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Article

Neighbourhood-level prevalence of teacher-reported Autism Spectrum Disorder among kindergarten children in Canada: A population level study

Ayesha Siddiqua [a,b,*], Eric Duku [a], Kathy Georgiades [a], Ronit Mesterman [c], Magdalena Janus [a]

[a] Offord Centre for Child Studies, Department of Psychiatry and Behavioural Neurosciences, McMaster University, 1280 Main Street West, MIP Suite 201A, Hamilton, ON, L8S 4K1, Canada
[b] Department of Health Research Methods, Evidence, and Impact, McMaster University, 1280 Main Street West, Hamilton, ON, L8S 4L8, Canada
[c] Department of Pediatrics, McMaster University, 1280 Main Street West, Hamilton, ON, L8S 4L8, Canada

1. Introduction

Autism Spectrum Disorder (ASD) is a commonly diagnosed neurodevelopmental disorder in Canada, with a national prevalence estimate of 1 per 66 children diagnosed in 2015 (Public Health Agency of Canada, 2018). ASD is a heterogeneous, behaviourally-defined neurodevelopmental disorder, which has been associated with multiple genetic conditions, but it has no unifying pathological or neurobiological etiology (Geschwind & Levitt, 2007). According to the Diagnostic and Statistical Manual of Mental Disorders – 5th Edition (DSM – 5), the core dysfunctions of ASD occur in two behavioural domains: difficulties in social communication and social interaction, as well as restricted, repetitive behaviours and interests (Lai, Lombardo, Chakrabarti, & Baron-Cohen, 2013). The characteristics and varying severity of ASD are now more widely recognized – thus, the diagnosis rate of this disorder has increased substantially over the years (McConachie & Diggle, 2007).

Children with ASD have heterogeneous developmental trajectories (Fountain, Winter, & Bearman, 2012). Children who are high functioning in early years tend to improve in their development more rapidly over time (Fountain et al., 2012). However, even children who are very low functioning in childhood through middle years can also improve in their development substantially by adolescence to match outcomes comparable to high functioning children (Fountain et al., 2012). Research suggests that participation in Early Intensive Behavioural Intervention (EIBI) improves adaptive behaviour, communication, daily living skills, and socialization capabilities among children with ASD (Eldevik, Hastings, Jahr, & Hughes, 2012; Peters-Scheffer, Didden, Korzilius, & Sturmey, 2011). There is evidence indicating that earlier intervention for these children is better for their development, including improving behavioural and cognitive outcomes (Janus et al., 2018a,b; McConachie & Diggle, 2007).

While several studies have demonstrated that ASD can be reliably diagnosed by the age of 2 years, the median age of ASD diagnosis remains over age of 4 years (Janus et al., 2018a,b; Monteiro et al., 2015). Thus, the identification of ASD among kindergarten children between the age of 4–6 years presents an optimal opportunity to target early interventions (Janus et al., 2018a,b). Although epidemiological studies suggest that the prevalence of ASD is increasing, there are several challenges associated with the current methods available for estimating prevalence (Matson & Kozlowski, 2011; Rice et al., 2010). Estimates based on administrative databases (which depend on special education classifications, ASD service eligibility, or medical billing codes) have several limitations (Zablotsky, Black, Maenner, Schieve, & Blumberg, 2015). For example, they may underestimate prevalence among specific subpopulations who have reduced access to systems that generate administrative counts and therefore are not captured in these counts – leading to socioeconomic disparities in the prevalence of ASD (Zablotsky et al., 2015). Furthermore, criteria for special education or other ASD services can differ across jurisdictions (Zablotsky et al., 2015). Survey-based estimations also have limitations – including respondents' lack of fluency to respond in the dominant language, general population surveys not being designed to include sufficient numbers of individuals affected by rare conditions precluding analyses that will generate reliable estimates for these sub-populations, reliance on respondents' ability to understand the questions asked and accurately recall the specific diagnosis assigned (Ouellette-Kuntz et al., 2012; Zablotsky et al., 2015). Determining the prevalence of ASD using multiple data sources remains a difficult task given different data maintenance and linkage procedures across systems and jurisdictions.

In the Canadian context, the Early Development Instrument (EDI), a population-based developmental assessment tool, presents a unique opportunity to monitor the prevalence and developmental health of kindergarten-age children with ASD (Janus & Offord, 2007). The EDI is implemented across Canada and is completed by teachers for each child

* Corresponding author. Offord Centre for Child Studies, Department of Psychiatry and Behavioural Neurosciences, McMaster University, 1280 Main Street West, MIP Suite 201A, Hamilton, ON, L8S 4K1, Canada.
E-mail address: siddia36@mcmaster.ca (A. Siddiqua).

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in kindergarten classes. It provides data on development in five domains: physical health and well-being, social competence, emotional maturity, language and cognitive development, and communication skills and general knowledge. While the EDI is completed for individual children, the data obtained are interpreted at different levels of aggregation (e.g. children attending a school, children living in a neighbourhood) to provide information on the strengths and weaknesses of children in a particular group/community. Given the wide-scale implementation, the EDI data provide valuable information on low-frequency populations such as children with special needs, who typically represent a small percentage of population at the community level (Janus et al., 2018a,b).

Although the National Autism Spectrum Disorder Surveillance System provides the prevalence of children with ASD living in some provinces and territories in Canada for 2015, including Newfoundland and Labrador, Prince Edward Island, Quebec, British Columbia, Nova Scotia, New Brunswick, and Yukon, our knowledge of prevalence of kindergarten children with this disorder in other provinces and territories, as well as the development of these kindergarten children across all provinces and territories remains limited (Public Health Agency of Canada, 2018). Examining the prevalence and development of kindergarten children with ASD at the neighbourhood level that represents a meaningful geographic unit of residence has particular value. There is growing evidence indicating that kindergarten children's health is influenced by neighbourhood characteristics (Curtis, Dooley, & Phipps, 2004; Kohen, Oliver, & Pierre, 2009; Minh, Muhajarine, Janus, Brownell, & Guhn, 2017). Furthermore, there is increasing consensus that inequalities in health outcomes of a population are usually not fully accounted for by combinations of individual level factors and may therefore be attributable to factors that operate at an aggregate level, such as the neighbourhood level (Pickett & Pearl, 2001). Pickett and Pearl (2001) noted that contextual factors may be the most important determinants of the health of a population. There is no consistency in literature regarding the association between neighbourhood socioeconomic status and prevalence of children with ASD (Emerson, 2012; Hock & Ahmedani, 2012; Li, Sjostedt, Sundquist, Zoller, & Sundquist, 2014; Thomas et al., 2012). In contrast, spatial clustering of children with ASD appears to be associated with neighbourhood resources that can facilitate diagnosis – including number of pediatricians, number of advocacy organizations, and regional center spending on ASD services (Mazumdar, Winter, Liu, & Bearman, 2013). Children who live in close proximity of other children previously diagnosed with ASD are more likely to be diagnosed with ASD as well – which has been attributed to the diffusion of information about ASD through social networks, a phenomenon that can lead to spatial clustering of children with ASD in neighbourhoods (Liu, King, & Bearman, 2010). In view of these findings, it is propitious to examine the prevalence of ASD, and the development of all children living in neighbourhoods with different levels of spatial clusters as this will allow to generate hypotheses about drivers of prevalence of ASD and its association with child development. Furthermore, identifying geographic and jurisdictional differences in the prevalence of ASD is integral for providing necessary early intervention services and community education in areas of need. Combination of availability of reliable developmental outcomes at a national, population level for kindergarten children with spatial and diagnostic information makes this task particularly promising.

The objectives of this study are to determine, among kindergarten children across provinces and territories in Canada (1) the variability in prevalence of ASD at the neighbourhood level; (2) the prevalence of neighbourhoods with no children with ASD; (3) the prevalence of neighbourhoods with different levels of spatial clusters of children with ASD; and (4) the developmental health status of children living in neighbourhoods with no children with ASD in comparison to children living in neighbourhoods with different levels of spatial clusters of children with ASD.

2. Methods

2.1. Kindergarten in Canada

Depending on the province or territory in Canada, children may start kindergarten at the age of 4–5 years. In Ontario, children can begin school in September of the calendar year they turn 4 years old, called "Junior Kindergarten". However, the majority of children in Canada begin school in the fall of the year they turn five, called "Senior Kindergarten". In this study, only data collected at the Senior Kindergarten level are used. Junior Kindergarten is universally implemented in only one province in this study (Ontario), therefore variable identifying participation in this level was excluded from this study.

2.2. Early Development Instrument

To determine the prevalence and developmental vulnerability of kindergarten children with and without ASD at the neighbourhood level, this study used data from the population-wide database of child development in kindergarten, collected using the EDI. The EDI has been administered at the population level in most Canadian provinces and territories since 2004 (Janus & Offord, 2007). The EDI is a measure of developmental health, a concept encompassing cognitive, social and behavioural development (Keating & Hertzman 1999), completed by teachers for children aged 4–6 years who are in their second term of senior kindergarten. It contains 103 items covering five broad domains of developmental health: physical health and well-being, social competence, emotional maturity, language and cognitive development, and communication skills and general knowledge. The EDI also includes a number of demographic questions, including child's date of birth, gender, first language, and "English or French as a Second Language Status" (E/FSL), which indicates a child's lack of fluency in the school's language of instruction, and postal code of child's residence. The psychometric properties and validity of the EDI have been reported in many studies, as well as associations with other developmental outcomes (Guhn et al., 2016; Janus et al., 2007; Janus & Offord, 2007). The EDI results are routinely used for monitoring and reporting on child development status at jurisdictional and geographic, community levels.

The questions on the EDI are answered on the dichotomous scale (yes/no: 0 = yes, 1 = no), or a Likert scale (e.g., Never/not true = 0, Sometimes/somewhat true = 5, Often/very true = 10). To determine the overall score for a domain or subdomain, the responses are summed and divided by the number of questions with valid answers. The scores are not validated for a clinical/diagnostic use. The scale is referenced to a normative baseline, where scores below the 10th percent cut-off indicate vulnerability on a domain, and vulnerability on one or more domains indicates overall vulnerability (Janus & Duku, 2007).

The EDI also includes teacher report on any health diagnosis the child may have, if they are aware "based on parent or health provider report". These items have been included on the EDI since the 2009/10 school year and include a list of over 30 most frequent childhood diagnoses (Janus et al., 2018a,b). The ASD is one of these diagnoses, and evidence indicates at least a fair concordance between the EDI-based prevalence with other data sources in two provinces (Reid-Westoby, Horner, & Janus, 2018). The data used in this study comes from the database created for the Canadian Children's Health in Context Study (Janus et al., 2018a).

2.3. Defining geographic neighbourhood boundaries

Discrete neighbourhoods were created to analyze the EDI data, using a detailed set of criteria (Guhn et al., 2016). Neighbourhood boundaries were established to reflect geographic and socioeconomic diversity across neighbourhoods. Neighbourhood boundaries were defined using the following criteria: must have a minimum of 50 EDI records; results should be verified with local contacts, where possible; should not have

more than 400–600 EDI records per unit; must be located within Statistics Canada Census Divisions (these are a group of neighbouring municipalities joined together for regional planning and managing common services, representing intermediate geographic areas between the province/territory level and the municipality (census subdivision)); should use local 'neighbourhood' or other applicable boundaries if possible; spatial units must be made up of dissemination blocks (DBs) (these are the smallest geographic areas covering the entire territory of Canada – where the area of each DB is equal to a city block that is bounded by intersecting streets). If a neighbourhood had more than 400–600 EDI records, it was further divided to display variance across spatial units, while prioritizing any pre-existing neighbourhood boundaries. As long as large rural areas included a minimum of 50 EDI records, they were included as individual units using Canada Census subdivisions, which are widely used as a proxy for rural municipality boundaries across the country. If EDI record density was low, Census subdivisions were used as the largest spatial unit. Each neighbourhood has been assigned with a unique name and a label.

2.4. Procedure

2.4.1. Sample

This study used EDI data on Senior Kindergarten (SK) children that teachers provided in school years 2010/11, 2011/12, 2012/13, 2013/14, and 2014/15. There were multiple implementations of the EDI in some provinces and territories over time during this study period (Janus et al., 2018a, Table 1). There were 5804 children with ASD, representing 1% of the children with available EDI records. New Brunswick, Prince Edward Island, and Nunavut were excluded from the study sample, as EDI data were not collected in these provinces during the study period. Children with ASD included in this study also had the following comorbidities: mental health disorders (1.6%), speech/language disorders (2.7%), sensory and motor disorders (1.3%), and other disorders (1.2%). Please note: since only kindergarten children are included in the sample, to simplify the language they will be sometimes referred to in Methods and Results only as "children".

2.4.2. Analyses

In order to determine prevalence of children with ASD at the neighbourhood level, the number of children with this disorder in a neighbourhood was measured. This was done to enhance the interpretability of the results, as the proportion of children with ASD among all kindergarten children in a neighbourhood was anticipated to be very small. While the number of kindergarten children with ASD may be higher in neighbourhoods that are more densely populated, a proportional representation of these children in a neighbourhood was not considered appropriate given the low-frequency of this population.

Descriptive statistics, including frequencies, percentages, means and standard deviations, were used to address the objectives of this study. This included examining the prevalence of children with ASD at the neighbourhood level, the prevalence of neighbourhoods without children with ASD (these neighbourhoods included typically developing kindergarten children as well as those with other medical diagnoses), and the prevalence of neighbourhoods with different levels of spatial clusters of children with ASD (these neighbourhoods included typically developing children, children with ASD, as well as those with other medical diagnoses). In order to examine spatial clusters, neighbourhoods were categorized according to their number, ranging from neighbourhoods with one child with ASD to neighbourhoods with two, three, four, five, and six or more. Neighbourhoods with one to five children with ASD were considered to have low level clustering and those with six or more were considered to have high level clustering. Further, descriptive statistics were used to examine the developmental vulnerability of all children living in neighbourhoods with no children with ASD in comparison to the vulnerability of children living in neighbourhoods with increasing levels of spatial clusters of children with ASD across provinces and territories in Canada.

2.4.3. Ethics

Ethics approval for this study was obtained from the Hamilton Integrated Research Ethics Board.

3. Theory

This study was informed by the "ecological model" of child development proposed by Bronfenbrenner, which highlights that there are many levels of influence on child development: individual, neighbourhood, regional, and jurisdictional (Adler et al., 1994; Hertzman, 1999). This study attempted to quantify the relationship between children's development and the neighbourhood where they live, by categorizing neighbourhoods according to the number of kindergarten children with ASD – which was expected to have differential impact on children's health. This represents an important contribution to the literature, as few studies have used the ecological model to study health of children with special needs thus far. Those that have, tend to focus on physical rather than mental disorders (e.g., Ben-David & Nel, 2013; Greenwood, Carta, & Atwater, 1991; Houtrow, Jones, Ghandour, Strickland, & Newacheck, 2012).

4. Results

Across Canada, there were 419 (21.1%) neighbourhoods without children with ASD and 1544 (78.6%) neighbourhoods with children with ASD. The demographic characteristics of neighbourhoods without children with ASD and with different levels of spatial clusters of children with ASD per neighbourhood are presented in Appendix A. In the majority of provinces and territories, the average age of children was 5.7 years and close to 50% of the children were male, regardless whether the neighbourhoods had or did not have children with ASD. Among the neighbourhoods without children with ASD, the average proportions of children with EFSL status ranged from 0.4% (in Newfoundland and Labrador) to 30.8% (in Manitoba). These proportions ranged from 0.8% (in Nova Scotia) to 31.7% (in Quebec) in neighbourhoods with different levels of spatial clusters of children with ASD.

4.1. Prevalence of children with and without ASD

At the national level, there were on average 2.89 children with ASD

Table 1
Implementation of EDI across provinces and territories in Canada from 2010 to 2015.

	Ontario	Manitoba	Alberta	British Columbia	Saskatchewan	Northwest Territories	Newfoundland and Labrador	Nova Scotia	Yukon	New Brunswick	Prince Edward Island	Quebec	Nunavut
2010	32184	0	17413	24671	8167	0	0	756	340	0	0	0	0
2011	37494	11841	17955	21767	5151	0	1088	2317	341	0	0	0	0
2012	55257	0	12710	12406	539	585	2090	2198	365	0	0	65042	0
2013	0	12886	16541	29854	7955	623	4835	8398	399	0	0	0	0
2014	0	0	0	1277	0	613	5069	1376	0	0	0	0	0
2015	132873	13224	0	0	0	602	0	8513	0	0	0	0	0

per neighbourhood (Table 2). In all provinces and territories but Northwest Territories, between 10.1% (Ontario) and 40% (Saskatchewan) of neighbourhoods had no children with ASD (Table 3). The minimum number of children with ASD in a neighbourhood (1) was observed in all provinces and territories but Northwest Territories and the maximum (21) was observed in Ontario. The average number of children with ASD in a neighbourhood ranged from 1.26 (in Quebec) to 5.15 (in Newfoundland and Labrador). With the exception of Manitoba, Newfoundland and Labrador, and Nova Scotia, there was a greater proportion of neighbourhoods with three or fewer children with ASD compared to neighbourhoods with four or five children with ASD. The proportion of neighborhoods with six or more children with ASD ranged from 3.3% (in Quebec) to 40.4% (in Nova Scotia).

4.2. Developmental vulnerability in neighbourhoods without children with ASD

The average developmental vulnerability of children living in neighbourhoods without children with ASD ranged from 22.4% (in Newfoundland and Labrador) to 40.9% (in Yukon) (Table 4). When vulnerability in specific areas of development was explored, the lowest average proportion of children vulnerable in a neighbourhood was observed in the Language and Cognitive Development domain in several provinces and territories (Table 4), and the highest in the Emotional Maturity domain and the Communication Skills and General Knowledge domain in most provinces and territories.

4.3. Developmental vulnerability in neighbourhoods with children with ASD

Overall, the average developmental vulnerability of children living in neighbourhoods with different levels of spatial clusters of children with ASD varied from 15.3% (in Newfoundland and Labrador) to 45.7% (in Yukon) (Table 5).

In neighbourhoods with one child with ASD, the average proportions of all children who demonstrated overall vulnerability ranged from 19.2% to 47.1%; in neighbourhoods with two children with ASD from 21.4% to 38.7%; in neighbourhoods with three children with ASD from 24.2% to 46.3%; in neighbourhoods with four children with ASD from 20.9% to 45.6%; in neighbourhoods with five children with ASD from 15.3% to 38.2%; and in neighbourhoods with 6 or more children with ASD from 20.6% to 36%.

As the number of children with ASD per neighbourhood increased, the average proportion of all children demonstrating overall vulnerability decreased in Alberta, starting from 32.5% (in neighbourhoods with one child with ASD) and decreasing to 29.4% (in neighbourhoods with six or more), a pattern that was not observed in other provinces and territories (Table 5).

None of the EDI domains showed a consistent pattern of vulnerability in neighbourhoods with each level of spatial cluster of children with ASD across provinces and territories (Appendices B to F). Neither of the specific spatial clusters showed a consistent pattern of vulnerability in individual EDI domains.

5. Discussion

While there have been some studies examining the prevalence of children with ASD in Canada, including some surveillance studies, to our knowledge, there are no studies that took a national approach in examining the prevalence of kindergarten children with this disorder based on kindergarten teacher report at a neighbourhood level (Ouellette-Kuntz et al., 2014; Public Health Agency of Canada, 2018). Our study found that in most provinces and territories, the number of kindergarten children with ASD per neighbourhood varied from none to as high as 21, as observed in Ontario. The average number of kindergarten children with ASD per neighbourhood ranged from 1.26 (in Quebec) to 5.15 (in Newfoundland and Labrador).

There are several possible explanations for the wide-ranging numbers of kindergarten children with ASD at the neighbourhood level across provinces and territories. Whether these children receive the ASD diagnosis by the time they enter school may be dependent on their province or territory of residence. Geographic variations in case ascertainment is a major factor that contributes to regional disparities in prevalence estimates (Ouellette-Kuntz et al., 2014). One study reported that there were differences in the median age of diagnosis for ASD across four regions of Canada as follows: Newfoundland and Labrador (3.25 years), Prince Edward Island (3.96 years), Manitoba (4 years), and Southeastern Ontario (4.58 years) (Ouellette-Kuntz et al., 2009). The lowest median age of diagnosis observed in Newfoundland and Labrador complements the results of our study, as the largest average number of kindergarten children with ASD living in a neighbourhood was seen in this province (5.15, see also Table 2). Similarly, the highest median age of diagnosis observed in Southeastern Ontario complements the results of our study, as the average number of kindergarten children with ASD living in a neighbourhood observed in this province (3.82, see also Table 2) was smaller than those observed in three other provinces. In areas where early intervention services are readily available with reduced wait times, there are increased opportunities for earlier diagnosis, which may influence the prevalence estimates of kindergarten children with ASD. For example, there is a “zero” waitlist policy for early intervention for preschool children diagnosed with ASD in Newfoundland and Labrador, whereas the waitlist for these services has been historically long in Ontario, which may influence the ASD diagnosis practices in this province (Gordon, 2012; Ouellette-Kuntz et al., 2009).

Our results show that the level of spatial clustering of kindergarten children with ASD at the neighbourhood level varies across provinces and territories. We found that the proportions of neighbourhoods with no kindergarten children with ASD could be as low as 10.1% (in Ontario) to as high as 40% (in Saskatchewan). Not surprisingly, there were greater proportions of neighbourhoods with three or fewer kindergarten children with ASD compared to those with four or five. We also found the proportion of neighbourhoods with six or more kindergarten children with ASD to be as low as 3.3% (in Quebec) to as high as 40.4% (in Nova Scotia). Considering the positive relationship between the availability of neighbourhood resources and ASD diagnosis, it is possible that families who are able to do so select to live in neighbourhoods with greater proximity or access to services for children with ASD, which may

Table 2
Number of kindergarten children with ASD at the neighbourhood level.

		Canada	Ontario	Manitoba	Alberta	British Columbia	Saskatchewan	Northwest Territories	Newfoundland and Labrador	Nova Scotia	Yukon	Quebec
Number of neighbourhoods		n = 1985	n = 790	n = 74	n = 265	n = 297	n = 55	n = 3	n = 41	n = 57	n = 6	n = 396
Number of kindergarten children with ASD per neighbourhood	Min	0	0	0	0	0	0	3	0	0	0	0
	Max	21	21	12	13	15	8	4	18	15	5	12
	Mean (SD)	2.89 (3.02)	3.82 (3.24)	4.04 (3.65)	1.76 (2.08)	2.84 (2.52)	1.51 (1.90)	3.33 (0.58)	5.15 (4.71)	4.72 (3.71)	2.00 (1.67)	1.26 (1.63)

Table 3
Distribution of neighbourhoods with different levels of spatial clusters of kindergarten children with ASD.

Number of kindergarten children with ASD in a neighbourhood	Ontario		Manitoba		Alberta		British Columbia		Saskatchewan		Northwest Territories		Newfoundland and Labrador		Nova Scotia		Yukon		Quebec	
	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)
0	80	10.1	12	16.2	86	32.5	45	15.2	22	40.0			8	19.5	7	12.3	1	16.7	158	39.9
1	118	14.9	13	17.6	63	23.8	63	21.2	14	25.5			1	2.4	5	8.8	1	16.7	116	29.3
2	129	16.3	7	9.5	50	18.9	50	16.8	7	12.7			4	9.8	6	10.5	3	50.0	66	16.7
3	123	15.6	8	10.8	32	12.1	47	15.8	4	7.3	2	66.7	6	14.6	9	15.8			24	6.1
4	74	9.4	8	10.8	7	2.6	32	10.8	2	3.6	1	33.3	3	7.3	6	10.5			12	3.0
5	77	9.7	6	8.1	10	3.8	19	6.4	3	5.5			4	9.8	1	1.8	1	16.7	7	1.8
6 or more	189	23.9	20	27.0	17	6.4	41	13.8	3	5.5			15	36.6	23	40.4			13	3.3

Table 4
Developmental vulnerability at the neighbourhood level of kindergarten children in neighbourhoods with no kindergarten children with ASD.

	Ontario	Manitoba	Alberta	British Columbia	Saskatchewan	Newfoundland and Labrador	Nova Scotia	Yukon	Quebec
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
% overall vulnerability per neighbourhood	25 (8.7)	24.9 (15.3)	31.3 (10.1)	35.8 (10.2)	29.7 (10.1)	22.4 (11.7)	29.3 (7.8)	40.9 (0.0)	24.5 (7.3)
% vulnerability on Physical Health and Well-Being domain per neighbourhood	10.9 (5.3)	8.7 (7.9)	15 (7.2)	18.7 (8.8)	14.1 (5.7)	5.4 (4.2)	13.4 (4.9)	28.2 (0.0)	7.2 (4.3)
% vulnerability on Social Competence domain per neighbourhood	10.9 (5.2)	8.3 (6.1)	11.1 (5.1)	13.5 (5.0)	12.1 (8.7)	9 (5.1)	12.4 (4.1)	14.1 (0.0)	7.8 (4.1)
% vulnerability on Emotional Maturity domain per neighbourhood	11.9 (4.8)	10.5 (7.0)	12.2 (5.2)	16.7 (6.2)	13.2 (8.1)	10.5 (8.3)	14 (5.9)	20.3 (0.0)	13.9 (5.5)
% vulnerability on Language and Cognitive Development domain per neighbourhood	6.3 (3.7)	8.4 (6.0)	11.7 (5.9)	9.8 (4.8)	12.8 (6.2)	10.9 (5.4)	8.2 (3.2)	9.5 (0.0)	9.4 (4.5)
% vulnerability on Communication Skills and General Knowledge domain per neighbourhood	11 (5.2)	13.7 (11.5)	16 (7.0)	17.6 (7.9)	14.6 (6.1)	10.1 (5.9)	11.7 (3.2)	17.5 (0.0)	8.4 (4.1)

*There were no neighbourhoods with no kindergarten children with ASD in Northwest Territories.

Table 5
Overall vulnerability at the neighbourhood level of kindergarten children living in neighbourhoods with different levels of spatial clusters of kindergarten children with ASD.

Number of kindergarten children with ASD in a neighbourhood	Ontario	Manitoba	Alberta	British Columbia	Saskatchewan	Northwest Territories	Newfoundland and Labrador	Nova Scotia	Yukon	Quebec
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
1	27.1 (6.8)	24.8 (11.7)	32.5 (9.6)	32.2 (10.5)	34.1 (10.6)		19.2 (0.0)	33.8 (10.3)	47.1 (0.0)	24.6 (7.6)
2	26.9 (7.5)	37.1 (8.8)	31.1 (9.3)	33.6 (8.5)	30.6 (8.4)		21.4 (3.8)	31.6 (6.2)	36.2 (6.6)	25.2 (7.1)
3	27.1 (5.8)	28.1 (8.8)	31.0 (8.0)	33.7 (7.4)	25.9 (3.1)	46.3 (1.5)	26.1 (13.5)	25.2 (7.8)		24.2 (4.3)
4	28.1 (6.9)	38.8 (9.6)	30.5 (9.9)	35.3 (9.2)	36.1 (7.3)	32.1 (0.0)	20.9 (5.0)	31.2 (6.4)		27.2 (6.1)
5	28.2 (6.4)	31.8 (6.1)	29.9 (9.9)	34.3 (7.6)	29.0 (10)		15.3 (5.7)	38.2 (0.0)	45.7 (0.0)	22.9 (5.6)
6 or more	28.6 (7.0)	33.0 (10.3)	29.4 (7.0)	36.0 (7.8)	30.8 (5.0)		20.6 (5.2)	31.1 (3.1)		26.3 (5.2)

lead to clustering of children with this disorder (Mazumdar, King, Liu, Zerubavel, & Bearman, 2010). Future study of the resources available in neighbourhoods across Canada may help explain the prevalence profile of kindergarten children with ASD, and the gradient in spatial clustering of kindergarten children with this disorder observed in different provinces and territories.

There is growing evidence regarding the heritability of ASD: several twin studies have suggested that the aggregation of twins with ASD within the same families is best attributed to shared genes rather than shared environment (Chaste & Leboyer, 2012). Having an older biological sibling with ASD has been identified as a significant predictor of the presence of this disorder among younger siblings (Ozonoff et al., 2011). Spatial clustering of kindergarten children with ASD observed in our study may be explained by the presence of families in a neighbourhood with multiple children with ASD, especially in provinces with several years of data, although we were not able to explore this hypothesis further given the lack of relevant family-level information in our study.

Spatial clustering of children with ASD can occur when parents of children exhibiting developmental markers of the disorder and yet not diagnosed with ASD have discussions with parents of children who are diagnosed with ASD, and they learn about symptoms of ASD, how to identify and approach a physician, and how to access and navigate services (Liu et al., 2010). Increased knowledge about ASD may prepare

parents to seek diagnosis for their children earlier – which has been defined as the "cul-du-sac effect" on the diagnosis (Schelly, Jimenez Gonzalez, & Solis, 2018). In this context, the wide-ranging clustering of kindergarten children with ASD observed in our study can also be attributed to the demographic characteristics of the neighbourhoods where they live – there may be a "cul-du-sac effect" on the diagnosis if there are already many children in the neighbourhood with ASD.

Results of a systematic review show that kindergarten children with ASD tend to be less school ready in social-emotional areas than both their typically developing and developmentally delayed peers (Marsh, Spagnol, Grove, & Eapen, 2017), a finding also observed in a previous study using the EDI-measured outcomes (Janus et al., 2018b). Specifically, they tend to have more externalizing behaviours and self-regulation difficulties that influence their school engagement and relationships with their teachers. Longitudinal research on children with ASD indicates significant heterogeneity in developmental pathways from preschool age to early adulthood, demonstrated by much diversity in functioning levels (Fountain et al., 2012; Lord, Bishop, & Anderson, 2015; Szatmari et al., 2015). As a neurodevelopmental disorder, it has been proposed that symptoms of ASD likely arise from the complex interaction between the child's vulnerabilities and their environment (Jones, Gliga, Bedford, Charman, & Johnson, 2014). There is a growing body of literature that have examined factors that influence development of children with ASD operating at individual and aggregate levels, including use of early intervention services, mother's education level, membership in minority groups, and socioeconomic factors (Eldevik et al., 2012; Fountain et al., 2012; Peters-Scheffer et al., 2011). We found that the average proportion of kindergarten children with developmental vulnerabilities varied among different levels of spatial clusters of kindergarten children with ASD. However, there appeared to be no systematic association between proportions of developmental vulnerability and the level of spatial cluster of kindergarten children with ASD. Most specifically, on average, the proportions of vulnerability were not lower among kindergarten children living in neighbourhoods with no kindergarten children with ASD.

Higher functioning preschool and kindergarten age children with ASD are more likely to be diagnosed within a spatial cluster than lower functioning children depending on neighbourhood resources available (Mazumdar et al., 2013). According to Mazumdar et al., an increased amount of neighbourhood resources such as number of pediatricians, number of advocacy organizations, regional center spending on ASD services, and socioeconomic status has led to more diagnoses of high-functioning ASD. Spatial clusters of children with less severe ASD can therefore be attributed to diagnostic expansion moderated through the presence of increased neighbourhood resources. Therefore, it was hypothesized that all children living in neighbourhoods with a higher concentration (six or more) of kindergarten children with ASD would be likely to show better developmental health. However, our results do not support this hypothesis: in most provinces and territories, as the number of kindergarten children with ASD per neighbourhood increased, the average proportion of kindergarten children demonstrating overall vulnerability did not decrease, with the exception of Alberta. Neither did we find that vulnerabilities increased with higher levels of clustering. This can be reflective of the fact that even though kindergarten children with ASD are, on average, more vulnerable than typically developing kindergarten children, this phenomenon is not necessarily true for all kindergarten children with ASD when using the EDI definition of developmental vulnerability, which is based on scores on the instrument. This also speaks to the varying severity of ASD and the possibility of children with this disorder to be high functioning in early years. Additionally, it is possible the proportions of neighbourhoods with different levels of clustering of kindergarten children with ASD observed across provinces and territories are not large enough to observe the association between clustering and kindergarten children's developmental health.

When examining specific areas of development, kindergarten children with ASD scored significantly higher in the Language and Cognitive Development domain compared to kindergarten children with developmental disabilities other than ASD (Janus et al., 2018b). While there has been no systematic mapping of ASD services' availability and usage among children with ASD across provinces and territories in Canada, a literature review on service use among children with ASD aged 3–9 years found that speech-language therapy is often the most common treatment they receive (Irvin, Patten, & Boyd, 2014). In contrast, our results show there is no specific area of development where the lowest or highest average proportion of kindergarten children demonstrated vulnerability in all provinces and territories, across all neighbourhoods with different levels of spatial clusters of kindergarten children with ASD. There were also no neighbourhoods with a specific level of spatial cluster of kindergarten children with ASD where kindergarten children consistently demonstrated the lowest or highest average proportion of vulnerability across all areas of development within a province or territory.

Since in our analyses we were able to differentiate between neighbourhoods with higher (six or more) and lower frequencies of kindergarten children with ASD, we demonstrated that there was no consistency in developmental vulnerabilities among those neighbourhoods. This emphasizes the importance of recognizing that early intervention service planning cannot be determined based on the size of the spatial clusters of children with ASD in a neighbourhood, but rather the developmental vulnerabilities observed in the neighbourhoods of their residence.

There are several strengths of this study. Until now, there was no population-based database with which the objectives of this study could be investigated. The use of the large EDI database presents an unprecedented opportunity to examine the prevalence of kindergarten children with ASD, as well as the developmental vulnerability of children living in neighbourhoods with no kindergarten children with ASD and different levels of spatial clusters of kindergarten children with this disorder across provinces and territories in Canada. Such analysis is not possible through sample-based research where children with ASD are commonly not available or included in sufficient numbers. The nationwide implementation of the EDI provides a large representative sample, improving generalizability of study findings.

There are also several limitations of this study. Implementation of the EDI did not occur every year from 2010 to 2015 in every province and territory, with more implementations occurring in some provinces and territories compared to others, which could have influenced the estimates of numbers of kindergarten children with ASD at the neighbourhood level. No formal evaluation yet has been conducted to compare the diagnosis reported on the EDI to data from health services based on 'gold standard' diagnostic procedures for ASD. However, the robustness of the EDI data as a source of ASD diagnosis can be ascertained through several points. First, findings from Manitoba and Ontario show there is fair concordance between EDI and population-level administrative data when identifying children with ASD (Kappa = 0.329; $p < 0.001$) (Reid-Westoby et al., 2018). Second, teachers are provided with extensive training materials to complete the EDI, which include an EDI Guide, electronic EDI Teacher's Manual, EDI Training Video, as well as a variety of presentations (https://edi.offordcentre.com/teachers/). While in the past few years, most training has moved to the online delivery, data included in this study were collected when most provinces conducted in-person training for teachers. Third, teachers report medical diagnoses on the EDI based on identification by accredited external health professionals (doctor or psychological professional), as per information shared by parents with the school. Fourth, social bias in case detection may not be a limitation of educational sources such as the EDI. Nonetheless, it is possible that ASD diagnosis is subject to over- or under-reporting, which may differ by place of residence across the country. Fourth, no information of participation in any early intervention is available for this sample. Finally, while lack of inclusion of sociodemographic variables in this report may be

considered as limitation, this decision was dictated by the lack of evidence of a consistent association between diagnosis of ASD and socioeconomic status reported earlier.

6. Conclusions

As a large population-level database, the EDI demonstrates significant utility from a population health perspective. Knowledge of prevalence of children with kindergarten teacher-reported ASD, as well as developmental vulnerability of kindergarten children living in neighbourhoods with and without kindergarten children with ASD at school entry derived from the EDI database presents a pragmatic first step to determine the association of type and location of services with their developmental health, which is not only crucial for early intervention service planning, but also for facilitating the planning of services for later years as children with ASD grow older.

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Ethics

Ethics approval for this study was obtained from the Hamilton Integrated Research Ethics Board.

Additional ethical considerations pertinent for publishing in Social Science and Medicine – Population Health has been described in the cover letter of this submission.

Declaration of competing interest

None.

Appendix A. Demographic characteristics of neighbourhoods with no kindergarten children with ASD and with different levels of spatial clusters of kindergarten children with ASD

Number of kindergarten children with ASD in a neighbourhood	Characteristics of the average neighbourhood	Ontario	Manitoba	Alberta	British Columbia	Saskatchewan	Northwest Territories	Newfoundland and Labrador	Nova Scotia	Yukon	Quebec
0	Mean age (SD)	5.7 (0.1)	5.7 (0.1)	5.7 (0.1)	5.6 (0.0)	5.7 (0.0)		5.7 (0.1)	5.7 (0.1)	5.8 (0.0)	6.0 (0.0)
	Mean % male (SD)	50.8 (7.5)	60.0 (18.8)	51.9 (4.0)	51.4 (4.3)	50.7 (4.3)		48.9 (6.1)	60.0 (30.3)	55.0 (0.0)	50.4 (5.5)
	Mean % EFSL	8.7 (10.7)	30.8 (35.5)	16 (16.5)	10.1 (15.1)	4.3 (2.5)		0.4 (0.7)	3.8 (5.1)	9.4 (0.0)	12.6 (14.5)
1	Mean age (SD)	5.7 (0.0)	5.7 (0.1)	5.7 (0.1)	5.7 (0.0)	5.7 (0.0)		5.7 (0.0)	5.7 (0.0)	5.7 (0.0)	6.0 (0.0)
	Mean % male (SD)	51.3 (3.9)	48.2 (15.0)	51.9 (3.9)	50.1 (4.4)	52.3 (4.1)		54.1 (6.0)	48.5 (3.0)	57.3 (0.0)	51.1 (5.4)
	Mean % EFSL (SD)	9.0 (9.7)	9.2 (9.0)	16.4 (15.7)	11.5 (15.4)	5.3 (4.2)		2.2 (3.1)	20.2 (21.6)	1.8 (0.0)	12.2 (12.1)
2	Mean age (SD)	5.7 (0.0)	5.7 (0.0)	5.7 (0.1)	5.7 (0.0)	5.7 (0.0)		5.6 (0.1)	5.7 (0.0)	5.72 (0.0)	6.0 (0.0)
	Mean % male (SD)	51.3 (2.9)	49.5 (2.1)	50.9 (4.0)	50.9 (3.6)	53.0 (1.9)		51.6 (3.9)	50.7 (3.3)	50.8 (6.1)	51.9 (4.7)
	Mean % EFSL (SD)	9.1 (8.6)	12.2 (9.1)	16.3 (16.3)	12.0 (17.8)	5.1 (7.0)		5.7 (11)	8.3 (5.0)	10.1 (3.3)	14.7 (16.0)
3	Mean age (SD)	5.7 (0.0)	5.7 (0.0)	5.6 (0.1)	5.6 (0.0)	5.7 (0.0)	5.7 (0.0)	5.6 (0.0)	5.7 (0.0)		6.0 (0.0)
	Mean % male (SD)	50.9 (3.4)	49.0 (1.4)	51.6 (4.7)	51.7 (2.5)	51.5 (1.6)	51.3 (0.1)	47.3 (4.1)	52.0 (3.6)		51.5 (3.7)
	Mean % EFSL (SD)	11.9 (10.6)	8.6 (6.0)	17.1 (14.1)	17.2 (20.0)	2.7 (1.5)	2.8 (2.7)	1.9 (3.1)	7.5 (4.4)		20.5 (20.8)
4	Mean age (SD)	5.7 (0.0)	5.7 (0.0)	5.7 (0.1)	5.7 (0.0)	5.7 (0.0)	5.7 (0.0)	5.7 (0.0)	5.7 (0.0)		6.0 (0.0)
	Mean % male (SD)	51.1 (3.0)	51.4 (1.7)	50.6 (4.6)	51.7 (2.3)	53.5 (0.4)	50.9 (0.0)	52.1 (4.2)	52.4 (2.6)		49.9 (3.6)
	Mean % EFSL (SD)	14.1 (12.7)	16.0 (9.3)	7.2 (7.4)	19.5 (22.4)	5.2 (0.1)	9.0 (0.0)	1.4 (1.8)	6.7 (5.4)		17.5 (21.4)
5	Mean age (SD)	5.7 (0.0)	5.7 (0.0)	5.7 (0.1)	5.6 (0.0)	5.7 (0.0)		5.7 (0.0)	5.7 (0.0)	5.71 (0.0)	6.0 (0.0)
	Mean % male (SD)	51.0 (2.8)	50.9 (3.0)	50.2 (2.9)	50.6 (2.3)	50.4 (1.2)		51.8 (3.1)	53.3 (0.0)	51.1 (0.0)	49.8 (2.2)
	Mean % EFSL (SD)	11.5 (8.8)	15.2 (6.6)	12.2 (9.7)	18.8 (20.2)	10.6 (1.1)		1.8 (1.1)	0.8 (0.0)	2.6 (0.0)	31.7 (21.5)
6 or more	Mean age (SD)	5.7 (0.0)	5.7 (0.0)	5.7 (0.1)	5.6 (0.0)	5.7 (0.0)		5.6 (0.1)	5.7 (0.0)		6.0 (0.0)
	Mean % male (SD)	51.5 (2.4)	51.0 (1.6)	52.2 (1.7)	51.4 (2.3)	50.4 (2.1)		51.6 (2.0)	52.2 (2.9)		52.6 (3.3)
	Mean % EFSL (SD)	12.9 (10.0)	11.3 (6.1)	13.7 (9.4)	24.5 (24.8)	12.8 (1.8)		1.8 (2.3)	3.3 (2.2)		30.7 (21.4)

Appendix B. Vulnerability on Physical Health and Well-Being Domain at the neighbourhood level of kindergarten children living in neighbourhoods with different levels of spatial clusters of kindergarten children with ASD

Number of kindergarten children with ASD in a neighbourhood	Ontario	Manitoba	Alberta	British Columbia	Saskatchewan	Northwest Territories	Newfoundland and Labrador	Nova Scotia	Yukon	Quebec
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
1	11.9 (5.0)	10.4 (7.0)	15.7 (6.7)	16.6 (7.7)	18.0 (7.0)		5.1 (0.0)	17.4 (11.0)	29.6 (0.0)	7.6 (4.2)
2	11.7 (5.1)	15.6 (5.5)	13.9 (5.8)	17.3 (6.7)	14.4 (7.4)		9.6 (2.4)	16.6 (5.2)	21.3 (3.2)	7.4 (3.8)
3	11.4 (4.6)	12.1 (6.0)	14.0 (5.7)	16.7 (5.5)	11.9 (1.3)	27.2 (2.3)	10.5 (8.1)	12.0 (4.5)		6.7 (2.6)
4	11.9 (4.5)	17.6 (8.2)	16.9 (6.7)	18.6 (6.0)	19.1 (7.0)	17.8 (0.0)	6.5 (3.0)	14.9 (3.6)		8.6 (4.3)
5	12.0 (5.4)	13.6 (4.9)	14.8 (6.7)	17.8 (6.1)	13.8 (7.3)		5.4 (2.3)	20.5 (0.0)	27.8 (0.0)	6.9 (2.3)
6 or more	12.0 (5.0)	14.8 (5.6)	14.2 (6.1)	17.4 (5.3)	15.1 (4.9)		7.4 (2.9)	15.8 (3.2)		7.9 (3.4)

Appendix C. Vulnerability on Social Competence Domain at the neighbourhood level of kindergarten children living in neighbourhoods with different levels of spatial clusters of kindergarten children with ASD

Number of kindergarten children with ASD in a neighbourhood	Ontario	Manitoba	Alberta	British Columbia	Saskatchewan	Northwest Territories	Newfoundland and Labrador	Nova Scotia	Yukon	Quebec
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
1	11.3 (3.9)	7.8 (4.4)	11.9 (4.8)	11.7 (5.7)	13.1 (5.4)		8.0 (0.0)	16.0 (9.1)	15.3 (0.0)	8.2 (4.3)
2	11.1 (4.5)	14.7 (10.1)	11.4 (5.0)	13.0 (4.8)	9.9 (3.6)		10.1 (2.7)	13.0 (4.1)	12.9 (2.6)	8.4 (4.0)
3	11.3 (3.6)	10.7 (3.0)	12.1 (5.1)	12.9 (4.0)	8.2 (1.3)	19.4 (3.1)	13.7 (9.7)	10.1 (2.7)		8.3 (3.0)
4	12.0 (4.1)	13.4 (4.7)	12.5 (7.5)	13.8 (5.2)	12.5 (2.6)	11.3 (0.0)	8.0 (3.4)	14.2 (5.6)		8.5 (2.6)
5	12.1 (3.8)	10.4 (3.8)	11.9 (6.5)	14.3 (4.3)	9.4 (3.8)		6.2 (1.4)	15.1 (0.0)	21.1 (0.0)	7.7 (2.3)
6 or more	12.3 (3.9)	12.8 (5.8)	10.6 (3.6)	14.8 (4.6)	8.9 (1.1)		8.9 (4.0)	13.7 (2.2)		8.6 (3.4)

Appendix D. Vulnerability on Emotional Maturity Domain at the neighbourhood level of kindergarten children living in neighbourhoods with different levels of spatial clusters of kindergarten children with ASD

Number of kindergarten children with ASD in a neighbourhood	Ontario	Manitoba	Alberta	British Columbia	Saskatchewan	Northwest Territories	Newfoundland and Labrador	Nova Scotia	Yukon	Quebec
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
1	13.1 (4.4)	10.8 (6.0)	13.4 (5.2)	14.4 (6.4)	14.0 (4.9)		6.1 (0.0)	14.9 (7.1)	23.5 (0.0)	13.8 (4.8)
2	12.9 (4.7)	17.4 (6.4)	12.5 (5.1)	16.0 (4.8)	11.1 (3.5)		8.1 (1.5)	14.5 (4.3)	17.8 (2.2)	13.7 (5.1)
3	12.7 (3.2)	11.5 (5.3)	12.0 (4.7)	15.9 (4.2)	10.2 (0.2)	24.3 (4.7)	14.2 (7.1)	11.4 (3.9)		13.5 (3.0)
4	13.0 (3.8)	15.9 (3.0)	11.5 (3.6)	16.3 (5.0)	13.9 (1.2)	12.7 (0.0)	7.9 (0.8)	15.4 (5.2)		15.0 (4.0)
5	13.7 (4.3)	13.3 (4.1)	12.1 (5.3)	14.9 (3.0)	12.1 (3.8)		7.1 (1.7)	17.0 (0.0)	23.0 (0.0)	11.4 (2.8)
6 or more	13.8 (4.1)	14.8 (6.7)	12.2 (4.0)	17.3 (4.4)	11.9 (0.5)		9.9 (3.3)	14.9 (2.6)		13.5 (3.1)

Appendix E. Vulnerability on Language and Cognitive Development Domain at the neighbourhood level of kindergarten children living in neighbourhoods with different levels of spatial clusters of kindergarten children with ASD

Number of kindergarten children with ASD in a neighbourhood	Ontario	Manitoba	Alberta	British Columbia	Saskatchewan	Northwest Territories	Newfoundland and Labrador	Nova Scotia	Yukon	Quebec
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)

(*continued on next page*)

(*continued*)

Number of kindergarten children with ASD in a neighbourhood	Ontario	Manitoba	Alberta	British Columbia	Saskatchewan	Northwest Territories	Newfoundland and Labrador	Nova Scotia	Yukon	Quebec
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
1	7.0 (3.1)	8.0 (5.9)	11.6 (4.8)	8.9 (4.8)	16.1 (6.7)		11.6 (0.0)	8.6 (6.4)	10.6 (0.0)	9.5 (4.5)
2	6.6 (3.6)	15.8 (8.1)	10.5 (4.8)	9.8 (4.7)	14.4 (5.1)		8.1 (3.0)	7.9 (4.6)	7.5 (3.1)	10.2 (4.5)
3	7.1 (3.0)	13.3 (6.7)	10.9 (4.6)	9.6 (4.0)	10.6 (2.1)	22.8 (2.5)	10.9 (8.7)	7.0 (2.8)		9.8 (3.6)
4	7.6 (3.3)	16.9 (7.4)	10.8 (4.3)	10.0 (4.0)	15.7 (6.4)	13.2 (0.0)	6.6 (3.2)	8.7 (2.5)		10.9 (3.4)
5	7.2 (2.9)	12.6 (3.1)	10.5 (8.4)	9.8 (3.8)	9.0 (5.3)		6.0 (2.8)	6.6 (0.0)	15.3 (0.0)	7.8 (2.6)
6 or more	7.3 (3.3)	13.0 (7.0)	9.3 (3.4)	9.6 (3.4)	10.3 (2.8)		7.2 (2.8)	8.0 (2.2)		9.7 (2.9)

Appendix F. Vulnerability on Communication Skills and General Knowledge Domain at the neighbourhood level of kindergarten children living in neighbourhoods with different levels of spatial clusters of kindergarten children with ASD

Number of kindergarten children with ASD in a neighbourhood	Ontario	Manitoba	Alberta	British Columbia	Saskatchewan	Northwest Territories	Newfoundland and Labrador	Nova Scotia	Yukon	Quebec
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
1	12.1 (4.3)	12.0 (5.2)	16.6 (7.2)	15.1 (7.6)	16.3 (5.5)		10.2 (0.0)	15.7 (8.1)	20.0 (0.0)	8.8 (4.1)
2	11.9 (4.7)	18.6 (4.5)	16.5 (6.6)	15.8 (6.3)	14.2 (4.6)		9.3 (1.4)	12.6 (3.6)	14.4 (7.2)	8.7 (4.0)
3	12.7 (4.2)	13.9 (5.3)	16.1 (6.6)	16.1 (6.0)	13.1 (2.2)	24 (2.0)	10.9 (6.8)	12.2 (4.7)		9.4 (3.8)
4	13.5 (5.0)	20.6 (4.5)	12.7 (4.5)	17.2 (6.7)	18.8 (2.0)	16.4 (0.0)	9.7 (5.8)	14.8 (3.1)		10.1 (4.8)
5	12.6 (3.2)	16.8 (3.5)	15.2 (8.5)	17.0 (6.4)	13.7 (5.7)		7.2 (2.8)	18.1 (0.0)	25.0 (0.0)	9.5 (3.7)
6 or more	13.8 (4.6)	17.2 (6.3)	14.5 (4.3)	18.1 (6.2)	15.5 (2.3)		9.5 (2.9)	13.8 (2.7)		10.9 (4.0)

Appendix G. Sample questions from the Early Development Instrument

Section A – Physical Well-Being				
Since the start of school in the fall, has this child sometimes (more than once) arrived:	Yes	No	Don't know	
2. over- or underdressed for school-related activities 3. too tired/sick to do school work 4. late				
Section B - Language and Cognitive Skills				
How would you rate this child's:	Very good/good	Average	Poor/very poor	Don't know
1. ability to use language effectively in English 2. ability to listen in English 3. ability to tell a story 4. ability to take part in imaginative play				
Section C - Social and Emotional Development				
Would you say that this child:	Often or very true	Sometimes or somewhat true	Never or not true	Don't know
3. plays and works cooperatively with other children at the level appropriate for his/her age 4. is able to play with various children 5. follows rules and instructions				

*Entire EDI questionnaire can be found here: https://edi-offordcentre.s3.amazonaws.com/uploads/2019/01/EDI-ON-ENG-2018.pdf.

Appendix H. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ssmph.2019.100520.

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