevention (CDC) are the largest investigations for variation of prevalence for ASDs between geographical regions. Out of 10 American states, Alabama had the minimum of rate with 3.3/ 1000; whereas New Jersey at 10.6/ 1000 had the highest prevalence rate in the year 2002 (Centers for Disease Control and Prevention, 2007). These rates changed to 7.2/1000 in Florida as the lowest and 21.2/1000 in Utah as the highest in the most recent CDC surveys (Centers for Disease Control and Prevention,

2012). These disparities in a study with the same methodology, at the same time, and children of the same age (8 years of age) reflected ascertainment variability between the included sites, rejecting the hypothesis of having an increase in incidence of ASDs. These variations might be explained through changes in the concept, definitions, service availabilities, differences in local policies, and awareness of general and professional public.

Another study in Atlanta found a rate of 34/10,000 for ASDs in children between 3 to 10 years of age. However, they mentioned that this might be an underestimate for the prevalence rate as cases were identified through screening and abstracting records at medical and educational sources and mild or high functioning ASD children were likely to be underrepresented (Yeargin-Allsopp et al., 2003).

Mandell and colleagues found an association between county of residence and Medicaid-enrolled ASD prevalence. Counties with higher number of pediatricians and pediatric specialists showed higher prevalence rates. They argued that families might have moved closer to health care services or this variation might be due to different state's policies in terms of local awareness or availability of education and other resources for this population of children. Unfortunately, availability of health care resources in each county was not measured (Mandell et al., 2010). In another study, Mandell et al. examined the variation among 50 US states in terms of prevalence of ASDs and the associated factors using administrative database. Secondary data was obtained from the US Department of Education and the American Board of Paediatrics. Range of diagnosed children was reported as 0.6 per 1000 to 4.6 per 1000 in 2000-2001. This variation in the administrative prevalence of ASD was associated with education-related expenditures, access to pediatricians and school-based health centres in each state. It is also possible that parents of children with ASDs moved to states which use more resources (Mandell & Palmer, 2005).

One factor that has not been studied in any of the previous studies is variation in prevalence rates of ASDs among geographic regions in relation to distance to an autism intervention centre. It might be beneficial for families with an affected child to live closer to one of the Regional Autism Intervention Program Service Providers, since interventions tend to be intense and families have to visit these centers frequently. Additionally, it might be easier for families to commute when they live closer to one of these centers to have interventions more easily available and accessible as children with ASDs are diagnosed at younger ages. It is possible, therefore, that families of young children with ASDs will cluster around regional centres leading to higher prevalence rates for these areas. To address this gap in the literature, this thesis was conducted with the main purpose of using data from a population-based study of kindergarten children in Ontario to examine patterns and differences among communities in relation to distance to a Regional Autism Intervention Program Service Provider. Demographic variables and socioeconomic factors will also be examined in this regard.

2.3. Important determinants of prevalence rate

Sex

Although the diagnostic classification of ASDs has changed in recent years, the ratio of diagnosed boys vs. girls has changed slightly from 4:1 to 5:1 (Autism and Developmental Disabilities Monitoring Network, 2007; Fombonne, 2008; Scott, Baron-Cohen, Bolton, & Brayne, 2002; Yeargin-Allsopp et al., 2003; Burd, Fisher, & Kerbeshian, 1987; Centers for Disease Control and Prevention, 2012). Studies that examined the underlying reason for this difference suggested that variants involving genes on the X chromosome, testosterone- related effects on brain development in pre-natal as well as post-natal life, or an association with fragile-

X syndrome may be an explanatory factor (Blasi et al., 2006; Jamain et al., 2003; Vincent et al., 2004; Filges, Boesch, Demougin, & Wenzel, 2011; Noor et al., 2010; Celestino-Soper et al., 2011; LaSalle & Yasui, 2009; Rogers, Wehner, & Hagerman, 2001; Auyeung, Taylor, Hackett, & Baron-Cohen, 2010; Baron-Cohen, Knickmeyer, & Belmonte, 2005).

Some of the studies examining the relationship between this sex ratio and parental age groups have reported higher ratios among children of older fathers (Reichenberg et al., 2006; Cantor, Yoon, Furr, & Lajonchere, 2007; Croen, Najjar, Fireman, & Grether, 2007; Glasson et al., 2004; Lauritsen, Pedersen, & Mortensen, 2005; Tsuchiya et al., 2008). Anello et al. examined the boys-to-girls ratio in relation to maternal age group, but did not find any significant relationship (Anello et al., 2009). Another large hospital-based historical birth cohort study conducted by Croen and colleagues reported independent associations between ASDs and both maternal and paternal age. These associations were slightly stronger for girls compared to boys, suggesting a decrease in sex ratio when considering parental age (Croen, Najjar, Fireman, & Grether, 2007).

Another recent study conveyed that the elevated sex ratio in ASDs can be due to knowledge of clinicians about this ratio and, therefore, identify more boys than girls as diagnosed with ASDs (Nichols, Moravcik, & Tetenbaum, 2008). This is confirmed by another study that found boys with ASDs to be more likely diagnosed than girls even though they had the same timing of the first developmental evaluation (Giarelli, Levy, Kirby, Pinto-Martin, & Mandell, 2010).

Age groups

Due to the changes in diagnostic criteria, lower sensitivity of case identification for younger ages, public awareness, and availability of services, the prevalence rates among different age groups is hard to interpret. Lower prevalence rates are reported for the age group of three and

four years of age, whereas these rates reach a peak for children aged 5 to 10 years (Kogan et al., 2009; Yeargin-Allsopp et al., 2003).

Yeargin-Allsopp examined the prevalence rate of ASDs for different age groups and found lower prevalence rates for 3 and 4 year olds (1.9 per 1000) as well as an unexpected decrease for 9 and 10 year olds (2.7 and 2 per 1000, respectively) (Yeargin-Allsopp et al., 2003). They also found a prevalence rate of 4.1 to 4.5 in 1,000 children for the age group of 5 to 8, which might be a more accurate rate because of developments in diagnostic criteria as well as availability of related services since the 1990s. Lower prevalence rates of ASDs for children younger than five years of age compared to the older age groups reflects that efforts to improve the diagnosis of children at early ages is still required and have not yet been accomplished.

Bilingualism

One of the main areas of impairment for children with ASDs is language delay. Although lots of studies have been conducted about language delay in children with ASDs, little research has been performed to study the association between bilingual environments and language development for diagnosed children with ASDs. Previous studies found no significant association between bilingual exposure and additional language delays in children with Language Impairment or Down Syndrome (Gutierrez-Clellen, Simon-Cereijido, & Wagner, 2008; Paradis, Crago, Genesee, & Rice, 2003; Feltmate & Kay-Raining Bird, 2008; Kay-Raining Bird et al., 2005). However, these studies had pitfalls such as low sample size in language-impaired groups who were exposed to bilingual environments. Hambly and colleagues carried out a study to find the impact of bilingual environments on language level and also social ability for children with ASDs by using Vineland Adaptive Behavior Scales-II (Hambly & Fombonne, 2012). They defined additional delays as smaller expressive vocabularies, lower levels of

language comprehension and production, and later onset of early language milestones for this population of children. The result suggests that there were no additional delays in language development for children with ASDs with bilingual exposure. Considerable limitations of this study were the inclusion of self-selected families to participate, and possibility of not having a large enough sample size to detect a mean vocabulary difference of 50 words.

Ethnicity

Evidence suggests that there might be differential recognition and diagnosis of autistic disorder by ethnicity. Some of the previous studies found later or under-diagnosis for ethnic minority groups compared to the Caucasian children (Palmer, Blanchard, & Jean, 2005; Mandell, Wiggins, & Carpenter, 2009; Centers for Disease Control and Prevention, 2006; Shattuck, Durkin, & Maenner, 2009). Possible reasons are reported to be poverty, different clinical presentations, and differences in parental behaviors (Mandell, Listerud, Levy, & Pinto-Martin, 2002; Coonrod & Stone, 2004; Dubay & Kenney, 2001).

A study conducted in Atlanta found no difference for prevalence of autism in relation to ethnicity, not even between subgroups of ethnicity and sex (Yeargin-Allsopp et al., 2003). However, two other studies found higher prevalence estimates for black children compared to their Caucasian peers (Croen, Grether, Hoogstrate, & Selvin, 2002; Hillman, Kanafani, Takahashi, & Miles, 2000). Yet there are still some differences between the Atlanta study and the other two studies. The former used a multiple source system including both governmental and public service providers for case identification; whereas the latter used only one public service provider (developmental disability service data). In contrast, the CDC study ascertained that white children had higher prevalence rates compared to Black or Hispanic children (Centers for Disease Control and Prevention, 2009). On this subject, Yeargin-Allsopp et al. found schools

as the most important source of information when cases were black or mothers were less educated (Yeargin-Allsopp et al., 2003). Furthermore, lower prevalence rates are reported for autism spectrum among Hispanic children compared to Non-Hispanic Whites (Autism and Developmental Disabilities Monitoring Network, 2007) (Croen, Grether, Hoogstrate, & Selvin, 2002; Croen, Grether, & Selvin, 2002). Related reasons of different prevalence rates for ethnic-minority groups are suggested to be less access to health insurance, living in households that fall below the poverty line, living in urban areas, lack of a regular source of medical care, and difficulty in having access to specialty care (Flores & Tomany-Korman, 2008; Palmer, Walker, Mandell, Bayles, & Miller, 2010). Also, Mandell and colleagues found older age for receiving a confirmed diagnosis of ASDs for Hispanic children compared to Non- Hispanic ones (Mandell, Listerud, Levy, & Pinto-Martin, 2002).

Parental culture can be another contributing factor in differentiating prevalence rates of autism in minority groups. Culture is defined as a group of people's way of life covering patterns of values, beliefs, attitudes, and behaviors, which are passed from each generation to the next (Kakai, Maskarinec, & Shumay, 2003). The way that parents describe their children's symptoms as well beliefs about causes, prognosis, and treatment stem from their culture. Cultural beliefs may also lead to the extent of their contribution to different intervention strategies. Additionally, autism is not usually diagnosed or reported in records if it is considered as a stigmatizing hereditary disorder (Grinker, 2007). In support for this, a study used the Autism Screening Questionnaire for all children aged 7 to 12 in South Korea. They reported that two-thirds of children with ASDs were participating in regular school classes without receiving any diagnosis for this disorder (Kim, Leventhal, Koh, Fombonne, & Laska, 2011).

Socio-economic (SES) indicators

A large number of clinical and population-based studies reported statistically significant associations between ASDs and SES indicators including parental education, occupation, and income (Fombonne, Simmons, Ford, Meltzer, & Goodman, 2001; Croen, Grether, & Selvin, 2002; Bhasin & Schendel, 2007; Williams, Thomas, Sidebotham, & Emond, 2008; Maenner, Arneson, & Durkin, 2009). It is reported that children from higher levels of SES are more likely to be diagnosed with ASDs than others (Brookman-Frazee et al., 2009). This might be because of availability of more resources to children with higher levels of SES, which makes them more likely to be recognized, receive a diagnosis, or request assessment for developmental problems.

Shattuck et al. used data from 13 sites of CDC in 2002 and found that income might be related to insurance status in the US. Families with lower levels of income are less likely to have a fully covered insurance plan and have limited availability of interventions in long waiting lists (Shattuck, Durkin, & Maenner, 2009). This might also play a significant role for children to be misdiagnosed with other developmental disorders compared to those with full coverage (Dubay & Kenney, 2001). In contrast, families with full coverage of insurance can provide their children with earlier and more intensive interventions in US (Shattuck, Durkin, & Maenner, 2009).

Another possible factor is reported to be ascertainment bias as the more knowledgeable parents of a child with ASDs are, the more likely they are to obtain an informed diagnosis (Newschaffer, Croen, Daniels, Giarelli, & Grether, 2007). Additionally, the role of educated parents who have the ability to learn interventional techniques and engage themselves as treatment collaborators are reported as crucial mediators for the better outcomes (Howlin, Magiati, & Charman, 2009; Dawson, 2008; Siller & Sigman, 2002).

Transiency might be associated with residential instability, which is reported to be a significant indicator for age of diagnoses (Mandell & Palmer, 2005). Instability in place of residence can contribute to the poor access and interruptions in pediatric health care. Therefore, the results suggest the positive impact of having coordinated continuous pediatric health care in improving outcomes for children with ASDs (American Academy of Pediatrics, 2001).

Place of residence and its impact on predicting health and health care can also play an important role in this regard. A cluster of children with ASDs in a specific geographic area can increase awareness of both physicians and families with this disorder, which may contribute to higher prevalence rates in specific regions (Slade, 2003).

A study in Texas studied the hypothesis that educational and familial resources are associated with diagnosis of ASDs. The results reflect a positive association between per capita availability of pediatricians and school-based health clinics with prevalence of ASDs among children: a six times higher prevalence of ASDs was found in the top decile of income compared to the bottom one (Palmer, Blanchard, & Jean, 2005).

Mandell found a significant association between hospitalization for children with ASDs and single-parent family structure. However, it is argued that hospitalization might be considered a break for families with limited support rather than a significant burden associated with this family structure (Mandell, 2008).

2.4. Summary of literature review

The prevalence rate of ASDs has been examined and reported to differentiate among countries, states, and also geographical regions. These studies vary greatly in methodology, case identification methods, and sources of data. Some of the important factors explaining these

variations are availability of health-care services, differences in local policies, and awareness among general and professional public of ASDs.

There have been a variety of studies on the association between ASDs and demographic as well as socioeconomic indicators and have reported inconsistent results. A large number of previous studies reported statistically significant associations between ASDs and SES indicators including parental education and income (Fombonne, Simmons, Ford, Meltzer, & Goodman, 2001; Croen, Grether, & Selvin, 2002; Bhasin & Schendel, 2007; Williams, Thomas, Sidebotham, & Emond, 2008; Maenner, Arneson, & Durkin, 2009). On the other hand, some other studies have reported no statistically significant association between ASDs and SES factors such as ethnicity (Yeargin-Allsopp et al., 2003). A possible factor for the lack of consistency is reported to be ascertainment bias as the more knowledgeable parents of a child with ASDs are, the more likely they are to obtain an informed diagnosis.

2.5. Limitations of the reviewed literature

Several limitations have been noted; most studies had small sample sizes to assess the prevalence rates and associated factors. These studies did not provide adequate power to test for small differences or to conduct more sophisticated analyses. Also, limited source of data (either clinical or administrative) makes it difficult to generalize findings to the larger population of children with ASDs.

Another notable limitation is that many of the studies reviewed contained examinations of the association of only two or three factors such as age, sex, parental education, and household income with being diagnosed with autism spectrum disorders. The limitation of this approach is that only the unadjusted effects of each factor are examined. Few studies have adequately

examined the combined influence of these factors and reported adjusted effects for age, sex, SES indicators and diagnosis of ASDs.

The majority of previous studies relied on existing service provider databases, educational databases, national registries to find participants matching the case definition on the study (Croen, Grether, Hoogstrate, & Selvin, 2002; Fombonne, Zakarian, Bennett, Meng, & McLean-Heywood, 2006; Gurney et al., 2003; Lazoff, Piperni, & Fombonne, 2002; Madsen, Hviid, Vestergaard, Schendel, & Wohlfahrt, 2002). All the above mentioned types of studies have the limitation of including a population group who are in favor of having access to service providers or agencies and not the population in large. Consequently, participants who were not in contact with services were not considered as potential cases leading to a possible underestimation of prevalence rates.

Finally, the majority of the studies on prevalence rates among geographical regions reviewed here were conducted in the United States and Europe; while mentioned rates are reported to be very similar to Canada, generalization of results from these studies to the Canadian context is limited. Additionally, none of the previous studies examined variations among geographical regions in relation to distance to a regional autism intervention provider.

2.6. Rationale for the current study

Currently, there is an increasing awareness about the importance of the early years in the child's success and development in future. Due to the fact that our data include virtually all children attending the Senior Kindergarten year in Ontario, this study provides a unique insight into prevalence rates of ASD among children in relation to distance to regional centres, demographic characteristics, and SES correlates in a population-based cohort of 5-year olds. Given the

limitations that were noted in the literature, the use of a large, systematically collected dataset offered a unique opportunity. Additionally, this population-based data helped us overcome power and sampling limitations of previous studies.

2.7. Objectives

- To examine differences in prevalence of ASDs in Ontario by Ministry of Child and Youth Services (MCYS) Regions.
- To assess the association of ASDs' diagnosis with age, sex, first language spoken at home, English/French as primary languages spoken at home, Aboriginal status, and distance to regional centres where diagnostic and treatment services for children with ASDs are provided.

3. Methods

This is a secondary data analysis using the Early Development Instrument (EDI). The project was carried out at the Offord Centre for Child Studies at McMaster University and McMaster Children Hospital. This section provides more information about this instrument and also the methods used in this thesis.

3.1. Participants

Data from all sites of Ontario with completed EDI in school years 2009/10 and 2010/11 were included in the study. The total number of included participants was 66,284 children in Senior Kindergarten (SK), of which 708 were reported as diagnosed with ASDs. Ninety-one percent of the diagnosed group and 92.6% of the non-diagnosed group were between five to six years of age.

3.2. Procedures

All SK teachers received training on how to use the instrument. The EDI was completed in the second half of the kindergarten year in order for the teacher to become familiar with the children's strengths and deficits. This also provided children with enough time to adjust to their new school environment and to the language of instruction.

As this dataset covers only two years of a three-year cycle, some of the sites were not covered completely. Consequently, 18 sites and eight regions where all schools have completed the EDI in the first two years of the 3-year-cycle were included in the analysis. This is because including all the sites with different percentage of coverage would result in inaccurate estimates for prevalence as the whole population is not counted in the analysis. Even though the data were not representative of the whole province, it was the full population of SK children in the included sites.

3.3. Measurement

Early Development Instrument: A population-based measure for communities (EDI) has been implemented since 1998 by the Offord Centre for Child Studies. It was employed in the Toronto community of North York for the first time and during the subsequent years entire province of Ontario has been covered. This tool measures children's readiness to learn at school entry, which is defined as the child's ability to meet the school's task demand covering playing and working with other children, listening to the teacher, following the rules, and being comfortable exploring and asking questions (Janus & Offord, 2007).

EDI is a teacher-completed questionnaire, available in both French and English in Canada, valid for children between 4 to 7 years of age and can be completed in less than 20 minutes. The instrument is reported to have high internal consistency and test- retest reliability ranged from 0.84 to 0.96 and 0.82 to 0.94; respectively (Janus & Offord, 2007). Inter-rater reliability between teacher's assessment of children in class and parents' assessments were at moderate level. The former ranged from 0.53 to 0.80; whereas the latter varied from 0.36 to 0.64 (Janus & Offord, 2007). Concurrent validity, external validity, and predictive validity of the instrument was also examined and found to be at acceptable level (Janus & Offord, 2007).

EDI encompasses 104 items grouped into five domains: physical health and well-being, social competence, emotional maturity, language/cognitive development, and communication skills and general knowledge (Janus & Offord, 2007). Scoring range for each domain is between 0 (lowest) to 10 (highest). Children with scores below the 10^{th} percentile in at least one of the domains are considered as "vulnerable" in terms of their school readiness. The instrument also includes an indicator of special problems and of special skills in section D of the EDI. In this section, teachers were requested to indicate whether a child had any kind of disability which impacted his

or her ability in completing school's tasks. Teachers had to specify if they were informed about any confirmed diagnoses by a doctor or psychologist. Information could be provided by the parents, medical diagnosis, and/or teacher's observation.

3.4. Variables

For the included participants, personal and demographic information were obtained from the EDI and Census Canada.

3.4.1. Measurement of Outcome

Diagnosis of ASDs

The main variable of interest in this study was the diagnosis of ASDs. Confirmed diagnosis of any disorders of the spectrum of ASDs and/or PDDs by a doctor or a psychological professional was reported by teachers on the EDI and these children were assigned to the diagnosed group. Rest of the population was allocated in the non-diagnosed group.

3.4.2. Measurement of Co-morbidity

All co-occurent disabilities with ASDs reported in section D of the EDI was considered as co-morbid disorders with ASDs. Table 1 shows list of the included special concerns:

Table 1
List of special disabilities reported on section D of the EDI

Special disabilities		
Acquired Brain Injury	Epilepsy/ Seizures	Juvenile Rheumatoid Arthritis
ADHD/ADD	Fetal Alcohol or Drug-exposed syndromes	Muscular dystrophies
ASD/PDD	Heart problems/stroke	Spina Bifida
Asperger's	Intellectual delay	Overweight
Autism	Learning disorder	Speech & Language disorders
Asthma	Mental Health disorders	Apraxia
Cancer/leukemia/brain tumour	Anxiety	Cleft palette/lip
Genetic/congenital disorders (CF & PKU)	Depression	Receptive or Expressive language
Down Syndrome	Oppositional defiant disorder/Conduct Disorder	Selective Mutism
Developmentally Delayed/Global delay	Motor impairments	Tourette's
Diabetes	Cerebral palsy	Other

3.4.3. Measurement of Covariates

Based on the literature, important predictors that may be associated with a diagnosis of ASDs were included in the study and considered as independent variables. The following section describes how each of these variables was defined as individual vs. neighborhood level variables.

a) Individual-level variables:

Child-level variables derived from the EDI are called Individual-level variables.

Age

The difference between the participant's date of birth and the date on which the EDI was completed was scaled to month and considered as the child's age. This variable was also examined as an ordinal variable with minimum of four years and two months and intervals of six months.

Sex

To assess the effect of this nominal variable as a confounder, association between sex and the dependent variable as well as with the independent variables was examined. This variable was coded as "0" for boys and "1" for girls. Children with missing values for this variable were excluded from analyses.

Bilingualism

The child's first language spoken at home was categorized as English only, French only, other only, English and French, English and other, French and other, and two other languages. It was then labelled as being monolingual (0) vs. bilingual (1). The former was chosen if the child was

grouped in any of the first three categories, whereas the latter was indicated if the child was classified in the rest of the categories.

English/ French as primary languages spoken at home

Child's first language spoken at home was also used to create another variable called "English/ French as primary languages spoken at home". Children living in families whose language spoken at home were only the two official languages in Canada were considered as having English/ French as primary languages spoken at home and assigned to the value of "0". These include categories of English only, French only, English and French. The rest of the population was categorized as not having English/ French as primary languages spoken at home (value=1).

Aboriginal Status

Teachers were instructed to report the child's background as "Aboriginal" if he or she was North American Indian, Metis, or Inuit. Value of "0" was assigned to each child with no Aboriginal status and "1" was appointed to the rest of the included children.

MCYS region

Although this nominal variable was calculated for each child and therefore is categorized under individual-level variables, it was not directly reported on the EDI. Distance was derived based on the postal code of each child's residence and also the closest Regional Autism Intervention Program Service Provider. Canadian postal codes have a six-character alpha numeric code in the format ANA NAN, where 'A' represents an alphabetic character and 'N' represents a numeric character. Postal codes are made of two segments where the first represents a 'Forward Sortation Area' (FSA) and the second represents the 'Local Delivery Unit' (LDU). The FSA represents a

specific area within a major geographic region or province. The first character of the FSA represents a province, and the second character identifies an urban or rural area; an urban postal code is a numeral from 1 to 9 and a rural postal code is the numeral 0 (Canada Post, 2009).

Currently, there are nine Regional Autism Intervention Program Service Providers in Ontario, of which one was removed from the analysis (North region) since not all the schools were covered during the first two years of implementing EDI. In the next step, address for the included MCYS regions was derived from Ministry of Child and Youth Services website. Finally, based on the postal code of child's place of residence, each child was assigned to the closest regional centre. Included regions in this study were: Central West (1), East (2), Hamilton/Niagara (3), North East (4), South East (5), South West (6), Toronto (7), and Central East (8). To include this categorical variable in logistic regression analysis, the region with the highest proportion of children with ASDs was assigned as the reference. This enabled us to compare the remaining regions with the one that includes the highest proportion of children with ASDs.

Distance

After assigning each child to the closest MCYS region, the distance of the child's household to the closest regional centre was calculated and recorded for each child in the population.

To find the most appropriate cut-off for categorizing distance, mean would be the first option to consider. If distance did not follow a normal distribution or had outliers, then the mean might not be the appropriate cut-off. In this case, the following steps were followed:

First, the median distance for all the population was considered as the cut-off. Median of all children regardless of their confirmed diagnoses with ASDs was included instead of only children with ASDs, mainly due to the definition of median. In other words, if we choose median

of children with ASDs, 50% of children with ASDs would always fall below the median and 50% would fall above the median.

Second, although the overall median seemed to be the best option for the cut-off, issues related to choosing the median still exist as it was probable that median comes from highly populated areas. In order to address this issue, data were divided into regions and median of distance for all the children living in each of the regions was calculated. Then, median of distance in each region was considered as the cut-off for this variable in the pertaining regions.

Finally, distance was divided into quartiles in each region to expand this variable and obtain more information about distribution of diagnosed children with using more categories of this variable. This was also useful in finding the right cut-off when the data were skewed.

Children living within the cut-off distance from their place of residence to the regional centres were considered as near (value=0) and the rest of the population was assigned to the category of far (value=1).

b) Neighborhood-level variables

Although the information on Socio-economic status (SES) variables was not available from the EDI, it was obtained from Census data at the neighborhood level of the child's place of residence. GIS software (ESRI's ArcMap10) was used to assign each child to a neighborhood based on their residence's postal code. Then, a neighbourhood level value was assigned to each child for the purpose of analyses.

The next steps for categorizing these variables for further analyses were the same as the ones taken for distance variable. This means if they follow a normal distribution and no outliers were present, the mean was used as the most appropriate cut-off. Otherwise, the median of the non-

diagnosed group was taken into account. Children with lower than the cut-off values for each of these variables were assigned to “0” and the rest were assigned to “1”. SES variables that were examined in this study are as follows:

Income

This continuous variable was measured in dollars. The median of the neighborhood income was calculated and assigned to each child. Median of income was indicated instead of mean as this statistic is not affected by the outliers (lowest and highest income values) in each neighbourhood.

Knowledge of English or French

This variable was defined as the percentages of the population with no knowledge of the official languages: English and French. The data from this question are used to track changes in the percentage of people in each neighborhood who cannot carry on a conversation in English or French.

Mobility

This variable provides information about the percentage of the population in each neighbourhood that has moved in the year prior to the census.

Single-parent status

This variable was measured as the percentage of all families headed by a single parent in the neighbourhood.

Education

Education was defined as the percentage of adults aged 25 to 64 with no certificate or high school diploma in the neighbourhood.

3.5. Statistical Analysis

Descriptive statistics were performed to determine the prevalence rate of ASDs by covariate subgroups within the study population and to examine each of the independent variables among diagnosed and non-diagnosed children. Numbers and percentages were provided for categorical variables of the population including age, sex, bilingualism, English/French as primary languages spoken at home, Aboriginal status, MCYS regions, and SES indicators. Mean and standard deviation (SD) were calculated for age as a continuous variable. Student's t-test and chi-square analysis were used to compare means and proportions. The same analysis was performed for the children with Aboriginal status. All analyses were conducted in SPSS (IBM SPSS Statistics 20).

The Binomial test was applied to assess if there is any significant difference in the prevalence of ASDs in each of the MCYS region compared to the prevalence rate reported by the most recent studies ($p < 0.05$). Thus, the test proportion was assigned to be equal to prevalence rate of 1.1%. To assess if there is any statistically significant difference in prevalence rate of ASDs among regions and to determine the regions that differ significantly, chi-square analysis and Post-hoc test was employed ($p < 0.05$).

To find the best cut-off for distance and SES variables, Kolmogorov-Smirnov test and Stem and Leaf plots were performed to examine normality and presence of outliers. If these variables did not follow a normal distribution or had outliers, overall median, regional median, and regional

quartiles were found and assigned as the cut-off. Then, the prevalence of children with reported diagnosis of ASDs in total and in each of the regions was reported.

In order to assess the effect of sex as a potential confounding variable, the association between sex and dependent variable as well as independent variables was examined using chi-square and t-test analyses. If sex was not a significant confounder, it was not entered in the regression models. This is mainly due to the huge effect of sex in diagnosis of ASDs, which might wipe out the effect of the other variables.

To address the primary hypothesis, that diagnosis of ASDs would be associated with distance, age, sex, bilingualism, English/French as primary languages spoken at home, Aboriginal status, socio-demographic variables, and MCYS regions, logistic regression analyses were carried out. Age was included as a continuous variable and unit of analysis was defined in months. In the next step, only the most significant variables were entered into the model (p <0.1).

The overall fit of the regression model was evaluated using the Hosmer and Lemeshow goodness-of-fit test. Under the null hypothesis that the fitted model is correct, a p-value greater than 0.2 for the Hosmer and Lemeshow test indicated a good fit for the regression model (Jarbrink & Knapp, 2001; Hauck & Miike, 1991; Hosmer & Lemeshow, 2000). To examine the model within each of the regional centres as sub-groups, logistic regression was employed for each of the regions. As the distance variable did not follow a normal distribution and was skewed in all the regions, the third quartile in each of the regions was assigned as the cut-off for this variable. As the next step, only the most significant predictors in each region were included into the model (p <0.1).

3.6. Data management

No identifying information on children was included in the EDI databases and all the data safety protocols were observed by the Principal Investigator (MJ). Research Ethics Board (REB) approval was obtained by the PI from McMaster University at the time of data collection for EDI.

4. Results

4.1. Participant characteristics

A total of 66,283 children were included in the study. Of these, the number of diagnosed children with ASDs was 708. This results in a prevalence rate of 1.0% for children with teacher reported-ASDs in this population-based study.

The mean and standard deviation (SD) for age of children with ASDs, in years, were 5.6 and 3.31, respectively. These indicators were close to those for the non-diagnosed group (mean (SD) = 5.6 (3.33)). The association between diagnosis of ASDs and sex, age, English/French as primary languages spoken at home, and MCYS region was statistically significant (p <0.05). However, there were no significant differences between the two groups in terms of first language spoken at home, bilingualism, and Aboriginal status. The sex ratio for boys vs. girls was found to be 1:1 among non-diagnosed children and 5:1 for the diagnosed group (p <0.0001). The proportion of children with Aboriginal status in diagnosed and non-diagnosed groups did not differ significantly and only a small number of children were reported to have Aboriginal status. Moreover, the proportion of children with reported diagnosis of ASDs living in MCYS regions was highest in Central West and Toronto regions (p <0.0001).

Descriptive characteristics and univariate analysis comparisons for the ASD diagnosis and the rest of the population are presented in table 2.

Table 2
Demographic characteristics and univariate analysis of categorical variables for the overall population

	n (%)		*p*
	Non-diagnosed	**Diagnosed group**	
Sex			<0.0001
Boys	33,344 (50.9)	588 (83.1)	
Girls	32,229 (49.1)	120 (16.9)	
Age (months)			0.01
4.2- 4.7	182 (0.3)	3 (0.4)	
4.8- 5.1	1,167 (1.8)	13 (1.9)	
5.2- 5.7	29,265 (44.6)	283 (39.9)	
5.8- 6.1	31,449 (48.0)	350 (49.5)	
6.2-6.7	3,393 (5.2)	51 (7.2)	
6.8+	57 (0.2)	6 (0.9)	
First language spoken at home			0.45
English	57,479 (88.5)	642 (91.3)	
French	14 (0.0)	0 (0.0)	
Other only	4,985 (7.7)	40 (5.7)	
English and French	36 (0.1)	0 (0.0)	
English and other	2,419 (3.7)	21 (3.0)	
French and other	3 (0.0)	0 (0.0)	
Two other languages	1 (0.0)	0 (0.0)	
English/French as primary languages spoken at home			0.02
Yes	57,529 (88.6)	642 (91.3)	
No	7,408 (11.4)	61 (0.8)	
Bilingualism			0.27
Monolingual	62,478 (95.2)	682 (97.0)	
Bilingual	2,459 (3.8)	21 (3.0)	
Aboriginal status			0.12
Yes	585 (1.0)	10 (1.6)	
No	59,709 (99.0)	621 (98.4)	
MCYS region of the child's			<0.0001
Central West	18,879 (28.8)	202 (28.5)	
East	2,771 (4.2)	37 (5.2)	
Hamilton- Niagara	8,445 (12.9)	106 (15.0)	
North East	983 (1.5)	10 (1.4)	
South East	4,455 (6.8)	58 (8.2)	
South West	3,529 (5.4)	16 (2.3)	
Toronto	22,057 (33.6)	197 (27.8)	
Central East	4,456 (6.8)	82 (11.6)	

In the next step, Kolmogorov- Smirnov test and Stem and Leaf plots were performed to examine the distribution of neighborhood-level variables. Although all the variables had normal distributions, missing values were still present. Therefore, median of the non-diagnosed group was assigned as the cut-off for categorizing these variables.

Except for knowledge of English/ French, association between SES variables and diagnosis of ASDs was not statistically significant. Proportion of children living in neighborhoods with a lot of English/French speakers was significantly higher in the diagnosed group compared to the non-diagnosed group. Socio-economic characteristics and univariate analysis for neighborhood-level variable are shown in table 3.

Table 3
Socioeconomic characteristics and univariate analysis of neighborhood-level variables for the overall population

Socioeconomic Variable	**n (%)**				***p***
	Non-diagnosed group (n=65,573)		**Diagnosed group (n=708)**		
	Below median	**Above median**	**Below median**	**Above median**	
Knowledge of English/French	32,911 (50.0)	32,664 (50.0)	404 (57.1)	304 (42.9)	<0.0001
Mobility	32,844 (50.0)	32,731 (50.0)	350 (49.4)	358 (50.6)	0.73
Parental education	32,870 (50.0)	32,705 (50.0)	372 (52.5)	336 (47.5)	0.21
Single-parent status	32,830 (50.0)	32,745 (50.0)	339 (47.9)	369 (52.1)	0.25
Family income	32,814 (50.0)	32,761 (50.0)	352 (49.7)	356 (50.3)	0.86

Table 4 shows co-morbidity rates reported by teachers for children diagnosed with ASDs, which ranged from 0.1% to 2.0%. Also, the proportion of children in non-diagnosed group with teacher-reported diagnosis of other special concerns and disabilities was provided.

Table 4
Comorbid disorders with ASDs and special concerns reported by teachers for the overall population

Comorbid disorders	**n (%)**	
	Non-diagnosed group (n=65,573)	**Diagnosed group (n=708)**
Acquired Brain Injury	14 (0.0)	2 (0.2)
ADHD/ ADD	30 (0.0)	8 (1.1)
Asthma	72 (0.1)	1 (0.1)
Cancer/ leukemia/ brain tumor	21 (0.0)	0 (0.0)
Genetic/ Congenital Disorder CF or PKU	19 (0.0)	0 (0.0)
Down Syndrome	58 (0.1)	3 (0.4)
Developmentally Global Delay	112 (0.1)	13 (2.0)
Diabetes	41 (0.1)	0 (0.0)
Epilepsy/ Seizures	44 (0.1)	4 (0.5)
Fetal Alcohol/ Drug exposed syndrome	25 (0.0)	1 (0.1)
Heart Problems/ Stroke	20 (0.0)	0 (0.0)
Intellectual delay: mild/ moderate	40 (0.1)	0 (0.0)
Learning Disorders	17 (0.0)	3 (0.4)
Anxiety	24 (0.0)	0 (0.0)
Oppositional Defiant Disorder/ Conduct Disorder	28 (0.0)	1(0.1)
Motor Impairments	23 (0.0)	1 (0.1)
Cerebral Palsy	56 (0.1)	1 (0.1)
Juvenile Rheumatoid Arthritis	9 (0.0)	0 (0.0)
Overweight	10 (0.0)	0 (0.0)
Speech and Language Problems	642 (0.9)	4 (0.5)
Apraxia	12 (0.0)	1 (0.1)
Cleft Palette/ lip	19 (0.0)	0 (0.0)
Receptive/ Expressive Lang	63 (0.1)	5 (0.7)
Selective Mutism	31(0.1)	1 (0.1)
Tourette	13 (0.0)	0 (0.0)

4.2. Descriptive characteristics of diagnosed children with Aboriginal status

Demographic characteristics of diagnosed children with ASDs show that only 10 out of 708 (1.4%) were reported to have Aboriginal status. Sex ratio for boys vs. girls was found to be slightly over 5:1 in non-Aboriginal children and 9:1 for Aboriginal children. Additionally, English was first language spoken at home for all the Aboriginal children and over 90% of the non-Aboriginal children. Demographic characteristics of diagnosed children in relation to Aboriginal status are reported in table 5.

Table 5
Demographic characteristics of categorical variables for Aboriginal children diagnosed with ASDs

Demographic Variable	n (%)	
	Non-Aboriginal Children (n=698)	**Aboriginal Children (n=10)**
Sex		
Boys	517 (83.3)	9 (90.0)
Girls	104 (16.7)	1 (10.0)
First language spoken at home		
English	555 (90.1)	10 (100.0)
French	0 (0.0)	0 (0.0)
Other only	40 (6.5)	0 (0.0)
English and French	0 (0.0)	0 (0.0)
English and other	21 (3.4)	0 (0.0)
French and other	0 (0.0)	0 (0.0)
Two other languages	0 (0.0)	0 (0.0)
Bilingualism		
Monolingual	595 (96.6)	10 (100.0)
Bilingual	21 (3.4)	0 (0.0)
MCYS region of the child's residence		
Central West	144 (23.2)	0 (0.0)
East	36 (5.8)	0 (0.0)
Hamilton- Niagara	101 (16.3)	2 (20.0)
North East	6 (1.0)	2 (20.0)
South East	50 (8.1)	0 (0.0)
South West	14 (2.3)	1 (10.0)
Toronto	193 (31.1)	3 (30.0)
Central East	77 (12.4)	2 (20.0)

Socioeconomic characteristics for neighborhoods with Aboriginal children show that 70% of these children were living in neighborhoods with a lot of English/ French speakers. The same proportion of children was living in families headed by a single parent. Moreover, 80% of these children were living in neighborhoods with lower levels of income. Results of socioeconomic characteristics for neighborhoods of residence of diagnosed children in relation to Aboriginal status are provided in table 6.

Table 6
Socioeconomic characteristics of neighborhoods of residence for Aboriginal children diagnosed with ASDs

Variable	**n (%)**			
	Non-Aboriginal Children (n=698)		**Aboriginal Children (n=10)**	
	Below median	**Above median**	**Below median**	**Above median**
Knowledge of English/French	333 (53.6)	288 (46.4)	7 (70.0)	3 (30.0)
Mobility	301 (48.5)	320 (51.5)	5 (50.0)	5 (50.0)
Parental education	325 (52.3)	296 (47.7)	4 (40.0)	6 (60.0)
Single-parent status	279 (44.9)	342 (55.1)	3 (30.0)	7 (70.0)
Family income	324 (52.2)	297 (47.8)	8 (80.0)	2 (20.0)

None of the diagnosed children with Aboriginal status were reported to have other co-morbid disorders or disabilities. Results for co-morbid disorders for diagnosed children with ASDs in relation to Aboriginal status are shown in table 7.

Table 7
Comorbid disorders for Aboriginal children diagnosed with ASDs

Comorbid disorders	**n (%)**	
	Non-Aboriginal Children (n=698)	**Aboriginal Children (n=10)**
Acquired Brain Injury	2 (0.2)	0 (0.0)
ADHD/ADD	8 (1.1)	0 (0.0)
Asthma	1 (0.1)	0 (0.0)
Down Syndrome	3 (0.4)	0 (0.0)
Developmentally Global Delay	13 (2.0)	0 (0.0)
Epilepsy/ Seizures	4 (0.5)	0 (0.0)
Fetal Alcohol/ Drug exposed syndrome	1 (0.1)	0 (0.0)
Heart Problems/ Stroke	3 (0.4)	0 (0.0)
Oppositional Defiant Disorder/ Conduct Disorder	1 (0.1)	0 (0.0)
Motor Impairments	1 (0.1)	0 (0.0)
Cerebral Palsy	1 (0.1)	0 (0.0)
Speech and Language Problems	4 (0.5)	0 (0.0)
Apraxia	1 (0.1)	0 (0.0)
Receptive/ Expressive Lang	5 (0.7)	0 (0.0)
Selective Mutism	1 (0.1)	0 (0.0)

4.3. Prevalence rate comparison among MCYS regions

Binomial test was conducted to examine if prevalence rate of ASDs in any of the regions differs significantly from the prevalence rate of 1.1% reported in the most recent studies (Centers for Disease Control and Prevention, 2012). This association was found to be significant for three regions (Table 8).

Table 8
Comparison of prevalence rate of ASDs in each region to the most recent prevalence rate reported in literature

Regions	**Observed proportion**	**Test proportion**	***p***
Central West	1.1	1.1	0.22
East	1.3	1.1	0.06
Hamilton-Niagara	1.2	1.1	0.04
North East	1.0	1.1	0.53
South East	1.3	1.1	0.06
South West	0.5	1.1	<0.0001
Toronto	0.9	1.1	0.06
Central East	1.8	1.1	<0.0001

To test if there is any statistically significant difference between prevalence rates among MCYS regions, a chi-square test was employed and found to be significant (p <0.05). A post-hoc test was used to demonstrate which regions differ significantly in terms of prevalence rates. Results of the post-hoc test are shown in table 9. Each subscript letter denotes a subset of MCYS regions whose row proportions do not differ significantly from each other (p <0.05). For instance, North East does not differ in prevalence from any other region as it has all the available letters.

Table 9
Comparison of prevalence rate of ASDs among MCYS regions

MCYS region of the child's residence	**Non-diagnosed group**	**Diagnosed group**
Central West	18879	202_{a}
East	2771	$37_{a, b}$
Hamilton- Niagara	8445	$106_{a, b}$
North East	983	$10_{a, b, c}$
South East	4455	$58_{a, b}$
South West	3529	16_{c}
Toronto	22057	$197_{a, c}$
Central East	4456	82_{b}

4.4. Exploration of the ASD prevalence rate in relation to distance

Distances from children's residences to the regional intervention centre were divided based on the overall median derived from the population as well as median and quartiles of distance calculated in each of the regions. Overall median of distance was found to be 22.5 kilometers and regional quartiles of this variable in kilometers (km) is reported in table 10.

Table 10
Regional median and quartiles for distance variable in km

Region	**Q1**	**Q2 (Median)**	**Q3**
Central West	11.3	23.8	52.5
East	52.0	81.1	95.3
Hamilton-Niagara	23.0	30.3	69.5
North East	209.1	279.1	287.3
South East	13.7	69.0	83.5
South West	93.8	101.5	139.1
Toronto	7.0	11.7	15.5
Central East	62.5	68.7	88.1

To find the cut-off for categorizing distance, mean was the first option that was considered. Kolmogorov- Smirnov test and Stem and Leaf plots showed that distance in general and also in each of the regions was not following a normal distribution and outliers were present. Thus, choosing mean as the cut-off for categorizing this variable would lead to distorting the prevalence estimates.

As the second step, distance from child's household to the regional intervention centre was divided based on the overall median derived from the population. Out of eight regions, in four of the regions, no children lived near the regional centres. Prevalence of ASDs was higher for children who live far from the regional centres except for Toronto. This uneven distribution of data was due to large differences among medians of sub-regions with a wide discrepancy of 11 to

280 km, which demonstrated that the overall median was not the most appropriate cut-off for categorizing distance.

In the next step, median of distance in each of the regions were calculated and used as the cut off for categorizing this variable. Although prevalence of ASDs among children in relation to the regionally-relevant distance calculation showed more even results, it was still exactly the same for both near and far groups in two regions (Table 11).

In an attempt to further investigate the possible relationship between prevalence rates and distance, this variable was divided based on the quartiles. Frequency of children living within the first quartile was low for most of the regions. Therefore, to expand distance variable, the third quartile was assigned as the cut-off for categorizing this variable.

The distribution of children with ASD in reference to overall and regional median of distance between their place of residence to the regional centre as well as regional quartiles is shown in Table 11.

Table 11
Frequency of children with Autism Spectrum Disorders (ASDs) in relation to distance to the regional intervention centre providers

Regions	n (%)					
	Overall median		Regional median		Regional quartiles	
	Near	Far	Near	Far	Near	Far
Central West	90 (44.6)	112 (55.4)	102 (50.5)	100 (49.5)	137 (67.8)	65 (32.2)
East	0 (0.0)	37 (100.0)	14 (37.8)	23 (62.2)	27 (72.8)	10 (27.2)
Hamilton-	23 (21.7)	83 (78.3)	37 (35.0)	69 (65.0)	68 (64.1)	38 (35.8)
North East	0 (0.0)	10 (100.0)	5 (50.0)	5 (50.0)	8 (80.0)	2 (20.0)
South East	22 (37.9)	36 (62.1)	33 (56.8)	25 (43.2)	46 (79.3)	12 (20.7)
South West	0 (0.0)	16 (100.0)	10 (62.5)	6 (37.5)	13 (81.3)	3 (18.8)
Toronto	194 (98.5)	3 (1.5)	94 (47.7)	103 (52.3)	138 (70.0)	59 (29.9)
Central East	0 (0.0)	82 (100.0)	41 (50.0)	41 (50.0)	65 (79.3)	17 (20.7)
Total	329 (46.5)	379 (53.5)	336 (47.5)	372 (52.5)	502 (71.0)	206 (29.0)

4.5. Examining predictors for diagnosis of ASD

As sex was highly associated with the dependent variable, the effect of this variable as a potential confounder was examined. The association between sex and independent variables was assessed and found to be statistically non-significant. Therefore, sex was considered as a significant predictor for diagnosis of ASDs and was not included in the regression models. Result of the overall regression model with including sex is provided as appendix. Table 12 shows results for the univariate analysis between sex and categorical independent variables.

Table 12
Univariate analysis between sex and categorical independent variables

Variable	χ^2	**d.f.**	***p***
English/French as primary languages spoken at home	0.00	1	0.97
Bilingualism	3.77	1	0.05
Aboriginal Status	1.53	1	0.22
Distance (categorical)	1.66	1	0.20
Knowledge of English/French	0.27	1	0.60
Mobility	2.75	1	0.09
Parental education	0.21	1	0.65
Single-parent status	2.68	1	0.10
Family income	0.86	1	0.35
MCYS regions	8.49	7	0.29

The results of the multivariable analysis indicate that diagnosis with ASDs did not differ in relation to distance. Children living in neighborhoods with more high school diplomas were more at risk of being reported as diagnosed. Also, children living in neighborhoods with a lot of single parent families were more likely to have a reported- diagnoses by teachers. Moreover, children living in all the regions, except Hamilton-Niagara and South East, were significantly more likely to be reported as diagnosed compared to Central West region. Hosmer Lemeshow chi- square test denoted that this model is a good fit of the data ($p = 0.91$).

Adjusted odds ratios, 95% confidence intervals, and associated p-values from the multivariable logistic regression analysis are presented in Table 13.

Table 13
Adjusted Odds Ratio estimates of diagnosis of ASDs

Variable	Odds Ratio	95% CI	*p*
English/French as primary languages spoken at home	1.14	[0.81, 1.63]	0.46
Bilingualism	0.95	[0.56, 1.61]	0.86
Aboriginal Status	0.70	[0.35, 1.37]	0.25
Distance (categorical)	0.89	[0.69, 1.14]	0.35
Age (months)	1.02	[0.99, 1.04]	0.27
Knowledge of English/French	1.09	[0.83, 1.41]	0.53
Mobility	0.93	[0.77, 1.11]	0.40
Parental education	1.25	[1.04, 1.51]	0.02
Single-parent status	0.70	[0.57, 0.86]	<0.05
Family income	1.04	[0.83, 1.29]	0.74
MCYS_Region			<0.0001
East	0.61	[0.42, 0.87]	0.01
Hamilton- Niagara	0.83	[0.55, 1.25]	0.38
North East	0.71	[0.51, 0.97]	0.03
South East	0.59	[0.28, 1.24]	0.16
South West	0.69	[0.47, 0.99]	0.05
Toronto	0.23	[0.13, 0.42]	<0.0001
Central East	0.51	[0.51, 0.35]	<0.0001

In the next step, distance and the most significant variables were entered into the model (p <0.1). Distance variable became a significant predictor for reported-diagnosis of ASDs. Children living near regional centres were less likely to be in the diagnosed group (OR=0.77). Again, Hosmer Lemeshow chi-square test confirmed a good fit of the (p = 0.83). Adjusted odds ratio estimates for ASDs diagnosis with including only the most significant predictors are shown in table 14.

Table 14
Adjusted Odds Ratio estimates for diagnosis of ASDs after including significant predictors

Variable	**Odds Ratio**	**95% CI**	***p***
Distance	0.77	[0.63, 0.94]	0.010
Parental education	1.27	[1.07, 1.49]	0.005
Single-parent status	0.73	[0.61, 0.87]	<0.0001
MCYS_Region			<0.0001
East	0.62	[0.47, 0.82]	0.003
Hamilton- Niagara	0.76	[0.51, 1.12]	0.166
North East	0.67	[0.49, 0.91]	0.009
South East	0.59	[0.30, 1.19]	0.131
South West	0.70	[0.50, 0.98]	0.039
Toronto	0.23	[0.13, 0.39]	<0.0001
Central East	0.48	[0.35, 0.64]	<0.0001

4.6. Examining the regression model within MCYS regions

Regression analysis was employed for each of the MCYS regions to examine independent variables at regional-level. In Hamilton-Niagara region, children living in neighborhoods with a lot of English/ French speakers were significantly more likely to be reported as diagnosed. In North East region, with each month increase in age, children were 1.19 times more likely to be reported as diagnosed. Lastly, Aboriginal status in Toronto region was found to be a significant covariate for diagnosis of ASDs and children with no Aboriginal status were more likely to be in the diagnosed group. Hosmer Lemeshow chi-square test confirmed a good fit of the data for all the regions ($p > 0.2$).

Adjusted odds ratios, 95% confidence intervals, and associated p-values from the multivariable logistic regression analysis for each of the regions are presented in table 15 to table 22.

Table 15
Adjusted Odds Ratio estimates of diagnosis of ASDs in Central West Region

Variable	Odds Ratio	95% CI	*p*
English/French as primary languages spoken at home	0.00	-	0.99
Bilingualism	1.05	-	1.00
Aboriginal Status	0.00	-	0.99
Distance (categorical)	0.96	[0.48, 1.92]	0.91
Age (months)	1.01	[0.97, 1.06]	0.55
Knowledge of English/French	1.19	[0.76, 1.85]	0.45
Mobility	1.00	[0.69, 1.44]	0.98
Parental education	1.25	[0.84, 1.85]	0.27
Single-parent status	0.73	[0.48, 1.12]	0.15
Family income	0.89	[0.53, 1.42]	0.57

Table 16
Adjusted Odds Ratio estimates of diagnosis of ASDs in East Region

Variable	Odds Ratio	95% CI	*p*
English/French as primary languages spoken at home	-	-	-
Bilingualism	-	-	-
Aboriginal Status	0.00	-	0.99
Distance (categorical)	0.84	[0.34, 2.07]	0.71
Age (months)	1.08	[0.99, 1.18]	0.07
Knowledge of English/French	-	-	-
Mobility	0.82	[0.09, 7.17]	0.86
Parental education	0.99	[0.20, 4.95]	0.99
Single-parent status	0.67	[0.08, 5.87]	0.72
Family income	1.31	[0.37, 4.68]	0.67

Table 17
Adjusted Odds Ratio estimates of diagnosis of ASDs in Hamilton-Niagara Region

Variable	Odds Ratio	95% CI	*p*
English/French as primary languages spoken at home	-	-	-
Bilingualism	-	-	-
Aboriginal Status	0.61	[0.15, 2.54]	0.49
Distance (categorical)	0.89	[0.54, 1.47]	0.65
Age (months)	0.99	[0.94, 1.05]	0.89
Knowledge of English/French	2.39	[1.14, 5.01]	0.02
Mobility	1.12	[0.65, 1.91]	0.67
Parental education	0.98	[0.55, 1.89]	0.95
Single-parent status	1.25	[0.59, 2.69]	0.55
Family income	1.86	[0.96, 3.61]	0.07

Table 18
Adjusted Odds Ratio estimates of diagnosis of ASDs in North East Region

Variable	Odds Ratio	95% CI	*p*
English/French as primary languages spoken at home	-	-	-
Bilingualism	-	-	-
Aboriginal Status	0.37	[0.07, 2.08]	0.26
Distance (categorical)	1.81	[0.15, 21.17]	0.63
Age (months)	1.19	[1.04, 1.37]	0.01
Knowledge of English/French	-	-	-
Mobility	0.00	-	0.99
Parental education	0.00	-	0.99
Single-parent status	0.00	-	0.99
Family income	0.00	-	0.99

Table 19
Adjusted Odds Ratio estimates of diagnosis of ASDs in South East Region

Variable	Odds Ratio	95% CI	*p*
English/French as primary languages spoken at home	-	-	-
Bilingualism	-	-	-
Aboriginal Status	0.00	-	0.99
Distance (categorical)	1.22	[0.62, 2.40]	0.57
Age (months)	0.98	[0.91, 1.07]	0.68
Knowledge of English/French	-	-	-
Mobility	0.84	[0.19, 3.70]	0.81
Parental education	1.27	[0.66, 2.51]	0.47
Single-parent status	0.54	[0.11, 2.76]	0.46
Family income	0.80	[0.34, 1.91]	0.62

Table 20
Adjusted Odds Ratio estimates of diagnosis of ASDs in South West Region

Variable	Odds Ratio	95% CI	*p*
English/French as primary languages spoken at home	-	-	-
Bilingualism	-	-	-
Aboriginal Status	0.00	-	0.99
Distance (categorical)	1.51	[0.32, 7.17]	0.61
Age (months)	0.94	[0.81, 1.09]	0.41
Knowledge of English/French	-	-	-
Mobility	1.12	[0.25, 4.98]	0.88
Parental education	1.75	[0.18, 17.35]	0.63
Single-parent status	0.31	[0.06, 1.54]	0.15
Family income	0.55	[0.05, 5.59]	0.61

Table 21
Adjusted Odds Ratio estimates of diagnosis of ASDs in Toronto Region

Variable	Odds Ratio	95% CI	*p*
English/French as primary languages spoken at home	1.25	[0.87, 1.81]	0.22
Bilingualism	0.91	[0.53, 1.55]	0.73
Aboriginal Status	0.15	[0.04, 0.50]	<0.05
Distance (categorical)	0.73	[0.53, 1.02]	0.06
Age (months)	1.01	[0.97, 1.05]	0.56
Knowledge of English/French	0.66	[0.39, 1.11]	0.11
Mobility	0.93	[0.68, 1.27]	0.66
Parental education	1.22	[0.85, 1.75]	0.28
Single-parent status	0.66	[0.42, 1.05]	0.08
Family income	0.95	[0.69, 1.44]	0.80

Table 22
Adjusted Odds Ratio estimates of diagnosis of ASDs in Central East Region

Variable	Odds Ratio	95% CI	*p*
English/French as primary languages spoken at home	0.00	-	1.00
Bilingualism	-	-	-
Aboriginal Status	0.00	-	0.99
Distance (categorical)	1.16	[0.37, 3.68]	0.79
Age (months)	0.99	[0.94, 1.07]	0.94
Knowledge of English/French	1.45	[0.33, 6.43]	0.63
Mobility	1.66	[0.85, 3.27]	0.14
Parental education	1.11	[0.53, 2.31]	0.40
Single-parent status	0.73	[0.54, 2.00]	0.56
Family income	1.54	[0.78, 3.03]	0.48

In the next step, the most significant variables in each of the regions were included in the model (p <0.1). Single-parent family structure in Toronto became significant predictors for teacher-reported diagnosis of ASDs. This means that children living in neighbourhoods with a lot of single-parent families were more likely to have reported-diagnosis of ASDs. Adjusted odds ratio estimates for ASDs diagnosis with including only the most significant predictors in the mentioned regions are shown in tables 23 and 24.

Table 23
Adjusted Odds Ratio estimates for diagnosis of ASDs in Hamilton-Niagara region after including significant predictors

Variable	**Odds Ratio**	**95% CI**	***p***
Knowledge of English/French	2.57	[1.40, 4.71]	<0.05
Family income	0.82	[0.69, 1.34]	0.16

Table 24
Adjusted Odds Ratio estimates for diagnosis of ASDs in Toronto region after including significant predictors

Variable	**Odds Ratio**	**95% CI**	***p***
Aboriginal Status	0.15	[0.04, 0.49]	<0.05
Distance	0.80	[0.58, 1.08]	0.15
Single-parent status	0.66	[0.44, 0.98]	0.04

5. Discussion

5.1. Interpretation and contribution to the literature

In this population- based study, data from all sites of Ontario with completed EDI in the first two years of a three-year cycle were included. Out of 66,284 children in SK included in this study, 708 were reported by teachers to have diagnosis of ASDs. This results in a prevalence rate of 1.0% for ASDs. Moreover, demographic and socioeconomic variables were examined to find significant predictors for diagnosis of ASDs. Distance of MCYS regions from the child's place of residence, parental education, single-parent status, and MCYS region that a child was living in were found to be significant predictors for teacher-reported diagnosis of ASDs.

Recently, more attention has been placed on contributing factors for different prevalence rates of ASDs/PDDs in geographical areas (Elsabbagh, Divan, Koh, Kim, & Kauchali, 2012; Fombonne, 2009; Williams, Thomas, Sidebotham, & Emond, 2008; Centers for Disease Control and Prevention, 2007; Centers for Disease Control and Prevention, 2012; Yeargin-Allsopp et al., 2003; Mandell et al., 2010; Mandell & Palmer, 2005). Results from most of the previous studies are limited as they include small samples without any information on the neighborhoods of children's place of residence. While this study does not employ a diagnostic instrument, it is unique in that it is a population-based study covering a relatively large number of children, which allows controlling for SES indicators and neighborhood-level variables. Moreover, this study examines the association between diagnosis of ASDs and distance to regional intervention centres that has never been taken into account by previous studies.

Descriptive characteristics of participants

One of the main purposes of this study was to examine prevalence rate of ASDs among SK children in Ontario. Prevalence rate 1 out of 100 for ASDs was determined for this population of

children, including approximately 2/3 of all children attending Senior Kindergarten. In the most recent studies, the general prevalence was reported at slightly higher level (1 out of 88) for children at 8 years of age (Centers for Disease Control and Prevention, 2012). Based on the literature, young children showed lower prevalence rates compared to the older ones as many of them may not have come to the attention of professionals and have not yet received a confirmed diagnosis (Yeargin-Allsopp et al., 2003; Levy, Merhar, Ittenbach, & Pinto-Martin, 2003; Mandell, Listerud, Levy, & Pinto-Martin, 2002). Additionally, teachers might not been informed about all the diagnoses of a child or might have reported only the primary diagnosis of a child as the main focus of this study was not reporting all special disabilities of a child.

Children with ASDs were not found to be significantly younger or older than typically developing children. This result shows that children with ASDs are attending regular kindergarten classes in Ontario without any apparent delays compared to other children of the same age. This is due to unavailability of special or home-based schools for children with ASDs in this age range. Therefore, all the children attend SK classes regardless of their diagnosis or severity of disorder.

The most recent studies have shown the boys-to-girls ratio among children aged 8 years to be at 5 to 1, which was the same as the one found in our study (Centers for Disease Control and Prevention, 2012). Additionally, socioeconomic indicators demonstrated normal distributions indicating that the majority of children in the study sample came from families with mid-level of SES.

Only very small percentages of children in both groups were reported by teachers to have other special disabilities. For children in the diagnosed group, the highest rates were related to Developmentally Global Delay and ADHD with co-occurrence rates of 2% and 1.1%,

respectively. In contrast to the previous studies, none of the diagnosed children with ASDs were reported to have anxiety or depression (Gadow, DeVincent, Pomeroy, & Azizian, 2004; Matson & Nebel-Schwalm, 2007). These rates were slightly lower than the ones reported by previous studies for typically developing preschool children (Ghuman, Arnold, & Anthony, 2008; Birmaher & Brent, 2007; Connolly & Bernstein, 2007). Since the included children are at young ages, they have not yet met age of onset for some of the co-morbid disorders. Also, teachers might report the primary diagnosis of each child as the main purpose of EDI differs from the objectives of this study. This might result in underestimation of co-morbidity rates.

Descriptive characteristics of Aboriginal children diagnosed with ASDs

This dataset is unique in that it allows for exploratory analysis on covariates besides the main objectives of the study. Subsequently, demographic and socioeconomic characteristics of children with Aboriginal status were assessed. Although the number of children with Aboriginal status was low in both diagnosed and non-diagnosed groups, it was encouraging to find the same proportions for diagnosis of ASDs in both groups. This is in contrast to the previous studies that found lower prevalence rates for ethnic minority groups (Flores & Tomany-Korman, 2008; Palmer, Walker, Mandell, Bayles, & Miller, 2010). Aboriginal children with ASDs in the present study were mostly boys, English speakers, from neighborhoods with lower levels of income, and none of them had other co-morbid disorders.

Prevalence rate comparison among MCYS regions

The variation in prevalence rates among MCYS regions of the province was also examined and found to be significantly different. Prevalence rates of ASDs ranged from 0.45 in South West to 1.80 in Central East region. One study found greater proportion of children in counties with more

pediatricians and pediatric specialists per capita, which can be due to families moving closer to the resources (Mandell et al., 2010). Other important factors explaining the observed variations among regional centres may be due to service availabilities, ascertainment variability, awareness of the general and professional public or other resources unmeasured in this study (Centers for Disease Control and Prevention, 2009; Mandell & Palmer, 2005). Furthermore, clustering of children with ASDs, which is more likely to be found in highly populated areas, might lead to more familiarity of families and physicians with this disorder.

Examining predictors for diagnosis of ASDs

Sex differences among children diagnosed with ASDs were examined and found to be significant. As it was demonstrated in the literature, boys were found more likely to be diagnosed with ASDs compared to girls (Centers for Disease Control and Prevention, 2012; Fombonne, 2008; Scott, Baron-Cohen, Bolton, & Brayne, 2002; Yeargin-Allsopp et al., 2003; Burd, Fisher, & Kerbeshian, 1987). This could be due to specific genes or factors that make boys to be more vulnerable. Additionally, ascertainment bias and knowledge of clinicians about more susceptibility of boys compared to girls for this disorder might be another explaining factor.

Perhaps the most important finding and contribution of this study to the literature is related to the examination of diagnosis of ASDs in relation to distance to the regional intervention centres. Children living far (farther than 75% of all children per region) were significantly more likely to be in the diagnosed group from those who live near (OR=0.77). This is in contrast to previous studies that found significant association between higher prevalence rates and factors such as availability of pediatricians and health care resources, public and professional awareness, and availability of educational services (Mandell et al., 2010; Mandell & Palmer, 2005; Centers for

Disease Control and Prevention, 2012). To explain this, different methods for delivering interventions are worth mentioning. With the purpose of making interventions available to all eligible children regardless of where they live, professional staff might drive or fly to the household or the nearest school of the place of residence of a diagnosed child in order to deliver interventions (J.A. Reitzel, personal communication, March 7, 2012). This lessens contribution of distance to the regional centres in prevalence rates of ASDs in Ontario as health care resources are available for all diagnosed children regardless of their distance to the regional centres. Additionally, information was not available on the number of pediatricians and health care clinics in each of the regions. In-detailed data on distance to the exact place of receiving interventions rather than the main regional centres could be beneficial as well.

A further finding of this study in terms of diagnosis of ASDs was related to the "Parental Education". Children living in the neighbourhoods with higher percentages of adults who have a high school diploma were found to be more likely to be in the diagnosed group, which was also shown by a number of previous studies (Brookman-Frazee et al., 2009; Newschaffer, Croen, Daniels, Giarelli, & Grether, 2007; Fombonne, 2003a). Ascertainment bias might be considered as an explanation for this result as children living in families with more knowledgeable parents might be more likely to obtain an informed diagnosis.

Finally, single-parent family structure was found to be a significant predictor of ASDs diagnosis. Children living in neighbourhoods with relatively high percentages of single-parent families were more likely to be reported as diagnosed. This can be considered as an important finding of this study which necessitates specific policies for these families to obtain appropriate services for their children and to reduce caregiver's stress and improve family functioning. Attending appointments or implementing home-based interventions was reported to even result in

sacrificing a day's pay for these families (Mandell & Palmer, 2005). However, no study in literature was found on this subject and, therefore, no further comparison could be made.

MCYS region in which the child resides was a significant predictor for the outcome variable. Except for Hamilton-Niagara and South East regions, children living in all the other MCYS regions were significantly more likely to be reported as diagnosed compared to Central West region. This can be due to discrepancy in availability of health care resources, and professional or public awareness about this disorder among regions, which were not measured in this study.

Examining the regression model within MCYS regions

Models were constructed for each of the regions to determine significant predictors at regional-level. In Hamilton-Niagara region, children living in neighborhoods with more English/French speakers were more likely to have teacher-reported diagnosis. This may be related to the better communication between families of these neighborhoods and their society. Risk for reported diagnosis of ASDs was increased by 1.19 in North East regions with each month of increase in age. Small number of diagnosed children with ASDs in this region makes it difficult to derive a reliable conclusion. However, this result is in compliance with previous studies that found higher prevalence rates for older age groups (Kogan et al., 2009; Yeargin-Allsopp et al., 2003). Developments in diagnostic criteria and lower sensitivity of case identification for younger ages might be some of the contributing factors.

In Toronto region, children with no Aboriginal status were significantly more likely to be in the diagnosed group. This is in line with the previous studies that found lower prevalence rates of ASDs for ethnic minority groups compared to the Caucasian children (Palmer, Blanchard, & Jean, 2005; Mandell, Wiggins, & Carpenter, 2009; Centers for Disease Control and Prevention,

2006; Shattuck, Durkin, & Maenner, 2009). Possible reasons might be poverty, different clinical presentations, and differences in parental behaviors. However, we should be cautious about this variable as only 10 out of 708 children in the diagnosed group were reported to have aboriginal status. Single-parent family structure was also found to be a significant predictor in Toronto region. Children living in neighbourhoods with a lot of single-parent families were more likely to be in the diagnosed group. Since no other study on this topic is reported, no comparison can be made in this regard.

5.2. Limitations

It is important to note the limitations of this study. Although inclusion of all Senior Kindergarten children was an advantage in this study, not having standardized measures available to determine ASDs diagnosis by professionals remains to be a limitation. Reports of ASDs diagnosis as well as other special concerns were all based on teacher's report. Although lack of a gold standard diagnostic tool and a one-on-one evaluation of the child by an expert clinician were ideal and more accurate, they were impractical and costly use for such a large study. Additionally, by completing this instrument during the second half of the school year when teachers are more familiar with each child's strengths and deficits, the potential for errors were reduced. Therefore, we can consider results of this study as accurate estimates for children with ASDs using an administrative dataset.

With regards to the prevalence rates among regions, no information about number of pediatricians, health clinics, and other health-related resources was available. It is possible that having higher than 1% prevalence rates in some of the regions was due to parental awareness

and/or more availability of pediatricians, health clinics or other centres that provide interventions.

Another limitation of this study is the inclusion of only two years of a three-year-cycle of the EDI. It is possible that children included in this study had characteristics and experiences different from those that were not included. Moreover, prevalence rates might differ after including all the children.

Although the analysis in this study was adjusted for many factors that might be related to ASDs diagnosis, there are likely other demographic and psychosocial factors that influence ASDs identification which were not included in this study. Detailed information about SES variables at individual-level, availability of health-related resources, public and professional awareness, and place of residence before and after receiving the diagnosis could be some of the contributing factors that should be taken into account.

5.3. Implications and future directions

The results of this study are relevant for use in future prevalence studies of ASDs among geographical regions. These studies are necessary and fundamental in understanding the time trend for incidence rates as well as the potential contributing factors. It has been noted here from existing literature that repeated surveys in defined geographical areas with constant methodology at different points in time can yield useful information on time trends. Therefore, future studies can be conducted with employing EDI data among regions to assess time trends for prevalence rates. Ideally changes in diagnostic criteria, lay and professional public awareness, service availabilities, and local centres that deliver interventions for children with ASDs should be taken into account for examining the time trend in prevalence rate studies.

Findings of this study have important policy implication. Given the high prevalence rate of ASDs in preschoolers who attend regular classes, it could be beneficial to provide diagnostic and prognostic information to the schools and education teams. This communication is particularly critical for general education personnel who may be educating children with ASD that are not eligible for an autism classification yet and, therefore, need accommodations in the general education setting. Collaboration between health professionals and education team could improve understanding and awareness of ASD diagnosis and its symptoms. Subsequently, this may advance the overall communication of education settings with diagnosed children and their families.

Additionally, having very small number of diagnosed children with Aboriginal status even in this large population-based study provide further evidence for the need for outreach to these groups of children and clinicians working with them to improve recognition of ASDs in this population of children.

With regard to the methodology of the study, it would be beneficial to employ Hierarchical Linear Models after the data are available for the entire province mainly due to the mentioned differences between the overall model and the regional models. In this way, the study will provide enough power to detect the differences at each level of analysis.

5.4. Conclusions

This is one of the largest studies undertaken to examine prevalence rate of ASDs and its significant predictors among MCYS regions in Ontario, which can assist in program planning and provide a potential mechanism to study long-term ASD trends. The identification of disparities in prevalence rates among regions may support efforts to improve ASDs' diagnosis, awareness, policies, and classification requirements across regions.

Reasons for different prevalence rates among regions remain unclear. In the present study, there is no definitive way to measure the portions of the variation that can be attributed to improved ASD awareness, diagnostic changes, or service authorities. It is also possible that in addition to the mentioned factors there is a true difference in prevalence due to an unknown environmental risk factor. Regardless, high prevalence rate of ASDs in 5-year-old children in some regions place severe burden on both families and education services.

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7. Appendix

Appendix 1:

Adjusted Odds Ratio estimates of diagnosis of ASDs after including sex

Variable	Odds Ratio	95% CI	*p*
Sex	0.21	[0.17, 0.25]	<0.0001
English/French as primary languages spoken at home	1.17	[0.81, 1.66]	0.40
Bilingualism	0.92	[0.54, 1.55]	0.75
Aboriginal Status	0.33	[0.36, 1.40]	0.33
Distance (categorical)	0.88	[0.69, 1.13]	0.33
Age (months)	1.14	[0.88, 1.49]	0.31
Knowledge of English/French	1.10	[0.85, 1.43]	0.48
Mobility	0.92	[0.77, 1.11]	0.40
Parental education	1.25	[1.04, 1.51]	0.02
Single-parent status	0.70	[0.56, 0.86]	<0.05
Family income	1.04	[0.83, 1.29]	0.75
MCYS_Region			<0.0001
East	0.61	[0.42, 0.87]	<0.05
Hamilton- Niagara	0.82	[0.54, 1.24]	0.34
North East	0.71	[0.51, 0.97]	0.03
South East	0.59	[0.28, 1.24]	0.17
South West	0.69	[0.48, 1.00]	0.05
Toronto	0.23	[0.13, 0.41]	<0.0001
Central East	0.51	[0.35, 0.75]	<0.0001

Appendix 2:

Adjusted Odds Ratio estimates of diagnosis of ASDs including the most significant variables

Variable	Odds Ratio	95% CI	*p*
Sex	0.21	[0.17, 0.25]	<0.0001
Parental education	1.25	[1.06, 1.48]	<0.05
Single-parent status	0.72	[0.60, 0.85]	<0.05
MCYS_Region			<0.0001
East	0.55	[0.43, 0.72]	<0.0001
Hamilton- Niagara	0.77	[0.52, 1.14]	0.19
North East	0.63	[0.47, 0.85]	<0.05
South East	0.67	[0.34, 1.31]	0.24
South West	0.71	[0.50, 0.99]	0.05
Toronto	0.25	[0.15, 0.43]	<0.0001
Central East	0.41	[0.31, 0.53]	<0.0001