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Association between neighbourhood socioeconomic status and developmental vulnerability of kindergarten children with Autism Spectrum Disorder: 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

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ABSTRACT

There is limited knowledge about the relationship between neighbourhood socioeconomic status (SES) and development of kindergarten children with ASD. The primary objective of this study was to determine the association between neighbourhood SES and developmental vulnerability of kindergarten children with ASD while controlling for family SES across 10 provinces and territories in Canada. This study used data from a population level database of child development in kindergarten, collected with the Early Development Instrument (EDI). The EDI covers 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. Neighbourhood SES was assessed with an SES index created using 10 variables from the 2011 Canadian Census and 2010 Taxfiler data. Family SES was assessed using 4 variables from the 2016 Canadian Census. Descriptive statistics and regression-based models were used in this study. Multilevel binary logistic regression analyses were used to examine the association between neighbourhood SES and child developmental vulnerability (yes/no), at the individual level, while controlling for family SES, demographic characteristics, and neighbourhood clustering. The association between neighbourhood SES and child developmental vulnerability at the individual level, while controlling for family SES and demographic characteristics was examined with binary single level logistic regression analyses. Multivariable linear regression analyses were used to examine the association between neighbourhood SES and developmental vulnerability at the neighbourhood level (% of kindergarten children with ASD demonstrating developmental vulnerability in a neighbourhood). In Ontario, British Columbia, Manitoba, and Newfoundland and Labrador, higher neighbourhood SES was associated with lower likelihood of developmental vulnerability. In Nova Scotia, higher neighbourhood SES was associated with higher likelihood of vulnerability in the social competence and communication skills and general knowledge domains. These findings emphasize the importance of addressing neighbourhood deprivation to support the development of children with ASD. Additionally, the inconsistency highlights the importance of examining the mechanisms through which neighbourhood SES impacts development of these children on a provincial basis.

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 Statistics Canada, 2018). ASD is a heterogeneous neurodevelopmental

disorder with no unifying pathological or neurobiological etiology (Geschwind & Levitt, 2007). According to the Diagnostic and Statistical Manual of Mental Disorders – 5th Edition (DSM – 5, American Psychiatric Association, 2013), 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,

* 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 4L8, Canada..

E-mail address: siddia36@mcmaster.ca (A. Siddiqua).

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Lombardo, Chakrabarti, & Baron-Cohen, 2013). Children with ASD have heterogeneous developmental trajectories (Fountain, Winter, & Bearman, 2012). There is a growing body of literature examining the risk factors for the occurrence of ASD, which include a variety of genetic, environmental, and epigenetic factors (Chaste & Leboyer, 2012; Grabrucker, 2012; Karimi, Kamali, Mousavi, & Karahmadi, 2017). There is also emerging evidence regarding factors influencing language development of children with ASD – for example, it has been found that children with ASD who are raised by parents with a high level of education demonstrate earlier language development (Fusaroli, Weed, Fein, & Naigles, 2018; Grandgeorge et al., 2009).

Substantial evidence indicates that higher socioeconomic status (SES) is associated with better health (Fiscella & Williams, 2004). Differences in health across levels of SES are referred to as the socioeconomic gradient, highlighting that differences in health outcomes are gradual and occur across the full spectrum of the SES continuum (Fiscella & Williams, 2004; Syme & Berkman, 1976). Lower SES is associated with higher morbidity, mortality, and disability rates for almost every disease and illness (Roberts & Power, 1996; Syme & Berkman, 1976). On the other hand, higher SES is associated with significant benefits to health (Schreier & Chen, 2013), although the positive relationship between SES and health can plateau at increasingly higher levels of SES (Carpiano, Lloyd, & Hertzman, 2009).

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 neighbourhood characteristics (Pickett & Pearl, 2001). Pickett & Pearl proposed that contextual factors, such as characteristics of neighbourhoods, may be the most important determinants of health of a population – highlighting the importance of examining the impact of neighbourhood SES on children's health outcomes at the population level. Neighbourhood deprivation is a feature of the neighbourhood environment, which is commonly defined by the proportion of residents with low SES, unemployed people and/or people receiving welfare assistance (Li, Sjostedt, Sundquist, Zoller, & Sundquist, 2014). Household income is typically geographically clustered, resulting in neighbourhoods with different levels of socioeconomic deprivation (Emerson, 2012). There is growing evidence demonstrating that a significant relationship exists between neighbourhood deprivation and children's developmental health, especially cognitive development (McCulloch, 1982; Sellstrom & Bremberg, 2006). Living in low-income neighbourhoods negatively impacts children's school readiness, academic achievement, and externalizing behaviour problems, even after controlling for individual level factors (McCulloch, 2006).

The relationship between neighbourhood SES and health of children with ASD remains largely unexamined. Thus far, research addressing the association between individual and neighbourhood SES with prevalence of children with ASD shows mixed findings (Bhasin & Schendel, 2007; Delobel-Ayoub et al., 2015; Emerson, 2012; Hock & Ahmedani, 2012; Li et al., 2014; Thomas et al., 2012). There is some evidence indicating that spatial clustering of children with ASD is 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 this context, it can be hypothesized that children with ASD who live in spatial clusters of children with this disorder in neighbourhoods may also have better developmental health as a result of information sharing about ASD early intervention services through social networks, as well as having access to these interventions. Thus, the larger the spatial cluster of children with ASD, the better their developmental health is

expected to be.

There is strong impetus to further explore the relationship between individual and neighbourhood SES with development of children with ASD. Reliable information on this relationship across provinces and territories is needed to identify regions with ASD populations showing poor development with inadequate access to necessary intervention programs or services. Providing support according to the needs of different areas can have long-term benefits on young children, as intensive behavioural interventions provided to preschool and school aged children with ASD have demonstrated long-term improvements in intellectual, academic, communication, social, and daily living skills (Eikeseth, Smith, Jahr, & Eldevik, 2007; Jacobson, Mulick, & Green, 1998). The median age of ASD diagnosis remains over age of 4 years, therefore identifying the socioeconomic gradient in the development of kindergarten children with ASD between the ages of 4–6 years presents an optimal opportunity to target early interventions (Janus et al., 2018; Monteiro et al., 2015).

The relationship between neighbourhood characteristics and child health outcomes have been largely examined in studies where health outcomes are examined at the individual level, or in ecological studies, where health outcomes are examined at the group level (Sellstrom & Bremberg, 2006). However, these studies do not consider the nested structure of the data, where families and children living in a neighbourhood are more likely to be similar to one another than those living in a different neighbourhood. The research objectives of this study were designed to address such shortcomings in the population of kindergarten children with ASD. There is particular value in examining the relationship between neighbourhood SES and health of children with ASD using a multilevel approach, where their health outcomes are examined at the individual level while accounting for clustering of these children in neighbourhoods. Our Objective 1 is to determine the developmental vulnerability in neighbourhoods with different levels of spatial clusters of children with ASD. If any level of variability in health outcomes of children is explained by differences between neighbourhoods, it is not appropriate to examine the relationship between neighbourhood SES and health outcomes of children without considering the clustering of this population in neighbourhoods. Objective 2 is to determine the association between neighbourhood SES and developmental vulnerability at the individual level, while controlling for family SES and neighbourhood clustering. If no variability in health outcomes of children is explained by differences between neighbourhoods, individual-based analysis to examine the relationship between neighbourhood SES and health outcomes of children is warranted. Objective 3, therefore, is to determine the association between neighbourhood SES and developmental vulnerability at the individual level, while controlling for family SES. An ecological analysis approach is valuable for illustrating whether the relationship between neighbourhood SES and health of children with ASD differs according to the unit of analysis, which has important implications for service planning. In Objective 4, we determine the association between neighbourhood SES and developmental vulnerability at the neighbourhood level, while controlling for family SES and spatial cluster level of children with ASD in neighbourhoods across provinces and territories in Canada.

2. Methods

2.1. Study design

A population level cross-sectional study design was used to address the research objectives.

2.2. Kindergarten in Canada

In Canada, children start kindergarten at the age of 4–5 years depending on the province or territory. 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 the present study, only data collected at the Senior Kindergarten level are used.

2.3. Data sources

2.3.1. Early Development Instrument database

To determine the developmental vulnerability of kindergarten children with ASD, this study used data from the large, population-wide database of child development in kindergarten, collected using the Early Development Instrument (EDI). The EDI is currently widely used across Canada, similar to a census (Janus & Offord, 2007). It 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 (i.e., development in behavioural, physical, and cognitive areas, Keating & Hertzman, 1999), which is completed by teachers for children aged 4–6 years in their second term of senior kindergarten (Janus & Offord, 2007). 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 (Janus & Offord, 2007). The EDI also includes a number of demographic questions, including child’s date of birth, sex, 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, based on its differential item functioning, multilevel validity, factor structure, internal consistencies, as well as associations with other developmental outcomes (Guhn et al., 2016; Janus et al., 2007; Janus & Offord, 2007).

Within each EDI domain, there are a series of questions, some of which are dichotomous (e.g., 0 = no, 10 = yes – unless otherwise stated), while others use a Likert scale (e.g., Never/not true = 0, Sometimes/somewhat true = 5, Often/very true = 10) (Janus & Offord, 2007). To determine the overall score for a domain, the responses to questions are summed and divided by the number of questions. The scores are not interpreted in a clinical/diagnostic manner for individual children; rather, they are always compared at a group level (e.g., between boys and girls, children in geographic communities etc.), where the mean and standard deviation of scores are considered and effect sizes of differences reported. The score 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., 2018). ASD is one of these diagnoses.

2.3.2. Census Canada and Income Taxfiler databases

To determine neighbourhood SES, socioeconomic and demographic information was derived from the 2006 and 2011 Canadian Census and the matching 2005 and 2010 Income Taxfiler databases (since Census data report on the previous year) at the smallest geographic areas available, which were Dissemination Blocks (DBs), then aggregated at the neighbourhood level based on a custom neighbourhood boundary definition (Forer et al., 2019; Guhn et al., 2016). After the EDI variables had been merged with the 2006 and 2011 Census and 2005 and 2010 Income Taxfiler demographic and SES variables at the neighbourhood level, a small subset of 10 variables was identified to create a neighbourhood SES index. This index represents an optimal compromise between maximizing the variance explained in the developmental health outcomes measured using the EDI, as well as restriction in the number of

variables to a reasonable number for interpretation and intervention (Table 1) (Forer et al., 2019; Webb et al., 2017).

Individual child’s family SES (henceforth, “family SES”) was determined by a proxy measure consisting of 4 variables derived from the 2016 Census, including marital status, education, language/immigration, and residential stability. For consistency with the neighbourhood SES index, these 4 variables were similar to 4 of the variables included in the neighbourhood index (Table 1). Family SES was determined at the Dissemination Area (DA; a small area composed of one or more neighbouring DBs and consists of approximately 400–700 persons) associated with a child’s postal code, which meant that all children living in this same small geographic unit were assigned the same family SES. The DA level SES was considered to be an appropriate proxy for family SES as it is a small geographic unit, therefore the SES of those living in the same unit were expected to be similar. This is a standard practice for analyses of large secondary databases, where individual family variables are not available (Carpiano et al., 2009).

2.4. Data linkage

2.4.1. Defining geographic neighbourhood boundaries

A detailed set of criteria was used to create discrete neighbourhoods to analyze the EDI data (Guhn et al., 2016). Neighbourhood boundaries were established to reflect geographic and socioeconomic diversity across neighbourhoods (Guhn et al., 2016). Overall, there were 2038 neighbourhoods with total population sizes of 355 to 95,295 people based on the 2006 Census (Webb et al., 2017). In each neighbourhood, there was a minimum of 50 and no more than 400–600 EDI records per unit (Guhn et al., 2016).

2.4.2. Linking census Canada, Income Taxfiler, EDI data

When the individual EDI variables were merged with the 4 SES variables from the 2016 Census using postal codes, 910 kindergarten children with ASD, representing 15.7% of the kindergarten children with ASD with available EDI records were excluded (Fig. 1). This exclusion was due to the lack of one-to-one match between postal codes of residence of kindergarten children with ASD from the EDI records with the postal codes included in the 2016 Postal Code Conversion File (PCCF; Statistics Canada, 2018), which provides correspondence

Table 1

Census and Income Taxfiler components for examining neighbourhood and individual SES.

Variables in Neighbourhood SES Index	
Marital Status*	Percent separated or divorced
Education*	Percent of those 25 to 64 with no high school diploma
Language/ Immigration*	Percent whose home language is a non-official language
Residential Stability*	Percent of individuals, non-migrant movers in the past year
High Income	Percent at or exceeding twice the median provincial income, families with children under 6
Poverty	Percent below Low Income Measure, lone parents with children under 6
Dues	Percent deducting dues, families with children under 6
Social Capital	Percent families declaring charitable donations, families with children under 6
Wealth	Percent families with investment income or capital gains, families with children under 6
Income Inequality	GINI coefficient quintiles (income inequality), lone female parents with children under 6
Variables used as proxies for Individual SES variables	
Marital Status**	Percent separated, divorced, or widowed
Education**	Percent above 15 years with no secondary diploma
Language/ Immigration**	Percent not speaking either official language at home
Residential Stability**	Percent of population who moved during the past 5 years

*Variables included in 2006 and 2011 Canadian Census; **Variables included in 2016 Canadian Census.

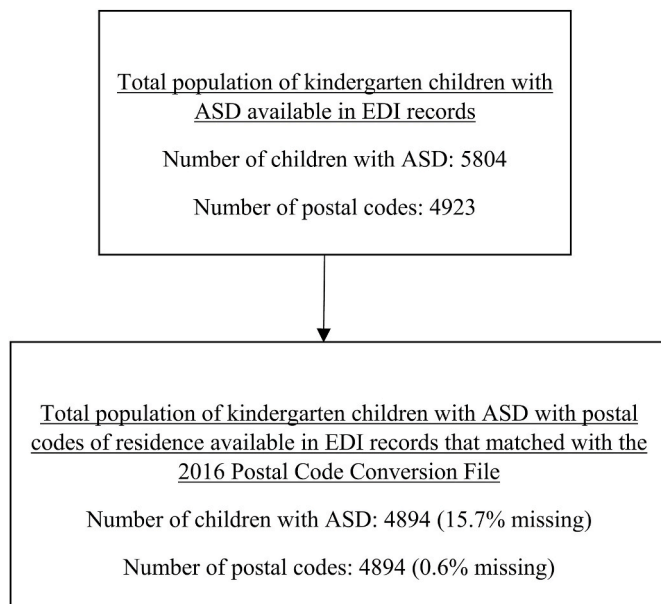


Fig. 1. Flowchart of sample of kindergarten children with ASD included in the study

between postal codes and standard geographic areas for which Census data are produced. This lack of one-to-one match led to the exclusion of 29 postal codes, representing 0.6% of the available postal codes for the kindergarten children with ASD included in the EDI records.

2.5. Sample

This study used linked EDI-SES data collected for the school years 2009/10 to 2014/15. There were between 1 and 6 implementations of the EDI per jurisdiction (province/territory) in those six years (Appendix 1). 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. There were 5804 children with ASD, representing 1% of the kindergarten children with available EDI records. The number of kindergarten children with ASD with individual level SES information available for analysis are summarized in Appendix 2.

2.6. Analyses

To examine spatial clusters, neighbourhoods were categorized according to the number of kindergarten children with ASD, ranging from neighbourhoods with one child to those with two, three, four, five, and six or more. Neighbourhoods were stratified in this manner to examine developmental vulnerability of kindergarten children with ASD living in neighbourhoods with incremental increase in the number of children with ASD in a neighbourhood. Descriptive statistics were used to examine average proportions of kindergarten children with ASD demonstrating developmental vulnerability while living in neighbourhoods with different levels of spatial clusters. Tests for linearity were conducted to determine whether the relationships between increasing sizes of spatial clusters of children with ASD in a neighbourhood and developmental vulnerability were linear or not.

The total number of kindergarten children with ASD across Canada were as follows: Ontario (3139); Manitoba (340); Alberta (475); British Columbia (849); Saskatchewan (91); Northwest Territories (10); Newfoundland and Labrador (217); Nova Scotia (287); Yukon (10); Quebec (497). For each of the models described below, in provinces where the minimum sample size was available for a specific model, all children were used in the analysis. In provinces where the minimum sample size was not available for a specific model, all children were

excluded in the analysis.

Multilevel binary logistic regression analyses were used to examine the association between neighbourhood SES and child developmental vulnerability at the individual level (yes/no), while controlling for family SES, demographic characteristics, and neighbourhood clustering. Since a minimum of 40 level 2 units are needed for multilevel logistic modelling, provinces and territories with less than 40 neighbourhoods were excluded from the multilevel analyses and included in the logistic regression analyses described below (Schoeneberger, 2016). Also, if the proportion of variability explained in the chance of a kindergarten child with ASD demonstrating developmental vulnerability across neighbourhoods was greater than zero in provinces with at least 40 neighbourhoods, this was interpreted as a necessity to account for neighbourhood level variation and multilevel models were created. If no variability explained in the chance of a kindergarten child with ASD demonstrating developmental vulnerability was attributed to between neighbourhood differences in these provinces, single level binary logistic regression analyses were conducted as described below.

Pan-Canadian and province specific approaches were used to conduct the multilevel analyses. In the first pan-Canadian approach (pan-Canadian analysis # 1), six provinces with at least 40 neighbourhoods were included in the analysis, which were Ontario, Manitoba, Alberta, British Columbia, Nova Scotia, and Quebec. In the second pan-Canadian approach (pan-Canadian analysis # 2), Ontario, British Columbia and Quebec were included as separate units, and remaining provinces were grouped into Prairies (Alberta, Saskatchewan, and Manitoba), and Atlantic provinces (Nova Scotia, Newfoundland), following the methodology established by Webb et al. (2020). The Prairies and Atlantic provincial groups were created to ensure inclusion of regions that had fewer than 40 neighbourhoods per province.

The multilevel models were analyzed using MLwiN and used in a sequential manner for both the pan-Canadian and province specific analyses approaches. The first model examined the extent to which overall vulnerability of kindergarten children with ASD varied across neighbourhoods. The second model included demographic characteristics (child's sex, age, having English/French as a second language (E/FSL)) and family SES (marital status, education, language/immigration, residential stability) of kindergarten children with ASD at level one in province specific analyses, and in the pan-Canadian analyses. In the pan-Canadian analyses, the second model also included a variable indicating these children's province of residence at level one. The third model included neighbourhood SES (neighbourhood SES index score for 2011) at level two. For the second and third models, all predictor variables at level one and two were entered as fixed effects, meaning their associations were constrained to be constant across neighbourhoods. Predictor variables were not centered as the purpose of centering is to ensure the intercept reflects the 'average' child, whereas the purpose of the multilevel models in this study was to identify the magnitude of association between neighbourhood SES and developmental vulnerability without focusing on the intercept. A marginal quasi-likelihood (MQL) estimation process was used to create the models. The MQL estimation process uses a linearization method and is used to transform a discrete response model to a continuous response model in multilevel analyses (Goldstein, 2003). Similar multilevel binary logistic regression analyses were used to examine the association between neighbourhood SES and developmental vulnerability on each of the EDI domains at the individual level, while controlling for demographic characteristics, family SES, and neighbourhood clustering.

Binary single level logistic regression analyses were used to examine the association between neighbourhood SES with overall vulnerability and developmental vulnerability on each of the EDI domains, while controlling for demographic characteristics and family SES. There is evidence indicating that the sample size guideline for logistic regression analyses, which requires at least 10 events per predictor in the model, may be too conservative (Vittinghoff & McCulloch, 2007). In this context, the sample size guideline for linear regression analyses, which

requires 10 to 20 observations per predictor in a model, was used for the logistic regression analyses in this study (Harrell, 2011). Thus, provinces with at least 80 kindergarten children with ASD that were excluded from the multilevel analyses were included in the single level binary logistic regression analyses. Provinces included in these logistic regression analyses for each of the vulnerability outcomes differed based on these sample size requirements.

Multivariable linear regression analyses were used to examine the association between neighbourhood SES and developmental vulnerability at the neighbourhood level (% of kindergarten children with ASD demonstrating vulnerability on each of the EDI domains and overall vulnerability in a neighbourhood), while controlling for neighbourhood demographic characteristics (% of male kindergarten children with ASD, average age of kindergarten children with ASD, % of kindergarten children with E/FSL status in a neighbourhood), family SES (% separated, divorced, or widowed, % above 15 years with no secondary diploma, % not speaking either official language at home, % of population who moved during the past 5 years in a neighbourhood), as well as spatial cluster level of kindergarten children with ASD in neighbourhoods (neighbourhoods with one, two, three, four, five, and six or more kindergarten children with ASD). Since 10 to 20 observations are needed per predictor in a linear regression model, at least 90 neighbourhoods were needed for these linear regression analyses and only provinces that met this sample size criterion were included (Harrell, 2011).

2.7. Ethics

3. Theory

The “ecological model” of child development proposed by Bronfenbrenner was used to inform this study. This model encapsulates the different levels of influence on child development and presents a nuanced framework to study individual, neighbourhood, and regional factors in relation to children’s health (Adler et al., 1994; Hertzman, 1999). This study contributes to the growing body of literature using the ecological model to examine children’s mental health and behaviour (Danforth, 2013; Heberle, Thomas, Wagmiller, Briggs-Gowan, & Carter, 2014).

4. Results

Since only kindergarten children with ASD are included in the sample, to simplify the language they will be sometimes referred to in this Results section only as “children”. Demographic characteristics of neighbourhoods with no kindergarten children with ASD and with different levels of spatial clusters of kindergarten children with ASD, as well as the prevalence of kindergarten children with ASD per neighbourhood can be found in Siddiqua, Duku, Georgiades, Mesterman, and Janus (2019). For the multilevel and individual single level logistic regression models described below, odds ratios greater than 1 should be interpreted as “with each unit increase in the neighbourhood SES index score, the odds of a child demonstrating developmental vulnerability increased by (factor indicated by the odds ratio).” Odds ratios less than 1 should be interpreted as “with each unit increase in the neighbourhood SES index score, the odds of a child demonstrating developmental vulnerability decreased by (factor indicated by the odds ratio). For the neighbourhood level multivariable linear regression model, beta coefficients greater than 1 should be interpreted as “with each unit increase in the neighbourhood SES index score, the percentage of children in a neighbourhood demonstrating developmental vulnerability increased by (factor indicated by beta coefficient) percent. Beta coefficients less than 1 should be interpreted as “with each unit decrease in the neighbourhood SES index score, the percentage of children in a neighbourhood demonstrating developmental vulnerability decreased by (factor indicated by beta coefficient) percent.

4.1. Developmental vulnerability of children with ASD

The average proportions, by province and territory in the study, of kindergarten children with ASD who demonstrated overall vulnerability across neighbourhoods with different levels of spatial clusters (with one,¹ two, three, four, five, and six or more) are presented in Table 2.

Across provinces and territories, the average proportions of children with ASD who demonstrated overall vulnerability across neighbourhoods with one child with ASD ranged from 75% to 100%. Across provinces and territories, the proportions of neighbourhoods with one child with ASD where the child demonstrated overall vulnerability ranged from 75% to 100% (Appendix 3). The average proportions of children with ASD who demonstrated overall vulnerability in neighbourhoods with higher levels of spatial clusters were: in neighbourhoods with two children with ASD, 57.1%–100%; in neighbourhoods with three children with ASD, 77.8%–90.5%; in neighbourhoods with four children with ASD, 75%–100%; in neighbourhoods with five children with ASD, 71.4%–100%; and in neighbourhoods with 6 or more children with ASD, 70.9%–90.1%.

When vulnerability in specific areas of development was explored, there were no consistent trends in any EDI domains for either lowest or highest average proportion of children with ASD demonstrating vulnerability in neighbourhoods with each level of spatial cluster across provinces and territories (Appendices 4 to 8). Although the trends in vulnerability across spatial clusters as the number of children with ASD increased in a neighbourhood were statistically linear in majority of provinces and territories, the magnitude of vulnerability as the number of children with ASD increased in a neighbourhood did not consistently decrease for overall vulnerability and different areas of development.

4.2. Neighbourhood SES and developmental vulnerability: multilevel models of overall and domain-specific vulnerability

Table 3 shows the extent to which developmental vulnerability varied across neighbourhoods. The between-neighbourhood variation in overall vulnerability in children with ASD was 1.6% and 5.5% of the total variation in overall vulnerability, in pan-Canadian analysis # 1 and pan-Canadian analysis # 2, respectively. The between-neighbourhood variation in vulnerability in specific areas of development ranged from 2.2% to 5.4% of the total variation in vulnerability, in the Emotional Maturity and Communication Skills and General Knowledge domains, respectively. In pan-Canadian analysis # 2, between-neighbourhood variation in vulnerability ranged from 2.1% in the Physical Health and Well-Being domain to 4.8% in the Communication Skills and General Knowledge domain. In the province specific analysis, the between-neighbourhood variation in overall vulnerability ranged from 0% in Manitoba, Alberta, Nova Scotia, and Quebec to 14% in British Columbia. For vulnerability in specific areas of development, the following intervals were observed: Physical Health and Well-Being domain, from 0% in Manitoba to 6% in Alberta; Social Competence domain, from 0% in Manitoba to 8% in British Columbia; Emotional Maturity domain, from 0% in Manitoba and Quebec to 8% in British Columbia; Language and Cognitive Development domain, from 2% in Alberta and Nova Scotia to 4% in Ontario and Manitoba; and Communication Skills and General Knowledge domain, from 0% in Manitoba to 7% in Alberta.

In pan-Canadian analysis # 1, higher neighbourhood SES was associated with lower odds of overall vulnerability (OR: 0.89, 95% CI: 0.80, 0.98; $p < 0.05$) (Table 4). Similar trends were observed when the associations between neighbourhood SES and vulnerability in specific areas of development were explored (Appendices 9–13). In pan-Canadian

¹ Average proportion of vulnerability for neighbourhoods with one child with ASD are provided to maintain consistency in results from neighbourhoods with higher levels of spatial clusters of children with this disorder and are not to be interpreted.

Table 2 Overall vulnerability at the neighbourhood level of kindergarten children with ASD 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	89.6	30.7	75.0	45.2	85.9	35.0	88.9	31.7	92.9	26.7	100	.0	80.0	44.7	100.0	.0	79.3	40.7		
2	91.3	21.0	100.0	.0	91.0	19.4	90.8	19.6	57.1	34.5	83.3	28.9	91.7	20.4	100.0	.0	72.7	31.8		
3	90.5	17.8	79.2	17.3	81.3	23.9	88.2	20.0	88.9	19.2	83.3	23.6	85.7	26.2	88.9	16.7	76.7	27.2		
4	91.6	15.6	90.6	12.9	87.5	18.9	88.3	21.0	91.7	14.4	100.0	.	75.0	25.0	87.5	20.9	77.1	22.5		
5	86.1	16.7	90.0	16.7	90.0	10.5	90.5	13.6	95.0	10.0			75.0	30.0	80.0		71.4	19.5		
6 or more	87.3	12.5	87.4	10.5	82.4	10.2	88.2	13.4	84.7	2.4			79.6	12.8	89.9	10.8	70.9	15.4		

* $p > 0.05$ for linearity tests for all provinces, with the exception of Northwest Territories and Yukon. Linearity test was not conducted for Northwest Territories as there were fewer than 3 levels of spatial clusters of kindergarten children with ASD, as well as for Yukon as there was no variance within the spatial clusters.

analysis # 2, no statistically significant association between neighbourhood SES and developmental vulnerability outcomes was observed.

In province-specific analysis, higher neighbourhood SES was associated with lower odds of overall vulnerability in Ontario (OR: 0.86, 95% CI: 0.75, 0.98; $p < 0.05$) and British Columbia (OR: 0.69, 95% CI: 0.52, 0.94, $p < 0.05$) (Table 4). When the association between neighbourhood SES and vulnerability in specific areas of development was explored, a similar trend was observed in several provinces (Appendices 9 to 13). Higher neighbourhood SES was associated with lower odds of vulnerability in the Physical Health and Well-Being domain in Ontario (OR: 0.90, 95% CI: 0.83 to 0.99; $p < 0.05$). Higher neighbourhood SES was associated with lower odds of vulnerability in the Social Competence domain in Ontario (OR: 0.89, 95% CI: 0.81 to 0.98; $p < 0.05$). Higher neighbourhood SES was associated with lower odds of vulnerability in the Emotional Maturity domain in British Columbia (OR: 0.73, 95% CI: 0.58 to 0.91; $p < 0.05$). It should be noted that the multilevel model conducted for the Emotional Maturity domain in Nova Scotia was modified to exclude E/FSL status, as the model did not converge when this variable was included, likely due to the fact that majority of children with ASD in Nova Scotia did not have E/EFSL status (97.45%). Higher neighbourhood SES was associated with lower odds of vulnerability in the Language and Cognitive Development domain in Ontario (OR: 0.87, 95% CI: 0.79 to 0.95; $p < 0.01$), and in Manitoba (OR: 0.74, 95% CI: 0.55 to 0.99; $p < 0.05$). Higher neighbourhood SES was associated with lower odds of vulnerability in the Communication Skills and General Knowledge domain in Ontario (OR: 0.86, 95% CI: 0.78 to 0.94; $p < 0.01$). In Nova Scotia only, higher neighbourhood SES was associated with higher odds of vulnerability in the Social Competence domain (OR: 2.13, 95% CI: 1.14 to 4.01, $p < 0.05$) and in the Communication Skills and General Knowledge domain (OR: 2.25, 95% CI: 1.14 to 4.43; $p < 0.05$).

4.3. Neighbourhood SES and developmental vulnerability: individual single level model

Due to sample size requirements described earlier, a different set of provinces was included in the logistic regression analyses for each of the developmental vulnerability outcomes (Table 5 and Appendices 14 to 18). Higher neighbourhood SES was associated with lower odds of vulnerability in the Physical Health and Well-Being domain in Newfoundland and Labrador (OR: 0.54, 95% CI: 0.33 to 0.88; $p < 0.05$) (Appendix 14).

4.4. Neighbourhood SES and developmental vulnerability: neighbourhood level model

Most jurisdictions had fewer than 90 neighbourhoods present, hence multivariable linear regression analyses were performed only for Ontario, Alberta, British Columbia, and Quebec. Higher neighbourhood SES was associated with lower percentage of children with ASD with overall vulnerability in Ontario (β : -2.90, 95% CI: -4.82 to -0.98; $p < 0.01$) (Table 6). Higher neighbourhood SES was also associated with lower percentage of children with ASD with vulnerability in the domains of Social Competence (β : -3.68, 95% CI: -6.67 to -0.69; $p < 0.05$), Language and Cognitive Development (β : -5.22, 95% CI: -8.23 to -2.16; $p < 0.01$), and Communication Skills and General Knowledge (β : -4.61, 95% CI: -7.38 to -1.83; $p < 0.01$) in Ontario (Appendices 19 to 23).

5. Discussion

Our study showed that the average proportions of kindergarten children with ASD demonstrating vulnerability overall and in specific areas of development were generally high across provinces and territories. Notably, these proportions did not consistently decrease with increase in size of spatial clustering of children with ASD per neighbourhood as hypothesized, even though the average proportions of

Table 3

Intra-class Correlation Coefficients examining the extent to which vulnerability on each EDI domain and overall vulnerability among kindergarten children with ASD vary between neighbourhoods.

	Pan-Canadian Analysis # 1	Pan-Canadian Analysis # 2	Ontario	Manitoba	Alberta	British Columbia	Nova Scotia	Quebec
Overall vulnerability	1.6%	5.5%	5%	0%	0%	14%	0%	0%
Vulnerability on Physical Health and Well-Being domain	2.3%	2.1%	2%	0%	6%	3%	1%	0%
Vulnerability on Social Competence domain	3.9%	4.3%	4%	0%	5%	8%	5%	0.1%
Vulnerability on Emotional Maturity domain	2.2%	3.7%	2%	0%	6%	8%	2%	0%
Vulnerability on Language and Cognitive Development domain	4.1%	3.3%	4%	4%	2%	4%	2%	2.8%
Vulnerability on Communication Skills and General Knowledge domain	5.4%	4.8%	6%	0%	7%	5%	5%	0.6%

Pan-Canadian Analysis # 1: Includes 6 provinces (Ontario, Manitoba, Alberta, British Columbia, Nova Scotia, Quebec); Pan-Canadian Analysis # 2: Includes 8 provinces (Ontario, British Columbia, Quebec, Prairies (Alberta, Saskatchewan, Manitoba), Atlantic provinces (Nova Scotia, Newfoundland)).

Table 4

Predictors of overall vulnerability among kindergarten children with ASD after accounting for clustering by neighbourhoods.

Pan-Canadian Analysis # 1				Pan-Canadian Analysis # 2		Ontario		British Columbia	
Variable	Classification	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Individual characteristics									
Age		0.87	0.70, 1.08	0.87	0.57, 1.32	0.69*	0.50, 0.97	1.80	0.99, 3.32
Sex (Female)	Male	1.40**	1.15, 1.72	1.47	0.99, 2.17	1.15	0.87, 1.53	1.45	0.83, 2.53
EFSL status (No)	Yes	2.12	1.51, 2.96	1.68	0.81, 3.50	2.49*	1.53, 4.38	2.39*	1.07, 5.37
Province (Ontario) ^a									
	Manitoba	0.85	0.59, 1.23						
	Alberta	0.79	0.59, 1.05						
	British Columbia	0.98	0.77, 1.25						
	Nova Scotia	1.12	0.73, 1.71						
	Quebec	0.45	0.34, 0.59						
Province (Ontario) ^b									
	British Columbia			–	–				
	Quebec			–	–				
	Prairies (Alberta, Saskatchewan, Manitoba)			–	–				
	Atlantic provinces (Nova Scotia, Newfoundland)			0.59*	0.39, 0.89				
Marital status		1.11*	1.01, 1.23	1.15	0.92, 1.43	1.23**	1.07, 1.43	0.89	0.68, 1.34
Education		1.13*	1.01, 1.27	1.04	0.85, 1.28	0.98	0.83, 1.16	1.51*	1.03, 2.23
Language/Immigration		1.07	0.96, 1.18	0.89	0.72, 1.09	1.11	0.97, 1.26	0.93	0.74, 1.19
Residential Stability		1.02	0.94, 1.12	1.09	0.92, 1.29	0.92	0.82, 1.03	1.29	0.96, 1.65
Neighbourhood characteristics									
Neighbourhood SES Index		0.89*	0.80, 0.98	0.90	0.71, 1.14	0.86*	0.75, 0.98	0.69*	0.52, 0.94

*p < 0.05; **p < 0.01.

^a Province variable only pertains to Pan-Canadian Analysis # 1.

^b Province variable only pertains to Pan-Canadian Analysis # 2.

vulnerable children with ASD in each level of spatial cluster were still high. The minimum average proportion of kindergarten children with ASD demonstrating overall vulnerability was 57.1% and the maximum average proportion of these children demonstrating overall vulnerability was 100% for all neighbourhoods. These findings complement current literature which suggests that despite the increased susceptibility of children with ASD to developmental vulnerabilities, there can be significant heterogeneity in their developmental pathways from youth to early adulthood age (Fountain et al., 2012; Lord, Bishop, & Anderson, 2015; Szatmari et al., 2015).

Approximately 5–10% of the variation in children’s development, well-being, and health can be explained by neighbourhood factors (Sellstrom & Bremberg, 2006); moreover, better health or education outcomes are observed among children who live in wealthier areas (Martens et al. 2014). There is also some evidence that higher neighbourhood SES may have diminishing rates of return on supporting enhanced child development (Carpiano et al., 2009). Carpiano et al. showed that kindergarten children’s highest average scores in four EDI domains (Physical Health and Well-Being, Social Competence,

Emotional Maturity, and Communication Skills and General Knowledge) were not found in neighbourhoods with highest SES, but rather in neighbourhoods where there were approximately equal proportions of affluent and disadvantaged families. A recent study shows that kindergarten children with special needs who live in high SES neighbourhoods have better developmental outcomes than those who live in lower SES neighbourhoods (Zeraatkar et al., 2020). The results of our study showed that in higher SES neighbourhoods, kindergarten children with ASD were generally less likely to demonstrate vulnerability.

It is useful to separate out neighbourhood effects from influences of individual and family characteristics when studying health effects of neighbourhood SES in order to inform interventions for social groups that have limited resources (Sellstrom & Bremberg, 2006) which can be achieved with the multilevel modelling approach. We did not predefine a minimum threshold for the proportion of variance required to be explained in the chance of a child demonstrating developmental vulnerability across neighbourhoods to proceed with multilevel modelling. While previous studies examined the impact of neighbourhood deprivation on children’s health, they were conducted in different

Table 5
Predictors of overall vulnerability among kindergarten children with ASD.

Variable	Classification	Manitoba		Alberta		Saskatchewan		Newfoundland		Nova Scotia		Quebec	
		OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Individual characteristics													
Age		0.89	0.40, 2.00			1.72	0.37, 7.99	1.30	0.57, 2.99	0.66	0.26, 1.68	1.11	0.61, 2.02
Sex (Female)	Male	0.50	0.21, 1.17			0.44	0.11, 1.76	0.52	0.22, 1.20	0.32*	0.14, 0.77	0.50*	0.29, 0.88
EFSL status (No)	Yes	4.09	0.52, 32.21			0	0, 0	1.54	0.13, 18.35	0.84	0.09, 8.11	0.70	0.34, 1.43
Marital status		1.15	0.77, 1.71			1.09	0.57, 2.07	1.24	0.72, 2.13	0.65	0.39, 1.10	1.06	0.79, 1.43
Education		1.23	0.83, 1.83			1.29	0.60, 2.76	0.89	0.64, 1.23	1.57	0.91, 2.71	1.20	0.91, 1.57
Language/Immigration		1.43	0.73, 2.77			1.84	0.22, 15.70	0.05*	0.00, 0.82	17.20	0.04, 7049.93	1.08	0.75, 1.56
Residential Stability		0.77*	0.51, 0.99			1.08	0.55, 2.13	1.25	0.83, 1.89	1.71	0.99, 2.94	1.12	0.87, 1.46
Neighbourhood characteristics													
Neighbourhood SES Index		0.98	0.66, 1.50			1.00	0.43, 2.29	0.80	0.45, 1.44	1.75	0.63, 4.82	0.97	0.74, 1.26

*p < 0.05.

Table 6
Predictors of proportion of kindergarten children with ASD with overall vulnerability in a neighbourhood.

Neighbourhood characteristics	Ontario		Alberta		British Columbia		Quebec	
	Unstandardized β	95% CI	Unstandardized β	95% CI	Unstandardized β	95% CI	Unstandardized β	95% CI
Mean age	1.38	-5.13, 7.90	-0.95	-10.29, 8.38	7.97	-2.07, 18.02	4.74	-8.62, 18.11
% male	-0.01	-0.06, 0.05	-0.05	-0.21, 0.11	0.06	-0.05, 0.16	0.22**	0.08, 0.37
% EFSL	0.07	-0.01, 0.15	0.10	-0.10, 0.30	0.14	0.00, 0.28	0.01	-0.16, 0.62
-5.35, 8.65	-0.37	-2.58, 1.84	-0.55	-5.86, 4.77	-0.83	-4.84, 3.19	1.65	
Mean % above 15 years with no secondary diploma	0.49	-1.98, 2.96	2.88	-2.50, 8.26	6.54**	1.72, 11.37	2.75	-3.04, 8.53
Mean % not speaking either official language at home	0.59	-1.17, 2.35	0.30	-6.24, 6.84	-2.03	-5.65, 1.59	1.51	-6.86, 9.88
Mean % of population who moved during the past 5 years	-0.56	-2.70, 1.59	4.35	-0.76, 9.46	2.09	-2.13, 6.31	4.14	-5.12, 1.33
Number of kindergarten children with ASD in a neighbourhood	-0.83*	-1.62, -0.03	-0.57	-3.11, 1.96	-0.03	-1.66, 1.60	-1.89	-5.12, 1.33
Neighbourhood SES Index	-2.90**	-4.82, -0.98	1.70	-3.70, 7.09	-1.23	-5.23, 2.77	-1.00	-6.95, 4.95

*p < 0.05; **p < 0.01.

settings using different methodology, usually among typically developing children. Given our focus on children with ASD in a Canadian context using a neighbourhood SES index newly developed to study child development, we chose to conduct an exploratory analysis to examine the level of variability in development that is explained by neighbourhood clusters. There are a wide range of factors at the neighbourhood (e.g. social capital, effectiveness of schools), family (e.g. maternal warmth, parenting style), and individual (psychological characteristics, health behaviours) levels that can influence child development (Chen & Miller, 2013), however, difficult to incorporate in population level studies due to lack of data availability. In this context, we did not expect a large proportion of variance in developmental

vulnerability to be explained by neighbourhood clusters alone. Our findings highlight that across provinces and territories, neighbourhood clusters explain different levels of variance in developmental vulnerability, ranging from 0.1% to 14%. In our analyses (the #1 pan-Canadian approach), higher neighbourhood SES was associated with lower likelihood of developmental vulnerability, while controlling for clustering, province, and individual demographics. This indicates that neighbourhood SES seems to have a Pan-Canadian impact on development of children with ASD regardless of the province of residence, despite different provincial health policies and systems in place that influence early identification and services.

In the province specific multilevel analyses, higher neighbourhood

SES was also associated with lower likelihood of demonstrating developmental vulnerability, including overall vulnerability and vulnerability in all the areas of development in several provinces. However, in Ontario, this trend was consistently observed in four areas of development (Physical Health and Well-Being, Social Competence, Language and Cognitive Development, and Communication Skills and General Knowledge). These findings indicate that neighbourhood SES has an independent effect on developmental vulnerability of kindergarten children with ASD, reflecting results of a number of studies that showed neighbourhood deprivation was associated with poor child development (e.g., [Kalfs et al., 2001](#); [Safra et al., 2016](#)). These findings also complement current literature which indicates that living in disadvantaged neighbourhoods represents an independent risk factor for health of children, even when controlling for individual demographic and socioeconomic characteristics ([Schneiders et al., 2003](#)). Both neighbourhood and family mechanisms are considered to play an important role in transmitting neighbourhood socioeconomic effects ([Kohen, Dahinten, Leventhal, & McIntosh, 2008](#); [Pickett & Pearl, 2001](#)). For example, [Kohen, Leventhal, Dahinten, and McIntosh \(2008\)](#) found that neighbourhood socioeconomic disadvantage manifested its effect on young children through lower neighbourhood cohesion, which was associated with maternal depression and family dysfunction. These mechanisms were in turn related to less stimulating and more punitive parenting behaviour and ultimately poor outcomes in children. In contrast, in Nova Scotia only, higher neighbourhood SES was associated with higher likelihood of demonstrating vulnerability in two areas of development (Social Competence and Communication Skills and General Knowledge). This highlights the importance of examining the mechanisms through which neighbourhood SES impacts development of children with ASD on a provincial basis, as although neighbourhood deprivation is generally associated with poor development, this was not the case for the province of Nova Scotia.

The region-specific analyses showed inconsistencies across the country in the patterns of association between neighbourhood SES and vulnerability of children with ASD in specific domains. Specifically, only in Newfoundland and Labrador, higher neighbourhood SES was associated with lower likelihood of demonstrating vulnerability in the Physical Health and Well-Being domain at the individual level. Only in Ontario, higher neighbourhood SES was associated with lower percentage of kindergarten children with ASD demonstrating overall vulnerability and vulnerability in specific areas of development at the neighbourhood level. Taken together with the results of the multilevel analyses, results of the individual and neighbourhood level analyses emphasize two main points. First, consideration of neighbourhood characteristics when addressing the needs of young children with ASD is relevant. Second, the incidence levels guiding intervention needs to be considered, as the type and location of interventions will be different if individual cases versus neighbourhood clustering of cases are considered. In order to address the socioeconomic gradient in development of children with ASD, a proportionate universalism approach can be taken to implement public health interventions ([Carey, Crammond, & Leeuw, 2015](#)). In low SES neighbourhoods, the following interventions can be provided in an universal manner to all children and their families, including children without a diagnosis, to support their development: income support programs, early intervention services, special needs parenting support, and inclusive schools that cater to different developmental and educational needs. In provinces where low neighbourhood SES was associated with developmental vulnerability among children with ASD, the scale and intensity of these interventions can be proportionate to the prevalence of children with this disorder as well as the proportion of low SES neighbourhoods in these provinces. Considering the median age of ASD diagnosis remains over age 4 years, there is value in taking a non-categorical approach to support all children in their early years regardless of their diagnosis.

Findings of this study can be used as a starting point to guide further research on the impact of neighbourhood SES on development of

children with ASD. In provinces where there was a significant association between these variables, each of the human, social, and economic components included in the neighbourhood SES index can be studied individually to examine which ones explain the most variance in the developmental vulnerability of children with ASD. Identifying components of neighbourhood SES that have the greatest influence can help facilitate a more targeted approach in service planning in the future.

There are 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 evaluate the reliability of the diagnosis reported on the EDI compared to data from health services based on 'gold standard' diagnostic procedures for ASD. However, the reliability 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 ([Reid-Westoby, Horner, & Janus, 2018](#)). Second, 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. Third, 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-diagnosis, which may differ by place of residence across the country. This is particularly relevant for children living in low SES neighbourhoods as they may not have access to services that can facilitate an early diagnosis of ASD. Although the multilevel analytical approach considers the similarity of kindergarten children with ASD in a neighbourhood, it is possible that a portion of the estimated effect of neighbourhood deprivation in the models may be attributable to individual level effects, which would be the case if families with particular unmeasured characteristics were more likely to live in disadvantaged than in advantaged neighbourhoods ([Schneiders et al., 2003](#)). We used small area level SES as a proxy for family SES, where not everyone living in that area may have the same SES. Last, we did not have information regarding the length of time for which children lived in their respective neighbourhoods, or if they moved during the study period. If a child lived in a neighbourhood for a short period of time, the effect of neighbourhood SES observed on their development may not be a true reflection of the association between these exposure and outcome variables.

There are also several strengths of this study. As a large population-level database, the EDI demonstrates significant utility from a public health perspective. Until now, there was no population-wide database with which the objectives of this study could be investigated – specifically separate impact of individual and neighbourhood characteristics on health of kindergarten children with ASD. The use of the large EDI database presents an unprecedented opportunity to examine the developmental vulnerability of kindergarten children with ASD in neighbourhoods with different levels of spatial clusters of these children, as well as the association between neighbourhood SES and children's developmental vulnerability across provinces and territories in Canada. This analysis was not possible through sample-based research where children with ASD are commonly not available or included in sufficient numbers. The nation-wide implementation of the EDI provides a large representative sample, improving generalizability of study findings. Using a composite SES index, that has shown relevant associations with development of young children, was also a strength as it captures the favourable and unfavourable SES characteristics of neighbourhoods through a reasonable number of variables ([Forer et al., 2019](#); [Webb et al., 2017](#)). The human, social, economic components of this index, all of which are important elements of SES, are not collectively included in other neighbourhood SES indices derived using Canadian Census data ([Webb et al., 2017](#)).

6. Conclusions

From a public health perspective, the EDI shows significant utility to examine the developmental health of low frequency populations such as kindergarten children with ASD.

Findings of this study emphasize the importance of addressing neighbourhood disadvantage to support the development of kindergarten children with ASD. Our study showed that the impact of neighbourhood SES on development of these children varies across provinces and territories, highlighting the importance of customized service planning.

Ethics

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

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Declaration of competing interest

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ssmph.2020.100662>.

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