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Socioeconomic gradient in the developmental health of Canadian children with disabilities at school entry: a cross-sectional study

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ABSTRACT

Objective To examine the relationship between developmental health and neighbourhood socioeconomic status (SES) in kindergarten children with disabilities.

Design Cross-sectional study using population-level database of children's developmental health at school entry (2002–2014).

Setting 12 of 13 Canadian provinces/territories.

Measures Taxfiler and Census data between 2005 and 2006, respectively, were aggregated according to custom-created neighbourhood boundaries and used to create an index of neighbourhood-level SES. Developmental health outcomes were measured for 29 520 children with disabilities using the Early Development Instrument (EDI), a teacher-completed measure of developmental health across five domains.

Analysis Hierarchical generalised linear models were used to test the association between neighbourhood-level SES and developmental health.

Results All EDI domains were positively correlated with the neighbourhood-level SES index. The strongest association was observed for the language and cognitive development domain (β (SE): 0.29 (0.02)) and the weakest association was observed for the emotional maturity domain (β (SE): 0.12 (0.01)).

Conclusions The magnitude of differences observed in EDI scores across neighbourhoods at the 5th and 95th percentiles are similar to the effects of more established predictors of development, such as sex. The association of SES with developmental outcomes in this population may present a potential opportunity for policy interventions to improve immediate and long-term outcomes.

Strengths and limitations of this study

- Our investigation uses a large, representative population-level database, which allowed us to focus on children with disabilities that make up only a small proportion of the population, while also maximising external validity and statistical power and minimising potential selection bias.
- We used data from the Early Development Instrument, a valid and reliable measure of children's developmental health.
- We focused on early childhood, a time that has been well documented to critically impact children's long-term academic and social trajectory.
- We applied a non-categorical approach to childhood disabilities that reflects current thinking in the field of child development.
- The study's limitation is the exclusive use of neighbourhood-level socioeconomic status indicators, without the ability to control for family level ones.

INTRODUCTION

To date, associations between a number of health outcomes and a combination of economic, human and social characteristics, commonly conceptualised as socioeconomic gradients, have been reported, including end-stage renal disease, breast cancer, obesity and cardiometabolic health.[1–6] These studies have mostly focused on chronic conditions in adulthood, with studies on the socioeconomic determinants of child health emerging only more recently.[7–11]

A socioeconomic gradient in typically developing children's developmental health has been reported in a number of high-income, middle-income and low-income countries,[12–14] including Canada.[8 15–17] Additionally, the prevalence of childhood disabilities has been consistently shown to be negatively associated with socioeconomic status (SES).[18] Currie and Stabile used data from the Canadian National Longitudinal Survey of Children and Youth for children between 0 and 11 years of age to illustrate an inverse relationship between the prevalence of chronic childhood disabilities and SES.[19] Msall *et al* reported a more than threefold difference in disability rates between children living in distressed versus advantaged neighbourhoods in Rhode Island.[20] However, little is known about the relationship between SES and

developmental outcomes in children with special needs. Existing evidence most often addresses specific diagnoses during middle childhood, is not representative of all disabilities experienced by children during early childhood and does not consider the impact of SES outside of the immediate family environment (ie, neighbourhood SES), which has been shown to be a significant influence on developmental outcomes in typically developing children.[8 21–23] Understanding determinants of developmental health in early childhood can help in identifying groups of children with disabilities that are likely to be most at risk for worse academic and social outcomes later in life. Such identification is useful for policy planning and the provision of health and education services. The objective of this study is to determine if there is a socioeconomic gradient in the developmental health of children with disabilities at school entry. This work extends existing research in that it focuses on early childhood, a time at which experiences set the trajectory for future academic and social outcomes, takes a diagnosis-free, non-categorical approach to childhood disability and uses population-level data.

METHODS

Patient and public involvement

Patients and the public were not involved in the design or conduct of this study.

Data source and measurement

Data for this study come from a Pan-Canadian database on early childhood development, which is held at the Offord Centre for Child Studies at McMaster University, a national repository for this database.[8 24 25] The database includes cross-sectional data from all Canadian provincial implementations between 2004 and 2014 of the Early Development Instrument (EDI), a population-level instrument developed by Janus and Offord. The EDI is used to evaluate children's developmental health outcomes during the kindergarten year across five core domains: physical health and well-being, social competence, emotional maturity, language and cognitive development and communication skills and general knowledge.[26] The EDI is completed by teachers in the second half of the kindergarten year (the year before grade 1)—usually between February and March—based on their observations of each child. It comprises 103 core items, and domain scores range from 0 to 10, with higher scores indicating better developmental health. Permission to collect EDI data on kindergarten children was obtained from the respective provincial and territorial governments. With the exception of the province of Alberta, which required written consent from parents, data were collected via passive consent. The EDI has been validated extensively for both typically developing children[26–35] and those with disabilities.[36]

The database also includes data on children's age, sex and whether they have a 'special needs' designation.[24] The 'special needs' designation is the operational indicator of childhood disability in our study. Definitions of 'special needs' are set by each province/territory,[37 38] but they are similar and generally include children with identified health problems, with or without formal medical diagnoses, which impede their ability to learn in a regular classroom. Children encompassed by this definition have a broad range of impairments, varying widely in both type (eg, physical or mental) and severity (eg, mild speech impairment to non-verbal). The most common disabilities in this population include learning disabilities and speech impairments, which is consistent with the prevalence of disabilities in children at school entry in high-income countries.[39 40] The EDI database has been linked to Canadian Census and Taxfiler data between 2006 and 2005, respectively, using custom-created neighbourhood boundaries.[41] Briefly, the neighbourhood boundaries were defined using Statistics Canada's dissemination blocks and were created to contain a minimum of 50 and a maximum of 600 valid EDI records per neighbourhood. The criterion of having at least 50 EDI records per neighbourhood was based on empirical data on EDI reliability. The custom-created neighbourhood boundaries were based on existing administrative and geographic divisions and were created in consultation with provincial/territorial governments, to maximise their meaningfulness. Guhn *et al* provide a more detailed description of the process for neighbourhood boundary definition.[41] Census and Taxfiler variables were used to create the *Can*adian *N*eighbourhoods and *E*arly *C*hild *D*evelopment (CanNECD) SES index, which includes indicators of education, language/immigration, marital status, wealth, income, dues, social capital, poverty, residential stability and income inequality (online supplementary table S1).

Analysis

All data analyses were conducted in SAS software using the GLIMMIX procedure.[42] Given that EDI domain scores are skewed and restricted in range, and that children are clustered within neighbourhoods and schools, the data were analysed using hierarchical generalised linear modelling. The fit of a range of distributions and link functions were assessed and it was found that the identity link and gamma distribution produced the best-fit model. EDI data were transformed by subtraction from 11 to allow for the gamma distribution to accommodate the left skew. Although children are clustered within two levels (neighbourhoods and schools), only neighbourhood of residence was included as a cluster variable due to data sparseness.[43] All models were performed using the Laplace approximation that allows estimation of likelihood statistics and has been shown to perform well with regard to accuracy and precision.[44]

EDI domain scores were used as the dependent variable. For each EDI domain, the analysis was performed hierarchically in three steps. First, an intercept-only model was constructed. Second, a model with child-level characteristics that have been found to be significant

predictors of children's developmental health (ie, age, sex and English/French language learner status (EFSL)) as fixed effects was constructed.[26 39] Additionally, year of data collection, province and the interaction between the two were included as categorical variables to control for variations in data collection procedures across time points and provinces. Finally, to evaluate the association between neighbourhood-level SES and children's developmental health, the SES index was added in the third model. Random effects of each of the individual predictors were added to the final model one-by-one and the overall improvement in the fit of the model was tested.

To assess whether the inclusion of child-level characteristics (age, sex, EFSL status), neighbourhood-level SES and random effects significantly improved model fit, partial likelihood ratio tests were performed, and goodness-of-fit indices (ie, Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC)) were compared between models. Multicollinearity was tested by examining variance inflation factor (VIF) statistics for age, sex, EFSL status and the SES index. VIF statistics for province of residence, time of data collection and their interaction are not included as these were artificially inflated due to having been dummy coded and included as part of a regression model with few predictors. Leverage statistics, along with plots of raw, Pearson and studentized residuals were used to identify outliers and influential observations. Observations with leverage statistics more than twice the mean of all leverage values were investigated for data entry error. A sensitivity analysis was conducted where observations with outlying studentized residuals, defined as studentized residuals with absolute values greater than two, were excluded in the estimation of the models. Cases with missing data were excluded from the analysis but were compared with those without missing data to ensure no substantial differences in demographic characteristics.

RESULTS

Population characteristics

A total of 29 520 children with disabilities were identified in the database. Population characteristics are presented in table 1.

These children resided in 2016 neighbourhoods. Neighbourhood characteristics are presented in table 2. Forty (1.95%) neighbourhoods in the database were excluded from the analysis due to not having any children with special needs (online supplementary table S2). These neighbourhoods included fewer children overall, were of higher SES, and did not proportionally represent Canadian provinces as the majority were in Quebec.

Characteristics of children missing any one of the five EDI domain scores are presented in online supplementary table S3. Overall, only a small proportion of children (<2%) were missing data on any of the EDI domains and these children did not differ in demographic characteristics from the analytic sample.

Table 1 Population characteristics

Sex	N (% of population of children with disabilities)
Female	8906 (30.2)
Male	20 585 (69.7)
Missing	29 (0.1)
Age	
Mean (SD)	5.79 (0.41)
Missing	114 (0.39)
EFSL status	**N (%)**
Yes	3637 (12.3)
No	25 402 (86.0)
Missing	481 (1.6)
Province	**N (%)**
Alberta	2099 (7.1)
British Columbia	5044 (17.1)
Manitoba	2468 (8.4)
New Brunswick	327 (1.1)
Newfoundland	641 (2.2)
Nova Scotia	1083 (3.7)
Northwest Territories	65 (0.2)
Ontario	13 198 (44.7)
Prince Edward Island	29 (0.1)
Quebec	3023 (10.2)
Saskatchewan	1440 (4.9)
Yukon	103 (0.3)
Year of data collection	**N (%)**
2004	474 (1.6)
2005	2332 (7.9)
2006	4304 (14.6)
2007	1471 (5.0)
2008	1762 (6.0)
2009	4786 (16.2)
2010	2658 (9.0)
2011	3494 (11.8)
2012	5140 (17.4)
2013	2711 (9.2)
2014	388 (1.3)
Mean (SD) EDI domain scores	
PHWB	7.02 (2.12)
SC	5.71 (2.63)
EM	6.13 (1.99)
LCD	6.18 (3.01)
CSGK	4.37 (3.27)

CSGK, communication skills and general knowledge; EM, emotional maturity; LCD, language and cognitive development; PHWB, physical health and well-being; SC, social competence.

Table 2 Neighbourhood characteristics (n=2016)

Province	Number of neighbourhoods (%)
Alberta	259 (12.8)
British Columbia	298 (14.7)
Manitoba	75 (3.7)
New Brunswick	48 (2.4)
Newfoundland	41 (2.0)
Nova Scotia	57 (2.8)
Northwest Territories	3 (0.1)
Ontario	795 (39.4)
Prince Edward Island	6 (0.3)
Quebec	373 (18.5)
Saskatchewan	55 (2.7)
Yukon	6 (0.3)
Median (IQR) number of children with disabilities in each neighbourhood	11 (6–19)
Median (IQR) number of children in each neighbourhood	128 (87–194)

Model results

Regression coefficients, their levels of significance and goodness-of-fit indices from the final model for each of the EDI domains are presented in table 3. Additional details on each step of model development along with goodness-of-fit indices are presented in online supplementary tables S4 to S8. The gamma distribution with an identity link produced the best fit for most domains, as assessed by AIC and BIC statistics (online supplementary table S9). Random effects of predictors did not significantly improve fit and so they were not included in the final model.

The results of the regression analysis indicate that both child-level characteristics and SES are significant predictors of children's EDI domain scores, as indicated by decreasing deviance, AIC and BIC statistics across models, as well as significant likelihood ratio tests (online supplementary tables S4 to S8).

Year of data collection, province/territory and the interaction between them were statistically significant for all domains. Age was statistically significant for all domains except physical health and well-being. Age was positively associated with language and cognitive development scores, and negatively with emotional maturity, social competence and communication skills and general knowledge, with the largest effect sizes seen in the latter two domains and the smallest in physical health and well-being. Sex was statistically significant for all EDI domains and, on average, girls had higher scores than boys on all domains of the EDI, with the smallest sex differences in language and cognitive development, and largest in emotional maturity. English/French language learners had higher scores than non-learners in emotional maturity (smallest absolute effect), but lower scores in language

Table 3 Final hierarchical generalised linear models (HGLMs) for the Early Development Instrument (EDI)

Variables	Physical health and well-being	Social competence	Emotional maturity	Language and cognitive development	Communication skills and general knowledge
	β-Coefficient (95% CI)	β-Coefficient (95% CI)	β-Coefficient (95% CI)	β-Coefficient (95% CI)	β-Coefficient (95% CI)
Age	−0.04 (−0.01 to 0.03)	−0.13 (−0.22 to −0.05)	−0.08 (−0.14 to −0.02)	0.10 (0.01 to 0.18)	−0.13 (−0.24 to −0.02)
Sex (M=0; F=1)	0.14 (0.08 to 0.19)	0.76 (0.69 to 0.83)	0.81 (0.76 to 0.86)	0.13 (0.05 to 0.21)	0.43 (0.33 to 0.53)
EFSL (no=0; yes=1)	0.04 (−0.04 to 0.12)	−0.10 (−0.20 to 0.01)	0.12 (0.05 to 0.20)	−0.43 (−0.56 to −0.31)	−1.11 (−0.94 to −1.27)
SES z-score	0.17 (0.14 to 0.20)	0.17 (0.13 to 0.21)	0.12 (0.09 to 0.15)	0.29 (0.24 to 0.33)	0.19 (0.14 to 0.24)

Note that coefficient presented in this table reflect the directionality of the association between variables and untransformed EDI scores.
EFSL, English/French as a second language; SES, socioeconomic status.

and cognitive development and communication skills and general knowledge (largest absolute effect). The SES index was a statistically significant predictor of all EDI domains and was consistently positively associated with all domain scores. The smallest association was observed for the emotional maturity scores, and the largest for and language ad cognitive development.

Model diagnostics and sensitivity analyses

Excluding categorical variables, all VIF statistics were below the cut-off of 10 and ranged from 1.05 to 1.10. Studentized residuals were used to identify influential and outlying observations. The results of the sensitivity analysis excluding cases with absolute studentized residual values greater than two are presented in online supplementary tables S10 to S14. The results from this sensitivity analysis were very similar to the results of the primary analysis.

DISCUSSION

The objective of this investigation was to examine the association between neighbourhood-level SES and developmental health in children with disabilities (operationally defined as 'special needs' designation) at school entry, in order to determine the importance of contextual factors in predicting outcomes in this population. The results indicate that neighbourhood-level SES is a consistent and significant predictor of developmental outcomes in this population. An average difference of 0.12–0.29 points in EDI domain scores was observed per SD difference in SES, with higher EDI domain scores being observed in higher SES neighbourhoods. Neighbourhood-level SES had the strongest association with the language and cognitive development domain and the weakest with emotional maturity domain.

Consistency with previous studies

Comparing the magnitude of association between SES and developmental health with previous literature is difficult due to differences in the operationalisation of these constructs and differences in analytic methods. Previous studies, mostly conducted with typically developing children,[12] have either explored the direct association between SES and developmental health[8 15–17 45] or investigated mediators of this relationship, including parent/child activities, access to a computer, participation in organised classes and activities and maternal mental health.[46–48] Most of these studies measured SES at the individual family level and all demonstrated a positive association between social and economic variables and developmental health.

Among the studies done in typically low-income and middle-income populations, five use EDI outcomes, with four including neighbourhood-level measures of SES.[8 15 17 49] All studies demonstrated a positive association between SES and the EDI. Webb *et al* compared neighbourhood effects in typically developing children using four published neighbourhood SES indices.[8] Forer *et al* examined the same association using the CanNECD index. Both these studies showed that the strength of association between the indices and EDI domains varied, depending on the domain and SES index used. Similar to our results, the strongest association was consistently found for the language and cognitive development domain.

The few studies done in children with disabilities also report a positive association between SES and academic and social outcomes.[21–23 50–52] These studies are different from the present investigation in that they only focus on a few high-incidence diagnoses, such as learning disabilities during middle childhood and adolescence and do not measure SES at the neighbourhood-level.

Strengths and limitations

There are several strengths of this study. First, we used population-level data, which made focusing on children with disabilities that only make up a small proportion of the population possible, while also maximising external validity and statistical power and minimising potential selection bias. Second, we focused on early childhood, a time that critically impacts children's long-term academic and social trajectory.[53] Third, we applied a non-categorical approach to childhood disabilities which reflects current thinking in the field of child development and findings that diagnostic categories often do not fully reflect the actual abilities and needs of children.[54–56] Fourth, the EDI has undergone extensive reliability and validity testing, and has been found to be predictive of academic achievement and social functioning throughout early and middle childhood.[26–35] The psychometric performance of the EDI in children with special needs has also been found similar to its performance in typically developing children.[36] Currently, the EDI is the only available indicator of developmental health that allows examination of variability across Canada at a population-level. Finally, the analytic methods used in this investigation appropriately take into account the skewed distribution and nesting of EDI data, which prevents artificially deflated SEs and hence inappropriate statistically significant findings.

This investigation is also subject to limitations. First, due to the cross-sectional design of this study, causality cannot be established. There is evidence that developmental problems in children may increase parental stress and impact the general socioeconomic well-being of families.[57 58] Additionally, there is the possibility of self-selection where families with similar experiences may choose to reside within similar neighbourhoods. Regardless of causality, or lack thereof, the results of this study indicate that services aimed at young children with disabilities that are particularly accessible in low SES neighbourhoods are likely to be most impactful.

Second, we used a very broad definition of disability, which is based on the designation of the child by the education system at kindergarten, and hence, children with disabilities who did not have this designation by the

education system were excluded. It is possible that a very small minority of children who were not typically developing but did not have this designation were excluded.

Third, the SES index may not accurately reflect the socioeconomic condition of the neighbourhoods in which children were raised. The variables used to construct the SES index come from 2005 to 2006, whereas EDI data were collected between 2004 and 2014. It is possible that changes in neighbourhoods or relocation of families could render the SES index less reflective of the true early environment for some groups of children, which may have led to underestimation of the association between SES and developmental outcomes. However, empirical evidence indicates that it is unlikely for neighbourhood characteristics to drastically change over time or for families move to neighbourhoods which are greatly different from their previous ones.[59] This appears to be confirmed by the remarkable stability of the CanNECD SES Index, the measure used in this study, over the period of 5 years.[49]

Finally, we were unable to control for family level SES in the models. Thus, it is not possible to determine whether this association is driven by neighbourhood or family characteristics. We were also unable to control for specific diagnoses or severity of disabilities that have undoubted impact on child development. Similar investigation should be extended for smaller subgroups of children who share diagnoses or functional impairments.

Implications

Our findings indicate that the relationship between SES and developmental outcomes also holds for children with disabilities.[8 15–17 45 60] This underscores the potential impact of the early environment of children on their development. Although clinicians often focus on biological factors, such as family history of disabilities and harmful exposures in utero, social influences have commonly been found to be more predictive of long-term developmental and academic outcomes and may be more amenable to change.[45] According to survey data, clinicians are receptive to screening for social determinants of health outside of the purview of clinical care, suggesting that the findings of this investigation are likely to be relevant and acceptable to those in the clinical community.[61] Our findings show that the association between child development and socioeconomic status, which is well-established for typically developing children, also exists for children with disabilities. This highlights the urgency for improving the social and economic context in which children are raised, in addition to targeted interventions delivered at the individual child level. Failure to do so will likely result in further perpetuation of inequities in child development—more so as children with disabilities are already among the most disadvantaged groups globally.[18 62] It remains to be seen whether large-scale policy interventions can help in reducing disparities in this population similar to other groups.[63]

It is important to consider the findings in context of the availability of support services for children with special needs in Canada prior to school entry. The strategies, programmes and accessibility vary by province/territory, and often within jurisdictions, as municipal and regional health units are often service providers, but generally access is easier for children with a specific diagnosis than for those with unspecified disorders.[55] While there are no detailed studies on the potential association of service availability or magnitude of waiting lists with neighbourhood SES per se, there could be at least two pathways to such relation. First, services tend to be located in large urban centres (with likely higher SES overall), where there are more professionals.[64 65] Second, navigation of the care systems, especially for preschool children rests largely on the shoulders of parents: the ability to do so effectively is likely associated with their personal and economic resources and where they live.[66 67]

Additional investigations could further strengthen and contextualise these findings. Specifically, establishing the consistency and relative strength of the relationship between SES and developmental outcomes across subgroups of physical, behavioural and learning disabilities, as well as subgroups based on severity of condition and time of diagnosis, would further untangle the relationship between SES, disabilities and development, and would be helpful in identifying service provision strategies that are likely to be most successful in improving outcomes.

CONCLUSION

The results from this investigation show neighbourhood SES to be significantly associated with the developmental health of children with disabilities at school entry. These findings have implications for policy planning and provision of health and educational service and draw attention to the universality of importance of contextual factors for development of all children.

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