CHILD DEVELOPMENTAL HEALTH OUTCOMES IN CANADA

INVESTIGATION OF EDUCATIONAL OUTCOMES, DEVELOPMENTAL HEALTH, AND REGIONAL POLICY DIFFERENCES FOR YOUNG CHILDREN WITH NEURODEVELOPMENTAL DISORDERS IN CANADA

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Lay Abstract

This dissertation aimed to explore the health and social outcomes of children with neurodevelopmental disorders in Canada. Three studies were undertaken: 1) a quantitative regression study on developmental and academic outcomes at school entry from kindergarten to Grade 6 in Ontario using data from the Early Development Instrument, 2) a realist review of literature from the last decade on child development programs and services in Ontario and Manitoba; 3) a quantitative multilevel model examining changes in prevalence rates of developmental outcomes over time in neighbourhoods in Ontario and Manitoba using data from the Early Development Instrument. Universal and targeted policy solutions could be implemented from prenatal to postpartum, to early childhood and beyond. These studies provide more empirical support for early intervention programs and special education services to ensure students develop the skills they need to succeed at home, school, and community, and have a higher quality of life.

Abstract

Educational and developmental trajectories can be modified with early identification of needs and early interventions to support children in meeting developmental milestones. The goal of the dissertation was to explore the health and social outcomes of children with parent-reported, diagnosed, or teacher-identified neurodevelopmental disorders (NDD) in Canada. This was done through three studies: 1) a quantitative regression study on developmental and academic outcomes from kindergarten to Grade 6 in Ontario, 2) a realist review of literature from the last decade on child development programs in Ontario and Manitoba; 3) a quantitative multilevel model approach to examine changes in prevalence rates of developmental outcomes over time in neighbourhoods in Ontario and Manitoba. The identification of developmentally vulnerable subgroups in these studies could help stakeholders decide on where and how universal and targeted policy solutions could be implemented. These studies provide more empirical support for early intervention programs and early entry to special education to ensure students develop the skills they need. Meaningful participation in school, community, and home is important for child and family development, and these studies show that meaningful participation can be facilitated by healthcare and community providers, educators, policymakers, and parents themselves. Including two provinces in two of the three studies allowed us to compare provincial health and educational policies and describe possible ways interprovincial variance exists in services and childhood outcomes. The results also showed socioeconomic and geographic inequities experienced by families and neurodiverse children between and within provinces. Additionally, the dissertation shows that a diagnosis of either autism spectrum disorder (ASD) or other NDD is associated with varied developmental and educational outcomes. Fundamentally, this dissertation showcases the necessity for collaboration in child

developmental health and education sectors to provide more seamless communication and support services across schools, clinics, and community agencies.

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List of Abbreviations

ADHD	Attention Deficit Hyperactivity Disorder
ASD	Autism Spectrum Disorder
CI	Confidence Interval
Df	Degrees of Freedom
EDI	Early Development Instrument
EFLL	English or French Language Learner
EQAO	Education Quality and Accountability Office
FASD	Fetal Alcohol Spectrum Disorder
MB	Manitoba
NDD	Neurodevelopmental Disorder(s)
ON	Ontario
OR	Odds Ratio
SD	Standard Deviation
SE	Standard Error
SES	Socioeconomic Status
SN	Special Needs Status

Declaration of Academic Achievement

This dissertation is a sandwich thesis with three original studies, one introductory chapter, and one concluding chapter. The quantitative datasets used in this dissertation were permitted and prepared by the Equity From The Start team, who manage a national research program funded by the Government of Canada to collect, analyze, and disseminate Early Development Instrument data.

This dissertation was financially supported by a doctoral fellowship awarded by the Social Sciences and Humanities Research Council. The funding agency did not have any role in the design or analyses of the studies. Other work was supported by the co-authors funding through insight grants from the Social Sciences and Humanities Research Council.

I, Rita Jezrawi, was responsible for each study's design, conception, and carried out data analyses. I am the lead author and primary researcher on the three standalone papers in this dissertation and wrote the original drafts. I was responsible for writing the introductory and concluding chapters. I received support, edits, methodological and analytical guidance, and intellectual feedback from manuscript co-authors (Rhyan Hawke, Drs. Marni Brownell, Scott Davies, Jessie-Lee McIsaac, Jean Paul Lefebvre, and Jennifer Enns), including my supervisory committee (Drs. James R. Dunn, Teresa Bennett, Eric Duku, and Magdalena Janus). I am responsible for the accuracy and integrity of this dissertation. The papers presented in this dissertation are the original (non-peer reviewed) manuscripts to be submitted to academic journals for publication.

Chapter 1

Introduction

The thesis provides a holistic view of kindergarten children's early capacities, including cognitive and non-cognitive domains, using quantitative and knowledge synthesis methods to provide insight on how individual and neighbourhood sociodemographic traits, and provincial resource systems contribute to changes in educational and developmental health outcomes. This chapter introduces a doctoral dissertation consisting of three original research studies. The introductory chapter describes the context, objectives, and definitions for the topic of interest – child developmental health. This first chapter includes a summary of the three studies in Chapters 2, 3, and 4.

Background and Terminology

Developmental health is a broad concept that refers to outcomes, skills, abilities, and competencies resulting from brain and biological development (Keating & Hertzman, 1999). Neurodevelopmental disorders (NDD) are conditions resulting from atypical or abnormal brain development during childhood; these conditions produce impairments in cognitive functioning, communication, behaviour, and social and physical skills, which may present as delayed or missed developmental milestones (Mullin et al., 2013; Morris-Rosendahl, 2020). Age-appropriate developmental milestones progress differently in children with NDD than in children who are developing typically, which also means that children with NDD (and their caretakers) have different needs and experiences within healthcare, education, and social service systems. Some well-known NDD include Autism Spectrum Disorder (ASD), Attention-Deficit Hyperactivity Disorder (ADHD), and Fetal Alcohol Spectrum Disorder (FASD). Other categories or dimensions of functioning that may be used to describe children experiencing issues with behaviour and skills are special needs status (SN) and functional impairment. A child may have SN due to a medical/health diagnosis and/or a need for special education services

(Janus et al., 2018; Equity from the Start, 2025). A child may have a functional impairment, defined as a physical, visual, hearing, speech, learning, emotional, behavioural problem that affects their ability to participate in a regular classroom (Equity from the Start, 2025).

Children with neurodevelopmental difficulties, formally diagnosed or otherwise, may encounter challenges in learning and socialization. Readiness to learn at school is a construct that reflects what a child should be able to achieve in their environment and in the context of typical developmental milestones. School readiness can be measured using a variety of instruments focused on direct observations and/or parent-reported or teacher-reported estimates of well-being. Measures may include scores on vocabulary, communication, academic skills (e.g., numbers), attention/self-regulation, self-control of behaviours, and social competence, as measured in the Canadian National Longitudinal Survey of Children and Youth [NLSCY] (Thomas et al., 2006). A Canadian readiness to learn tool, the Early Development Instrument [EDI], measures developmental outcomes in five domains: physical, social, emotional, language/cognition, and communication/general knowledge (Janus & Offord, 2007). Developmental vulnerability as measured by the EDI is operationally defined as an average score below the 10th percentile on one or more of the five domains of age-appropriate developmental expectations at school entry, and thus children in this category are not ready to learn at school or have increased needs (Janus, Offord, & Walsh, 2001). Children's developmental vulnerability is associated with characteristics such as age, sex, and health status or family traits such as family structure, level of education, income, parental health, and parental involvement in literacy skill development (Janus & Duku, 2007). Children with various types of NDD are also more likely to reside in neighbourhoods with lower socioeconomic status (SES) than typically developing children (Zeraatkar et al., 2020).

Variations in the prevalence and incidence of neurodevelopmental concerns impacting a child's ability to succeed in their environment can result from health inequities, social determinants of health, and the availability and cost of child development identification/intervention programs (Edwards et al., 2022). Given that early life experiences and events can impact future health outcomes, quality of life, and overall wellbeing, it is worthy to understand the role and impact of child development policies and to leverage factors known to improve child developmental health in future policymaking to facilitate better developmental outcomes.

Canadian Context

In Canada, child development services cut across healthcare, education, and social service sectors, and are governed by provincial governments under both federal and provincial legislation. Physicians, pediatricians, and social service agencies are often initial points of contact for families with questions or concerns about their child's development and facilitate early identification of SN or NDD. Early interventions, delivered during 'critical periods' of child development can be delivered by physicians, clinicians, communities, and schools. A qualitative analysis of policy documents in the United Kingdom showed that early interventions are concerned with equitable distribution of opportunities available to help children succeed in the early years and have the same opportunities as others to succeed later in life (Mortimer et al., 2018). Early interventions to address NDD provide exposure to multi-modal sensory experiences to address behavioural concerns and stimulate the development of more complex neural pathways needed for communication, cognition, and physical movement (Sullivan et al., 2014; Cioni et al., 2016; Hertzman & Boyce, 2010). These sensory interventions target developmental pathways essential for social information processing, attention/cognitive control, and sensory-motor processing, and neural connectivity (Gliga et al., 2014).

Research, Policy, and Practice Challenges

Advancements in child policy in Canada can be partly credited to the research efforts of the Early Years Research Series, which advocated for community-based and family-based programming in the early years, prior to school entry (i.e., 0-6 years of age) (Bertrand et al., 1999). Their recommendations were based on evidence that parental involvement facilitated healthy child development and that positive stimulation during critical periods of child development enabled healthy brain development (Bertrand et al., 1999). The series also found that academic performance was associated with specific demographic factors, one being SES, further solidifying the linkages between social and environmental determinants of health, health status, and education (Bertrand et al., 1999). Others have also highlighted that cognitive abilities and developmental health at school entry are predictors of academic achievement (Costa et al., 2024; O'Connor et al., 2020). Studies in other countries have found that children with NDD experience more absences, more disciplinary action for their behaviours, lower exam participation, lower exam scores, and more post-graduation unemployment than children without any NDD (Fleming et al., 2020; Daalsgard et al., 2020). No studies have been conducted in Canada to explore the relationship between a diagnosis of NDD in kindergarten and academic achievement in later grades. This necessitates exploring the various developmental profiles of children and investigate the basic differences between children with various NDD and the relationship with school and developmental outcomes.

Research gaps also exist in understanding who is more likely to respond to particular early interventions and how, i.e., under what circumstances, and their cost-effectiveness (Lord et al., 2022). The availability and breadth of child neurodevelopmental services may be a result of complex policy processes, bringing attention to certain policy problems and enabling them to rise to the decision agenda, while neglecting others. The changing nature of policymaking means policy issues can rise and fall off the agendas and budgets, which could impact service delivery and could contribute to differences in health outcomes. For example, differences in age at diagnosis for ASD have been found among several provinces (Ouellette-Kuntz et al., 2009; Zwaigenbaum et al., 2019). Another study using the EDI investigated the association between neighbourhood prevalence of health disorders (operationally defined as including SN, diagnosed health conditions, or limitations affecting a child's ability to function in classroom) and neighbourhood-level SES found overall prevalence intervals differed across provinces (Janus et al., 2024). In Ontario, the prevalence of health disorders ranged from 4.4-39.1% by neighbourhood with a total of 14.8% of children with health disorders across 798 neighbourhoods (Janus et al., 2024). In the adjacent province of Manitoba, neighbourhood prevalence of health disorders ranged from 6.9-37.7% with a total of 15.5% of children with health disorders across 75 neighbourhoods (Janus et al., 2024). The causes of regional differences in prevalence rates or other health outcomes are not known and hard to measure. True increases in incidence, migrations out of the province, and differences in data collection censoring methods may impact regional variation in prevalence of disorders (Ouellette-Kuntz et al., 2009; Ouellette-Kuntz et al., 2014). Resources tend not to be either equitably or equally divided by type of NDD and may be predetermined based upon eligibility criteria which can prioritize children in the early years, with higher needs, or with autism (Don & O'Byrne, 2022). These variations impact developmental health outcomes and contribute to (dis)advantages based on the sociodemographic profiles of children and their families, and what services are available in those regions that are utilized by families. Those living in provinces with a mean older age at diagnosis are at a disadvantage for delayed treatment during formative years, likely because there are differences in policies and programs available across jurisdictions. The reasons for these provincial variations have not been identified yet. Regional variations in policies and resources, family history, or accessibility of interventions need further investigation in how they facilitate or delay diagnosis of NDD (Daniels and Mandell, 2014; Loubersac et al., 2021). Due to the importance of early intervention during critical periods of early childhood, there is a need to understand and address the factors that impact the process of seeking timely diagnoses.

Prior to the creation of a dataset linking multiple sources of social, educational, and biological data, Canada lacked longitudinal, population-level knowledge on academic achievement of students from kindergarten through to secondary school (Sinclair et al., 2023). Research studies have also typically underrepresented socioeconomically, culturally, and linguistically diverse children (Keller-Bell, 2017; Izuno-Garcia et al., 2022).

Current policy challenges include equitable access to resources, opportunities, and variations in eligibility for publicly funded diagnostic assessments or early interventions in each province or territory (Canadian Academy of Health Sciences, 2022; Lord et al., 2022). Practitioners also lack specialized clinical skills and training to discern what behaviours deviate from typical trajectories (Lord et al., 2022, Norbury & Sparks, 2013). Further understanding of the current strengths and challenges of the health and education sectors and the populations served by these sectors will inform decision makers on optimal service delivery and availability of supports for children with NDD.

Objectives

The overall objectives of the dissertation were:

1) To explore academic achievement patterns of children with NDD and explore the influence of social determinants on developmental health in Canada;
2) To understand social, environmental, and policy factors that facilitate or hinder early identification and early intervention services, how they work, and how/why developmental outcomes vary;
3) To explore and document regional differences in developmental and educational trajectories and services for young children with or vulnerable to NDD; and
4) To make recommendations on changes to facilitate improvements to education policy and child health policy.

Overarching Research Questions

The following questions guided the development of the dissertation: 1) What is the impact of having an NDD on academic achievement and developmental health trajectories over time, given other sociodemographic characteristics?; and 2) What are the service pathways to early identification and intervention for families and children vulnerable to neurodevelopmental challenges or concerns?

Rationale and Scope

Services and supports are not distributed equally across different types of NDD. Variations related to type of care and access to care and other social determinants suggest there are contextual, environmental, and social factors that affect the behaviour of individuals within the larger context of the social systems they interact with. Investigation of individual and neighbourhood traits enabled us to quantify this variability and explore several environments, relationships, and microsystems that impact a child's development: community/neighbourhood, health services, schools, education systems, household/family, and individual traits. The scope of this dissertation involved Canadian children in the early years (0-6 years of age).

Regional differences in age of diagnoses under surveillance programs have been reported in Manitoba, Ontario, Newfoundland and Labrador, and Prince Edward Island (Ouellette-Kuntz et al., 2009). Causes of differences in prevalence or other health outcomes are hard to measure. True increases in incidence, differential migrations out of the province, and differences in data collection censoring methods may also impact regional variation in prevalence of disorders (Ouellette-Kuntz et al., 2009; Ouellette-Kuntz et al., 2014).

Community traits within and between provinces may further contribute to health inequalities. The focus on Ontario for this dissertation was in part because Ontario is the province of residence for the authors, and because the members of the dissertation committee and other advisors have expertise working in Ontario. Additionally, Ontario has had many changes in their early identification and intervention systems over the last three decades which make it an interesting province to examine. The selection of Manitoba as another province is for several reasons. First, there are sufficient similarities/differences in community characteristics (e.g., overall population size, rural population size, household income, low-income families, health spending, or physician availability) and differences in NDD prevalence/incidence rates and policy priorities that suggest there are enough differences to begin studying whether and what regional differences in systems contribute to differential health outcomes. A brief examination of the two provinces using EDI data showed some variations in service usage and service needs (e.g., school-based support and early interventions) for children with SN, NDD, and/or developmental vulnerability. Next, the thesis builds on other studies that have used linked administrative databases and surveillance programs in Ontario and Manitoba, with the advantage of having data availability within our own team to support quantitative analyses. Next, existing professional contacts and networks within Ontario and Manitoba could be leveraged to disseminate the research. Lastly, and anecdotally, Manitoba has a strong early identification/intervention system outside of the autism spectrum, and thus could be a good example for other provinces to learn from. Therefore, the dissertation aimed to uncover some of these underlying systems, service, and/or policy differences using multiple methods in two provinces.

Overarching Theoretical Worldview

This research was guided by a commonly applied, though rarely used for children with NDD, theoretical model of human development: the Bronfenbrenner ecological systems theory (Bronfenbrenner, 1995). This model, centred on child and family, explains the interplay between micro- and macro-systems such as social services, neighbourhoods, schools, health services, as well as familial and individual traits, and time periods (Bronfenbrenner, 1995). The underlying belief is that individual behaviour and development inextricably impact one another and are influenced by system-level interactions (Bronfenbrenner, 1995). Interactive processes that produce this relationship also depend on the socioenvironmental contexts where development occurs (e.g., family history, family socioeconomic status), the child's biopsychological characteristics, historical events, environmental changes over time (i.e., chronosystem) (Bronfenbrenner, 1995). Several social and environmental factors influence child development. In the microsystem, family resources, relationships, and support influence child neurodevelopment; in the macrosystems, peer and community relationships, school, socioeconomic status, culture, and politics are influential factors (Guedeney & Dupong, 2020).

The interactions and relationships between systems enable individuals to change or stagnate in the context of protective and risk factors.

The research was also informed by the life course perspective which emphasizes that early life exposures and social, behavioural, biological, and genetic factors affect health outcomes in later life stages (Osler, 2006). Different genetic and biological responses to environmental experiences (life events, transitions into different roles and statuses) determine whether those experiences will trigger protective or harmful genetic expressions and can affect a person's vulnerability or resilience to adversity early and later in life, causing cumulative risk or disadvantages (Braveman & Gottlieb, 2014). Children born into adverse social environmental circumstances have higher risk of developmental issues, and their childhood health can impact their long-term educational career and social mobility trajectories (Solar & Irwin, 2010).

System-level influences from schools and the education system as a whole can impact a developing child. Support and services to children early on during important developmental periods can positively impact their physical, social, emotional, communication, language, and other cognitive skills. Educational trajectories involve transitions between grades, life events, and turning points that can close or open opportunities or change oneself or environment. Children with ASD/NDD have diversity in life course pathways (as examined through incorporation of covariates as individual, social, or economic contexts) and may have different developmental risk and protection, which will impact their future life transitions and events.

Bronfenbrenner's ecological and life course frameworks map onto hypotheses and analyses in subsequent chapters in several ways (Figure 1):

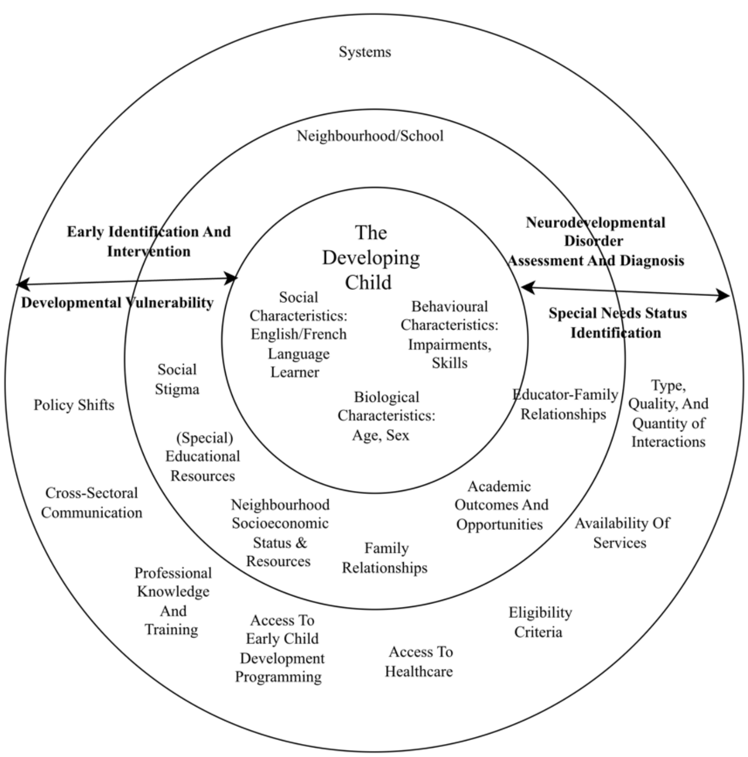
1) Exploring the systematic variation in developmental outcomes that vary based on environmental and individual characteristics (Bronfenbrenner, 1995);

2) Exploring the direction, content, and strength of processes (interactions) over a regular basis, across extended periods of time, and in the stage of life a person is in (Bronfenbrenner, 1995); and

3) Exploring how to leverage or change processes to protect against the impact of systematic differences in environmental and individual characteristics (Bronfenbrenner, 1995). Physicians, pediatricians, educators, and social service agencies are often initial points of contact for families who have questions concerns about their child's development. The type, quality, and quantity of interactions and touchpoints within and between microsystems and mesosystems in combination with environmental and sociodemographic contextual factors could result in differential developmental and educational outcomes, which would impact future quality of life.

Figure 1

Conceptual Model of Ecological Systems Frameworks Applied To The Thesis



Chapter Overviews

This dissertation examines the educational and child development systems in Ontario and Manitoba. The first study investigated standardized math and literacy assessment participation and achievements of 2,748 students with ASD and NDD attending publicly funded schools in Ontario. Early development and sociodemographic factors were analyzed with descriptive statistics and binary logistic regression using the EDI. Data from the EDI was obtained for senior kindergarten students and linked with educational data from the Education Quality and Accountability Office for these students in Grade 3 and 6. Assessment participation was low, at 19.3-36.7%, and only 10.1-20.9% of those who participated in assessments met curriculum-based expectations (i.e., Level 3 out of 4 or Level 4 out of 4). The low participation rates with respect to this type of assessment raises concerns about selection bias, the representativeness of academic outcomes, and the need for more inclusive methods of tracking academic achievement. I used the theoretical lenses to make sense of the results of the quantitative analysis, namely that system interactions (e.g., opportunities for services and supports, family and individual contexts) may differentially impact children and families and lead to varied educational journeys and developmental health outcomes.

A realist review was conducted for the second study to understand how child developmental programs/policies in Ontario and Manitoba facilitate entry to early identification/intervention and generate developmental outcomes for children in the early years (0-6 years old). This methodology was chosen as it is a very focused approach to reviewing literature and provides a guide to organize and interpret patterns in data, and findings can be transferable to other settings and participants. Themes in documents across both provinces that were identified included: 1) importance of engaging, connected, and shared policy environment,

2) adequate evidence base for clinical guidelines, and knowledge/training for clinicians on assessment, treatment, referral of NDD, 3) intervention environment focused on opportunities to develop social, emotional, psychological, behavioural and cognitive skills, 4) consistent, frequent, accessible, and informative program composition, and 5) intervention success dependent on child and family characteristics and provider/system barriers.

Using growth curve modelling in the third and final study, changes over time in prevalence of 1) SN, 2) NDD, and 3) developmental vulnerability of kindergarten children residing in Ontario and Manitoba between 2010 and 2019 were examined using Early Development Instrument data. Increasing prevalence of SN, NDD, and developmental vulnerability were found at the neighbourhood level, which may result in increased unmet healthcare and educational needs.

The current research landscape also lacks systems-focused data on the school and home environments that influence children's development, and this thesis provides a better understanding of how to optimize these systems and the relationships between the systems. The studies overlap in theoretical worldviews, inclusion criteria, and a portion of quantitative data that were sourced from the same dataset. These studies provide empirical support for usefulness of early intervention programs and early entry to special education to ensure students develop the skills they need to succeed at home, school, and community, and have a higher quality of life. Meaningful participation in school, community, and home is important for child development and family wellbeing. This thesis adds evidence on how meaningful participation and early identification and interventions can be facilitated by healthcare and community providers, educators, policymakers, and parents themselves. The results of the studies also showed socioeconomic and geographic inequities experienced by families and neurodiverse children between and within provinces. Additionally, the dissertation shows that the type of NDD is associated with different developmental and educational outcomes. Fundamentally, this dissertation showcases the necessity for collaboration between child developmental health and education sectors to provide seamless communication and support services across schools, clinics, and community agencies.

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Chapter 2

Accessibility And Inclusion In Assessment: Exploring The Links Between Early Development And Educational Success For Children With Neurodevelopmental Disorders

Preface

The paper presented in the following section is the final, non-peer reviewed paper to be submitted for consideration in an academic journal. I conducted the study under the guidance of my supervisory committee of MJ, TB, ED, JRD and wrote the original draft. All authors, Rita Jezrawi, Teresa Bennett, James R. Dunn, Marni Brownell, Scott Davies, Eric Duku, Jessie-Lee McIsaac, and Magdalena Janus contributed to the conceptualization of the study and approved the final version to be submitted for publication.

Ethics approval for this study was obtained from the Hamilton Integrated Research Ethics Board (under project #8149). The study received support from a grant from a Social Sciences and Humanities Research Council Insight Grant and a Social Sciences and Humanities Research Council Doctoral Fellowship.

Abstract

Background: Little is known about how academic progress is assessed and tracked for children with neurodevelopmental disorders and special educational needs. Past research has shown a link between social determinants of health, developmental outcomes, and academic achievement, which may influence future quality of life.

Methods: Using a unique individually linked dataset, standardized math and literacy assessment participation and ability to meet assessment expectations were examined among 2,748 students with neurodevelopmental disorders attending publicly funded schools in Ontario, Canada. Logistic regression analysis was conducted with data from the Early Development Instrument (EDI) from 2010-2012 that was linked with Grades 3 (2013-2015) and 6 (2016-2018) standardized provincial reading, writing, and mathematics assessments.

Results: Assessment participation ranged from 19.3-36.7% and only 10.1-20.9% met curriculum-based expectations. Children with autism spectrum disorder were more likely to participate in standardized assessments than children with other neurodevelopmental disorders.

Conclusion: Lack of participation raises concerns about the appropriateness of current educational policy and assessments informed by data excluding most children with neurodevelopmental disorders, the need for adequate teaching methods for students with diverse learning needs, and early prioritization of healthy child development to set students up for academic success.

Keywords: autism spectrum disorders, assessment, early intervention, special education

For students with neurodevelopmental disorders (NDD) who have special educational needs, tracking academic progress in the traditional fashion may not be conducive to children's learning and assessment needs. These neurological conditions that arise from various medical, genetic, or environmental factors contribute to impairments in cognition, behaviour, and communication during childhood developmental periods (Mullin et al., 2013; Morris-Rosendahl & Crocq, 2020), which affect academic performance and learning. It is unclear how children with various NDD fare in provincially mandated standardized testing given the possible ranges of cognitive, sensory, social, and communication abilities across disorder categories. Clinical boundaries categorizing these disorders are not clear as typical symptoms and behaviours featured in one diagnosis can overlap or are comorbid with other diagnoses (Morris-Rosendahl & Crocq, 2020). One comparatively well-defined NDD classification is Autism Spectrum Disorder (ASD), which commonly affects sensory, social, and emotional skills. ASD is indisputably an NDD, yet it occupies a very idiosyncratic category. Even though it can present in a very heterogeneous way, having a diagnosis of ASD gives a child a unique classification in the Ontario, Canada, educational system of special education and standardized assessment procedures, solely based on diagnosis, while the others are impairment-based categories. The remaining behavioural, physical, or communication categories are all based on functional impairments or limitations such as behavioural, speech or language impairment, intellectual or learning disability, physical or development disability, blind/low vision, deaf/hard of hearing, or multiple/non-identified limitations (Ontario Ministry of Education, 2017). So far, no evidence exists whether this distinction, combining health and administrative components is in any way reflected in children's academic outcomes. Our study investigates whether children with a diagnosis of autism spectrum disorder, one type of NDD, may fare differently on academic achievement outcomes compared to children who had a diagnosis of other NDD.

Pathways synergistically linking early childhood development to education, health, and socioeconomic position have been well documented (Low et al., 2005). Ross and Wu (1995) describe how education impacts health indirectly by influencing work and economic conditions, social and psychological resources, and lifestyle and health behaviours, outlining the importance of early child capacities and academic achievement for children who may be academically and developmentally vulnerable. One marker of child development is readiness to learn at school-age (Low et al., 2005). Yet, traditional educational assessments are not always inclusive of different learning needs and abilities, even with educational supports available. This makes it challenging for teachers to incorporate the appropriate learning strategies for students and raises concerns about the compatibility of traditional methods such as standardized testing.

Canadian and international research have shown links between education and developmental health for children with ASD or other NDD. Early (prelinguistic) language problems and behavioural difficulties associated with ASD predict academic and social school functioning (Zaidman-Zait et al., 2021). Australian studies found that children with ASD or other NDD generally received assessment scores below typical standards and had difficulty completing and succeeding in age-appropriate academic tests in reading, writing, and mathematics and have more emotional and behavioural issues than their typically developing peers (Ashburner et al., 2008; 2010).

The Educational Context in Ontario, Canada

In the site for this study, the Province of Ontario, elementary school curriculum learning expectations reflect the standardized census assessments administered by the Education and

Quality Accountability Office of Ontario (EQAO) (EQAO, 2013). The agency administers, scores, and reports on provincial testing; all elementary and secondary school students are expected to participate in Grade 3, 6, 9, and 10 assessments though advancing to the next grade is not contingent upon participation (EQAO, 2013). Decisions about accommodations or exemptions are made on an individual basis before assessments take place, involving teachers, parents/guardians, and the student; parents can make a final decision to allow their child to participate (EQAO, 2024).

While there is reporting on the overall prevalence of NDD, little is known how academic progress is assessed and tracked for children with special educational needs. Students with neurodevelopmental exceptionalities may fare differently in provincially mandated testing; further understanding of this will improve decisionmakers' understanding of how to improve developmental outcomes and academic trajectories.

Objective

The primary objective of this study was to explore the association between a diagnosis of ASD or other NDD in kindergarten and: i) the likelihood of participation in standardized academic assessments in Grades 3 and 6; and ii) academic achievement measured by meeting assessment expectations from cohorts of children attending public kindergarten from 2010-2012 followed through to Grade 3 and 6 between 2013-2018 in Ontario, Canada. The secondary objective was to examine whether and what student sociodemographic characteristics (e.g., sex, language, socioeconomic status) in kindergarten were correlated with later academic achievement outcomes.

Theoretical Framework

The study design, research question, and interpretation has been informed by previous child development research investigating the predictive strength of child physical, social/emotional (e.g., attention), communicative, and cognitive skills (e.g., reading, writing, numeracy) in later academic achievement (Guhn et al., 2016; Duncan et al., 2007; Brinkman et al., 2013). I was informed by a desire to understand whether the current form of monitoring academic progress was equitable among children with varied needs. I have approached the study using a life course perspective (Osler, 2006) interpretation to special education to highlight that children learn from their early experiences, so providing support in the transition from kindergarten to elementary school with early interventions, pre-kindergarten education, and readiness to learn programs will facilitate their academic achievement. Canadian literature indicates linkages between education and developmental health. For example, lower participation in education activities by children with NDD (Mâsse et al., 2013), lower early developmental scores for kindergarten children with ASD, special needs status, or other non-autism disability compared to those without (Janus et al., 2018b; Janus et al., 2010, Janus 2011), and strong predictors of developmental health scores with academic achievement in Ontario (Davies et al., 2022). Based on this, I hypothesized the more developmentally or socioeconomically vulnerable a child with ASD or other NDD was, they would be less likely to participate in assessments than their peers and meet academic assessment expectations. The first step in this approach was to explore this hypothesis quantitatively, keeping in mind that children with a particular diagnosis (such as ASD) are categorized and treated differently in the education system than children with other NDD.

Methods

Study Design

A quantitative retrospective observational study design was used. This was consistent with the objectives of the study, which were to explain the associations between early child development and NDD diagnosis and later academic achievement variables (assessment participation and meeting assessment expectations).

Data Sources

Ontario was chosen due to its size (Canada's most populous province) and the availability of linked population-level educational data sources which allows us to investigate small population sub-groups, though it may not be representative of all Canadian provinces. The Early Development Instrument (EDI, Janus & Offord, 2007) dataset was chosen as it holistically measures children's competencies in various developmental areas and reflects a developmental systems approach that considers family and neighbourhood factors (Janus et al., 2010). The EDI is a cost-effective, psychometrically validated, and widely used teacher-completed questionnaire of kindergarten children's developmental health including physical, social, emotional, language/cognitive development, and communication/general knowledge domains, where a domain score is calculated as a mean score of all valid answers, and higher scores indicate better preparedness for the school day (Janus & Offord, 2007; Janus et al., 2011). Domain scores are then divided into binary categories indicating whether a child has scored at or below the lowest 10^{th} percentile of normative distribution in at least one domain and is thus deemed vulnerable or having developmental vulnerability.

The dataset was deidentified and merged with a 2011 neighbourhood-level geographic socioeconomic status (SES) index created from Canadian census data standardized to a mean of zero (Janus et al., 2018a). The tool collects information on whether a child has an identified special needs status (SN), which is a professional medical, physical, or mental health diagnosis (also defined in Zeraatker et al., 2020). The EDI data from 2010-2012 were linked with Grades 3 (2013-2015) and 6 (2016-2018) standardized provincial reading, writing, and mathematics assessment participation/exemption data provided by a partnership with the Education Quality and Accountability Office (EQAO). The EDI implementation years correspond to the 2009/2010, 2010/2011, and 2011/2012 kindergarten cohort years. The kindergarten cohort years correspond to annual Grade 3 assessments completed in 2013-2015 and annual Grade 6 assessments completed in 2016-2018. The standard benchmark for students that meet academic expectations on the standardized assessments is Level 3 or 4 out of four levels, which are transformed from the raw scores of students. More information about the assessments, the database, and the matching and merging processes are available online (Sinclair, Davies, & Janus, 2023).

Categorization of ASD and NDD Groups

For the purpose of this study, two diagnostic groups were created: children with a diagnosis of ASD and children with a diagnosis of other NDD in kindergarten. This independent variable was measured by a question in section D on the EDI which asked teachers*: "Does the child have a problem that influences their ability to do schoolwork in a regular classroom? If the child has received a diagnosis or identification by a doctor or psychological professional, please indicate. You can indicate up to three diagnoses."* Children could have both ASD and another NDD recorded in the dataset, though children who had the first diagnosis listed as ASD and a subsequent NDD were placed in the group of children with ASD. Most children had only one diagnosis listed in the analytic dataset, with the most frequent being ASD followed by ADHD. A grouped diagnosis of other NDD included the remainder of the possible diagnoses in the mental health disorders and developmental disabilities categories and excluded sensory disorders (such as visual and hearing impairment), motor disorders (such as cerebral palsy), and other disorders (such as asthma or diabetes). Therefore, the other NDD group diagnoses consisted of attention deficit hyperactivity disorder (ADHD), anxiety, depression, oppositional defiant disorder (ODD), other mental diagnosis, global delay, Down Syndrome, Fetal Alcohol Spectrum Disorder (FASD), intellectual delay, Rett's/childhood disintegrative disorder (CDD), and learning disability. Although anxiety and depression are not always classified as NDD, they were included because at the age of the sample, anxiety or depression is likely to have some neurodevelopmental causes (Leonardo & Hen, 2008). Heterogeneity exists within the NDD categories; it is possible that behavioural or biological differences between subtypes under this grouping could be associated with larger or smaller effects towards the outcomes. The choice to categorize in this way was that a diagnosis of ASD in the education system is separated, tracked, serviced, and funded differently from other NDD, while other NDD are grouped as impairment-based categories. Another reason to not disaggregate further is that there is high concordance on ASD diagnoses in the EDI with administrative health records (89.4% positive predictive value), but lower positive predictive values for ADHD (61.9%) and anxiety (4.8%) (Saunders et al., 2021).

Covariates

The covariates were year, biological sex, impairment (defined as having a problem that affects ability to participate in classroom, including physical, visual, hearing, speech, learning, emotional, and/or behavioural problem), SN (defined as having an identified health problem and/or having special education needs), English or French second Language Learner (EFLL; defined as fluency in the language of instruction), developmental vulnerability (defined as an average score in the 1owest 10th percentile on any domain of the EDI), SES index, and age at the time of questionnaire completion, which were derived from EDI questionnaire items. I chose these to describe the various developmental profiles of the children in the study and investigate the basic differences between children with developmental disorders. These are also known sociodemographic characteristics which may influence educational, social, and health outcomes over time (Davies et al., 2016; Low et al., 2005, Hair et al., 2006; Janus & Duku, 2007), aligning with life course and child development perspectives.

Inclusion Criteria

Prior to applying inclusion criteria, the full dataset at the time included records from 265,007 kindergarten children between 2010 and 2015. This dataset contained records of standardized assessment participation and achievement outcomes for 201,884 Grade 3 students and 129,071 Grade 6 students. The dataset had 2,814 children out of 129,071 (2.18%) with any NDD (including ASD) from the EDI collected between 2010 and 2012. Of those, 1,272 (45.2%) of children had a primary diagnosis of ASD. The following inclusion criteria were applied to the dataset:

1) child was in the classroom for at least one month and did not move out of classroom or school;

2) valid EDI (defined as less than 25% of missing items on the child's EDI questionnaire) which was collected between 2010 and 2012; and

3) no missing data on the binary outcome variables, independent variable, or sociodemographic covariates (as required to complete logistic regression analyses).

Ten cases were excluded due to lack of a valid EDI and 17 cases were excluded because the child was not in the classroom for more than a month or had moved out of the class/school;

the remaining 39 cases (<2%) were excluded due to missing data on covariates, specifically age, EFLL, SES, and/or SN. The exclusion of 66 children resulted in a final count of 2,748 children in the analytic dataset.

Statistical Analysis

In descriptive and logistic regression models that follow, the binary outcomes for the study were: 1) participating in Grade 3 and/or Grade 6 assessments and 2) meeting provincial expectations on reading, writing, and mathematics assessments. The latter is a threshold for how many items are answered correctly and whether the child has demonstrated they meet provincial education curricula expectations in that year. Levels are grouped based on the raw data scores. This threshold value fluctuates yearly but those meeting Level 1 and Level 2 are not meeting expectations, and those in Level 3 and 4 are meeting curriculum-based expectations. Descriptive statistics and cross-tabulation analyses were used to assess the differences in probability of assessment participation and meeting academic expectations between children who have a diagnosis of ASD or other NDD. A block (method = enter) binary logistic regression was used to calculate odds ratios (*OR*) using SPSS version 28 (IBM Corporation, 2021). The first block unadjusted model only included diagnosis, of which ASD was the reference category. The adjusted full model/second block included the diagnosis and the sociodemographic covariates. This model included the continuous variables of age and neighbourhood-level SES, and the dichotomous variables of biological sex at birth (female was the reference category), SN (yes/no), EFLL (yes/no), developmental vulnerability on at least one EDI domain (yes/no), and presence of any functional impairments influencing ability to participate in a regular classroom (yes/no and checklist of applicable impairments). Year of completion (2010 was the reference category) was included in the regression to account for any potential cohort differences.

Wald tests identified the significance of individual coefficients. Pearson's chi-square tests were used to determine associations between demographics and assessment outcomes. Likelihood ratio tests and other measures were used to assess the accuracy and goodness-of-fit of the models, which can be found in the Appendix. Significance levels were set at $p = .05$ but adjusted post hoc using a Bonferroni correction to account for multiple hypothesis testing and set at $p = .001$.

Results

Demographic Characteristics

The final analytic sample consisted of 2,748 children (2.13%) with a kindergarten diagnosis of ASD or other NDD. Of those, 1,243 (45.2%) had a primary diagnosis of ASD and 1,505 (54.8%) had a primary diagnosis of other NDD, most commonly ADHD or global delay. The sample was predominately male (73.5%), had English/French as a first language (86.7%), had SN designation (71.8%), and was deemed vulnerable on at least one domain of the EDI (83.3%). The mean ages were similar between both groups ($p = 0.73$). The overall mean SES index was 0.11 (1.06 *SD*), with a mean difference of 0.37 on the 2-sided t-test ($p < .001$) with the NDD group living in slightly more socioeconomically disadvantaged neighbourhoods. On the independent samples two-sided t-test, the NDD group had higher mean domain scores in all EDI domains except language ($p < .001$). In the chi-square cross tabulations and t-tests, there was an association between either diagnosis and male biological sex, presence of impairment, SN, speaking English/French, vulnerability, and SES ($p < .001$). More children with ASD were receiving school-based support (85.7%) or receiving further assessments (56.9%) compared to children with other NDD receiving support (56.6%) or assessments (45.3%) ($p < .001$). Full details on demographics (Table A1) and regression results (Table A2 and Table A3) are in the Appendix.

Comparison of EDI Scores Between Groups

More children with ASD were vulnerable on one or more domains (89.4%) than children with other NDD (78.3%) as well as on two or more (76.9% compared to 64.9%). Children with ASD were more often in the lowest 10th percentile on physical, social, emotional, and communication domains of the EDI (all $p < .001$), but not language domains ($p = .007$). The domain scores ranged from 3.4-6.8 for children with ASD and 4.69-7.05 for children with other NDD, with the two-sided t-test of each domain showing significant differences in vulnerability between the groups (all $p < .001$ except for physical domain at $p < .04$).

Demographics and Standardized Academic Assessments

Approximately 19.3% of children with ASD and 20.1% with other NDD participated in Grade 3 assessments while 36.7% of children with ASD and 25.8% of children with other NDD participated in Grade 6 assessments. Among children with ASD who participated in assessments, 51.7-67.2% met Grade 3 provincial expectations and 34.3-60.8% met Grade 6 provincial expectations. Among children with other NDD who participated in assessments, 53-67.3% met assessment expectations in Grade 4 while 25.3-63.1% met assessment expectations in Grade 6. Only Grade 6 math expectations were significantly different between the groups (the ASD group had a greater proportion of expectations met) at the original significance level but not after Bonferroni adjustments ($p = .003$).

There were no significant associations between male biological sex and Grade 3 or 6 assessment participation ($p = .06$-$.66$) or meeting assessment expectations ($p < .001$-$.79$). There were also no significant associations between having EFLL status and assessment participation in Grade 3, (p = .26-.69) and Grade 6 (p = .002-.004) or for meeting assessment expectations in Grade 3 (p = .44-.93) and Grade 6 (p = .02-.22) after the Bonferroni correction ($p < .001$).

There were significant associations with having a SN, impairment, and vulnerability and not participating in any Grades 3 and 6 assessments ($p < .001$). There were some associations with not meeting assessment expectations and presence of SN ($p < .001$-.63) but only significant in Grade 6 reading and writing, impairment ($p < .001$ except in Grade 3 math at p = .002 and Grade 6 math at p = .01), and vulnerability in one or more domains on the EDI ($p < .001$).

Comparison of Assessment Outcomes Between ASD and Other NDD Groups

Math Assessment

In Grade 3, no statistically significant differences were found for assessment participation in the unadjusted model based on a 95% confidence interval (*CI*). No differences were found between groups in meeting curriculum expectations in either the unadjusted or adjusted models. In the adjusted model, children with other NDD were 31.0% less likely to participate in the math assessments than children with ASD (0.53-0.9 *CI*) in Grade 3. In Grade 6, children with other NDD were 17% less likely to participate in the math assessments in the unadjusted model (0.71-0.97 *CI*) and 38.0% less likely in the adjusted model (0.51-0.76 *CI*). They were also 35.0% less likely to meet assessment expectations in the unadjusted model (0.49-0.86 *CI*) and 41.0% less likely in the adjusted model (0.40-0.87 *CI*).

Reading Assessment

In Grade 3, there were no statistically significant differences between assessment participation or meeting expectations in the unadjusted models. In the adjusted models, Grade 3 children with other NDD were 30% less likely to participate in the reading assessments (0.54-0.91 *CI*) and 49.0% less likely to meet the assessment expectations than children with ASD

(0.32-0.82 *CI*). In Grade 6, children with NDD were 18.0% less likely to participate in the reading assessments in the unadjusted model (0.7-0.96 *CI*) and had 0.62 lower odds in the adjusted model (0.51-0.75 *CI*) but did not significantly differ in meeting assessment expectations.

Writing Assessment

In Grade 3, there were no statistically significant differences in assessment participation or meeting expectations in the unadjusted models. Grade 3 children with other NDD were 29.0% less likely to participate in the writing assessment than children with ASD (0.54-0.92 *CI*) and 40.0% less likely to meet assessment expectations in the adjusted models (0.37-0.96 CI). In Grade 6, children with other NDD were 18.0% less likely to participate in the writing assessment in the unadjusted model (0.7-0.96 *CI*) and 38.0% less likely in the adjusted model (0.51-0.75 *CI*). Though there were no significant differences in the unadjusted model, Grade 6 children with other NDD were 43.0% less likely to meet assessment expectations in the adjusted model (0.41-0.81 *CI*).

The other NDD diagnosis variable was also significant on the Wald test in the regression models with statistically significant ORs which indicates that the variable contributes to the prediction of academic achievement outcomes (p < .001-.03). Likelihood ratio tests to compare nested models without covariates from the full model were done and the models with predictors were significantly different from zero, contributing to the prediction of assessment outcomes (p < .001).

There was no concern for multicollinearity between covariates in the regression models based on their low standard errors (SE). There were no moderate or high correlations in the correlation matrices apart from having SN which had some positive correlations with the diagnosis variable in assessment participation outcomes ranging from .43-.47 and in meeting assessment expectations outcomes ranging from .51-.57.

Discussion

Understanding the patterns of school-age achievement for children with neurodevelopmental disabilities is critical for facilitating inclusive education and early intervention. Guided by the life course perspective and inclusive special education, this study set to explore the nuances in the academic achievement of children with NDD by comparing children with ASD, one specific NDD diagnosis that is uniquely singled out in the educational system, with children with other NDD. The results of the quantitative analysis were interpreted with life course and ecological systems theories. Specifically, that system interactions (e.g., opportunities for services and supports, family and individual contexts) may differentially impact children and families and lead to varied educational journeys and developmental health outcomes. The results of this study indicate that the majority of Grade 3 and 6 students with ASD and other NDD do not write provincially mandated standardized educational assessments and among those who do, only a small proportion meets assessment expectations, raising issues of accessibility and inclusion in Ontario's education system with respect to this type of assessment and the current accommodations available. The regression models showed that children with other NDD generally had lower odds of assessment participation and meeting academic expectations than children with ASD, especially when including the demographic covariates.

Children with ASD were more likely to be vulnerable, have an impairment, and have SN than children with other NDD in kindergarten. On the other hand, they also received significantly more school-based support and were receiving/waiting to receive further assessment in kindergarten significantly more often. This finding may signal a discrepancy between services available to children with ASD and services available to children with other NDD. There may be more direct approaches to receiving early intervention or special educational services for children with a confirmed diagnosis of ASD than for children with other NDD, irrespective of need and functional difficulties. This disparity in available services also makes it difficult for educators to adequately support all their students and ensure continual learning in their academic trajectories. Under the life course perspective, children diagnosed earlier also receive earlier interventions that contribute to greater language and cognitive abilities at school age, and it is known that preschool early intervention support improves academic outcomes (Clark et al., 2018; Campbell & Ramey, 1994). School, family, healthcare, or community environments and the teacher-peer-family interactions in such environments play a complex role in the development and wellbeing of children, impacting their physical, social, emotional, communication, language, and other cognitive skills. An enhanced ability for families to access early identification of neurodevelopmental concerns and interventional treatment services would reduce long term effects of developmental vulnerability on academic or other outcomes. The availability and efficiency of early intensive behavioural interventions at a younger age contribute to improved educational outcomes (Dimian et al., 2020). Low rates of educational intervention utilization may be attributed to resource constraints, strict criteria for service enrolment, and policy or insurance barriers constricting access to services, and subsequently contributing to unmet needs (Bilaver et al., 2016). The education system is a resource for families to receive further information and/or early interventions, but the consistent availability and accessibility of services matters to promote children's health at crucial time points in their development, which will ultimately have an impact on their future educational experiences.

In Ontario, children typically get accommodations on standardized assessments that are consistent with their education plans in their classrooms. Inability to participate or complete standardized assessments with existing accommodations suggests changes should be considered with respect to the current accommodations list, special education practices, and/or how assessments are structured. Early academic performance predicts later academic success, and education is a social determinant of health, therefore it is important that students with NDD are supported in the classroom. Considering the life course perspectives, system influences from schools and education system can impact a developing child, and our recommendation for more support and services to children early on during important developmental periods aligns with these perspectives. Educational trajectories involve transitions between grades, life events, and turning points that can close or open opportunities or change oneself or environment. Children with NDD experience diverse life course pathways (as examined through incorporation of covariates as individual, social, or economic contexts) and may have different developmental risk and protection, which will impact their future life transitions and events. This has implications for education policy: closer monitoring of educational achievement (and inclusive special education policies), earlier identification of students with diverse learning needs and promoting readiness to learn before kindergarten, and greater incorporation of learning support strategies for children with NDD (e.g., differentiation, peer learning, modified assessment format and length, modified reading levels, or assessment aids). Assessments, standardized or otherwise, should reflect equitable and inclusive methods of teaching and learning that teachers may already be utilizing in the classroom.

The low participation rates found in this study raises concerns about whether the standardized testing, in its current format, is helpful for children with ASD or other NDD, as it does not appear to meet their learning or assessment needs. It is possible that other assessments not explored in this study would more accurately reflect learner ability. Second, our results suggest that existing assessments or accommodations should be tailored to meet a wider array of needs, not just for students with ASD and other NDD, but universally. This would ensure systems are able to support students throughout their educational journeys, beginning in kindergarten, without requiring a diagnosis, as is typically the case for Ontario education services. Offering assessments that inherently address broad needs for anyone who has learning difficulties for any reason would be more helpful than requiring students to go through accommodations or exemption processes, work against their abilities, or removing standardized testing altogether. For instance, changing the examination process, content, or format of standardized or non-standardized assessments to promote inclusivity may be done using universal design principles such as in the ecological systems theory-based Universal Design for Early Childhood Education framework which encourages multiple means of information representation, engagement, and knowledge sharing to cater to students' needs and strengths (Darragh, 2007; Kieran & Anderson, 2019). This aligns with the current policy regarding accommodations for standardized testing, but improvements can be made to enhance assessment participation rates or shift focus to assessments that can showcase learner ability and skills.

Researchers have identified other factors that influence test performance, such as improving motivation and attention, providing early behavioural interventions, or asking students to repeat exam questions back to teachers (Koegel et al., 1997; Eldevik et al., 2012; Grindle et al., 2012). Teaching test-taking skills may also differ within specific educational settings (e.g., inclusive classroom versus a separate classroom for children with special educational needs), which in turn could impact a child's academic journey; thus, decisions about appropriate classroom placement should be based on the child's needs and strengths as *some* children have greater cognitive or academic skills after attending inclusive settings alongside typically developing peers compared to specialized interventions/programs (Keen et al., 2021; Nahmias et al., 2014).

The expertise and knowledge of educators and the availability of appropriate early intervention and learning settings in schools can affect children's academic trajectories. Academic, cognitive, and developmental outcomes may also differ between different teaching practices, school board policies (e.g., slight differences in special education plans or availability of supports), pre-service teacher education and teacher comfortability and confidence. In the context of this study, it would be difficult to attribute specific policies within school boards, particularly because the school boards must adhere to provincial policy mandates. Educators are also utilizing other forms of regular assessments and universal design principles that were not explored here.

One implication of the study is that the use of the EDI data linked to EQAO assessments has identified factors associated with academic achievement, which is tied to one's health, socioeconomic status, and overall quality of life. Identification of early factors identified in kindergarten, such as the impairments and developmental vulnerability in children with ASD or other NDD, can inform areas where educational, social, and health policies can address students vulnerable to challenging academic journeys. Policies for early interventions and behavioural therapies could ensure students develop the skills they need to take standardized assessments and demonstrate their academic skills. In Ontario, services and supports are not distributed equally across different NDD types, and in some school boards, services such as reading interventions are not available to those without a formal diagnosis or psychoeducational assessment (Ontario

Human Rights Commission, 2022). The results of our study provide more empirical support for early intervention programs to improve children's healthy development and school readiness (Ramey & Ramey, 2004) and add to the literature on the importance of early entry to special education and continued academic supports for sustained academic achievement (Ehrhardt et al., 2013; Starr et al., 2016).

Lack of participation and achievement in standardized assessments is not simply a reflection of learner ability. It is also a reflection of the learning environment and educator ability to teach students with NDD in ways they are receptive to as school staff do not have adequate training, preparation, and leadership guidance to teach students with NDD (Bölte et al., 2021). It is also a reflection of societal ability to provide accessible opportunities for infants and children to engage in early language, literacy, and math concepts, in addition to social and family programming.

Strengths and Limitations

This study has several strengths. This longitudinal approach uses demographics and individual level characteristics to understand progress of academic achievement among different populations. Individual, group, and place-based characteristics of children with ASD or other NDD impact their academic and developmental outcomes. This study sets the stage for further exploration into the policy factors and regional differences in healthcare and/or special education available and accessible to families of children with NDD, particularly for NDD other than ASD. Future research directions for system accountability and quality improvement of inclusive special education policies in Ontario could involve eliciting responses from caregivers, families, and students with all NDD on an ideal process of monitoring of educational progress.

There are also several limitations. First, due to a large quantity of missing data on presence/type of accommodations and/or reasons for non-participation in these assessments, these variables were not included in the study, which could limit interpretation of participation gaps. Second, only one measure of academic achievement was used, which constrains construct validity; future work can incorporate other assessment scores. There may be school-, child- and family-related factors that contributed to individual differences in these skill areas that were not available in this dataset (Caro et al., 2009; Ellefsen & Beran, 2007; Broer et al., 2019). The included sample was subject to under-reporting and may have missed students who did not have a teacher-reported diagnosis but were still vulnerable academically and developmentally, or missed students who had an undocumented diagnosis. A younger age at diagnosis of ASD is more likely when the child has more severe symptomatology, greater parental worry and concern over behaviours, more interactions with health and education systems, a higher parental SES, and received referrals from early intervention programs (Daniels & Mandell, 2014; Loubersac et al., 2021). In a recent systematic review, the mean age at diagnosis for ASD was 2.7-7.2 years internationally (Loubersac et al., 2021) and our sample consisted mainly of children 5 to 6 years old, which suggests that majority of children are diagnosed at the time of EDI data collection. There is still a possibility that children presenting with other NDD at kindergarten are more accurately diagnosed with ASD or a different NDD such as an intellectual disability or global delay, at a later age, which is not reflected in this study.

The study was limited to children in Ontario, Canada and does not represent other age groups, educational settings (e.g., private schools, home schools), provinces, or other countries. The study only represents kindergarten children with valid EDI data that were able to be successfully matched in later grades. Neighbourhood-level SES was used as data on individual-level SES is not available. Results are not reflective of any potential recent changes in standardized assessments or accommodations since the data were collected. The EDI does not currently collect data on race, ethnicity, or family dynamics. Although this study is missing subjective indicators from students themselves, academic achievement for children with autism may be a less important predictor of quality of life than employability, self-esteem, and happiness at school which could be explored in intervention evaluation studies to determine if a treatment is successfully working (Burgess & Gutstein, 2007).

Conclusion

The low level of participation in standardized assessments for children with ASD or other NDD identified in this study sows doubt about the utility and equity of provincially mandated assessments if students are not provided the tools, resources, and support (through health/education policies beginning in kindergarten) to set them up for success as much as possible into the elementary and middle school years. Children with ASD were more vulnerable in kindergarten but had better academic participation outcomes in Grade 3 and 6 which may reflect differences in available supports and services; further research could investigate this potential difference. This study enables further exploration on how educational stakeholders can create change in academic achievement and monitor academic progress for children with any NDD with a more equitable and inclusive methodology such as using multiple assessments or altering the format of exams (e.g., non-written). In conclusion, provincially mandated assessments are not well designed for non-typically developing children but the necessity to monitor educational patterns and social determinants of health can inform the development of more equitable assessment strategies.

Appendix 1

Descriptive Statistics And Logistic Regressions Of The Analytic Dataset

Table A1

Demographic Characteristics, Developmental Vulnerability, And Assessment Participation of Canadian Children With A Teacher-Reported Diagnosis of ASD Or Other NDD

Characteristic	Full sample	ASD	NDD	X^2 (2-sided sig.)	*Cramer's V*
Number of children	2,748	1,243 (45.2%)	1,505 (54.8%)	-	-
Mean age (*SD*)	5.72 (0.34)	5.71 (0.33)	5.72 (0.34)		-
Male sex	2,019 (73.5%)	1,034 (83.2%)	985 (65.4%)	**109.89***	**.2***
Presence of impairment	2,255 (82.1%)	1080 (86.9%)	1,175 (78.1%)	**35.92***	**.11***
Learning disability impairment	899 (32.7%)	390 (39.4%)	721 (47.9%)	5.18 (.16)	.04 (.16)
Special needs status	1,973 (71.8%)	1,180 (94.9%)	793 (52.7%)	**599.87***	**.47***
English or French language learner	364 (13.3%)	128 (10.3%)	236 (15.7%)	**18.12***	**.08***
Developmental vulnerability	2,290 (83.3%)	1,111 (89.4%)	1,179 (78.3%)	**59.76***	**.15***
Physical domain mean score *(SD)*	6.98 (2.06)	6.8 (1.88)	7.05 (2.20)	**-**	-
Social competence domain mean score *(SD)*	5.05 (2.43)	4.6 (2.25)	5.41 (2.51)	**-**	-
Emotional maturity domain mean score *(SD)*	5.62 (1.87)	5.30 (1.64)	5.89 (1.99)	**-**	-
Language domain mean score *(SD)*	6.35 (3.05)	6.5 (2.96)	6.17 (3.12)	**-**	-

Communication domain mean score *(SD)*	4.11 (3.27)	3.4 (2.96)	4.69 (3.40)	**-**	-
Mean socioeconomic Status index Z-score (*SD*)	.11 (1.06)	.31 (1.05)	-.058 (1.06)	-	-
Grade 3 math Participation	540 (19.7%)	240/1243 (19.3%)	300/1505 (19.9%)	0.17 (.68)	.008 (.68)
Grade 3 reading participation	543 (19.8%)	241/1243 (19.4%)	302/1505 (20.1%)	0.19 (.66)	.008 (.66)
Grade 3 writing participation	544 (19.8%)	241/1243 (19.4%)	303/1505 (20.1%)	0.24 (.63)	.009 (.63)
Met Grade 3 math expectations	284 (10.3%)	124/240 (51.7%)	160/300 (53.3%)	0.15 (.7)	.017 (.7)
Met Grade 3 reading expectations	295 (10.7%)	135/241 (56.02%)	160/302 (53%)	0.5 (.48)	.03 (.48)
Met Grade 3 writing expectations	366 (13.3%)	162/241 (67.2%)	204/303 (67.3%)	0.001 (.98)	.001 (.98)
Grade 6 math participation	935 (34.0%)	452/1243 (36.4%)	483/1505 (32.1%)	**5.531 (.02)**	.04 (.02)
Grade 6 reading participation	947 (34.5%)	459/1243 (36.9%)	388/1505 (25.8%)	**6.12 (.01)**	.05 (.01)
Grade 6 writing participation	948 (34.5%)	459/1243 (36.9%)	489/1505 (32.4%)	**5.93 (.01)**	.05 (.01)
Met Grade 6 math expectations	277 (10.1%)	155/452 (34.3%)	122/482 (25.3%)	**9.02 (.003)**	.1 (.003)
Met Grade 6 reading expectations	575 (20.9%)	271/459 (59%)	304/488 (63.1%)	1.05 (.31)	.03 (.31)
Met Grade 6 writing expectations	566 (20.6%)	279/459 (60.8%)	287/489 (58.7%)	0.43 (.51)	.02 (.51)
Receiving school-based support	1,825/2586 (66.4%)	1,064/1,242 (85.7%)	761/1,344 (56.6%)	**262.2***	**.32***

Currently receiving further assessment	1,275/2525 (46.4%)	644/1132 (56.9%)	631/1393 (45.3%)	**33.58***	**.12***
On wait list to receive assessment	866/2382 (31.5%)	422/1052 (40.1%)	444/1330 (33.4%)	**11.5***	**.07***
Needs assessment	1,278/2489 (46.5%)	545/1106 (49.3%)	733/1383 (53%)	3.4 (.06)	.04 (.06)
Vulnerability on 2 or more scales	1,932/2748 (70.3%)	956/1243 (76.9%)	976/1505 (64.9%)	**47.43***	**.13***
Physical lowest 10th percentile	1,514/2733 (55.1%)	727/1236 (58.8%)	787/1497 (52.6%)	**10.7 (.001)**	**.06 (.001)**
Social lowest 10th percentile	1,618/2737 (58.9%)	812/1233 (65.9%)	806/1503 (53.6%)	**42.17***	**.12***
Emotional lowest 10th percentile	1,657/2734 (60.3%)	860/1239 (69.4%)	797/1495 (53.3%)	**73.6***	**.16***
Language lowest 10th percentile	1,069/2732 (38.9%)	448/1232 (36.4%)	621/1500 (41.4%)	**7.2 (.007)**	**.05 (.007)**
Communication lowest 10th percentile	1,620/2745 (59.0%)	849/1241 (68.4 %)	771/1504 (51.3%)	**82.68***	**.17***
1, 2, or 3 diagnoses (2 df)	2,673 (97.3%) have one; 66 have 2; 9 have 3	1,230/1243 (98.9%)	1,443/1505 (95.9%)	**25.5***	**.096***
2010 Cohort year	866 (31.5%)				
2011 Cohort year	648 (23.6%)				
2012 Cohort year	1,234 (44.9%)				

* $p < .001$

Table A2

Binary Logistic Regression Model Odds Ratios Examining Children With Other NDD Participating In Assessments Compared To Children With ASD (95% CI)

Math	Reading	Writing
Unadjusted ORs		
Grade 3		
1.04 (0.86-1.26)	1.04 (0.86-1.26)	1.05 (0.87-1.27)
Grade 6		
0.83 (0.71-0.97)*	**0.82 (0.7-0.96)***	**0.82 (0.70-0.96)***
Adjusted ORs		
Grade 3		
0.69 (0.53-0.9)*	**0.7 (.54-0.91)***	**0.71 (0.54-0.92)***
Grade 6		
0.62 (0.51-0.76)**	**0.62 (0.51-0.75)****	**0.62 (0.51-0.75)****

*$p < .05$; **After Bonferroni correction: $p \leq .001$.

Table A3

Binary Logistic Regression Model Odds Ratios Examining Children With Other NDD Who Met Assessment Expectations Compared To Children With ASD (95% CI)

Math	Reading	Writing
Unadjusted ORs		
Grade 3		
1.07 (0.76-1.5)	0.89 (0.63-1.24)	1.01 (0.70-1.44)
Grade 6		
0.65 (0.49-0.86)*	1.15 (0.88-1.49)	0.92 (0.71-1.19)
Adjusted ORs		
Grade 3		
0.7 (0.44-1.11)	**0.51 (0.32-0.82)***	**0.6 (0.37-0.96)***
Grade 6		
0.59 (0.4-0.87)*	0.87 (0.62-1.22)	**0.57 (0.41-0.81)****

*$p < .05$; **After Bonferroni correction: $p \leq .001$.

Table A4

Ratio of Participation in Assessments for Children with A Primary Diagnosis of Other NDD

Primary other NDD diagnosis	Grade 3 Math	Grade 3 Reading	Grade 3 Writing	Grade 6 Math	Grade 6 Reading	Grade 6 Writing
ADHD	207/777 (26.6%)	206/777 (26.5%)	206/777 (26.5%)	309/777 (39.7%)	310/777 (39.9%)	311/777 (40.0%)
Anxiety	21/81 (25.9%)	21/81 (25.9%)	21/81 (25.9%)	41/81 (50.6%)	41/81 (50.6%)	41/81 (50.6%)
Depression	1/4 (25.0%)	1/4 (25.0%)	1/4 (25.0%)	1/4 (25.0%)	1/4 (25.0%)	1/4 (25.0%)
ODD	14/51 (27.4%)	14/51 (27.4%)	14/51 (27.4%)	20/51 (39.2%)	20/51 (39.2%)	20/51 (39.2%)
Other mental	4/16 (25%)	4/16 (25%)	4/16 (25%)	6/16 (37.5%)	6/16 (37.5%)	6/16 (37.5%)
Global delay	24/252 (9.5%)	24/252 (9.5%)	24/252 (9.5%)	44/252 (17.4%)	45/252 (17.8%)	45/252 (17.8%)
Down Syndrome	4/128 (3.1%)	4/128 (3.1%)	4/128 (3.1%)	4/128 (3.1%)	5/128 (3.9%)	5/128 (3.9%)
FASD	9/65 (13.8%)	9/65 (13.8%)	9/65 (13.8%)	18/65 (27.7%)	18/65 (27.7%)	18/65 (27.7%)
Intellectual delay	8/97 (8.2%)	9/97 (9.2%)	9/97 (9.2%)	24/97 (24.7%)	25/97 (25.8%)	25/97 (25.8%)
Rett's/CDD	0	0	0	0	0	0
Learning disability	10/44 (22.7%)	11/44 (25.0%)	12/44 (27.3%)	16/44 (36.4%)	17/44 (38.6%)	17/44 (38.6%)

Table A5

Levene's Test And T-Tests For Continuous Variables

	Df	*F* (sig.)	*t*-statistic (95% CI)	Sig. 2-sided p	Mean difference	Cohen's *d* point estimate (95% CI)
Age	2746	0.09 (0.76)	-0.352 (-0.29-0.02)	.73	-0.004	-0.01 (-0.89-0.06)
Socioeconomic status	2746	1.78 (.18)	9.208 (0.29-0.45)	**< .001**	0.37	0.4 (0.28-0.43)

Physical domain	2731	51.83 **(< .001)**	-2.033 (-0.32- -0.005)	0.04	-0.16	-0.08 (-0.15- -0.003)
Social domain	2735	20.85 **(< .001)**	-8.45 (-0.96- -0.59)	**< .001**	-0.78	-0.32 (-0.4- -0.25)
Emotional domain	2732	65.35 **(< .001)**	-8.31 (-0.72- -0.44)	**< .001**	-0.58	-0.31 (-0.38- -0.24)
Language domain	2730	12.21 **(< .001)**	3.52 (0.18-0.64)	**< .001**	0.41	0.14 (0.06-0.21)
Communication domain	2743	51.98 **(< .001)**	-10.40 (-1.52- -1.03)	**< .001**	-1.28	-0.4 (-0.47- -0.32)

Table A6

Cross-Tabulations Of Sociodemographic Variables With Assessment Participation Outcomes For Children With Other NDD

Variable	Grade	Participation variable	X^2 and *p*-value (2-sided sig.)	Cramer's *V* (2-sided sig.)
Sex	3	Math	2.93 (.09)	0.03 (.09)
		Reading	3.38 (.07)	0.04 (.07)
		Writing	3.68 (.06)	0.04 (.06)
	6	Math	0.21 (.65)	0.01 (.65)
		Reading	0.19 (.66)	0.01 (.66)
		Writing	0.25 (.62)	0.01 (.62)
English or French language learner	3	Math	2.69 (.26)	0.03 (.26)
		Reading	0.76 (.68)	0.02 (.68)
		Writing	0.74 (.69)	0.02 (.69)
	6	Math	11.09 (.004)*	0.06 (.004)*
		Reading	11.38 (.003)*	0.06 (.003)*
		Writing	12.26 (.002)*	0.07 (.002)*
Special needs status	3	Math	**50.65 (< .001)**	**0.14 (< .001)**
		Reading	**49.17 (< .001)**	**0.13 (< .001)**
		Writing	**48.68 (< .001)**	**0.13 (< .001)**
	6	Math	**27.22 (< .001)**	**0.1 (< .001)**
		Reading	**26.7 (< .001)**	**0.1 (< .001)**
		Writing	**26.43 (< .001)**	**0.1 (< .001)**
Presence of impairment	3	Math	**86.01 (< .001)**	**0.18 (< .001)**
		Reading	**91.44 (< .001)**	**0.18 (< .001)**
		Writing	**90.84 (< .001)**	**0.18 (< .001)**
	6	Math	**26.72 (< .001)**	**0.1 (< .001)**
		Reading	**26.39 (< .001)**	**0.1 (< .001)**

		Writing	**26.19 (< .001)**	**0.1 (< .001)**
Developmental vulnerability	3	Math	**59.74 (< .001)**	**0.15 (< .001)**
		Reading	**60.49 (< .001)**	**0.15 (< .001)**
		Writing	**60.07 (<. 001)**	**0.15 (< .001)**
	6	Math	**51.1 (< .001)**	**0.14 (< .001)**
		Reading	**49.27 (< .001)**	**0.13 (< .001)**
		Writing	**48.99 (< .001)**	**0.13 (< .001)**

*p < .05. Significance level after Bonferroni correction: $p \leq$ .001

Table A7

Cross-Tabulations Of Sociodemographic Variables With Meeting Assessment Expectation Outcomes For Children With Other NDD Who Participated In The Assessments

Variable	Grade	Met expectations variable	X^2 and p-value (2-sided sig)	Cramer's V (2-sided sig)
Sex	3	Math	0.068 (.79)	0.011 (.79)
		Reading	3.95 (.05)	0.085 (.047)
		Writing	**10.23 (.001)**	0.14 (.001)
	6	Math	5.12 (.02)*	0.07 (.02)*
		Reading	0.97 (.33)	0.03 (.33)
		Writing	**13.38 (< .001)**	**0.12 (< .001)**
English or French language learner	3	Math	1.64 (.44)	0.05 (.44)
		Reading	0.63 (.73)	0.03 (.73)
		Writing	0.15 (.93)	0.02 (.93)
	6	Math	3.06 (.22)	0.06 (.22)
		Reading	4.32 (.12)	0.07 (.12)
		Writing	7.63 (.02)*	0.09 (.02)*
Special needs status	3	Math	6.77 (.01)*	0.11 (.01)*
		Reading	5.23 (.02)*	0.1 (.02)*
		Writing	7.46 (.01)*	0.12 (.01)*
	6	Math	0.23 (.63)	0.02 (.63)
		Reading	**13.97 (< .001)**	**0.12 (< .001)**
		Writing	**14.15 (< .001)**	**0.12 (< .001)**
Presence of impairment	3	Math	9.99 (.002)*	0.14 (.002)*
		Reading	**17.21 (< .001)**	**0.18 (< .001)**
		Writing	**16.82 (< .001)**	**0.18 (< .001)**
	6	Math	6.17 (.01)*	0.08 (.01)*
		Reading	**20.94 (< .001)**	**0.15 (< .001)**
		Writing	**32.24 (< .001)**	**0.19 (< .001)**
Developmental vulnerability	3	Math	**38.18 (< .001)**	**0.27 (< .001)**
		Reading	**50.52 (<.001)**	**0.31 (< .001)**
		Writing	**29.04 (< .001)**	**0.23 (< .001)**

	6	Math	**19.89 (< .001)**	**0.15 (< .001)**
		Reading	**38.56 (< .001)**	**0.20 (< .001)**
		Writing	**58.18 (< .001)**	**0.25 (< .001)**

*$p < .05$. Significance level after Bonferroni correction: $p \leq .001$

Table A8

Adjusted And Unadjusted Odds Ratios For Children With Other NDD Who Participated In Grade 3 Math Assessments And Met Assessment Expectations

	Logit (p)	OR (95% CI)	Wald test (*p*)
Block 0	-1.41 (0.05 SE)	0.245	860.5 (< .001)
Math participation unadjusted	-1.43 + 0.04*D	1.04 (0.86-1.26)	0.17 (.68)
Math participation adjusted	-19.2 – 0.37*D – 0.3*S – 0.5*E – 0.11*A – 0.57*SN – 0.39*I – 0.50*V + 0.11*SES + year	**0.69 (0.53-0.9)**	7.79 (.005)
Block 0	0.104 (0.09 SE)	1.109	1.45 (.23)
Met math expectations unadjusted	0.067 + 0.067*D	1.07 (0.76-1.5)	0.15 (.7)
Met math expectations adjusted	2.613 – 0.36*D + 0.24*S + 0.11*E – 0.17*A – 0.31*SN – 0.22*I – 1.35*V + 0.19*SES + year	0.7 (0.44-1.11)	2.23 (.13)

Note: Abbreviations in the log-odds models refer to: D: diagnosis (0=ASD reference category); S: sex (0= female reference category); E: EFL status; A: Age; SN: Special needs status; I: Impairment; V: Vulnerability; SES: socioeconomic status; Y: Year (2012=reference category). As no SE are greater than 2.0, there is no concern for multicollinearity (they were all below 0.3). None of the variables are moderately or highly correlated in the correlation matrices except SN which is moderately correlated with diagnosis in meeting math expectations (0.54) and participating in math assessments (0.43).

Likelihood ratio tests to compare nested models without covariates from the full model were also conducted to determine if the models with predictors were significantly different from zero and contributed to the prediction of assessment outcomes. The null hypotheses were that a diagnosis of ASD or NDD given the covariates was equal to zero; the alternative hypothesis was that the diagnosis of ASD or NDD given the covariates are not equal to zero. The equation used was: *-2LogLikelihood (-2LL) of the reduced model without covariates – -2LL of the full model*. Significance levels were set at p =.05 but adjusted post hoc using a Bonferroni correction to account for multiple hypothesis testing and set at p = .001.

Table A9

General Likelihood Ratio Test Comparing Full And Reduced Models For Grade 3 Math Assessments

Outcome	-2LL Reduced	-2LL Full	Deviance X^2	*Df*	*P*-value	Reject null?
Math participation	2,723.22	1,898.1	825.11	9	< .001	Yes
Met math expectations	747	697.45	49.55	8	< .001	Yes

Table A10

Adjusted And Unadjusted Odds Ratios For Children With Other NDD Who Participated In Grade 3 Reading Assessments And Met Assessment Expectations

	Logit (p)	OR (95% CI)	Wald test
Block 0	-1.40 (0.05)	0.25	855.66 (< .001)
Reading participation unadjusted	-1.43 + 0.04*D	1.04 (0.86-1.26)	0.2 (.66)
Reading participation adjusted	-18.9 – 0.36*D – 0.04*S – 0.54*E – 0.16*A – 0.51*SN – 0.45*I – 0.5*V + 0.11*SES + year	**0.7 (0.54-0.91)**	7.13 (.008)

Block 0	0.174 (0.09 SE)	1.190	4.06 (.04)
Met reading expectations unadjusted	0.24 – 0.12*D	0.89 (0.63-1.24)	0.49 (.48)
Met reading expectations adjusted	1.45 – 0.67*D – 0.24*S – 0.14*E + 0.2*A – 0.14*SN – 0.48*I – 1.56*V – 0.004*SES – year	**0.51 (0.32-0.82)**	7.81 (.005)

Note: As no SE were greater than 2.0, there was no concern for multicollinearity (they were all below 0.3). None of the variables were moderately or highly correlated in the correlation matrices except SN which was moderately correlated with diagnosis in meeting reading expectations (0.53) and participating in reading assessments (0.43).

Table A11

General Likelihood Ratio Test Comparing Full And Reduced Models For Grade 3 Reading Assessments

Model	-2LL Reduced	-2LL Full	Deviance X^2	Df	*P*-value	Reject null?
Reading participation	2,731.62	1,898.65	832.97	9	< .001	Yes
Met reading expectations	748.19	675.68	72.51	8	< .001	Yes

Table A12

Adjusted And Unadjusted Odds Ratios For Children With Other NDD Who Participated In Grade 3 Writing Assessments And Met Assessment Expectations

	Logit (p)	OR (95% CI)	Wald test
Block 0	-1.4 (0.05 SE)	0.25	854.04 (< .001)
Writing participation unadjusted	-1.43 + 0.05*D	1.05 (0.87-1.27)	0.24 (.63)

Writing participation adjusted	-18.86 – 0.35*D – 0.05*S – 0.55*E – 0.17*A – 0.5*SN – 0.44*I – 0.5*V – 0.09*SES + year	**0.71 (0.54-0.92)**	6.87 (.009)
Block 0	0.72 (0.09 SE)	2.056	62.23 (< .001)
Met writing expectations unadjusted	0.72 + 0.005*D	1.01 (0.70-1.44)	0.001 (.98)
Met writing expectations adjusted	3.6 – 0.52*D – 0.57*S – 0.32*E – 0.11*A – 0.19*SN – 0.55*I – 1.1*V – 0.03*SES – year	**0.6 (0.37-0.96)**	4.62 (0.03)

Note: As no SE were greater than 2, there was no concern for multicollinearity (they were all below.3). None of the variables were moderately or highly correlated in the correlation matrices except SN which was moderately correlated with diagnosis in meeting writing assessment expectations (.51) and participating in the writing assessments (.43).

Table A13

General Likelihood Ratio Test Comparing Full And Reduced Models For Grade 3 Writing Assessments

Model	-2LL Reduced Block	-2LL Full Block	Deviance X^2	Df	*P*-value	Reject null?
Writing participation	2,734.38	1,901.44	832.94	9	< .001	Yes
Met writing expectations	687.81	638.59	49.22	8	< .001	Yes

Table A14

Diagnostic Testing And Residuals Of 'Block 2' Adjusted Models For Children With Other NDD Who Participated In Grade 3 Assessments And Met Assessment Expectations

Measures	Math participation	Met math expectations	Reading participation	Met reading	Writing participation	Met writing

				expectations		expectations
Specificity (true negatives)	96.4%	72.7%	96.6%	64.9%	96.7%	14.0%
Sensitivity (true positives)	16.5%	55.6%	16.8%	65.1%	16.7%	93.4%
Area under the curve (AUC)	.84	.68	.84	.70	.84	.68
Hosmer-Lemeshow Test*	8.29 (.4 sig.)	14.13 (.08)	3.96 (.9)	4.57 (.8)	4.99 (.76)	3.08 (.93)
Max leverage	0.026	0.1	0.02	0.11	0.02	0.12
Max normalized residual	2.92	1.68	2.76	1.69	2.77	1.17
Max deviance residual value	2.12	1.64	2.07	1.64	2.08	1.31

*8 Df

Note: The Hosmer-Lemeshow test results have relatively small X^2 values and *p*-values are not significant (< .05), but some residuals are greater than 2 which could indicate some poor fit of the adjusted models and less accurate prediction of academic achievement outcomes based on observed values. Additionally, the AUC is consistent with the conclusion that the models can discriminate between those who participated in assessments than those who did not better than the models can discriminate between those who met assessment expectations and those who did not meet assessment expectations.

Table A15

Adjusted And Unadjusted Odds Ratios For Children With Other NDD Who Participated In Grade 6 Math Assessments And Met Assessment Expectations

	Logit (p)	OR (95% CI)	Wald test
Block 0	-0.66 (0.04 SE)	0.52	270.5 (< .001)
Math participation unadjusted	-0.56 – 0.19*D	**0.83 (0.71-0.97)**	5.53 (.02)
Math participation adjusted	2.2 – 0.47*D + 0.02*S – 0.42*E – 0.3*A – 0.51*SN – 0.19*I – 0.55*V + 0.06*SES + years	**0.62 (0.51-0.76)**	23.05 (< .001)
Block 0	-0.86 (0.07 SE)	0.42	145.34 (< .001)
Met math expectations unadjusted	-0.65 – 0.43*D	**0.65 (0.49-0.86)**	8.97 (.003)
Met math expectations adjusted	2.55 – 0.53*D + 0.48*S + 0.44*E – 0.5*A – 0.05*SN – 0.23*I – 0.9*V + 0.15*SES + years	**0.59 (0.4-0.87)**	7.29 (.007)

Note: As no SE were greater than 2, there was no concern for multicollinearity (they were all below 0.3). None of the variables were moderately or highly correlated in the correlation matrices except SN which was moderately correlated with diagnosis in meeting math expectations (.57) and participating in math assessments (.47). There were small correlations with vulnerability and impairment (~.3).

Table A16

General Likelihood Ratio Test Comparing Full And Reduced Models For Grade 6 Math Assessments

Model	-2LL Reduced block	-2LL Full block	Deviance X^2	Df	*P*-value	Reject null?
Math participation	3,518.51	3,415.8	102.71	9	< .001	Yes
Met math expectations	1,126.59	1,078.21	48.38	9	< .001	Yes

Table A17

Adjusted And Unadjusted Odds Ratios For Children With Other NDD Who Participated In Grade 6 Reading Assessments And Met Assessment Expectations

	Logit (p)	OR (95% CI)	Wald test
Block 0	-0.64 (0.04)	0.53	256.45 (< .001)
Reading participation unadjusted	-0.54 – 0.2*D	**0.82 (0.7-0.96)**	6.1 (.01)
Reading participation adjusted	2.25 – 0.48*D + 0.02*S – 0.43*E – 0.3*A – 0.51*SN – 0.19*I – 0.54*V + 0.06*SES + years	**0.62 (0.51-0.75)**	23.98 (< .001)
Block 0	0.44 (0.07 SE)	1.55	42.83 (< .001)
Met reading expectations unadjusted	0.37 + 0.14*D	1.15 (0.88-1.49)	1.05 (.31)
Met reading expectations adjusted	3.84 – 0.14*D + 0.07*S – 0.008*E – 0.35*A – 0.37*SN – 0.48*I – 0.95*V + 0.12*SES + years	0.87 (0.62-1.22)	0.64 (.43)

Note: As no SE were greater than 2, there was no concern for multicollinearity (they were all below.3). None of the variables were moderately or highly correlated in the correlation matrices except SN which was moderately correlated with diagnosis in meeting reading assessment expectations (.53) and participating in reading assessments (.47).

Table A18

General Likelihood Ratio Test Comparing Full And Reduced Models For Grade 6 Reading Assessments

Model	-2LL Reduced block	-2LL Full block	Deviance X^2	Df	P-value	Reject null?
Reading participation	3,533.59	3,430.51	103.08	9	<.001	Yes
Met reading expectations	1,267.92	1,204.34	63.58	9	<.001	Yes

Table A19

Adjusted And Unadjusted Odds Ratios For Children With Other NDD Who Participated In Grade 6 Writing Assessments And Met Assessment Expectations

	Logit (p):	OR (95% CI)	Wald test
Block 0	-0.64 (0.04 SE)	0.53	255.29 (<0.001)
Writing participation unadjusted	-0.54 – 0.2	**0.82 (0.70-0.96)**	5.92 (0.02)
Writing participation adjusted	2.25 – 0.48*D + 0.01*S – 0.44*E – 0.3*A – 0.5*SN – 0.2*I – 0.54*V + 0.06*SES + years	**0.62 (0.51-0.75)**	23.45 (<0.001)
Block 0	0.39 (0.07 SE)	1.48	35.26 (<0.001)
Met writing expectations unadjusted	0.44 – 0.09*D	0.92 (0.71-1.19)	0.43 (0.51)
Met writing expectations adjusted	4.61 – 0.56*D – 0.41*S + 0.41*E – 0.35*A – 0.41*SN – 0.55*I – 1.12*V + 0.13*SES + years	**0.57 (0.41-0.81)**	10.19 (0.001)

Note: There was no concern for multicollinearity (SE were all below .3). None of the variables were moderately or highly correlated in the correlation matrices except SN which was moderately correlated with diagnosis in meeting writing assessment expectations (.54) and participating in the writing assessments (.47).

Table A20

General Likelihood Ratio Test Comparing Full And Reduced Models For Grade 6 Writing Assessments

Model	-2LL Reduced block	-2LL Full block	Deviance X^2	Df	P-value	Reject null?

Writing participation	3,535.06	3,431.86	103.2	9	< .001	Yes
Met writing expectations	1,277.84	1,175.86	101.97	9	< .001	Yes

Table A21

Diagnostic Testing And Residuals Of 'Block 2' Adjusted Models For Children With Other NDD Who Participated In Grade 6 Assessments And Met Assessment Expectations

Measures	Math participation	Met math expectations	Reading participation	Met reading expectations	Writing participation	Met writing expectations
Specificity (true negatives)	94.6%	95.4%	94.4%	28.0%	94.4%	39.5%
Sensitivity (true positives)	12.0%	9.0%	12.2%	84.0%	12.3%	79.9%
Area under the curve (AUC)	.62	.65	.62	.65	.62	.68
Hosmer-Lemeshow test*	12.69 (.12)	5.63 (.69)	8.41 (.4)	6.62 (.58)	10.3 (.25)	15.33 (.05)
Max leverage	0.01	0.06	0.01	0.06	0.01	0.06
Maximum normalized residual	2.70	2.78	2.71	1.38	2.72	1.65
Maximum deviance residual value	2.06	2.08	2.06	1.46	2.07	1.62

*8 Df

Note: The Hosmer-Lemeshow test results have relatively small X^2 values (though larger than Grade 3 cohort) and almost all *p*-values are not significant (< .05), but most residuals are greater than 2 which could indicate some poor fit of the adjusted models and less accurate prediction of academic achievement outcomes based on observed values.

Table A22

Number Of Children With Other NDD Who Also Had A Secondary Or Tertiary Diagnosis Of ASD

Other NDD	Number of children
ADHD	7
Anxiety	0
Depression	1
ODD	0
Other mental disorder	4
Global delay	0
Down Syndrome	1
FASD	3
Intellectual delay	13
Learning disability	3

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Chapter 3

Exploring The Role Of Child Development Policies And Programs In Two Canadian Provinces: A Realist Review

Preface

The paper presented in the following section is the final, non-peer reviewed paper to be submitted for consideration in an academic journal. I conducted the study under the supervision of MJ, TB, ED, JRD and wrote the original draft. RH and I conducted the screening and analysis of the articles. All authors, Rita Jezrawi, Teresa Bennett, James R Dunn, Rhyan Hawke, Eric Duku, and Magdalena Janus contributed to the conceptualization of the study, methodology design, editing and reviewing the manuscript, and approved the final version.

The study did not require ethics approval. The study received support from a Social Sciences and Humanities Research Council Doctoral Fellowship.

Abstract

Background: Differences in the range of child developmental policies, early identification, or early intervention programs contribute to differential health outcomes.

Methods: A realist review with a systematic search and qualitative description analysis was conducted in three databases for articles from 2014-2024 with content focused on early years (0-6 years) child development policies or programs to understand how child developmental programs/policies facilitate entry to early identification/intervention in Ontario and Manitoba.

Results: 31 out of 514 potential articles and 7 webpages were included. Themes developed from qualitative description and inductive analyses were: 1) consistent and accessible educational programming 2) interconnected policy environment 3) clinical evidence and training 4) provider, system, and family/child traits.

Conclusion: Child development can be enhanced by addressing training and access barriers for families and care providers. Challenges in referrals, waitlists, clinical training, and eligibility criteria can be addressed to streamline access to services.

Early childhood interventions are practices or policies that enhance a child's healthy development, if they are vulnerable to atypical development due to material, biological, or socioenvironmental factors. Early intervention strategies aim to create psychosocial priming mechanisms that encourage new skill development, exploration of the environment, and stimulate language development, thus contributing to cognitive, social, and emotional changes in children (Ramey & Ramey, 1998). The goal of early intervention is to prevent atypical development or identify/treat neurodevelopmental concerns and facilitate supportive relationships in the home and school (Center on the Developing Child, 2007). Interventions to address these issues, such as early identification and early intervention programs may vary from jurisdiction to jurisdiction, potentially contributing to differential health outcomes for children with neurodevelopmental conditions. This paper reviews child neurodevelopmental policies and programs in the Canadian provinces of Ontario and Manitoba and explores how these policies and programs facilitate entry to early identification/early intervention services and developmental outcomes from birth to school age. Established programs and policies implemented decades prior may be responsible for changes in developmental health and educational outcomes. For example, changes related to screening services, education strategies, cross sectoral collaboration, new guidelines, and programs such as financial subsidies, diagnostic clinics, literacy centres, or behavioural analysis programs, could introduce more effective identification and intervention methods for children with neurodevelopmental concerns. Exploration of the community traits, neighbourhood differences, and provincial barriers responsible for variations in access to services sheds light on the potential predictors/risk factors for vulnerability to developmental concerns and possible impacts on health outcomes (e.g., academic outcomes, prevalence rates of health disorders over time).

Neurodevelopmental disorders (NDD) result from atypical brain development during childhood and are characterized by impairments in functioning, communication, behaviour, and social and physical skills (Mullin et al., 2013; Morris-Rosendahl, 2020). During 'critical periods' of brain development, psychosocial stressors or material conditions can contribute to neurodevelopmental issues, and as the child ages, the capacity to learn and adapt can become more difficult, thus affecting them long term (Center on the Developing Child, 2007). Early identification and early intervention have been shown to make a significant impact on outcomes for children. Several evidence-based programs and early interventions have been developed and studied, such as the Kids in Transition to School (KITS) intervention involved therapeutic playgroups and skill development (Hoffman et al., 2020; Pears et al., 2018), the Naturalistic Developmental Behavioural Interventions (NDBI) (Schreibman et al., 2015), and parent focused programs such as Incredible Years (Gardner & Leijten, 2017) or Family Check Up (Metcalfe, 2024).

Substantive Theories

Guralnick (2001;2005) outlines a model for early intervention for children and families that involves moving through stages of screening, referral, assessments, entry into intervention programs, and ongoing monitoring of outcomes before transitioning out of early intervention and into other forms of care. Outreach and intervention might be done in traditional childcare or kindergarten classroom settings, community and family-based programs, or clinical programs in healthcare settings (Underwood, 2012). The developmental systems model also outlines child and family characteristics that impact child development outcomes. These can be stressors such as family distress, resource needs, confidence threats, information needs, and quality of parent-child transactions, family-child experiences, and health and safety provided by the family (Guralnick, 2011).

The Bronfenbrenner ecological systems theory is a commonly applied, though rarely used for children with NDD, theoretical model of human development. This model is centred on child and family and explains the interplay between components of micro- and macro-systems such as social services, neighbourhoods, schools, health services, as well as familial and individual traits (Bronfenbrenner, 1995). Interactions within and between different levels of social systems can impact behaviour; a child's development often depends on the environmental contexts where development occurs, the child's biopsychological characteristics, and historical events and environmental changes over time (Bronfenbrenner, 1995). Supportive and positive family interactions, community resources, and the presence or absence of stressful conditions (or damaging social determinants of health) can motivate or discourage families from seeking out early identification or early intervention services.

Objectives

The aim of this study was to conduct a review to explore infant and child neurodevelopmental services across two Canadian provinces. The second aim was to understand how contexts and mechanisms of healthy child development policies related to early intervention and identification services can generate differential developmental or health-related outcomes. The research questions were: 1) What child neurodevelopmental policies and programs operate in the Canadian provinces of Ontario and Manitoba, and 2) how do these policies facilitate entry to early identification/early intervention services and developmental outcomes from birth (0) to school age (6)?

Methodology

The literature review methodology used was a realist review/synthesis approach (Pawson et al., 2004). Early identification/intervention systems involve many actors and processes which are embedded in social systems that are susceptible to changes over time (Pawson et al., 2004). This makes a realist review a suitable methodology for studying early child development policies and programs. The purpose of a realist review is to answer what generative causal forces (mechanisms) make a program or policy work (outcomes) for whom and under what circumstances (contexts) (Pawson et al., 2005). Context refers to the environmental background of a program and any social, economic, political, and organizational structures (e.g., legislation, history, geography), cultural and social norms and relationships which may facilitate or prevent mechanisms from being triggered (Wong et al., 2013a; Pawson et al., 2004; Weger et al., 2020; Jagosh, 2019). Mechanisms are processes (typically unobservable) involving people's reactions and interactions associated with the intervention that triggers changes and produces outcomes (Wong et al., 2013a; Weger et al., 2020; Jagosh, 2019). Outcomes refer to unintended or intended effects of a particular intervention (Jagosh, 2019). This review followed the RAMESES publication standards for realist syntheses (Wong et al., 2013b). Ethics approval was not required.

Data Search

Exploratory literature searching on the Internet using Google Search engine and Google Scholar identified child development program/substantive theories that formed the basis of the introductory section of the paper and tested key search terms for their effectiveness in curating relevant articles. The databases chosen covered health and social science research fields: ProQuest (Canadian Business and Current Affairs, Canadian Research Index, Politics Collection, Sociology Collection, ERIC), Ovid (Embase, Medline, HEALTHSTAR, APA PsycInfo), and

Web of Science Core Collection and Theses. Geographic search filters were applied as per the inclusion criteria. The second phase of the search was purposive hand searching using free text terms on Google Scholar for published literature. The third phase was a non-exhaustive search for public policies on provincial websites (healthcare and child/youth and family services webpages) to fill in knowledge gaps where the systematic search did not capture certain known? policies or groups (e.g., autism-specific policies). The searches are provided in Table 1.

Inclusion/Exclusion Criteria

The inclusion criteria were as follows:

1) Publications are written in English
2) Based in Ontario, Canada or Manitoba, Canada
3) Content focused on child development policies/services/projects/programs, including pathways to early identification of neurodevelopmental concerns or early intervention practices
4) Content includes information on mechanisms (processes or structures that trigger outcomes) or effectiveness/implementation outcomes (effectiveness, unintended effects, equity, cost, acceptability, or feasibility)
5) Includes the 'early years' child population aged 0 up to and including school-entry (ages 5-6)
6) Papers are published between 2014-2024 (last 10 years)

The exclusion criteria were as follows:

1) Topic solely based on children in child protective services or welfare system
2) Topic solely based on population of middle years 6-12 or adolescents aged 13-18
3) Topic solely based on hearing or vision services

4) Topic solely based on mental health/addiction issues
5) Topic solely based on childcare facilities/centres
6) Topic based on assistive devices and technology
7) Programs/policies solely within federal jurisdiction
8) No full-text article available
9) Study protocols

Ontario and Manitoba were the jurisdictions chosen for several reasons: 1) similarities in community characteristics but differences in neurodevelopmental prevalence, incidence, and policy priorities suggest there are enough differences in policies to make for a fuller analysis, 2) builds on other studies that have used linked administrative databases and surveillance programs in Ontario and Manitoba, in addition to data availability to support a future quantitative analysis to supplement this study and 3) anecdotally Manitoba has a strong early identification/intervention system beyond autism-focused services, and thus is a good example for other provinces to learn from, while Ontario has had many changes in their early identification and intervention systems over the last few decades.

The search and extraction were conducted from January to April 2024. Results were extracted into EndNote software and then Covidence. Duplicates were mainly automatically removed by Covidence with some manual removal of duplicates. Articles were screened for relevance and inclusion criteria based on their title and/or abstract in the first stage and then their full text in the second stage. In full-text screening, studies were judged based on their relevance to the synthesis and their ability to contribute to theory generation (Morestin et al., 2010; Pawson et al., 2005). A data extraction form was created and included the year of the article, year of the policy/program introduction (if applicable), province, methods used, and major findings. A critical appraisal of study quality was not conducted; there was a diversity of mixed methods, qualitative, and quantitative studies which makes a uniform quality appraisal difficult to do for public policy research (Morestin et al., 2010). Appraisal of evidence in realist reviews is typically based on its relevance to addressing the theories/programs (Pawson et al., 2004).

Data Analysis

The full-text articles were uploaded into EndNote. Data from the articles and webpages were recorded into the data extraction form in Microsoft Excel by the primary investigator (RJ). I collected the descriptive data on publication year, policy/program name, province covered, study design, objective, and main findings in the data extraction form to provide an overview of each document's characteristics. I took a general inductive qualitative analytical approach based on the interpretation of raw data and constant comparison (Thomas, 2003), and a qualitative description approach (Sandelowski, 2000). Qualitative description is a form of inquiry that sticks close to the data collected and describes phenomenon in the form of a comprehensive summary or answer to a question (Sandelowski, 2000). The purpose of the general inductive approach is to summarize text and establish clear links between the research questions and the data (Thomas, 2003). The main approach consisted of coding the papers, identifying patterns, and linking the findings to theory (Doyle et al., 2020).

Each paper was read, and text segments were highlighted and categorized with the realist evaluation framework of context, mechanism, and outcome, and summarized in the data extraction form (Peters, 2024). The extracts were then consolidated by aggregating similar programs together. Codes of salient phrases or words were generated from the grouped summaries and aggregated into similar categories presented in Table A6. The categories were consolidated to create common themes. This analysis was iterative, with the authors going back and forth between articles and text segments. The data extraction and analysis were conducted by the primary investigator (RJ), a research assistant (RH), and reviewed by the research team. Results were discussed in an ongoing process with the research team.

Results

The screening of articles was conducted by the primary investigator (RJ) with a second title and abstract screen by a research assistant (RH). Any discrepancies were discussed and resolved. Figure 1 outlines the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flowchart for the article selection process. From 514 potential articles uploaded into Covidence, 34 duplicates were removed and 435 were excluded during title/abstract screening by both reviewers, which left 45 articles for full-text review. Of 45 articles, 31 articles were included.

Of the 31 articles retained for analyses, four articles discussed both Ontario and Manitoba, 8 focused on Manitoba, and the remaining 19 on Ontario. Main characteristics of the studies are outlined in Table A1. I also purposively searched provincial government webpages and identified seven webpages on public programs/policies that did not appear in the literature search. Analytical results of the studies are outlined in the Tables A2, A3, A4, and A5.

Themes in documents in both provinces were identified (Table 2): 1) importance of engaging, aligned, connected, and shared policy environment, 2) adequate evidence base for clinical guidelines, and knowledge/training for clinicians on assessment, treatment, referral of NDD, 3) intervention success dependent on child and family characteristics and provider/system barriers, 4) intervention environment focused on opportunities to develop social, emotional, psychological, behavioural and cognitive skills, and 5) consistent, frequent, accessible, and informative program composition.

Discussion

Contexts

Social Contexts and Family Characteristics

The programs reviewed in both provinces underwent similar constraints such as family circumstances (e.g., time, motivation, socioeconomic status, knowledge) or limited system resources (e.g., workload and documentation burden) which made it difficult to access or continue participation in child development programs. Social determinants of health outlined in the documents provide some context for how these programs operate. Those experiencing the impacts of family poverty/socioeconomic status (Enns et al., 2019; Russell et al., 2019; Wright et al., 2019), ethnicity/newcomer status (Russell et al., 2018) and single parenthood (Struck et al., 2021; Enns et al., 2019; Russell et al., 2018) may benefit from child development services designed for them in mind.

Policy Environments, System Focus, and System Capacity

In Manitoba, collaborative and community-centric policy networks and similar values across departments highlighted the importance placed on healthy child development across several sectors, including education (Auclair, 2019). Manitoba's political and organizational structures have facilitated a wide range of public services and supports for families and children with neurodevelopmental concerns not documented in Ontario at the time of this study, such as prenatal benefits and childcare subsidies, though recent federal-provincial agreements and other municipal programs can provide subsidized childcare.

In Ontario, child development policy has shifted with growing evidence that supported early years investments and family-centred services, though siloed and fragmented communication pathways remain (Underwood & Trent-Katz, 2015; Williams et al., 2021;

Cressman et al., 2020; Cressman et al., 2021). Ontario's health system has been focused on the provision of diagnostic and treatment services, such as developmental screening and autism treatment hubs. Some articles discussed the use of standardized measurement tools in Ontario to monitor developmental and communication milestones (Binns et al., 2022), despite mixed evidence and professional support at the time (Guttmann et al., 2020). The introduction of federal clinical guidelines also facilitated service uptake (Novak, 2014; Geddes, 2015; van den Heuvel et al., 2016). The burden in Ontario for accessing these services also rested heavily on the work of families and parents who interacted with institutions for referrals, assessments, and treatments, much of which depend on everchanging documentation and eligibility requirements (Underwood et al., 2016).

Manitoba has a large system capacity for assessment/treatment of FASD; one large, centralized FASD diagnostic clinic in Manitoba has a greater clinical capacity than Ontario's 15 smaller clinics (Popova et al., 2024). Manitoba's FASD Centre is coordinated alongside school divisions; strong partnerships enable streamlined referrals to the centres by schools, parents, family services, or physicians (Millar et al., 2017). FASD professional development training is also provided to teachers and educational assistants to better support the student educational experience (Millar et al., 2017). Communication and collaboration occur between workers and families to produce individualized learning plans for children, follow-ups at school, and personalized support strategies for the child, which serve to improve social, emotional, educational, and physical outcomes for children with FASD (Millar et al., 2017). Ontario also has school-based strategies such as partnerships between hospitals to conduct developmental assessments at school clinics (Cheung et al., 2017) and mental-health related service providers accessed at school, especially for behavioural disorders (Georgiades et al., 2019). However, these settings do not solely focus on FASD and there is no established coordination between schools and diagnostic centres, resulting in fragmented care.

Mechanisms

Social, Psychological, and Cognitive Skill Development

Greater awareness of NDD within public and government spheres has created more opportunities to provide healthy child development policies and address social inequities (e.g., Millar et al., 2017; Wright et al., 2019). The programs reviewed were family-oriented, and targeted social and psychological mechanisms to boost family-child attachments, parenting education, community participation and engagement, and emotional, social, and/or financial support. For instance, access to timely support or healthcare when challenges arise results in less anxiety (Wright et al., 2019). The programming in both provinces aimed to increase social or community support and positive/prosocial behaviour for children and families (e.g., MCCSS, 2019; MCCSS, 2022b) or provide some referral, diagnostic, or clinical services (e.g., Georgiades et al., 2019; Dugas et al., 2022; Popova et al., 2024).

For social and community programming to be most effective, interventions should be delivered frequently and regularly. Some programs focused on cognitive development, providing children with early and repeated exposures to literacy and math concepts that may not be readily practiced in the home (Polyzoi et al., 2020). More frequent practice of language and communication skills and reciprocal social interaction using play in the Preschool Speech and Language Program enables children with speech challenges to better express themselves, communicate with peers and family, which build their relationships and compound their language skills in and outside of the intervention setting (Braund & Timmons, 2021; Binns et al., 2022; Cunningham & Rosenbaum, 2015; Cunningham et al., 2017; Cunningham et al., 2018).

System and Provider Characteristics, Knowledge, and Training

Human and clinical resources, waitlists, service caps, eligibility criteria or proof of documentation lead to reduced service access and availability and less contact with the public healthcare system; programs that provide material resources (e.g., meal programs) may incentivize others to access services (Russell et al., 2018; Wright et al., 2019). Physician remuneration also motivates providers to conduct developmental assessments (Guttmann et al., 2020; Novak, 2014, Nurse et al., 2024; van den Heuvel et al., 2016). Provider traits also impact the success of these programs in identifying or intervening in early child development. Physician education, type and recency of clinical training, professional difference of opinion, timely availability, impact if and how referrals and assessments are conducted; some physicians provide more comprehensive care if they are aware of a potential or definite diagnosis of autism (Binns et al., 2022).

Manitoba has strong stakeholder relationships, partnerships and collaboration between providers, and family input in education planning (Auclair, 2019; Millar et al., 2017). In Ontario, formal and informal interdisciplinary support, and presence of guidance documents for professionals enable families and providers to discuss a child's developmental status more openly (Guttmann et al., 2020; Novak, 2014, Nurse et al., 2024; van den Heuvel et al., 2016). The emphasis in both provinces on interdisciplinary staffing models and guidelines may also facilitate early identification and intervention as interdisciplinary providers can conduct a more holistic assessment and provide/help the family navigate a variety of intervention treatments based on child and family needs. The focus on diagnostic tools in Ontario may facilitate early identification by providers who do not have specific training on NDD and need guidance on what functional skills and milestones they should be cognizant of.

Child Characteristics

Child traits such as responsiveness and severity of symptoms also impact how intervention progresses. Socially responsive children may have an easier time learning new concepts and increasing positive interactions with family as parents help build the child's language skills by modelling and expanding sentences for the child (Binns et al., 2022; Cunningham & Rosenbaum, 2015; Cunningham et al., 2017; Cunningham et al., 2018).

Family Characteristics

Family characteristics such as willingness/agreement to participate or share information (Russell et al., 2018), emotional stigma (Binns et al., 2022), urban living environment (Struck, 2020; Struck et al., 2021), mistrust in the healthcare system (Struthers et al., 2019) affect the consistency and frequency of interaction with programs. For example, mothers with vulnerable profiles (e.g., low income, single parenthood, substance use) are more likely to use the Healthy Baby Community Support program (Struck, 2020), suggesting that this program is successfully targeting those with negative social determinants of health. Less frequent exposure to programming in rural areas means the full benefits of participation are not achieved (Struck, 2020). Non-participation in unconditional programs such as the Healthy Baby Prenatal Benefit may be hindered by lack of existing social support and lack of awareness of eligibility (Struthers et al., 2019).

Program Composition

Other programming mechanisms such as a welcoming atmosphere (Underwood & Trent-Katz, 2015) or family-focused and evidence-based teachings and techniques (Province of Manitoba, 2019) enable families to feel more connected, empowered, educated, and provide direction to monitor their child's developmental progress. Trust in the healthcare system seems to preclude applying to eligible benefits (Enns et al., 2021), suggesting that public health systems and governments need to invest in building or rebuilding trust to target vulnerable groups and ensure those who are aware of and eligible for such programs will not be discouraged from applying. Family involvement and motivation or willingness to participate in early interventions is important, and relies on knowledge of the programs existing, the accessibility of the intervention, and awareness of how atypical development may present in children.

Similar explanatory mechanisms are mentioned in the literature. The quality of family-child interactions, quality of school supports, and a child's experiences are impacted by family stressors such as family characteristics, financial resources, social networks, and the child's traits (Guralnick, 2005). Higher quality, more positive family-child experiences, support (as opposed to social isolation), adequate healthcare (e.g., immunizations), protection, and nutrition produce positive developmental outcomes (Guralnick, 1998; Guralnick, 2005). Interventions generate emotional and psychological responses in caregivers, as they feel more supported and motivated, more responsive and involved, understand their child better, and have more family cohesion (Guralnick, 2005; Green & Garg, 2018). Children also respond with more attentiveness, joint attention, and cognitive stimulation (Reynolds et al., 2017).

Outcomes

Across both provinces, the practice of identifying developmental concerns was intended to be accessible, family-centred, and evidence based. However, due to system and provider barriers, referrals and screenings may not result in timely diagnoses. The early interventions promoted language/speech, behavior regulation, cognition, and the development of other crucial life skills, though barriers to access these interventions involved wait times and diagnosis-dependent eligibility criteria. Social, emotional, communication, and behavioural outcomes were mixed in Ontario and Manitoba. For instance, the Families First Home Visiting program found no associations with child developmental health at school entry (Enns et al., 2019). The Healthy Baby Prenatal Benefit demonstrated positive associations with program participation and language/cognitive development and general knowledge/communication domains of child development at school entry for First Nations children (Enns et al., 2021), but no associations with any domains for Metis women (Struck et al., 2021). The Healthy Baby Community Support Program had lower odds of developmental vulnerability in some domains (Struck, 2020). There was a positive association with a childcare subsidy program for children with special needs and higher developmental scores, but not for extremely poor families (Polyzoi et al., 2020).

Program Composition and Satisfaction

Quality of programming was a facilitator of child neurodevelopment services and early intervention. Ontario has clinical, school, and community-based programming to identify and address developmental concerns (e.g., standardized screening checklists) but in one study caregivers reported lower satisfaction with specialized services and more satisfaction with general family-based programming (Underwood & Trent-Katz, 2015). Trusted connections between family and staff make it easier for parents to continue with programming, seek further care, and be encouraged to join other programming. For example, the Families First home visiting program recipients have a gateway to Healthy Baby Community Support program (Enns et al., 2019).

The results of this study further reinforce the importance of collaborative and communicative policy environments for decision-making, as well as collaborative and connected healthcare, education, and social systems that provide professionals with up-to-date training and knowledge on how to assess, refer, or treat children with developmental concerns or vulnerable to atypical development, thus improving service provision and quality of care. The comparative nature of this study contributes to knowledge on how variations in program access, type, and availability result from provincial decisions and system arrangements and interactions that occur over time between public policies and actors, events, contexts, and outcomes (Weible, 2018). The comparisons also highlight implementation considerations for existing policies which can also be extrapolated for prospective policy proposals. The results provide opportunity to compare how political, economic, and social decisions regarding child development services facilitate entry to early identification or intervention, and how early intervention does not necessarily begin once a child has been identified with a developmental concern.

Similarities and differences reflect the literature synthesized here and not a reflection of all child development policies related to early identification or intervention, nor a reflection of how these programs play out in real life. Research and policy documents do not always reflect the true nature of program success especially with fluid political and economic conditions, but this type of analyses was outside of the scope of the study. This is a future avenue to explore using administrative health data repositories in both provinces. Realist reviews hold some limitations such as the breadth of the literature covered, the nature and quality of the literature, and thus limitations on what recommendations are possible to make (Pawson et al., 2005). The absence of input from policymakers or practitioners left a gap in stakeholder validation of results. Future consultation with policymakers could strengthen the plausibility and usability of mechanisms, and what stakeholder perspectives have influenced the acceptability of these programs across provinces.

Conclusion

This study provides a synthesis and overview of early identification and intervention policies, programs, and projects within Ontario and Manitoba, with a variety of quantitative and qualitative data that spans decades. The composition, intent and purposes of the programs explored in this study align with evidence and theories on healthy child development. The documents support existing evidence that interventions that are convenient (e.g., low effort/low barrier to entry for families), accessible (e.g., in physical proximity, in pre-existing establishments such as school, hospital, or community), and free/low cost may improve early identification and early intervention practices. Early intervention services do not need to be clinical in nature, as shown in the documents reviewed. Manitoba and Ontario have similar challenges within their health and social systems, but care can be improved in both provinces by targeting barriers in family circumstances that limit their ability to participate or access care more efficiently. Additionally, addressing limitations in the process of referral, waitlists, and eligibility would ensure more streamlined access to relevant and culturally appropriate services. Addressing current resource limitations such as communication bottlenecks, service caps, and up-to-date clinical training would ensure care providers are equipped to identify developmental concerns and educate caregivers.

Table 1

Systematic Search Strategy in Three Databases For Literature On Child Development Policies In Manitoba And Ontario

Database	Search string	Filters applied	Number of results
ProQuest (Canadian Business and Current Affairs, Canadian Research Index, ERIC, Politics Collection, Sociology Collection)	((noft(Ontario) OR noft(Manitoba)) AND (noft(child development) OR noft(infant development)) AND (noft(health) OR noft(developmental disorder) OR noft(early identification) OR noft(early intervention) OR noft(referral) OR noft(entry point) OR noft(centralized intake) OR noft(diagnosis) OR noft(screening) OR noft(educational assessment)) AND (noft(policy) OR noft(program)))	2014-2024; English; Peer-reviewed; Ontario, Canada; Manitoba, Canada	133
Web of Science Core Collection	TS=(((Ontario Canada or Manitoba Canada) and (child development or infant development) and (health or developmental disorder or early identification or early intervention or referral or entry point or centralized intake or diagnosis or screening or educational assessment) and (policy or program)))	2014-2024; English; Canada; Child or Infant MeSH headings	300

Ovid (Embase, Medline, HealthSTAR, APAPsycInfo, AMED, EMCARE)	((Ontario or Manitoba) and (child development or infant development) and (health or developmental disorder or early identification or early intervention or referral or entry point or centralized intake or diagnosis or screening or special education or inclusive education or educational assessment) and (policy or program)).mp. [mp=ti, ab, hw, tn, ot, dm, mf, dv, kf, fx, dq, nm, ox, px, rx, an, ui, bt, sy, ux, mx, tc, id, tm]	Keyword, 2014-current, English, Humans, auto-de-duplicate	18
Google Scholar/Personal Library	Keyword search: Manitoba, Ontario and early and child and development and identification and intervention Manitoba Ontario and early and child and development and referral and early identification Ontario autism program Manitoba autism program	n/a	63

Table 2

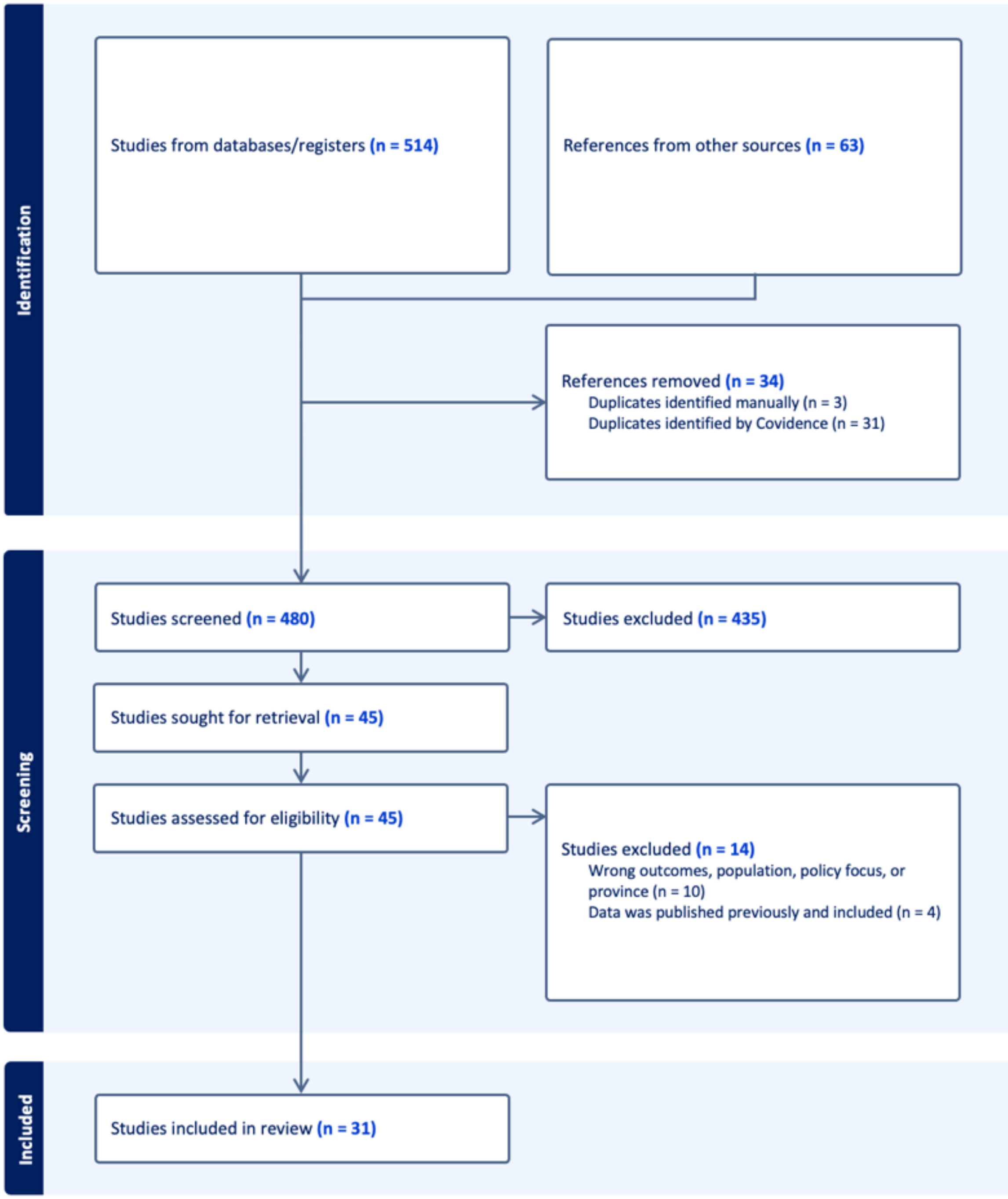
Categories And Themes Developed From The Data Extraction Summaries

Themes	Categories
A connected, engaging, aligned, and shared policy environment	• Policy environment • Policy acceptability • Information exchange • Stakeholder engagement • Resource availability • Data generation and surveillance • Family-centred principles
Adequate evidence and training for providers on assessment, treatment, and referrals	• Physician training • Physician demographics • Physician knowledge • Research/evidence base • Lack of communication/collaboration • Diagnostic assessments and early identification
Intervention success dependent on provider and system barriers and facilitators and child/family characteristics	• Wait times • Availability of resources and programs • Accessibility of resources and programs • Outreach • Provider barriers & facilitators • System barriers & facilitators • Staff to educate and support • Child/family circumstances • Child/family characteristics • Social determinants of health • Parental knowledge and acceptance

Intervention environment focused on opportunities to develop skills for child and family	• Child development • Family wellbeing • Social, literacy, cognitive, emotional, psychological, and sensory development • Family attachment • Informed and educated family • Ability to care for child
Consistent, frequent, accessible, and informative program composition	• Resource sharing and capacities • Further assessments • Meaningful outcomes • Diagnosis, diagnostic capacity, and accuracy • Eligibility and referral processes • Program resource availability and accessibility • Connection to other programs or resources • Authority to diagnose or treat • Interdisciplinary care

Figure 1

PRISMA Flow Diagram



Appendix 1

Data Analyses of Included Articles

Table A1

Characteristics of the Articles Included in The Synthesis

Author-year	Province	Policy year	Policy name	Study purpose and methods
Auclair, J.V. (2019).	MB	2000 (legislated 2007)	Healthy Child Manitoba Strategy	Qualitative document analysis and 24 semi-structured interviews of policy actors collected in 2015 to explore perceived benefits and challenges of the policy strategy
Binns, A. V., Cunningham, B. J., Andres, A., & Cardy, J. O. (2022).	ON	1997/1998 (estimate)	Preschool Speech and Language Program	Qualitative and quantitative cross-sectional online survey for speech/language clinicians to understand assessment and intervention practices used by clinicians delivering the program
Braund, H., & Timmons, K. (2021).	ON	2016	Revised play-based full day kindergarten	Qualitative document analysis of the 2016 Ontario kindergarten curriculum and content analysis of theories in existing literature from the last ten years, conducted in 2018-2019 to compare conceptualization and definitions of self-regulation within the kindergarten program to existing theories and definitions in the literature
Burns, J. I., Harding, K. D., Watson, S. L., Unsworth, K., & Cook, J. L. (2023).	ON	2011 (first clinic)	FASD Diagnostic Clinic	Retrospective chart review of secondary quantitative data analysis of 292 children assessed for FASD to describe profile of children who receive assessments for FASD and who receive a diagnosis in Northeastern clinics
Cheung, A., Jegathesan, T., Mantini, A., Chan, J., Das, R. V., Aiyadurai, R., & Freeman, S. (2017).	ON	2011	Models School Pediatric Health Initiative School-Based Health	Conference proceeding of retrospective chart review from 2011 to 2014 to assess impact of clinic on wait times for developmental health assessments

			Clinic (SBHC)	
Cressman, C., Miller, F. A., Guttmann, A., Cairney, J., & Hayeems, R. (2020).	ON, MB	2009	Developmental screening; 18-month enhanced well baby visit	Case study design and interpretive qualitative analysis of interviews with expert informants from 2014-2015 to explore how Canadian experts rationalize their push for population-level developmental screening interventions and their policy goals
Cressman, C., Miller, F. A., Guttmann, A., Cairney, J., & Hayeems, R. Z. (2021).	ON, MB	2009 (ON), 2000 (MB)	Ontario 18-month Enhanced Well Baby Visit; Healthy Child Manitoba Strategy	Comparative case study design utilizing qualitative document analysis and key informant interviews from 2014-2015 to understand child health policy governance arrangements and agenda setting in Ontario and Manitoba
Cunningham, B. J., & Rosenbaum, P. L. (2015).	ON	1997/1998 (estimate)	Preschool Speech and Language Program	Framework analysis and application of bioecological theoretical framework to program to identify intervention environment, child-level, and system-level factors that influence child development and communicative participation outcomes
Cunningham, B. J., Hanna, S. E., Oddson, B., Thomas-Stonell, N., & Rosenbaum, P. (2017).	ON	1997/1998 (estimate)	Preschool Speech and Language Program	Longitudinal secondary data analysis of program evaluation data of cohorts of children accessing services from 2012-2016; mixed effects modelling to explore communication and functional outcomes of preschool children accessing the program
Cunningham, B. J., Hanna, S. E., Rosenbaum, P., Thomas-Stonell, N., & Oddson, B. (2018).	ON	1997/1998 (estimate)	Preschool Speech and Language Program	Longitudinal secondary data analysis of program evaluation data (two assessment tools and informal checklists completed by speech language pathologists every 6 months) of cohorts of children accessing services from 2012-2016; mixed effects modelling to explore predictors of outcomes of preschool children accessing the program and receiving assessments two or more times between 18-67 months of age

Dugas, E. N., Poirier, M., Basque, D., Bouhamdani, N., LeBreton, L., & Leblanc, N. (2022).	Western and Central Canada	N/A	Canadian FASD Research Network (2005); Canadian FASD Diagnostic Guidelines for diagnostic clinics (2016)	Cross-sectional quantitative survey in 2021 of participating clinics in the network found via purposive sampling to describe clinical capacity (skills/resources to conduct assessments and diagnoses and support) for FASD assessment and diagnosis in three groups - infants <18 months, preschool children 18 months-5 years, and youth/adolescents 6-18 years old in Western and Northern Canada (British Columbia, Alberta, Manitoba, Saskatchewan, and Yukon), Central Canada (Ontario and Quebec), and Atlantic Canada
Enns, J. E., Chartier, M., Nickel, N., Chateau, D., Campbell, R., Phillips-Beck, W., Sarkar, J., Burland, E., Lee, J. B., Katz, A., Santos, R., & Brownell, M. (2019).	MB	1999	Families First Home Visiting Program	Quantitative secondary analysis of 2003-2016 program data linked with administrative data of families who met eligibility criteria for the program at the universal newborn screen and parent survey (2003-2009) and enrolled compared to those who did not enroll to assess impact of program on public health outcomes
Enns, J. E., Nickel, N. C., Chartier, M., Chateau, D., Campbell, R., Phillips-Beck, W., Sarkar, J., Burland, E., Katz, A., Santos, R., & Brownell, M. (2021).	MB	2001	The Healthy Baby Program (Healthy Baby Prenatal Benefit)	Generalized linear models of linked administrative datasets of cohorts of First Nations women who were eligible and received the benefit versus those who were eligible but did not receive the benefit for live births between 2003-2011 to determine impact of prenatal benefit on birth and childhood health outcomes
Geddes, A. (2015).	ON	N/A	FASD services	Integrative literature review of literature published up to 2015 to describe FASD services in Ontario,

				strengths/weaknesses, and recommendations for improvement
Georgiades, K., Duncan, L., Wang, L., Comeau, J., Boyle, M. H., & Ontario Child Health Study. (2019).	ON	N/A	General mental health services	Parent reported service contact in a province-wide cross-sectional survey using a cluster and stratified sample of families from the Canadian Child Tax Benefit file and a neuropsychiatric diagnostic interview from 2014-2015 to determine prevalence and sociodemographic predictors of mental disorders and service contact
Guttmann, A., Saunders, N. R., Kumar, M., Gandhi, S., Diong, C., MacCon, K., & Cairney, J. (2020).	ON	2009	Enhanced 18-month well-child visit	Cross-sectional, quantitative analysis of linked health and administrative datasets of cohorts of children from 2009-2017 aged 17-24 months to determine uptake using physician billing claims and covariate characteristics of child, family, and providers
Millar, J. A., Thompson, J., Schwab, D., Hanlon-Dearman, A., Goodman, D., Koren, G., & Masotti, P. (2017).	MB	N/A	FASD education programs	Literature review/knowledge summary; consensus-generating workshop of 36 FASD education professionals in 2013 to describe prevalence and impact of FASD and purpose of FASD special education strategies and programs
Novak, N. E. (2014).	ON	2009	Enhanced 18-month well-child visit	Document text analysis and key informant interviews using institutional ethnography of EWBV implementation practices and knowledge in Ontario in 2013 to explore how knowledge is integrated into practice by health professionals and how primary care organizational dynamics facilitate uptake
Nurse, K. M., Parkin, P. C., Keown-Stoneman, C. D. G., Bayoumi, I., Birken, C. S.,	ON	2009	Enhanced 18-month well-child visit	Quantitative logistic regression analysis of a cross-sectional questionnaire and Infant Toddler Checklist of 2,188 children attending an 18-month health supervision visit between 2011-2020 to determine association between

Maguire, J. L., Macarthur, C., & Borkhoff, C. M. (2024).				developmental screening outcome and child/family sociodemographic traits
Peters, R. D., Petrunka, K., Khan, S., Howell-Moneta, A., Nelson, G., Pancer, S. M., & Loomis, C. (2016).	ON	1993	Better Beginnings, Better Futures intervention project	Quasi-experimental longitudinal evaluation with a two-group design and cost savings analysis to compare costs, savings, and child development outcomes from 1997-2008.
Phan, J., Jegathesan, T., Dunlap, H., Young, E., Huber, J., & Minhas, R. (2017).	ON	N/A	Community service agencies as a primary point of care	Grounded-theory qualitative focus groups of 12 school board workers and community agency employees in Toronto to explore their experiences as a primary point of care contact
Polyzoi, E., Acar, E., Babb, J., Skwarchuk, S. L., Brownell, M., Kinnear, R., & Cliteur, K. (2020).	MB	1974	Child Subsidy Program	Multiple regression quantitative analysis of six linked datasets from 2000-2013 to determine if subsidized childcare prior to kindergarten affects developmental outcomes at kindergarten for children living in extreme poverty versus children from working poor families, and for children with and without special needs
Popova, S., Dozet, D., Temple, V., McFarlane, A., Cook, J., & Burd, L. (2024).	ON, MB	N/A	FASD diagnostic clinics	Retrospective cross-sectional survey of FASD diagnostic clinics (33/58 participating from 2018-2020) to identify annual numbers of assessments and diagnoses in various provinces and territories from 2015 to 2019
Russell, K., Gilbert, L., Hébert, D., Ali, A., Taylor, R. S. L., &	ON	1997/1998	Healthy Babies Healthy Children Screening	Quantitative analysis of completed screens between 2013-2016 to determine profiles of families screened in the Healthy Babies Healthy Children program and associations between questions and identification of a high-risk developmental assessment

Hendriks, A. (2018).				
Struck, S. (2020).	MB	2001	The Healthy Baby Program (Healthy Baby Community Support Program)	Quantitative logistic regression analysis of multisector data, and linked administrative attendance records to Early Development Instrument data from 2004-2011 to measure impact of participation on developmental health of children at school entry
Struck, S., Enns, J. E., Sanguins, J., Chartier, M., Nickel, N. C., Chateau, D., Sarkar, J., Burland, E., Hinds, A., & Katz, A. (2021).	MB	2001	The Healthy Baby Program (Healthy Baby Prenatal Benefit)	Quantitative analysis of a multisectoral administrative data repository for eligible Metis mothers who were low income (on income assistance) and had a live birth between 2003-2011 to determine association of prenatal benefit with early childhood outcomes compared to eligible women who did not receive benefit
Struthers, A., Metge, C., Charette, C., Enns, J. E., Nickel, N. C., Chateau, D., Chartier, M., Burland, E., Katz, A., & Brownell, M. (2019).	MB	2001	The Healthy Baby Program (Healthy Baby Prenatal Benefit)	General inductive case study design of quantitative data, documentary analysis, and key informant interviews in 2015-2016 of academics, policymakers, and program staff to understand how and why the program was implemented and the barriers, facilitators, and perceptions of the program's success
Underwood, K., & Trent-Kratz, M. (2015).	ON	Established 1981; expanded 2007-2008	Parenting and Family Literacy Centres	Qualitative focus groups in 2012, questionnaire; appreciative inquiry approach to understand how schools participate in early childhood experiences and the parent/family experience
van den Heuvel, M., Borkhoff, C. M., Koroshegyi, C., Zabih, W., Reijneveld,	ON	2009	18-month health supervision visit	Cross sectional prospective survey from 2012-2015 of children 18-20 months old visiting primary care practices within the research network who had completed the Nipissing District Developmental Screen and Infant Toddler Checklist to assess criterion

S. A., Maguire, J., Birken, C., Parkin, P., & Collaboration, T. A. K. (2016).				validity of instruments and describe parent responses screening questions
Williams, U., Teplicky, R., Rosenbaum, P., & Gorter, J. W. (2021).	ON	2011-2017	Applied behavioural analysis (ABA) program	Cross sectional survey of families using the program between 2015-2018; descriptive analysis to assess parental experience and perception of quality of autism programs at 13 children's service provider agencies that provided applied behavioural analysis treatment for autism spectrum disorder
Wright, A. L., Jack, S. M., Ballantyne, M., Gabel, C., Bomberry, R., & Wahoush, O. (2019).	ON	1997/1998; 2000	Mainstream and Indigenous-led Healthy Babies Healthy Children; Indigenous Friendship Centre mother-infant classes	Interpretive description of semi-structured interviews of Indigenous mothers and health providers to explore Indigenous mothers' experiences with choosing and using early childhood development programs (mainstream and Indigenous-led)

Table A2

Analysis Of Child Development Policies and Programs In Manitoba, Canada

Policy	Context	Mechanism	Outcome
Healthy Child Manitoba Strategy (Auclair, 2019)	• Multistakeholder governmental and non-governmental policy network • Main committees receptive to influence of advisory committees • Community-centric vs. government-	• Community engagement and input • Aligned priorities and commitments from sectoral offices • Mutual exchange of information between stakeholders • Involvement of policy actors (some	• Increased societal importance of early child development • Shared responsibilities between early childhood development and education sectors • Acceptability and positive perceptions of policy (valuable,

	centric decision making • Shared policy spaces • Legislation of strategy provided legitimacy • Interdepartmental policy strategy to promote local decision making and coalition influence	disengaged, others welcomed) • Closer relationships between sectors • Institutional support normalizes rationale for investments in children's development	beneficial, evidence-based)
Healthy Baby Prenatal Benefit (Struck et al., 2021; Struthers et al., 2019; Enns et al., 2021)	• Largest proportion of Indigenous residents • Research capacity to link datasets together • Multigenerational Indigenous trauma • Colonial practices • Cultural differences and predisposed health risks/social determinants of health • Policy shift to new strategy to provide prenatal health investments accessible to all low income families • Requires an application, physician confirmation, and awareness of program • Unconditional nature of benefit • Growing policy emphasis and interest in early child development as a result of	• Sense of empowerment and psychological changes • Feelings of choice and flexibility to purchase for family • Parent capacity and readiness for parenthood/single parenthood • Reduced financial stress • Connection to supportive community resources and healthcare providers • Improved health and nutrition from buying healthy food • Preparation for baby's arrival • Enabling self-care behaviours • Enhanced or new knowledge from parenting education resources • Motivation, trust in healthcare system, and/or adequate social support system	• Increased food quality and quantity • Lower risk of birth weight and preterm birth outcomes • Higher risk of hospital readmission within 28 days and larger gestational weight scores • Some impact on developmental vulnerability (language/cognitive and general knowledge/communication domains) at school entry and breastfeeding initiation

	increasing evidence base	prior to application, to encourage applying	
Healthy Baby Community Support Program (Struck, 2020)	• Ability to refer through direct contact with participants • Scaled up recruitment/outreach strategies • Frequency of programming varies by region and availability • Accessibility barriers that limit participation – distance, time, travel • Policy strategy identifies vulnerable families through newborn universal screening	• Psychological and social development of parent and child • Parent practice, capability, confidence, and stress relief • Parents get to know each other and develop connections with public sector, employees, and other families • More positive parenting practices learned • Motivation to participate impacted by stigma, trust in healthcare system, and inconsistency of frequency of interaction with program • Engaging with and learning from professionals and other families in a supportive environment	• Increased participation for families who did not receive prenatal benefit or income assistance • Frequent (at least weekly) programming results in lower developmental vulnerability at school entry (except for emotional maturity) • Successfully targeted access to program for vulnerable families
Child Subsidy Program (Polyzoi et al., 2020)	• Legislation in Childcare Standards Act sets out maximum fees and curriculum • Family characteristics define eligibility • Subsidy direct to centre of parent's choice	• Reduction of psychological and/or financial-related stress • Promotion of child social and cognitive development from early exposure to math and literacy • Provide supportive specialized programming resources for children	• Buffering effect for children with special needs; higher mean Early Development Instrument scores • Typically developing children experience greater socioemotional vulnerability than non-attending counterparts • No buffering for extreme poverty: negative

		with special needs unavailable at home • Different care environment compared to home for typically developing children (less attention, more conflict)	developmental outcomes even with subsidy
FASD Centre (Millar et al., 2017)	• Paradigm shift in understanding FASD • Creation of FASD classrooms • Data surveillance of prenatal alcohol exposure • Systems-level approach to identification and diagnosis with national diagnostic guidelines and provincial education standards • Assessment and diagnosis required prior to receipt of special education supports by province • Professionals trained in FASD programming • Increased awareness of FASD in public and government • Referrals to Manitoba FASD Centre can be done by physician, parent, school, or child and family services	• Professional development: professionals know how to adapt the environment and provide personalized learning • Collaboration and partnerships between schools, FASD Centre, and families supports referral and assessment pathways • Child social, psychological, and cognitive development: social skills, self-esteem, self-understanding, self-acceptance • Perception of having caring teachers	• Increased system capacity to refer and diagnose • Diagnosis at FASD Centre results in follow-ups at school and informs educational planning • Family has opportunity for input in education planning
Families First	• Colonial history	• Paraprofessionals building trust with	• No association with child developmental

Home Visiting Program (Enns et al., 2019)	• High proportion of Indigenous people in Manitoba • Socioeconomic and health risk factors • Paraprofessionals receive cultural training • Participation may be hindered by family characteristics or system-level barriers	families and in public health system • Family social development • Referral to community resources and more contact with public healthcare system • Confidence in parenting skills • Need encouragement to participate in program • Cultivate positive family environment	health at school entry, suggesting need for additional programming • Program families more likely to attend Healthy Baby Community Support Program

Table A3

Analysis of Child Development Policies and Programs In Ontario, Canada

Policy	Context	Mechanism	Outcome
Preschool Speech and Language Program (Binns et al., 2022; Cunningham & Rosenbaum, 2015; Cunningham et al., 2017; Cunningham et al., 2018)	• Accessible and free to all children with identified speech and development concerns • Delivered by professionally regulated speech-language pathologists • No diagnosis/referral process required – self-referral • Length of participation varies by impairment level and age • Structured in consecutive blocks for regular practice of speech	• Reduced social isolation from prior behavioural/communication difficulties • Increased parental capacity to support child's needs • Increased understanding of how child can communicate with peers and family • Understanding of importance of early learning environment facilitates enrolment in program • Increases reciprocal human interactions • Frequent and daily interventions result in more exposure to	• Increased communicative participation during intervention periods, tracked through standardized tools • Older children achieve higher communicative participation scores • Lower levels of functional communication enter the program at younger age and stay in program longer • Receiving intervention and increased time spent in intervention increased predicted communication scores for children with lower baseline

	and language skill development • Family circumstances (desire, time, financial ability, severity of communication deficits) affects time spent in intervention • Child's disposition, social responsiveness, curiosity, cognitive ability affects time spent in intervention • Human and clinical resources limit availability and put caps on services	social interaction compared to weekly interventions • Emotional stigma • Under-valuation of services compared to applied behavioural analysis • Some clinicians respond differently to children with autism diagnosis: More support, parent counselling, coaching, referrals, assessments, and visual/sensory interventions provided to children with autism diagnosis • Proper knowledge and access to clinical professional training on autism facilitate clinical service delivery	communication function scores
Enhanced 18-Month Well Baby/Child Visit for standardized developmental screening (Guttmann et al., 2020; Novak, 2014, Nurse et al., 2024; van den Heuval et al., 2016)	• Fee code introduced by Ministry of Health under universal funding for primary care • Free at point of service for families • Billing prerequisites include documentation of child's development using screening tool	• Parental awareness of the range of vocabulary infant can have • Provider awareness of agreement between different checklists • Doubled financial incentive motivates physicians to conduct the enhanced visit • Referrals provided if tools suggest developmental milestones not met	• Over the first 9 years of the program, 54.2% of children were screened • Rates of uptake increased over time (39% to 61%) • Odds of being screened increased with each birth year • Physicians with more recent training and pediatricians more likely to conduct the visit compared to family physician • Odds of being screened were lower

	• Conflicting evidence to support developmental screening from professional organizations • Authoritative policy and regulatory documents to guide clinical practice context and implementation • Groups of expert panels created proposals and reports to support a standardized developmental assessment at 18-months of age • Physician demographics impact adherence to guidelines • Tool provides standardized approach to identify communication difficulties	• Discussion with family • Clear and shared goals, vision, roles, and objectives enables program sustainability, access to information, and sharing information between providers • Formal and informal social organizations and interdisciplinary support (e.g., committees, conferences, collaborative practices with other staff, daily office interactions), social interaction between organizational leaders and peer champions encouraged active use of guidance documents	for children with low birth weights, in the lowest family income quintile, with mothers under 19 years of age, or refugee mothers • Low family income (less than CAD $40,000) was associated with positive identification of communication impairment • Infant Toddler Checklist during the 18-month visit may help identify children vulnerable to developmental issues and living in poverty
FASD Diagnostic Clinics (Burns et al., 2023; Geddes, 2015)	• Referrals to clinics require confirmation of prenatal alcohol exposure • Geographic and economic disparities in northern Ontario • Challenges in access to culturally appropriate care	• Providers are not well trained in identifying and treating prenatal alcohol exposures • Lack of education and awareness of FASD leading to older age at diagnosis • Family concerns over development	• Children are referred for behavioural, learning, and social difficulties stemming from mental health or neurodevelopmental impairments • Average age of access to diagnostic service is 10 years of age • Access to support services at school

	• Ministries guided by principles: need for equal access; inclusion; collaborative, coordinated and integrated services; improved supports to promote wellbeing; accountability; efficiency	leads to assessment seeking behaviors • Adoptive children may have more contact with social service agencies and doctors, leading to assessment • Increased awareness of need and demand for services due to introduction of Canadian guidelines	dependent on a diagnosis • Misdirected assessments and treatment planning results in higher system costs and emotional burdens on family
Healthy Babies, Healthy Children Screening and Program (mainstream and Indigenous) (Russell et al., 2018; Wright et al., 2019)	• Required to contact families with high-risk postpartum screening tool results within 48 hours of hospital discharge • Based on parenting sociodemographic and social determinants of health risk factors • Indigenous women face social disadvantage and adverse health outcomes resulting from colonialism, poverty, and gender inequality	• Doctors make professional judgements on family's strengths and child interactions • Family agreement/willingness for a home visit • In-depth assessment results enables referral to home visitor program • Family education through resources provided • Incentives such as meal programs motivate families to participate • Text messaging to family home visitors and health providers enabled access to timely support, resulting in less anxiety and improved parenting confidence • Mothers felt comfortable in their relationships with	• High risk families use the program more than moderate risk • Program successfully contacted 83% out of 95% of high-risk families • Home visits for in depth assessments were not completed for 56% of contacted families • 29% of assessed families were deemed high risk, and 7% were deemed moderate risk • Indigenous mothers tend to use the Indigenous-led program, not mainstream • Mainstream and Indigenous-led programs were comprehensive and connected to community resources • Home visiting services provided immediate health teaching and

		home visitors to share their needs and receive tailored support • Increased family advocacy and contextual awareness of social inequities by Indigenous providers • Long-term trusting relationships created with Indigenous-led home visitor program	eliminate accessibility barriers • Strengthened family relationships • Indigenous-led programming facilitates cultural and spiritual needs of infants
Ministry of Child and Youth Services-Funded Community-Based Agencies (Phan et al., 2017)	• School boards and community service agencies can assess, refer, and intervene in child developmental concerns • Restrictions on referrals and delay in time to physician assessment • Interactions between community agencies, family, and physicians varies	• Parental denial of issues • Professional difference in opinions on child development between agency staff and physician • Lack of communication and collaboration	• Identification of developmental disability can be delayed or inaccurate
Better Beginnings, Better Futures (Peters et al., 2016)	• Integration with local services, school-based, and family-based programming delivered in socioeconomically disadvantaged neighbourhoods	• Parents experienced increased social support, marital satisfaction, family functioning • More positive prosocial behaviour development by children; resulting in fewer emotional	• Higher healthcare service utilization costs • Lower educational system costs (special education, school grade repetition) • Lower family social service costs

	• Shared goals of health promotion, illness prevention, and enhanced community environment • Shared principles of ecological modelling, community-driven decisions, universal availability	and behavioural issues in elementary school	• Net cost savings $3,826 by age 18 • Initial cost savings of 1:1.31 increased to 1:2.5 • Costs relative to other early childhood intervention projects were cheaper
School-Based Health Clinics developmental assessments and mental health care services (Cheung et al., 2017)	• Provided in inner-city schools • Modeled from United States clinics • Long wait times for traditional pathways to developmental assessments in Ontario (15.5 months)	• Interdisciplinary professional staffing expertise • Timely accessibility to physicians within school who can diagnose developmental concerns	• 71.3% identified with a developmental concern • Wait time for developmental assessment is 6.3 months • 55.9% of children had at least one mental health concern; 13.6% received a neurodevelopmental disorder diagnosis, 25.7% referred to psychological services
Parenting and Family Literacy Centres (Underwood & Trent-Katz, 2015)	• Political realignment of priorities for early years policy • Centres located within schools and aligned with school curriculum • Evidence regarding parent engagement in early literacy skills	• Family social development with other families • Parents feel less alone • Community engagement: Parents connect to professionals who refer family to school or health supports • Welcoming atmosphere and staff involvement	• High-quality programming benefits family and child • Families were happy with the curriculum and structure of the programming and believed it supported children's school readiness, literacy, and social development

	• Free drop-in programming strategically placed in high-needs neighbourhoods (low income, newcomers)	facilitate continued attendance and participation • Child language and cognitive development in a stimulating educational environment • Proximity with/familiarity to school environment helps child transition to school • Exposure to skills associated with literacy and school such as structured routines and storytelling	
General Mental Health/Behavioural Disorder Service Contact (Georgiades et al., 2019)	• Social determinants of health impact prevalence of mood or behaviour disorders • Family context shapes treatment pathways • School-based and general practitioners most common resources to identify disorders and referrals to specialist	• Parenting relationship disruptions, family stressors, and parental mental illness makes them less likely to seek services for their child • Parental under-identification of mental health concerns among girls	• Overall prevalence of any mental disorder for children 4-11 years old and service contact was 18.1% and 61.5% • Disorder prevalence and service contact was lower among children living with 2 biological parents or in an immigrant family • Children with mood or behaviour disorders were more likely to have contact with health care providers, specifically general healthcare providers, and within a school-based setting • Children with comorbid mood and behaviour disorders

			had the most service contact
Government-Funded ABA Program (Williams et al., 2021)	• Service delivery options and settings vary by the service agency's capacities and resources. • Family-centred services succeeded a clinician-driven health service model	• Parents feel comfortable and treated as equals and individuals • Caring atmosphere with respectful, coordinated, and supportive care • Educated on autism through general and specific service agency resources	• Quality of ABA services rated consistently from very good to excellent by parents • Services delivered in home and individually had higher positive perceptions of the processes of care than services delivered at the agency or in a group setting.
Revised Play-based Full Day Kindergarten (Braund & Timmons, 2021)	• Child-centred pedagogical approach with emphasis on the link between play, self-regulation, and learning • Curriculum emphasizes the need for multiple opportunities throughout the day for co-regulation with teachers and peers • Curriculum has more balanced conceptualization of self-regulation to allow for cognitive and emotional regulation, metacognition, and focus/attention • Non mandatory form of preschool	• Children empowered to be creative and explore • Practice emotional self-regulation and use language to express emotions • Educators provide opportunities for children to think and self-reflect (engage in cognitive processes) in a less regimented manner • Cognitive skill development such as memory and attention • May lead to identification of developmental difficulties and better recognition of behavioural needs in the classroom which are also communicated to caregivers	• Expected outcome that children learn behavioural regulation in interaction with teachers and peers • Expected outcome that children more engaged in learning when their voices are heard and their learning environment is planned collaboratively with them

Table A4

Analysis of child development policies and programs of documents covering both provinces

Policy	Context	Mechanism	Outcome
FASD Diagnostic Clinics (Dugas et al., 2022; Popova et al., 2024)	• Canadian guidelines require age-specific interdisciplinary teams to diagnose • Varied referral processes and waitlist availability • Manitoba has one large centralized regional diagnostic clinic • Ontario has smaller diagnostic clinics • Inconsistent team compositions and workforce shortage • Inconsistent eligibility criteria • Limited human and financial resources and costs to fund interdisciplinary teams	• Clinics provide information and support during and after diagnosis • Educational resources and healthcare worker training could lead to more accurate early identification and service utilization • Social stigma and lack of awareness of FASD within primary healthcare providers • Centralized clinics may deliver improved access and better data linkages	• Most cases go undiagnosed • Most clinics do not diagnose children under 18 months of age • 22 average monthly assessments in Manitoba; 2-4 in Ontario • 2.6 daily average number of diagnoses in Manitoba (78 per month); 68 in Ontario • Diagnostic capacity in Ontario was 22-32 slots allotted to diagnoses and 10-49 individuals per year waiting for assessment • Diagnostic capacity in Manitoba was 272 slots per year for diagnoses and 118 children on the waitlist every year (5-month waitlist for evaluation) • Percentage of children 0-18 diagnosed per year in Manitoba is 1.8-1.1%, and 0.5-0.8% in Ontario relative to estimated national prevalence of 2.5-4.0%

Developmental Screening/Enhanced Early Well-Baby Visit (Cressman et al., 2020; Cressman et al., 2021)	• Both provinces support child health investments • Only Ontario formally implemented developmental screening with fee code • Manitoba created cross-departmental strategy, Healthy Child Manitoba • Dominant perspective that developmental screening is the route to early identification • Guidance and evidence for screening is mixed and confusing • Strong data surveillance in Manitoba • Ontario had financial resources and cultural environment (new full day kindergarten) to support screening	• Collaboration, structured decision making, and interest alignment in Manitoba • Ontario decision making and communication was siloed and fragmented • Manitoba had normalized collaborative culture between researchers and bureaucrats • Screening is a therapeutic dialogue tool for parent-provider engagement, talking to family, and referring to other resources • Positive perception of staking a claim for child health and engaging policymakers • Sense of urgency to invest in the early years • Fee code motivates physicians to conduct visits	• Manitoba pursued coordinated governance without developmental screening • Ontario had limited capacity to evaluate quality and effectiveness outcomes • Developmental screening intended to enhance communication and social wellness for families • Developmental screening identifies health disorders or risks • Effectiveness research insufficient • Increased attention from policymakers • Potential that screening not done or not done properly

Table A5

Supplemental Website Search Results Of Ontario And Manitoba Government Webpages

Policy	Context	Mechanism	Outcome
Ontario SmartStart Hubs	• Families do not always know where to go for	• Supporting parents allows them to be employed and to maintain their own well-	• Starting point for families to access services and

(Ministry of Community, Children and Social Services [MCCSS], 2022a)	help or what information to trust • Access barriers such as poor internet connection, lack of transport, difficulty communicating, invalidating experiences with service providers, uncoordinated service provision, and intimidating assessments and program eligibility criteria • Parents of children with special needs are more likely to be unemployed or work fewer hours, be more stressed, and have poorer health • Hub is not a mandatory access point • Diagnosis is not required • Self-referrals or service provider referrals in other programs such as enhanced 18-month well-baby visit	being and reduce family breakdown • Providing earlier interventions may promote successful school transitions, school participation, better learning, and independent living • Proactive information sharing and coordination with other providers • Training provided to staff on anti-racism, cultural safety, family-centred and trauma-informed service delivery • Families provide information about child's strengths and needs in an exploratory conversation • Connections to services do not require action by family • Families will feel empowered to support child • Connection to other families and other information resources	streamlined assessments and services as early as possible • Intended outcomes include access to information, early identification of needs, timely delivery of services, consistent experiences, culturally safe services, family capacity to support child • Intended to help children participate meaningfully in home and school

	• Value informed decision-making and parents as experts on their child		
Needs-based Ontario Autism Program (MCCSS, 2019)	• Barriers to diagnosis especially in rural and remote areas • Many children waiting for supports, and only those with a diagnosis of autism are eligible • Shortage of Francophone and First Nations service providers • Lack of alignment with other ministries (education, child mental health)	• Receipt of respite, family support, and caregiver training to combat caregiver burnout • Receipt of core health services • Those without a confirmed autism diagnosis must wait for care • Parents do not know about all the special education services at schools • Poor communication with families on waitlists	• Intended effects of this program: support mental health, promote equitable access to technology, aid decision-making; improve access to services for undeserved communities; reduction in wait times for early intervention, mental health and urgent response services • Alternative choices without access to timely services include use of emergency department, child protection services, or residential placements
Ontario Infant and Child Development Program (MCCSS, 2022b)	• Publicly funded and free to families who have concerns about their child's development without medical diagnosis or referral, from birth to school entry	• Assessments of children's needs and parenting support to generate positive parent-child interactions • First point of contact to connect families to resources • Provides early intervention services in collaboration with other service providers and within the child's daily home environment	• Intended effects to help children and caregivers build life skills • Access to early intervention for those with or at risk of developmental issues

		• Child and family routines observed, created, and maintained within the home	
Manitoba Children's DisABILITY Services & Eligibility Policy (Province of Manitoba, 2021a; Province of Manitoba 2021b)	• Each family is unique, families are experts in child's development and families are a constant in a child's life • Waitlists dependent on available resources, and families may be chosen for services based on their needs • Families of children with disabilities may have additional needs not otherwise covered by other programs • Children are eligible for this program if they are <18 years living with their legal guardian(s) in Manitoba, and they present with at least one of the following: intellectual delay, developmental delay, lifelong physical	• Staff visit the child's home/natural environment and build a relationship with the caregivers • Caregivers are actively involved in goal setting • Parents are provided with further information to help them understand their child's service plan	• Intended to support families in supporting the healthy development of their preschool children with developmental or physical disabilities • Intended to be individualized, family-centred, flexible, accessible, collaborative, preventative and evidence-based

	disability that limits mobility, autism, developmental disability, or high probability of developmental delay		
Manitoba Child Development Clinic (Province of Manitoba, n.d.)	• Doctors may refer to child development specialists within the Child Development Clinic, or other health professionals • Some services have waitlists • Specialized services are not available in all regions • Doctors rely on parent's reports and observation of children's skills to determine if a child is meeting developmental milestones	• Appointments with family doctor enable information sharing, and referrals for other assessments or clinics • Some parents may be unwilling to share all information, reports, and assessments with professionals • Receiving the results of an assessment may be overwhelming for parents	• After a child is assessed, the doctor may provide recommendations for services, activities to do at home, follow-up assessments, and connect to community resources
Manitoba Autism Outreach Policy (Province of Manitoba, 2019)	• Open to children within Children's DisABILITY services who have a diagnosis of autism spectrum disorder • Family participation in early autism	• Individualized developmental/relationship-based naturalistic behavioural and joint attention interventions, and modeling • Encourage child socialization, self-regulation and play skills • Transfer skills and knowledge of autism to caregivers through hands-	• A joint individualized development plan created with goals and strategies to achieve them • Intended outcome is to optimize social, emotional, communication, and behavioural outcomes for

	intervention is critical for success • Autism specialists consult up to 12 visits over 3-4 months after enrolment • Enrolment and waitlists depend on service capacity • During the transition to childcare and school, but resources may be limited to the first half of the school year	on teaching. modeling, coaching, feedback, educational seminars • Increased family understanding of autism and child's needs • Visits from outreach staff occur in the home, childcare facility, school, or other natural environments to discuss expectations and assess a child's needs and abilities in the home	preschool-aged children with autism

Table A6

Codes Developed From Grouped Summaries

Policy	Context	Mechanism	Outcome
Healthy Child Manitoba Strategy (Auclair, 2019)	• Policy network • Influential actors • Local decision making • Government-centric • Shared policy spaces	• Legislation legitimacy • Stakeholder input • Mutual information exchange • Negativity within policymaking process • Unequal stakeholder engagement • Alignment of priorities • Knowledge translation • Institutional support facilitates responsiveness to policy	• Multi-sectoral connections • Societal importance established • Setting priorities • Varied policy acceptability • Changed values • Mutually beneficial • Shared responsibilities •

Healthy Baby Prenatal Benefit (Struck et al., 2021; Struthers et al., 2019; Enns et al., 2021)	• Multigenerational colonial trauma and history • Cultural predispositions to negative health risks • Social determinants of health • Research capacity • Accessible healthcare • Positive value in child health	• Empowerment • Feeling of choice • Freedom • Capacity to provide • Social connections • Knowledge gathering • Trust in healthcare system • Social motivation and support system • Self-care • Flexibility • Preparing for baby • Educational resources	• Healthier • Positive but varied developmental outcomes • Better birth outcomes • Worse hospital outcomes
Healthy Baby Community Support Program (Struck, 2020)	• Easier to reach participants directly • Variability of programming by region • Screening supports developmental risk identification • Positive value in investments in prenatal health	• Stress relief • Focus on parent and child capacity and wellbeing • Connection to healthcare system • Connection to other families • Social motivation and support system • Fear of judgment/stigma • Parental readiness	• Better participation outcomes with frequent programming • Successfully reached mothers • Barriers limit participation
Child Subsidy Program (Polyzoi et al., 2020)	• Curriculum established through legislation • Eligibility barriers • Parental choice of centre	• Stress relief • Child social development • Child cognitive development • Exposures to curriculum concepts • Supportive resources • Division of attention • Possibility of conflict	• Buffering effect • Better development • Socioemotional vulnerability • Mixed effects
FASD Centre (Millar et al., 2017)	• Better understanding of condition • Awareness of condition	• Professional training • Integration of education and healthcare	• Efficiency in diagnosis • Fewer barriers • Results in appropriate and family-centred future planning

	• Data surveillance and research capacity • Eligibility barriers • Direct referral to centralized centre • Shared responsibility	• Child social development • Child cognitive development • Child psychological development • Support system • Adaptive to needs •	
Families First Home Visiting Program (Enns et al., 2019)	• Multigenerational colonial trauma and history • Cultural predispositions to negative health risks • Social determinants of health	• Social development • Encouragement to participate • Trust in and contact with healthcare system • Positive family environment • Skill development	• No long term development impact • Use of community resources
FASD Diagnostic Clinics (Dugas et al., 2022; Popova et al., 2024)	• Interdisciplinary team requirements • Varied referral processes • Varied waitlist availability • Centralized versus dispersed clinics • Inconsistent team compositions • Workforce shortage • Inconsistent eligibility criteria • Limited human and financial resources	• Information resources • Support at all stages • Worker training and diagnostic accuracy • Worker training and service uptake • Social stigma • Lack of provider awareness of FASD • Improved access and better data linkages (MB)	• Un/under-diagnosed • Most cases go undiagnosed • Shorter centralized vs longer dispersed clinic wait times • Greater diagnostic assessment capacity (MB) • More diagnoses (MB)
Developmental Screening/Enhanced Early Well-Baby Visit (Cressman et al., 2020;	• Support child health investments • Inadequate evidence base (MB, ON) • Strong data surveillance in Manitoba	• Collaboration (MB) • Interest alignment (MB) • Collaborative work culture (MB) • Siloed decision making (ON) • Structured decision making (MB)	• Coordinated governance (MB) • Limited evaluation capacity (ON) • Enhance communication (ON) • Identify health disorders or risks (ON)

Cressman et al., 2021)	• Resource availability (ON) • Cultural acceptability (ON) • Cross-department strategy (MB) • Data generation (MB) • Political tradeoffs (ON) • Formal stakeholder recommendations (ON)	• Fragmented communication (ON) • Incentivization of physicians (ON) • Dialogue tool • Parent-provider engagement • Connection to other resources talking to family, and referring to other resources • Engaging policymakers (MB)	• Effectiveness research insufficient (MB) • Increased attention from policymakers (MB) • Uptake/implementation risks (ON) • Risk for ignoring adolescent health (ON)
Ontario SmartStart Hubs (Ministry of Community, Children and Social Services [MCCSS], 2022a)	• Lack of knowledge on resources • Access barriers • Communication barriers • Coordinated care • Eligibility barriers • Program accessibility • Social determinants of health risk factors • Connection with other programs • Parents as sources of information	• Supporting parents to support children • Ability to conduct knowledge transfer and sharing • Adequate training • Seamless connection to services and resources • Empowerment • Learning and independence • Early intervention promotes school readiness	• Access • Streamlined and timely care • Consistency and quality of care • Enhance family capacity • Meaningful school and home participation
Needs-based Ontario Autism Program (MCCSS, 2019)	• Social determinants of health risk factors • Eligibility barrier • Lack of multisector alignment	• Supporting parents to support children • Wait lists • Lack of knowledge on resources • Lack of communication	• Equity and access • Wait times • Use of emergency services
Ontario Infant and Child Development Program (MCCSS, 2022b)	• Accessible • Concerned parents	• Supporting parents to support child • Positive parent-child interactions • Connection to resources	• Life skills • Access to early intervention

		• Conversation with family • Multi-sectoral providers • Child and family routines established	
Manitoba Children's DisABILITY Services & Eligibility Policy (Province of Manitoba, 2021a; Province of Manitoba 2021b)	• Families as experts • Resource availability • Needs based • Eligibility criteria for diagnosis	• Staff-caregiver relationship • Caregiver knowledge transfer and goal-setting • Connection to resources to facilitate service plan	• Support families to support child • Individualized • Accessible and preventative
Manitoba Child Development Clinic (Province of Manitoba, n.d.)	• Doctor authority • Resource availability • Doctor knowledge based on parent's reports and observation	• Information sharing • Referrals • Family unwilling to share all information • Emotional overwhelm	• Connection to community resources and services • Follow-up care plans for home
Manitoba Autism Outreach Policy (Province of Manitoba, 2019)	• Diagnosis eligibility criteria • Family participation • Resource restrictions and service capacity limits	• Encourage child socialization • Child self-regulation • Play skills • Knowledge transfer and skill development • Modelling positive behaviours • Coaching for positive behaviours • Educating caregivers • Needs assessment	• Joint individualized development plan • Optimize development outcomes
Preschool Speech and Language Program (Binns et	• Accessible • Unconditional • Regulated delivery • Needs, circumstances, and	• Reduced social isolation • Support parent to support child	• Increased communicative participation • Length of participation affects outcomes

al., 2022; Cunningham & Rosenbaum, 2015; Cunningham et al., 2017; Cunningham et al., 2018)	age-based participation length • Structured • Human and clinical resource limitations • Service caps	• Increased understanding of child • Better family-child communication • Prior understanding of importance of early learning environment • Social interactions • Frequency of social interactions • Emotional stigma • Under-valuation of services • Differential treatment • Adequate training	• Age at entry of participation • Standardized tracking • Age affects outcomes • Prior functional communication affects outcomes
Enhanced 18-Month Well Baby/Child Visit for standardized developmental screening (Guttmann et al., 2020; Novak, 2014, Nurse et al., 2024; van den Heuval et al., 2016)	• Accessible and free • Billing prerequisites • Conflicting evidence • Guidance from policy, expert, and regulatory documents • Physician demographics • Standardized approach	• Parental awareness of infant vocabulary • Provider awareness of tools • Financial incentive as motivation • Referrals provided • Discussion with family • Information access and sharing • Clear and shared goals • Formal and informal social organizational endorsement • Physician peer influence	• Rates of uptake increased over time • Odds of being screened increased over time • Physician training and age impacts uptake • Sociodemographic of family impacts odds of screening • Poverty associated with early identification
FASD Diagnostic Clinics (Burns et al., 2023; Geddes, 2015)	• Referral restrictions • Geographic and economic disparities • Access to culturally appropriate care	• Professional training • Lack of education • Lack of awareness of FASD • Older age at diagnosis • Family concerns facilitate information seeking	• Referrals provided for impairments • Services dependent on diagnosis • Misdirected assessments and treatment planning • System costs • Emotional burden

	• Shared Ministerial principles in guidelines	• Contact with other service leads to assessment • Increased awareness of service need	
Healthy Babies, Healthy Children Screening and Program (mainstream and Indigenous) (Russell et al., 2018; Wright et al., 2019)	• Consideration of family risk factors • Consideration of social determinants of health risk factors • Social inequities	• Professional judgements • Family agreement/willingness • Refer to home visitor program • Family education resources • Incentives • Motivation to participate • Access to timely support • Less anxiety • Parenting confidence • Comfortable to share needs • Tailored support • Relationship building • Increased family advocacy • Long-term trusting relationships	• High risk families use the program more than moderate risk • Successfully reach target audience • Assessments less successful • Categorize family's level of risk • Connected families to community resources • Health teaching • Eliminated accessibility barriers • Strengthened family relationships • Culturally appropriate programs facilitate cultural and spiritual needs
Ministry of Child and Youth Services-Funded Community-Based Agencies (Phan et al., 2017)	• School boards and community service agencies authority • Restrictions on referrals • Wait times for assessments • Varied experiences with communication	• Parental denial of issues • Professional difference in opinions • Lack of communication • Lack of collaboration	• Delayed diagnosis • Inaccurate diagnosis
Better Beginnings, Better Futures (Peters et al., 2016)	• Service integration • School-based • Family-based • Shared goals • Community environment	• Family social support • Better family functioning	• Higher costs in healthcare • Cost savings in education • Cost savings in social services

	• Ecological modeling • Community-driven decisions • Universal availability	• More positive prosocial behaviour development • Fewer emotional and behavioural issues	• Higher healthcare service utilization costs • Relative cost efficiency
School-Based Health Clinics developmental assessments and mental health care services (Cheung et al., 2017)	• Consideration of higher needs families • Availability of developmental assessments	• Interdisciplinary professional staffing expertise • Timely accessibility to physicians within school who can diagnose developmental concerns	• 71.3% identified with a developmental concern • Wait time for developmental assessment is 6.3 months • 55.9% of children had at least one mental health concern; 13.6% received a neurodevelopmental disorder diagnosis, 25.7% referred to psychological services
Parenting and Family Literacy Centres (Underwood & Trent-Katz, 2015)	• Political realignment of priorities • School-focused • Evidence-based • Accessible • Consideration of higher needs families	• Family social development with other families • Parents feel less alone • Community engagement • Connection to resources • Welcoming atmosphere • Socialization with staff • Child language and cognitive development • Easier transition to school • Exposure to school skills and routines	• Perceived high-quality programming • Curriculum and program satisfaction • Promotes child development • Promotes readiness to learn at school • Sustained participation
General Mental Health/Behavioural Disorder	• Social determinants of health • Family circumstances	• Parental wellbeing and information seeking	• Family composition/demographics affects service contact

Service Contact (Georgiades et al., 2019)	• Practitioner authority to identify and refer	• Gendered identification of problems	• General practitioner support • School contact • Type of disorder affects service contact • Comorbidity affects service contact
Government-Funded ABA Program (Williams et al., 2021)	• Service agency capacities • Resource availability • Family-centred services	• Comfortable • Parents as decision makers • Caring • Coordinated • Connection to resources and education	• Quality of services • Positive perceptions
Revised Play-based Full Day Kindergarten (Braund & Timmons, 2021)	• Child-centred • Learning through play • Co-regulation with teachers and peers • Balanced self-regulation concepts • Cognitive and emotional regulation	• Empowerment • Creativity and exploration • Language learning • Emotional expression • Opportunity • Cognitive skill development • Recognition of needs and abilities • Caregiver communication	• Behavioural regulation • Regular interaction • Engagement • Collaborative learning plans

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Chapter 4

Change Over Time In Children's Developmental Health In Two Provinces In Canada: A Multilevel Model Analysis

Preface

The paper presented in the following section is the final, non-peer reviewed paper to be submitted for consideration in an academic journal. I conducted the study under the guidance of my supervisory committee of MJ, TB, ED, JRD and wrote the original draft. All authors, Rita Jezrawi, Eric Duku, Jean Paul Lefebvre, Jennifer Enns, James R. Dunn, Teresa Bennett, Magdalena Janus contributed to the conceptualization of the study, methodology, editing, and approved the final version to be submitted for publication. Ethics approval for this study was obtained from the Hamilton Integrated Research Ethics Board (under project #2403). The study received support from a grant from a Social Sciences and Humanities Research Council Doctoral Fellowship.

Abstract

Background: Differences in prevalence rates of neurodevelopmental disorders (NDD) and other developmental concerns across jurisdictions in Canada provide opportunities to further examine current and ideal systems, policies, and resource planning for early identification and intervention services.

Objective: The objective was to examine changes over time in prevalence of 1) special needs (SN) status, 2) NDD and 3) developmental vulnerability of kindergarten children residing in Ontario and Manitoba from 2010-2019.

Methods: A multilevel growth modeling approach to examine changes over time in neighbourhood prevalence was used with multiple waves of population-level, cross-sectional panel data collected with the Early Development Instrument. The analytic dataset (N=452,031) was aggregated by neighbourhood and measurement occasion for all variables including covariates sex, age, English/French language learner (EFLL) status, presence of functional impairments, and socioeconomic status (SES).

Results: The conditional growth models showed mean prevalence rates in 2011 in Ontario for SN, NDD and vulnerability were 4.1%, 2.3%, and 28.4%, respectively, and increased by .001 points (.1%) each year. Mean prevalence rates in Manitoba for SN, NDD and vulnerability were 3.9%, 2.1%, and 31.4%, respectively, and increased by .001 points (.1%) each year, except for SN which demonstrated a U-shaped growth pattern. Prevalence estimates were higher in neighbourhoods with higher levels of functional impairments and EFLL and lower in neighbourhoods with higher SES and greater proportions of females.

Conclusions: There were changes in prevalence of special needs status, neurodevelopmental disorders, and developmental vulnerability in kindergarten children over time, which may result in increased unmet healthcare and educational needs. Policymakers should consider expansion of interventions that address healthy child development, particularly in vulnerable neighbourhoods.

Keywords: growth curve, early development, children

Children with neurodevelopmental disorders (NDD) typically need special health, therapeutic, and social supports and may also have special healthcare needs (McPherson et al., 1998). Tracking the prevalence rates of NDD assists with identification of possible causes and planning of treatment or preventive services (Stein, 1981). National trends in prevalence and incidence rates of certain NDD suggest increased rates over time (Prasad et al., 2021) and variations in prevalence rates by province for specific disorders (Ouelette-Kuntz et al., 2014). For example, prevalence estimates of childhood attention deficit hyperactivity disorder (ADHD) in four provinces ranged from 6.9-8.6% from 2008 to 2015 (Morkem et al., 2020). In Ontario, ADHD prevalence rates increased from 2014 to 2020 (Butt et al., 2024). Similarly, across Canada, the prevalence of autism spectrum disorder (ASD) is estimated at 2% nationally but differs between provinces; for example, rates are 2.1% in Ontario and 1.7% in Manitoba, with the lowest prevalence in Saskatchewan (0.8%) and highest in New Brunswick (4.1%) (Public Health Agency of Canada, 2022). In Manitoba, prevalence and incidence rates of ASD have been increasing steadily since 2004 (Hamad et al., 2019).

Studies have shown that community characteristics such as population size, education levels, and other sociodemographic traits are associated with differences in prevalence rates, incidence rates, service access, service availability, pathways to diagnosis, and health status. Recent literature has shown that prevalence rates of various disorders co-vary with SES, school board sizes (Shenouda et al., 2022), race/ethnicity (Wallis et al., 2023; Shenouda et al., 2022), receipt of primary care in urban sites (Wallis et al., 2023), and neighbourhood proximity to green spaces (Lavigne et al., 2024). In a multi-province study, wait times and costs of care in Manitoba were lower than the national average, while in Ontario cost barriers were higher than the national average (Edwards et al., 2022). Growing public awareness of NDD, including recognition of signs/symptoms and information-seeking behaviours about these conditions, may also be contributing to changes in prevalence estimates (Zeidan et al., 2022).

Ontario and Manitoba have different policies and programs to promote healthy child development from infancy to childhood and later into adulthood. A variety of services, pathways, and professionals are involved in the early identification of NDD and early interventions to address or prevent atypical child development during critical periods of brain development. Investigating causal policy explanations for differences in prevalence estimates across regions is challenging as there are many actors and interactive processes that are difficult to disentangle. However, comparisons of NDD prevalence rates provide opportunities to further examine current and ideal systems, policies, and resource planning for early identification, clinical/physician services, and educational intervention services.

Previous child development research linked developmental vulnerability with social and biological determinants such as male sex, low SES, English as a second language, and mental health issues (Talarico et al., 2023; Curtin et al., 2013). Additionally, neighbourhood-level research in Saskatchewan, Canada showed that scores in some domains of school readiness decreased over time, varied across neighbourhoods, and were influenced by lower neighbourhood SES (Cushon et al., 2011). Using a different statistical method, mapping growth curves in the context of these known sociodemographic characteristics would allow us to characterize changes in developmental health outcomes over time and make policy decisions about where, when, and for whom early identification and intervention programs will be made available.

Objectives and Research Question

The objective of this study was to examine changes over time in the prevalence of special needs (SN) status, NDD, and developmental vulnerability at the neighbourhood level in Ontario and Manitoba, while controlling for differences in sociodemographic profiles. The research question was: For children aged 5-6 years attending kindergarten in Ontario and Manitoba from 2010-2019, what are the neighbourhood-level temporal trends in the prevalence of 1) SN, 2) NDD, and 3) developmental vulnerability? The secondary research question was: How do time trends in SN, NDD, and developmental vulnerability vary on the basis of neighbourhood characteristics?

The research question and analysis were driven by Bronfenbrenner's biological systems perspective emphasizing relationships between systems, institutions, people, and a child's characteristics, early life experiences, and social determinants of health (Bronfenbrenner, 1995). I hypothesized that the prevalence of developmental vulnerability would be higher than SN or NDD, would align with the national estimate of 25% (Public Health Agency of Canada, 2018), and would increase over time. Increases in proportions of children with developmental vulnerability over time have been documented in other provinces such as British Columbia (Human Early Learning Partnership, 2022) and Quebec (Government of Quebec, 2022).

Methods

Study Design

A multilevel mixed model approach (Raudenbush & Bryk, 2002) was used to examine within- and between-neighbourhood changes over time in each province. I wanted to determine how repeated measurements of neighbourhood prevalence rates changed as a function of time and to specify what percentage of that variation could be explained by neighbourhood differences over time. Multilevel growth curve analyses can determine which factors explain variation in an outcome in individuals or neighbourhoods, the rate of change over time and which neighbourhood characteristics or predictors interact with time effects and/or explain the magnitude of change (Hayes, 2006).

Measurement Instrument

An observational study design was used with a de-identified, population-level EDI dataset (Janus & Offord, 2007). The EDI dataset was chosen as it is explicitly linked to geography via Canadian Neighbourhoods Early Child Development (CanNECD) neighbourhoods based on postal codes (Forer et al., 2022). The EDI is a validated tool for the measurement of kindergarten children's developmental health and school readiness in physical, social, emotional, and language/cognitive development, and communication/general knowledge domains. It is completed by teachers in the second half of the school year for all students in their classroom in 1- to 3-year provincial data collection cycles (Janus & Offord, 2007).

The EDI dataset contains multiple waves of cross-sectional panel data. The longitudinal change and repeated measures apply to neighbourhoods but not individuals. Manitoba and Ontario were chosen due to the availability of provincial data sources, though these provinces are not representative of all of Canada. Additionally, the EDI holistically measures children's competencies in various developmental areas and reflects a developmental systems approach that considers family and neighbourhood characteristics (Janus et al., 2010).

As neighbourhood was the primary unit of analysis, the data were aggregated to the measurement occasion (level 1) and the neighbourhood level (level 2) to explore how prevalence rates change over time and may be related to other predictors. Level 1 neighbourhood prevalence rates represent a single moment in time and level 2 represents grand mean prevalence rates for neighbourhoods across all included timepoints. Ethics approval for this study was obtained from the Hamilton Integrated Research Ethics Board (#2403). SPSS Version 30 (IBM Corp, 2024) was used to prepare and conduct data analysis.

Outcomes

The independent variable was cycle of EDI implementation, which vary within and between provinces and may span several years. Ontario had 3 data collection cycles (2010-2012, 2015, 2018) while Manitoba had 5 (2011, 2013, 2015, 2017, and 2019). Years were re-coded as 0 (2011- in Ontario this includes 2010 and 2012 as part of the same cycle of data collection), 2 (2013), 4 (2015), 6 (2017), 7 (2018), and 8 (2019) to represent the real gaps between cohorts. The binary dependent variables at each time point for each province were: 1) overall developmental vulnerability, defined as scoring in the lowest 10^{th} percentile in any of the 5 domains on the EDI, 2) presence of NDD diagnosis (yes/no), and 3) presence of SN (yes/no). A diagnosis of NDD included any one or more of autism spectrum disorder (ASD), attention deficit hyperactivity disorder (ADHD), anxiety, depression, oppositional defiant disorder (ODD), other mental diagnosis, global delay, Down Syndrome, Fetal Alcohol Spectrum Disorder (FASD), intellectual delay, Rett's/childhood disintegrative disorder (CDD), or learning disability.

Covariates

The following level 1 time-varying neighbourhood level covariates derived from the EDI questionnaire items were included: age in years and months (continuous), biological sex (categorical), English or French language learner status (categorical; non-native in the language of instruction) (EFLL), and functional impairment (physical, visual, hearing, speech, learning, emotional, behavioural) (categorical - combined). The neighbourhood-level SES z-score index in 2016 (minimum -2.48 to maximum 3.21) was a level 2 time-invariant covariate. The 2016 SES index was chosen as it was the midpoint of the data collection periods and indices demonstrated very high stability in each five-year period (Forer et al., 2022). The categorical variables of impairment, EFLL, and sex were coded as 0 and 1 binary outcomes and then aggregated as the mean for each neighbourhood to represent average prevalence differences in a neighbourhood with proportions of 0% or 100% of these covariates on a given measurement occasion. The continuous variables of age and SES were aggregated as the mean for each neighbourhood.

Inclusion Criteria

Prior to applying inclusion criteria, the dataset had 469,187 children with records, of whom 455,774 (97.1%) had a valid EDI (see next paragraph). The initial dataset had 11,911 (2.5%) children with NDD, 20,452 (4.4%) with SN, 129,934 (27.7%) with developmental vulnerability, and 60,103 (12.8%) with a functional impairment.

The following inclusion criteria were applied to the dataset: 1) child was in the classroom for at least one month; 2) valid EDI (less than 25% of missing items on the child's EDI questionnaire); 3) in senior kindergarten, 4) age equal to or greater than 3.6 and less than or equal to 7.5 years old. The resulting analytic sample was 454,197 records, but 2,166 children with no neighbourhood code were excluded. The final analytic dataset had 452,031 records and was prepared in long format (each neighbourhood had separate and multiple rows of observations for each measurement occasion). The covariates age, sex, impairment, and EFLL were centred around the grand mean to examine within-neighbourhood change (level 1) and between neighbourhood differences (level 2) in age, sex, impairment, and EFLL on prevalence of SN, NDD, and developmental vulnerability.

Statistical Analysis

Descriptive statistics including mean, minimum, maximum, standard deviation (SD), and cross-tabulations with effect sizes (Cramer's *V*) were conducted after aggregation by neighbourhood and time on all variables of interest (Appendix, Table A4 & Table A5). I descriptively examined whether the covariates in each province varied across time points using mean and *SD*. There were no large changes over time, suggesting that provincial neighbourhood means of covariates were stable over time. Small R^2 values suggested that changes over time accounted for a small portion of total variation in between- and within-neighbourhood prevalence (Appendix 1, Figures A1-A12).

Mixed Model Building

Separate models were used to get an independent picture of prevalence rates in Manitoba and Ontario to prevent Manitoba from being overshadowed by the larger number of neighbourhoods in Ontario. Manitoba had five measurement occasions, consequently a quadratic term was tested to determine if it would be suitable to add to the model. With only three measurement occasions for Ontario, a quadratic term was not included in the model for time. Time was included as a random effect; all other level 1 effects were treated as fixed effects.

A null 'no growth' model was generated with no predictors to measure grand mean prevalence of each outcome averaged across all measurement occasions with a random intercept to allow for the average of outcomes at initial measurement occasion to vary by neighbourhoods (Appendix 1, Table A8). Intraclass correlations (ICCs) were generated from the null model which represent the total level 2 variance between-neighbourhoods (as opposed to within-neighbourhood variance). In Ontario, the ICCs were .05 for SN, .09 for NDD, and .5 for developmental vulnerability (Appendix 1, Table A8). In Manitoba, the ICCs were .02 for SN, .16

for NDD, and .68 for developmental vulnerability. During model testing, most of the models did not converge using autoregressive covariance types and negligible differences were observed between restricted maximum likelihood and maximum likelihood estimation. Therefore, the assumption was that there was no correlation between measurement occasions and visual boxplots showed little variance at each time point (Beaumont, 2012), so scaled identity random effect covariance structure was selected for parsimony. In some cases, unstructured random effect covariance types were substituted to achieve convergence. Restricted maximum likelihood estimation was used and model building was conducted using the *linear mixed model* procedure in the following steps:

1) Unconditional linear growth curve model with time as a fixed effect to represent the initial outcome at time zero and predicted change in prevalence outcomes beyond the initial time point (Appendix 1, Table A9).
2) Added time in as random effect to allow for variation across neighbourhoods in linear rate of change. For Manitoba only, a quadratic term was added for time to represent non-linear increase or decrease in the rate of change in SN.
3) Added fixed effects for time invariant covariates (SES) and time-varying covariates (age, sex, impairment, EFLL) one at a time until all were in the model to look at changes in the mean of outcomes due to covariates.
4) As rates of EFLL and impairment were hypothesized to vary by neighbourhood, random effects for EFLL and impairment were added separately and then together, to estimate a distinct effect of EFLL and impairment proportion on the outcomes for each neighbourhood.

5) Added an interaction term of time and SES index as a fixed effect to determine if the relationship between time and prevalence was different for low SES than higher SES neighbourhoods. The interaction term was removed if it was not statistically significant ($p > .05$). All other covariates remained in the model even if they were not statistically significant.

Results

Demographic characteristics at the individual and neighbourhood level are presented in Appendix 1. Results of the null models, unconditional linear growth models, and final mixed models with mean-centred predictors are presented with a significance level of $\alpha = .05$. Visualizations of the model-implied trajectories were created (Figures 1-7).

Final Mixed Models

The conditional growth models showed mean prevalence rates in 2011 in Ontario for SN, NDD and developmental vulnerability were 4.1%, 2.3%, and 28.4% (Table 1-3). Mean prevalence rates in Manitoba for SN, NDD and developmental vulnerability were 3.9%, 2.1%, and 31.4% (Table 4-6). The interaction of time and SES index was not statistically significant in most final models; thus the final models were presented without the interaction term, except for developmental vulnerability in Ontario (Table 3). All other covariates were significant predictors of prevalence of SN, NDD, and developmental vulnerability in Ontario. Results of the interaction term models are in Appendix 2 (Tables A1-A18). Examination of standard errors (SE), tolerance, and variance inflation factors revealed no issues with multicollinearity in the final mixed models. Residual (unexplained) variances in Ontario were equal to or smaller than .004; random intercept/slope variances were equal to or less than .001. Significance levels were all < .001 with extremely small SE values. Residual variance in Manitoba ranged from < .001-.005 and random intercept/slope variances were equal to or less than .001, with extremely small SE values. Significance levels were <.001 for NDD and developmental vulnerability, but not significant for SN (p = .12). Low intercept variances indicated the variation in the means across neighbourhoods and measurement occasions is narrow while low slope variances indicate the effects of predictors with random effects varied only modestly from neighbourhood to neighbourhood.

Special Needs Status in Ontario

For each subsequent measurement occasion after baseline, mean prevalence of SN was expected to increase by .001 points (.1%). Mean prevalence of SN was expected to decrease with an increase in neighbourhood proportion of females and higher SES, while prevalence of SN was expected to increase with an increase in neighbourhood proportions of older children, EFLL, and impairments (Table 1).

Neurodevelopmental Disorders in Ontario

For NDD, the final model included the fixed effects, random intercept, and random slope for time to achieve convergence (Table 2). For the final model, every one-unit increase in time was associated with an increase of .001 points (.1%) in mean prevalence of NDD. For every one-unit increase in neighbourhood mean age, impairment, or proportion with EFLL status, mean prevalence was expected to increase by .02, .12, and .01 points respectively. For every one-unit increase in neighbourhood mean SES and proportion of females, mean prevalence of NDD was expected to decrease by .002 and .026 points, respectively.

Developmental Vulnerability in Ontario

For each subsequent measurement occasion after baseline, mean prevalence of developmental vulnerability was expected to increase by .001 points (.1%) (Table 3). Decreases in prevalence were expected with increases in mean proportion of females, older age, and higher SES. Increases in prevalence were expected with increases in mean proportion of impairment and EFLL. The trajectory for the interaction term for time and SES showed that developmental vulnerability was increasing slower in more affluent neighbourhoods and stayed consistently higher over time in poorer neighbourhoods compared to the mean (Figure 4).

Special Needs Status in Manitoba

Sex, age, EFLL, and SES were not significant predictors of prevalence of SN (Table 4). Prevalence decreased slightly from the initial timepoint in 2011 and then began to increase in 2015. For a one-unit increase in proportion of impairments, the expected prevalence of SN increased by .26 points.

Neurodevelopmental Disorder in Manitoba

SES index and EFLL status were not significant predictors of prevalence of NDD (Table 5). For each subsequent measurement occasion after baseline, mean prevalence of NDD was expected to increase by .001 points (p = .02) or .1%. For a one-unit increase in proportion of females or mean age, the expected mean prevalence of NDD decreased by 0.3 (p = 007) and .05 points (p = .003), respectively. For a one-unit increase in proportion of impairments, the expected mean of NDD increased by .13 points (p < .001).

Developmental Vulnerability in Manitoba

Sex, age, and time were not significant predictors of prevalence of developmental vulnerability (Table 6). For each subsequent measurement occasion after baseline, mean prevalence of developmental vulnerability increased by .001 points (.1%) (p = .75), suggesting no time trend in vulnerability in Manitoba. For a one-unit increase in proportion of females or mean SES, the expected mean prevalence of developmental vulnerability decreased by .04 (p =

0.32) and .03 points (*p* < .001). For a one-unit increase in proportion of impairments or EFLL status, the expected mean of developmental vulnerability increased by .7 (*p* < .001) and .13 points (*p* = .003).

Discussion

This study set out to determine the changes over time in prevalence of SN, NDD, and developmental vulnerability of kindergarten children residing in Ontario and Manitoba from 2010 to 2019. The growth curve analyses show small but mostly increasing changes over time in the prevalence of SN, NDD, and developmental vulnerability across neighbourhoods in Ontario and Manitoba, at around 0.1% each year. The compounded growth rates show increases that range from 2%-38% over the decade under investigation. The absence of interactions between neighbourhood characteristics such as SES and time is also an important finding that shows differences in outcomes between advantaged and disadvantaged neighbourhoods are stable over time.

The results also present additional evidence for child's sex and neighbourhood SES as reliable predictors of children's developmental outcomes. Generally, in neighbourhoods with higher proportions of females and higher SES, the predicted prevalence of SN, NDD, and developmental vulnerability decreased over time. Other individual-level population research has also documented an increased risk of developmental vulnerability and/or presence of health disorders associated with male sex and lower neighbourhood SES (Curtin et al., 2013; Janus et al., 2019; Janus et al., 2024; Prasad et al., 2015). Individual characteristics are related to neighbourhood-level characteristics, which can explain variability in initial trends and changes over time (Huie et al., 2001). The conceptual model presented by Huie (2001) suggests that individual proximate determinants (e.g., stress, health behaviours) and exposure to social and environmental conditions (e.g., human capital, school, social activities, gender, race) within neighbourhoods contribute to varied health, mortality, and social outcomes. Neighbourhood socioeconomic disadvantage contributes to lower neighbourhood cohesion, family difficulties, and child language and behavioural difficulties (Kohen et al., 2008). A similar study demonstrated that variances in school readiness which could be explained at the neighbourhood-level also varied by EDI domain (Oliver et al., 2007). Neighbourhood characteristics associated with readiness to learn measured by EDI domain scores were median family income, lone-parent families, and percentage of the population that were non-native language speakers (Oliver et al., 2007). Changes in these neighbourhood characteristics may have an impact on rates of SN, NDD, and developmental vulnerability over time.

Older mean neighbourhood age was associated with increased prevalence for all outcomes, except developmental vulnerability in Ontario, where the opposite was true: older mean neighbourhood age was associated with decreasing developmental vulnerability prevalence estimates. In individual-level data, older age was associated with higher EDI domain scores until about 6.3 years of age, after which the mean domain scores started to decrease (Janus et al., 2019). Children with a designated SN were also generally older than typically developing children (Janus et al., 2019), which may explain the pattern between older age and prevalence estimates of SN and NDD and the opposite relationship with developmental vulnerability in this study. The relationship between age and prevalence estimates may be related to other sociodemographic factors experienced in early childhood, such as neighbourhood or institutional resources, parenting behaviours, or school environment (Leventhal, 2018; Kohen et al., 2009).

The findings of this study are consistent with those of van Dyck and colleagues (2004) who found children older than 6 years of age, of male sex, and from families in poverty had a higher prevalence of special healthcare needs in the United States. In another study in Australia, teachers more often reported emerging special healthcare needs than families did, particularly for children from families of lower SES or whose families were less involved at school (O'Connor et al., 2016), which demonstrates the importance of family characteristics and family history on a child's health. The Ontario Child Health Study also found increasing trends from 1983 to 2014 for child/youth mental disorders and perceived needs for professional help (Comeau et al., 2014). Considering these findings in the broader context of health and educational systems, increases in prevalence rates of SN, NDD, or developmental vulnerability may contribute to increased unmet healthcare and educational needs, if clinical, educational, and support services do not meet the increase in demand. More services will be needed to improve access and outcomes for this population. Professional training on how to support children with SN or developmental concerns also needs improvement. Some physicians in Ontario report lacking information regarding early signs and diagnostic criteria of NDD (Davin et al., 2024; Ghaderi & Watson, 2019). This could impact the accuracy of prevalence rates by making room for underdiagnosis or misdiagnosis and reduce time spent in early intervention services. Universal interventions administered by trained professionals could be beneficial in filling the gap of timely and accurate early identification/intervention.

Policy and Practice Implications

Our study opens possibilities for interprovincial discussions on ways to promote and enhance healthy child development and learning from other governments' decisions. Using this type of data on developmental health trajectories, policy decisions can be made on universal and targeted interventions to promote healthy child development to vulnerable groups. Significant increases in prevalence rates of SN or NDD or developmental vulnerability at school entry could put pressure on existing systems and neighbourhood communities responsible for administering early identification, clinical intervention, and special educational services. On one hand, an increase in prevalence rates of SN, NDD, or developmental vulnerability could signal better diagnostic practices and recognition of pre-existing developmental issues. Conversely, changes in prevalence rates may also reflect true increases in developmental issues because of social, environmental, and genetic factors. To some extent, prevalence rates may also be attributed to changes in data collection methods, migration, diagnostic criteria and definitions of NDD. More research is needed to uncover the reasons for changes in prevalence rates over time, and to explore whether environmental (in)stability impacts the processes that facilitate development (Bronfenbrenner, 1995). Neighbourhoods affected by these changes in prevalence rates may be supported through government interventions to improve the psychosocial, behavioural, material, and biological determinants of health and subsequently reduce vulnerability to poorer health outcomes (Solar & Irwin, 2010). Policymakers can consider adding or modifying policies to address socioeconomic and geographic inequities related to access to care (Shepherd & Waddell, 2015). Income supplement policies or greater availability of free and low-cost prenatal, newborn/infant, and early child development programs and services may mitigate factors associated with negative developmental outcomes for vulnerable neighbourhoods.

Strengths and Limitations

One strength of this study was the longitudinal approach of repeated cross-sectional measurements. Sociodemographic characteristics were used to understand the average and changing developmental health outcomes of kindergarten children nested within neighbourhoods. Comparisons of prevalence rates provided the opportunity to examine current systems, policies, and resource planning for early identification and intervention services and tailor changes to more vulnerable groups. The multilevel modelling method and restricted maximum likelihood estimation methods allowed us to include neighbourhoods with missing data, an unequal number of neighbourhoods in each measurement occasion, and use random effects to account for possible values of covariates outside of the current sample averages. Another strength was the inclusion of three separate outcomes, which provided a comprehensive view of neighbourhood-level patterns of meeting age-appropriate developmental expectations.

The analytic approach enabled us to classify different levels of social structures by aggregating students of cohorts into neighbourhoods and in separate provinces. This strategy allowed for a flexibility with time-unstructured (data collection occurs at different times) and unbalanced (number of observations differ) data, which is suitable for complex models of change (Holt, 2008). The analytic approach also enabled us to study intra-neighbourhood and inter-neighbourhood differences in rates of change with respect to sociodemographic predictors (Shek & Ma, 2011), leading us to quantify the state of children's developmental health over time, which can be used to inform policymaking.

There may be unexplained variation in prevalence estimates from family, geography, child, or school factors unaccounted for as the data were not available. Due to small proportions of specific NDD, the change over time of NDD was only investigated as one combined category. The study was also limited to two provinces and may not reflect Canada as a whole. However, the study population was large, and these two provinces were selected because of excellent EDI data availability. The nesting structure in the multilevel models could be expanded in future work to consider the effect of schools and/or school boards. Additionally, measurement invariance could occur across waves of any measurement instrument used over long periods of time.

Conclusion

This study found prevalence rates of SN, NDD, and developmental vulnerability consistently increased over time in kindergarten children in two Canadian provinces. Increases in prevalence rates of these conditions may result in increased unmet healthcare and educational needs if health and social systems are unable to keep up with the increasing demand for services. Greater access to universal and targeted interventions to address healthy child development in disadvantaged neighbourhoods will moderate potential negative developmental health outcomes at school entry. More research is needed to explain why prevalence rates are steadily increasing over time.

Table 1

Final Mixed Effects Model Of Special Needs Status In Ontario

Parameter	Estimate	Standard error	Df	t-value	Significance	95% Confidence interval	
						Lower Bound	Upper Bound
Intercept	.041	.001	1,695.63	55.48	<.001	.040	.042
Time	.001	<.001	2,269.30	6.98	<.001	.001	.002
Centred age	.052	.008	2,175.44	6.23	<.001	.035	.068
Centred sex	-.025	.008	2,348.97	-3.16	.002	-.040	-.009
Centred impairment	.222	.009	2,348.03	23.71	<.001	.204	.240

Centred English French language learner	.024	.005	2,266.46	5.25	<.001	.015	.033
Socioeconomic status index	-.001	.001	1,898.38	-2.39	.017	-.002	< .000

Table 2

Final Model Of Neurodevelopmental Disorder In Ontario

Parameter	Estimate	Standard error	Df	t-value	Significance	95% Confidence interval	
						Lower Bound	Upper Bound
Intercept	.023	.001	829.57	24.10	<.001	.021	.025
Time	.001	<.001	838.36	4.46	<.001	<.001	.001
Centred age	.022	.008	2,369.24	2.66	.008	.006	.039
Centred sex	-.026	.007	2,193.38	-3.61	<.001	-.040	-.012
Centred impairment	.120	.008	1,853.54	14.28	<.001	.103	.136
Centred English	.012	.004	1,432.69	2.80	.005	.003	.020

French Language Learner							
Socioeconomic status index	-.002	.000	887.817	-5.158	<.001	-.003	-.002

Table 3

Final Mixed Effects Model Of Developmental Vulnerability In Ontario

Parameter	Estimate	Standard error	Df	t-value	Significance	95% Confidence interval	
						Lower Bound	Upper Bound
Intercept	.284	.002	1,608.11	137.50	<.001	.280	.288
Time	.001	.000	2,291.76	2.90	.004	.0004	.002
Centred age	-.148	.023	2,186.08	-6.54	<.001	-.192	-.103
Centred sex	-.130	.021	2,357.06	-6.14	<.001	-.172	-.089
Centred impairment	.601	.025	2,330.45	23.74	<.001	.551	.651

Centred English French Language Learner	.071	.012	2,235.30	5.77	<.001	.047	.094
Socioeconomic status index	-.037	.002	1,725.17	-18.09	<.001	-.041	-.033
Time*Socioeconomic status index interaction	.001	.0004	2,293.46	2.71	.007	.0003	.002

Table 4

Final Mixed Effects Model Of Special Needs Status In Manitoba

Parameter	Estimate	Standard error	Df	t-value	Significance	95% Confidence Interval	
						Lower Bound	Upper Bound
Intercept	.039	.003	287.12	13.20	< .001	.033	.045
Time	-.005	.002	303.56	-2.70	.007	-.008	-.001
Quadratic time	.001	< .001	280.33	3.66	< .001	< .001	.001
Centred age	-.048	.025	366.56	-1.93	.054	-.096	.001
Centred sex	-.022	.017	356.56	-1.28	.198	-.055	.012
Centred impairment	.248	.025	324.31	9.87	< .001	.199	.298

Centred English French Language Learner	.012	.014	217.02	0.84	.400	-.016	.041
Socioeconomic status index	-.002	.002	197.39	-1.35	.178	-.005	.001

Table 5

Final Mixed Effects Model Of Neurodevelopmental Disorder In Manitoba

Parameter	Estimate	Standard error	Df	t-value	Significance	95% Confidence Interval	
						Lower Bound	Upper Bound
Intercept	.021	.002	310.06	13.12	< .001	.018	.024
Time	.001	.000	176.90	2.32	.021	<.001	.002
Centred age	-.051	.017	353.13	-3.02	.003	-.084	-.018
Centred sex	-.031	.011	342.45	-2.71	.007	-.054	-.009
Centred impairment	.131	.018	367.98	7.26	< .001	.095	.166
Centred English French Language Learner	-.011	.011	327.85	-1.02	.306	-.033	.010

Socioeconomic status index	.0003	.001	296.76	.27	.786	-.002	.003

Table 6

Final Mixed Effects Model Of Developmental Vulnerability In Manitoba

Parameter	Estimate	Standard error	Df	t-value	Significance	95% Confidence Interval	
						Lower Bound	Upper Bound
Intercept	.314	.006	302.26	49.18	< .001	.301	.326
Time	.001	.002	98.93	0.31	.755	-.003	.005
Centred age	.060	.068	325.04	0.87	.382	-.074	.193
Centred sex	-.045	.046	315.19	-0.98	.327	-.136	.045
Centred impairment	.716	.074	351.27	9.71	< .001	.571	.861
Centred English French Language Learner	.139	.047	360.67	2.98	.003	.047	.231
Socioeconomic status index	-.031	.005	329.65	-5.73	< .001	-.042	-.020

Figure 1

Unconditional And Conditional Model-Implied Trajectories Of Prevalence Rates Of Special Needs Status In Ontario

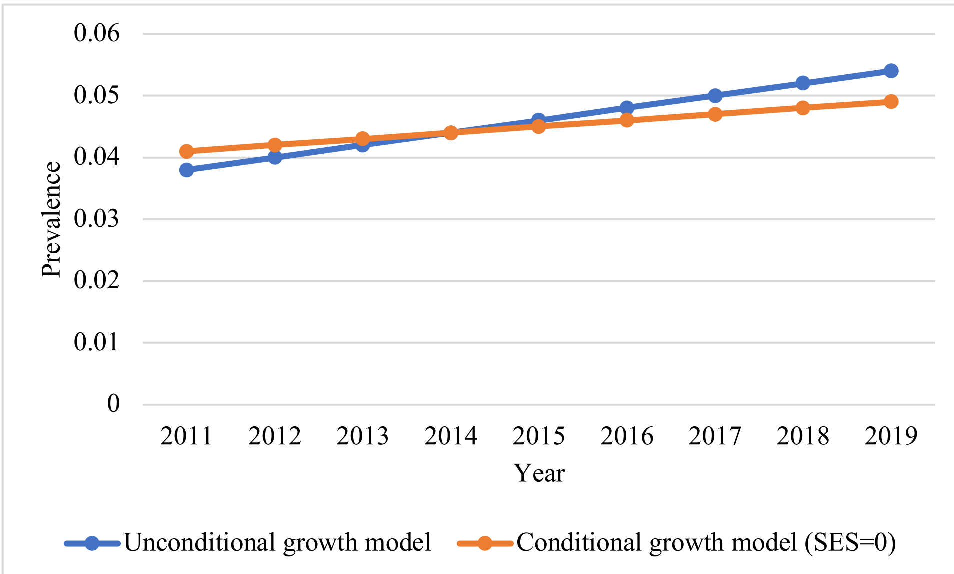


Figure 2

Unconditional And Conditional Model-Implied Trajectories Of Prevalence Rates Of Neurodevelopmental Disorder In Ontario

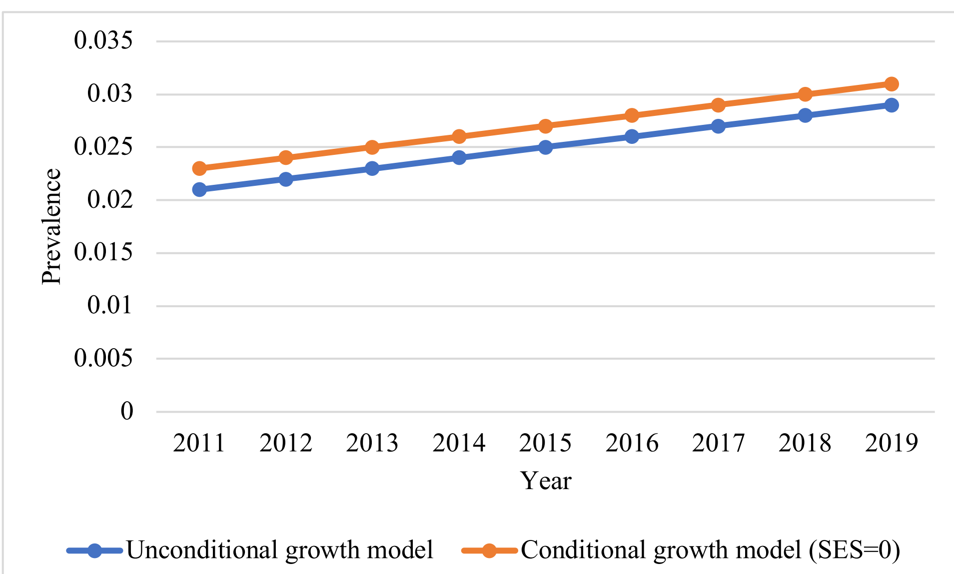


Figure 3

Unconditional And Conditional Model-Implied Trajectories Of Prevalence Rates Of Developmental Vulnerability In Ontario

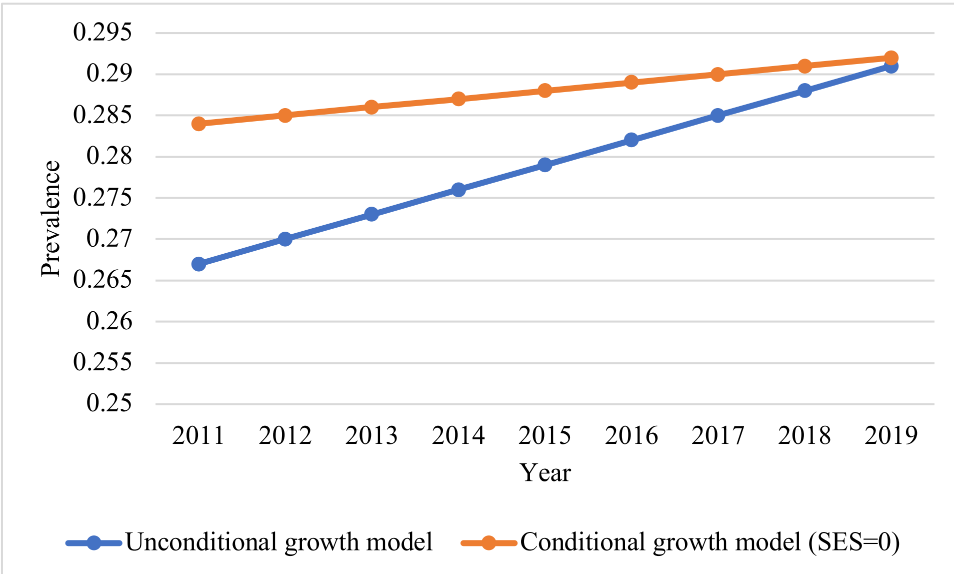


Figure 4

Simple Model-Implied Trajectories Of Developmental Vulnerability Prevalence In Ontario At Three Levels Of Neighbourhood SES

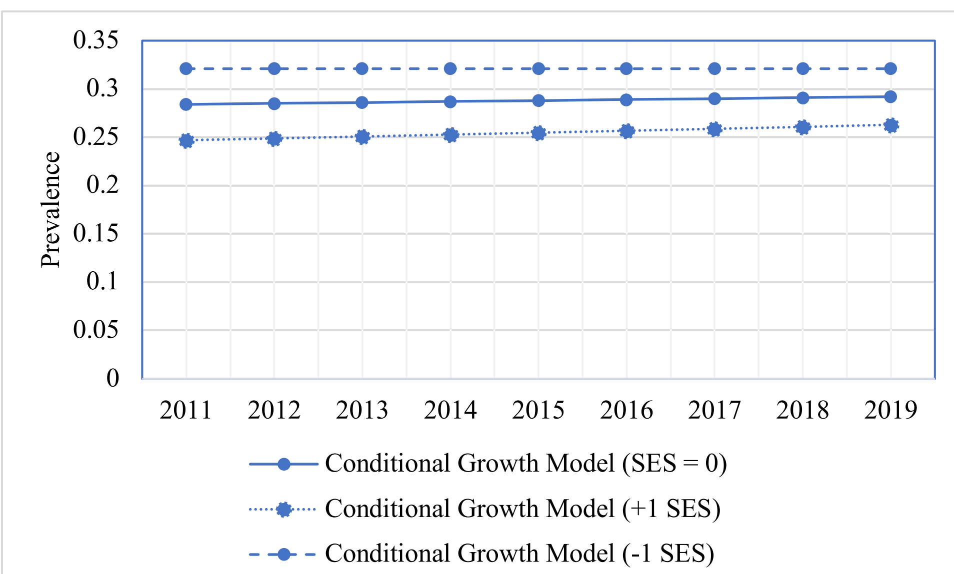


Figure 5

Unconditional And Conditional Model-Implied Trajectories Of Prevalence Rates Of Special Needs Status In Manitoba

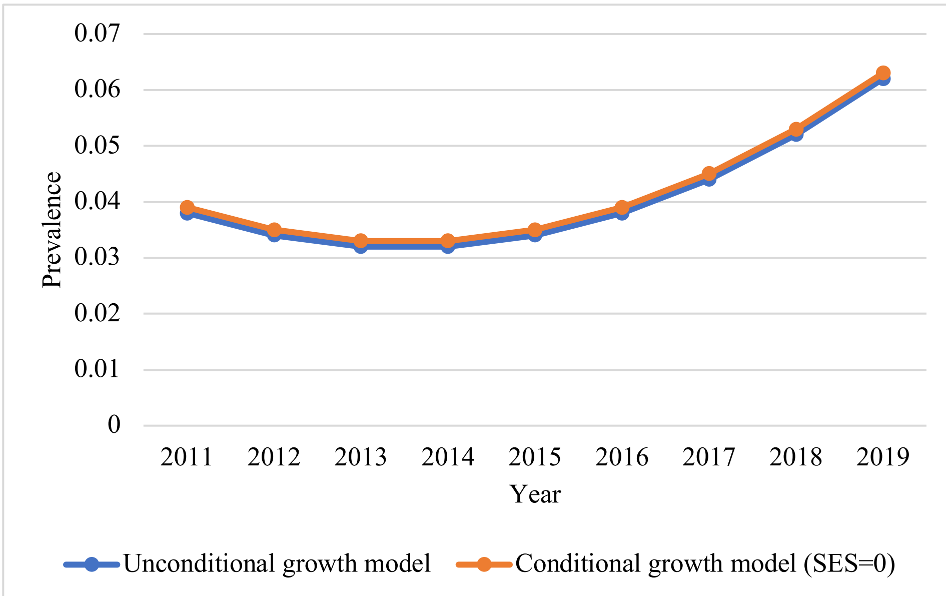


Figure 6

Unconditional And Conditional Model-Implied Trajectories Of Prevalence Rates Of Neurodevelopmental Disorders In Manitoba

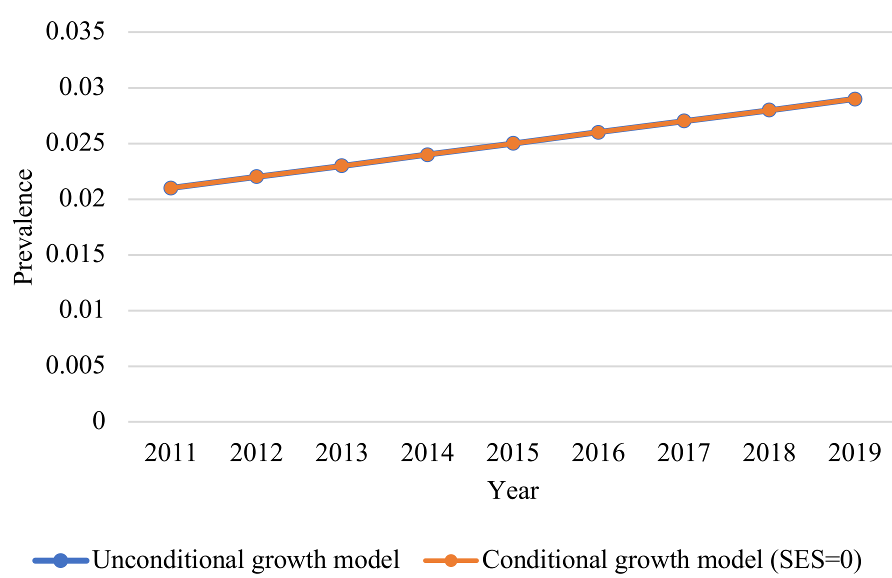
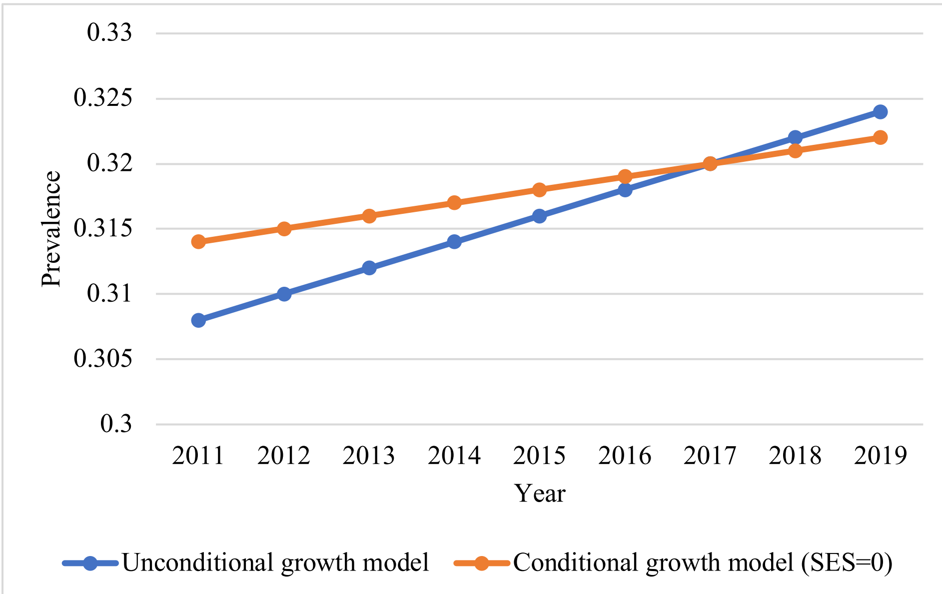


Figure 7

Unconditional And Conditional Model-Implied Trajectories Of Prevalence Rates Of Developmental Vulnerability In Manitoba



Appendix 1

Data Analyses

Table A1

Demographic Characteristics At The Individual Level

Variable	Total (%)	Manitoba	Ontario	Cramer's V value (2-sided sig.)
N	452,031	64,401 (14.2%)	387,630 (85.8%)	-
Mean age (SD)	5.69 (0.3)	5.69 (0.3)	5.68 (0.3)	-
Male biological sex	51.3% (231,950/452,028)	51.0% (32,848/64,399)	51.36% (199,102/387,629)	.002 (.09)
Special needs status	4.35% (19,665/451,603)	3.87% (2,494/64,354)	4.43% (17,171/387,249)	.01 (< .001)
Neurodevelopmental disorder	2.59% (11,714/452,031)	2.67% (1,723/64,401)	2.58% (9,991/387,630)	.002 (.15)
Overall vulnerability	28.38% (128,291/452,031)	32.12% (20,687/64401)	27.76% (107,604/387,630)	.03 (< .001)
Functional impairment	13.14% (59,384/452,031)	13.48% (8,682/64,401)	13.08% (50,702/387,630)	.004 (.005)
English or French second language	13.38% (60,330/450,836)	14.39% (9,264/64,349)	13.21% (51,066/386,487)	.01 (< .001)
Aboriginal status	7.86% (14,112/179,434)	19.79% (12,384/62,567)	1.48% (1,728/116,867)	.32 (< .001)
Vulnerability in physical domain	12.15% (54,889/451,683)	14.09% (9,070/64,374)	11.83% (45,819/387,309)	.02 (< .001)
Vulnerability in social competence domain	11.75% (53,101/451,935)	11.79% (7,591/64,387)	11.74% (45,510/387,548)	.001 (.7)

Vulnerability in emotional maturity domain	13.20% (59,482/450,512)	13.88% (8,910/64,182)	13.09% (50,572/386,330)	.008 (< .001)
Vulnerability in language domain	8.08% (36,492/451,163)	13.00% (8,361/64,283)	7.27% (28,131/386,880)	.07 (< .001)
Vulnerability in communication domain	13.24% (59,817/451,894)	16.72% (10,765/64,387)	12.66% (49,052/387,507)	.04 (< .001)
Physical domain mean score (SD)	8.72 (1.43)	8.62 (1.54)	8.74 (1.41)	-
Social competence domain mean score (SD)	8.21 (1.96)	8.2 (1.98)	8.22 (1.96)	-
Emotional maturity domain mean score (SD)	7.96 (1.63)	7.87 (1.63)	7.97 (1.63)	-
Language domain mean score (SD)	8.62 (1.83)	8.07 (2.09)	8.71 (1.76)	-
Communication domain mean score (SD)	7.7 (2.63)	7.44 (2.8)	7.74 (2.60)	-
Mean SES Index Z-score (SD) Time 3 2016	0.28 (1.01)	0.05 (0.98)	0.32 (1.01)	-
Receiving school-based support	8.72% (37,039/424,572)	13.13% (8,051/61,301)	7.98% (28,988/363,271)	.06 (< .001)

Currently receiving further assessment	5.83% (25,617/439,192)	6.48% (4,119/63,548)	5.72% (21,498/375,644)	.01 (< .001)
On waitlist to receive assessment	4.87% (21,272/436,636)	4.35% (2,749/63,245)	4.96% (18,523/373,391)	0.01 (< .001)
Needs assessment	13.11% (57,137/435,783)	10.90% (6,883/63,098)	13.4% (50,254/372,685)	0.03 (< .001)
Attended early intervention	9.70% (35,161/362,213)	15.03% (8,845/58,838)	8.67% (26,316/303,375)	0.08 (< .001)

Table A2

Proportion Of Children With Special Needs Status, Neurodevelopmental Disorder, And Developmental Vulnerability

Province	2011	2013	2015	2017	2018	2019	Overall
Special needs status							
Manitoba	442/11,703	443/12,830	422/13,125	510/13,205	-	677/13,491	3.39% (2,494/64,354)
Ontario	4,793/123,769	-	5,501/132,197	-	6,877/131,283	-	4.43% (17,171/387,249)
Neurodevelopmental disorder							
Manitoba	265/11,718	344/12,846	328/13,132	365/13,209	-	421/13,496	2.68% (1,723/64,401)
Ontario	2,755/123,769	-	3,238/132,423	-	3,998/131,438	-	2.58% (9,991/387,630)
Developmental vulnerability							
Manitoba	3,692/11,718	4,094/12,846	4,146/13,132	4,331/13,209	-	4,424/13,496	32.12% (20,687/64,401)
Ontario	32,680/123,769	-	37,243/132,423	-	37,681/131,428	-	27.78% (107,604/387,630)

Table A3

Proportion of Children with Developmental Vulnerability in Each EDI Domain

Domain	2011	2013	2015	2017	2018	2019	Total
Manitoba							
Physical	1,486/11,707	1,830/12,843	1,775/13,127	1,939/13,206	-	2,040/13,491	14.09% (9,070/64,374)
Social	1,362/11,716	1,516/12,845	1,463/13,130	1,619/13,203	-	1,631/13,493	11.79% (7,591/64,387)
Emotional	1,567/11,674	1,738/12,801	1,765/13,106	1,919/13,177	-	1,921/13,424	13.88% (8,910/64,182)
Language	1,484/11,679	1,638/12,837	1,563/13,107	1,739/13,198	-	1,937/13,462	13.00% (8,361/64,283)
Communication	1,947/11,717	2,107/12,843	2,188/13,130	2,204/13,202	-	2,319/13,495	16.72% (10,765/64,387)
Ontario							
Physical	13,143/123,582	-	16,099/132,337	-	16,577/131,390	-	11.83% (45,819/387,309)
Social	13,081/123,738	-	16,465/132,402	-	15,964/131,408	-	11.74% (45,510/387,548)
Emotional	14,360/123,221	-	18,535/132,056	-	17,677/131,053	-	13.09% (50,572/386,330)
Language	9,116/123,327	-	8,815/132,244	-	10,200/131,309	-	7.27% (28,131/386,880)
Communication	16,502/123,717	-	16,147/132,384	-	16,403/131,406	-	12.66% (49,052/387,507)

Table A4

Descriptive Statistics at The Neighbourhood Level in Ontario (Number of Observations =2,387)

Variable	Minimum	Maximum	Mean	Std. Deviation	Range	Variance
Special needs status	0	0.33	0.045	0.027	0.33	0.001
Neurodevelopmental disorder	0	0.51	0.026	0.024	0.51	0.001
Developmental vulnerability	0	1.00	0.279	0.084	1.00	0.007
Age	5.36	6.16	5.684	0.056	0.79	0.003
Female biological sex	0	1.00	0.488	0.060	1.00	0.004
Impairment	0	0.50	0.132	0.055	0.50	0.003
Socioeconomic status index (z-score)	-2.48	3.21	0.301	1.003	5.69	1.006
English or French language learner	0	0.71	0.124	0.112	0.71	0.013
Physical domain vulnerability	0	0.50	0.121	0.058	0.50	0.003
Social domain vulnerability	0	0.35	0.117	0.049	0.35	0.002
Emotional domain vulnerability	0	0.45	0.132	0.052	0.45	0.003
Language domain vulnerability	0	1.00	0.073	0.045	1.00	0.002

Communication domain vulnerability	0	1.00	0.126	0.056	1.00	0.003
Physical domain mean score	6.92	10.00	8.730	0.324	3.08	0.105
Social domain mean score	5.71	10.00	8.218	0.368	4.29	0.135
Emotional domain mean score	5.78	10.00	7.961	0.313	4.22	0.098
Language domain mean score	5.38	9.81	8.701	0.381	4.42	0.14
Communication domain mean score	3.75	10.00	7.750	0.538	6.25	0.29
Receiving school-based support	0	50.0	8.318	4.939	50.0	24.40
Currently receiving further assessment	0	33.3	5.866	3.223	33.3	10.38
On waitlist to receive further assessment	0	26.5	5.084	3.062	26.5	9.38
Needs assessment	0	100.0	13.778	5.577	100.0	31.11
Attended early intervention program (n=2,384)	0	0.50	0.089	0.051	0.50	0.003
Neighbourhood groupings	1	763	162.39	93.86	0.33	0.001

Table A5

Descriptive Statistics At The Neighbourhood Level In Manitoba (Number Of Observations=375)

Variable	Minimum	Maximum	Mean	Std. Deviation	Range	Variance
Special needs status	0	0.33	0.039	0.034	0.33	0.001
Neurodevelopmental disorder	0	0.33	0.025	0.023	0.33	0.001
Developmental vulnerability	0	1.00	0.315	0.117	1.00	0.014
Age	5.23	6.03	5.696	0.061	0.80	0.004
Female biological sex	0	1.00	0.491	0.086	1.00	0.007
Impairment	0	0.38	0.134	0.066	0.38	0.004
Socioeconomic status index (z-score)	-2.41	2.46	0.028	1.052	4.87	1.11
English or French language learner	0	1.00	0.1372	0.110	1.00	0.01
Physical domain vulnerability	0	0.39	0.1384	0.076	0.39	0.006
Social domain vulnerability	0	0.40	0.114	0.066	0.40	0.004
Emotional domain vulnerability	0	1.00	0.139	0.08	1.00	0.006
Language domain vulnerability	0	0.52	0.126	0.078	0.52	0.006

Communication domain vulnerability	0	0.41	0.161	0.074	0.41	0.005
Physical domain mean score	7.31	10.00	8.675	0.439	2.69	0.19
Social domain mean score	6.50	10.00	8.246	0.492	3.50	0.24
Emotional domain mean score	5.00	10.00	7.876	0.456	5.00	0.21
Language domain mean score	5.64	9.81	8.111	0.611	4.17	0.37
Communication domain mean score	5.55	10.00	7.512	0.716	4.45	0.51
Receiving school-based support	0	45.9	13.696	6.639	45.9	44.08
Currently receiving further assessment	0	50.0	6.781	4.703	50.0	22.11
On waitlist to receive further assessment	0	33.3	4.608	3.716	33.3	13.81
Needs assessment	0	49.5	10.967	5.449	49.50	29.69
Attended early intervention program	0	1.00	0.158	0.149	1.00	0.02
Neighbourhood groupings	1	558	171.74	110.158	0.33	0.001

Table A6

Comparison of Means of Outcome Variables for Each Measurement Occasion In Manitoba

Time and number of observations		Special needs status	Neurodevelopmental disorder	Developmental vulnerability
0 (76)	Mean	0.038	0.022	0.31
	Std. Deviation	0.03	0.015	0.107
	Variance	0.001	0	0.012
	Std. Error	0.0038	0.0018	0.012
2 (76)	Mean	0.032	0.023	0.308
	Std. Deviation	0.021	0.016	0.103
	Variance	0	0	0.011
	Std. Error	0.002	0.001	0.011
4 (75)	Mean	0.034	0.022	0.309
	Std. Deviation	0.041	0.017	0.116
	Variance	0.002	0	0.014
	Std. Error	0.005	0.002	0.013
6 (74)	Mean	0.035	0.024	0.312
	Std. Deviation	0.021	0.017	0.119
	Variance	0	0	0.014
	Std. Error	0.002	0.001	0.013
8 (74)	Mean	0.053	0.033	0.332
	Std. Deviation	0.043	0.039	0.135
	Variance	0.002	0.002	0.018
	Std. Error	0.005	0.004	0.015
Overall (375)	Mean	0.039	0.025	0.315
	Std. Deviation	0.034	0.023	0.116
	Variance	0.001	0.001	0.014
	Std. Error	0.00175	0.001	0.006

Table A7

Comparison Of Means Of Outcome Variables For Each Measurement Occasion In Ontario

Time and number of observations		Special needs status	Neurodevelopmental disorder	Developmental vulnerability
0 (805)	Mean	0.039	0.022	0.266
	Std. Deviation	0.026	0.031	0.086
	Variance	0.001	0.001	0.007
	Std. Error	0.001	0.001	0.003
4 (792)	Mean	0.0415	0.0244	0.2817
	Std. Deviation	0.024	0.017	0.081

	Variance	0.001	0	0.007
	Std. Error	0.001	0.001	0.003
7 (790)	Mean	0.053	0.031	0.289
	Std. Deviation	0.029	0.021	0.084
	Variance	0.001	0	0.007
	Std. Error	0.001	0.001	0.003
Overall (2,387)	Mean	0.045	0.026	0.279
	Std. Deviation	0.027	0.024	0.084
	Variance	0.001	0.001	0.007
	Std. Error	0.001	0.001	0.002

Table A8

Estimates Of Unconditional Null Mean Model With No Predictors Of Mean Prevalence Of The Dependent Variables Averaged Across Measurement Occasions

Parameter	Estimate	Std. Error	df	t-test	Sig.	95% Confidence Interval		Intraclass Correlation Coefficient
						Lower Bound	Upper Bound	
Ontario								
Intercept[a]	0.045	0.001	787.87	68.85	< .001	0.044	0.046	.09
Intercept[b]	0.026	0.001	802.77	47.89	< .001	0.025	0.027	.05
Intercept[c]	0.279	0.002	807.10	114.10	< .001	0.274	0.284	.50
Manitoba								
Intercept[a]	0.038	0.002	56.68	21.31	< .001	0.035	0.042	.02
Intercept[b]	0.025	0.002	63.94	16.46	< .001	0.022	0.028	.157
Intercept[c]	0.317	0.013	65.46	25.26	< .001	0.291	0.342	.687

a. Dependent Variable: Special needs status.
b. Dependent Variable: Neurodevelopmental disorder.
c. Dependent Variable: Developmental vulnerability.

Table A9

Unconditional Linear Growth Curve Model With Time As Fixed And Random Effects To Represent Growth Rates At Subsequent Measurement Occasions

Parameter	Estimate	Std. Error	df	t-test	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Ontario							
Intercept[a]	0.038	0.001	1624.880	47.51	< .001	0.037	0.040
Time	0.002	0.000	2134.95	9.51	< .001	0.001	0.002
Intercept[b]	0.021	0.001	807.30	21.68	< .001	0.019	0.023
Time	0.001	0.000	805.78	6.38	< .001	0.001	0.002
Intercept[c]	0.267	0.002	1613.54	107.33	< .001	0.262	0.271
Time	0.003	0.001	2085.15	5.65	< .001	0.002	0.005
Manitoba							
Intercept[a]	0.032	0.003	303.40	11.07	< .001	0.026	0.038
Time	0.002	0.001	294.59	2.59	.010	0.000	0.003
Intercept[b]	0.021	0.002	316.04	11.88	< .001	0.018	0.025
Time	0.001	0.000	198.10	2.111	.036	0.00006	0.002
Intercept[c]	0.308	0.008	325.52	40.68	< .001	0.293	0.323
Time	0.002	0.003	95.46	0.67	.502	-0.003	0.007

a. Dependent Variable: Special needs status.
b. Dependent Variable: Neurodevelopmental disorder.
c. Dependent Variable: Developmental vulnerability.

Note: The addition of time as a fixed effect estimates the typical rate of change for each outcome whereas the addition of time as a random effect allows for variation in each neighbourhood's typical rate of change. The mean prevalence rates in Ontario were predicted to increase by .001-.003 points in each measurement occasion. The outcomes in Ontario were predicted to increase by .002-.003 points each year. In Manitoba, the mean rates of change were expected to increase by .001-.002 points in each measurement occasion after the initial time point.

Table A10

Covariance Parameters For Final Models In Ontario

Parameter	Estimate	Std. Error	Wald Z	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Special needs status						
Residual	<0.001	<0.0001	27.730	< .001	<0.001	0.001
Random Intercept + Random Slopes Variance	<0.0001	<0.0001	4.263	< .001	<0.0001	<0.0001
Neurodevelopmental disorder						
Residual	<0.001	<0.0001	19.78	< .001	<0.001	<0.001
Random Intercept + Random Slope Variance *UN (1,1)*	<0.001	<0.0001	11.90	< .001	<0.001	0.001
UN (2,1)	<0.0001	<0.0001	-11.43	< .001	<0.0001	<0.0001
UN (2,2)	<0.0001	<0.0001	10.05	< .001	<0.0001	<0.0001
Developmental vulnerability						
Residual	0.004	<0.001	27.64	< .001	0.003	0.004
Random Intercept + Random Slopes Variance	<0.0001	<0.0001	3.49	< .001	<0.0001	<0.0001

Table A11

Covariance Parameters For Final Models In Manitoba

Parameter	Estimate	Std. Error	Wald Z	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Special needs status						
Residual	0.001	<0.0001	11.74	< .001	0.001	0.001
Random Intercept + Random Slopes Variance	<0.0001	<0.0001	1.54	.123	<0.0001	<0.0001
Neurodevelopmental disorder						
Residual	<0.001	<0.0001	11.83	< .001	<0.001	<0.001
Random Intercept + Random Slopes Variance	<0.0001	<0.0001	3.87	< .001	<0.0001	<0.0001
Developmental vulnerability						
Residual	0.005	<0.001	11.026	< .001	0.004	0.006
Random Intercept + Random Slopes Variance	<0.001	<0.0001	3.895	< .001	<0.001	<0.001

Figure A1

Scatter Plot of Special Needs Status Across Time in Ontario

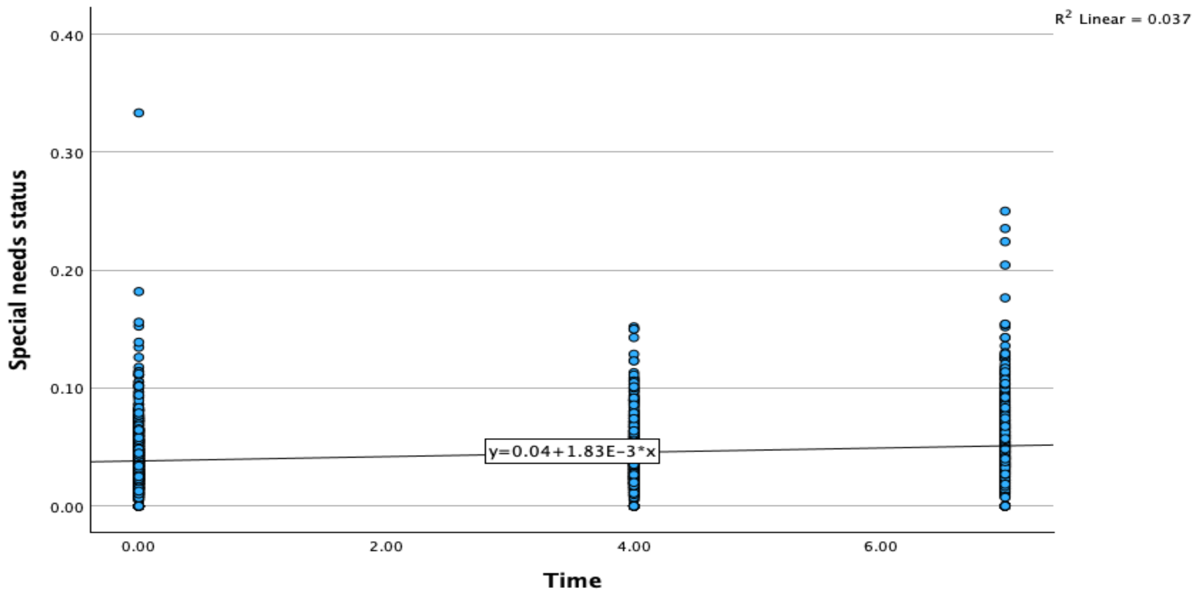


Figure A2

Scatter Plot of Neurodevelopmental Disorder Across Time in Ontario

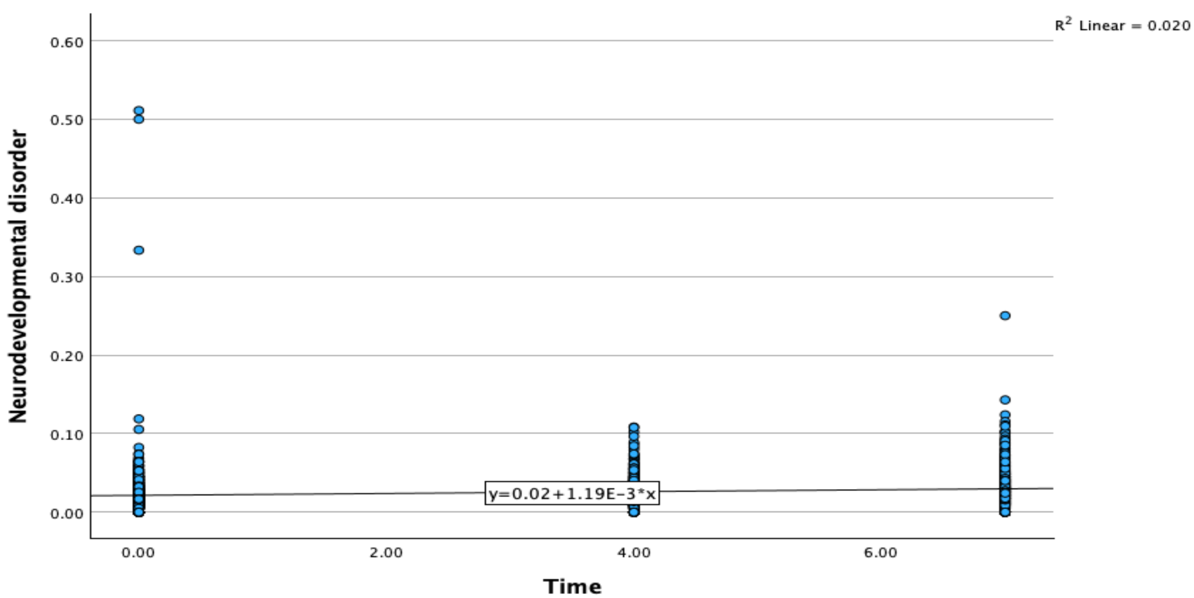


Figure A3

Scatter Plot of Developmental Vulnerability Across Time in Ontario

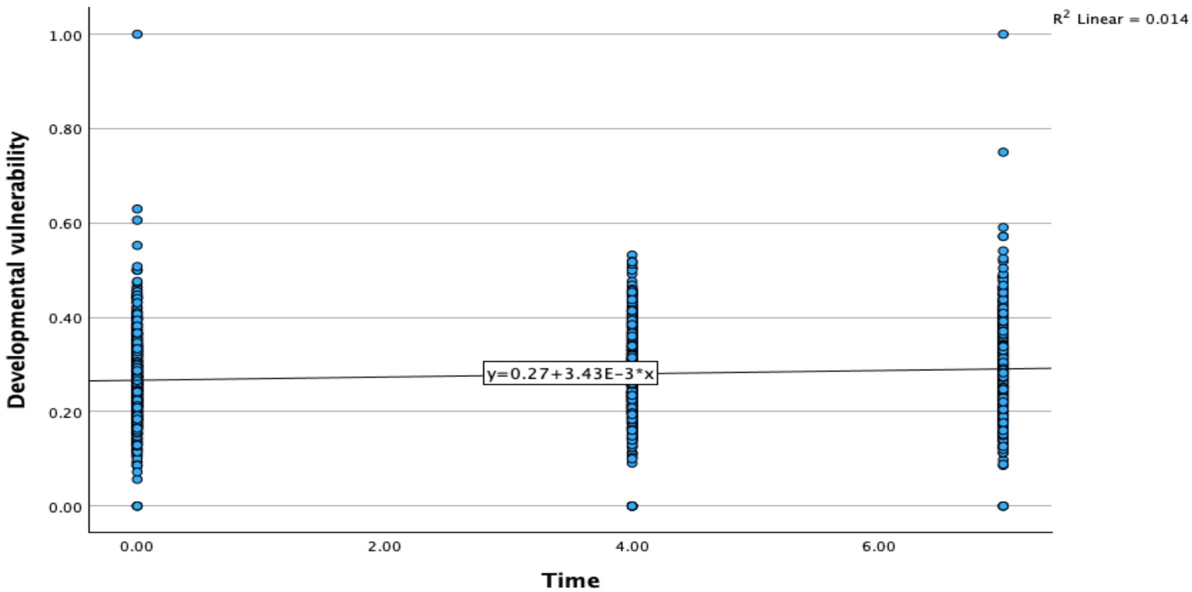


Figure A4

Box and Whisker Plot of Special Needs Status Across Time in Ontario

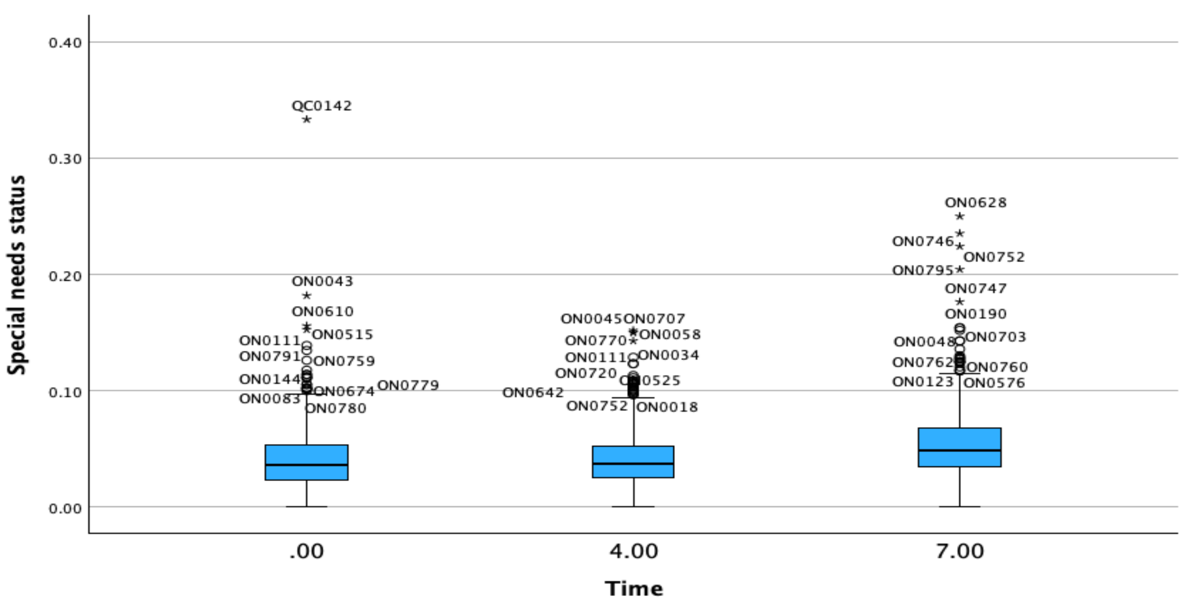


Figure A5

Box and Whisker Plot of Neurodevelopmental Disorder Across Time in Ontario

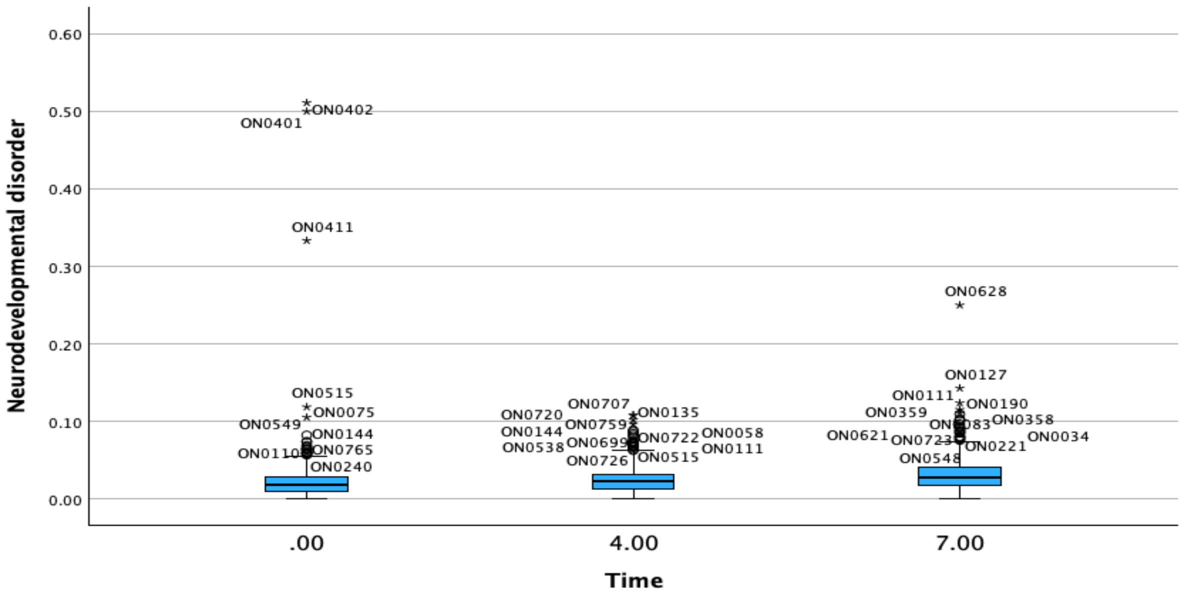


Figure A6

Box and Whisker Plot of Developmental Vulnerability Across Time in Ontario

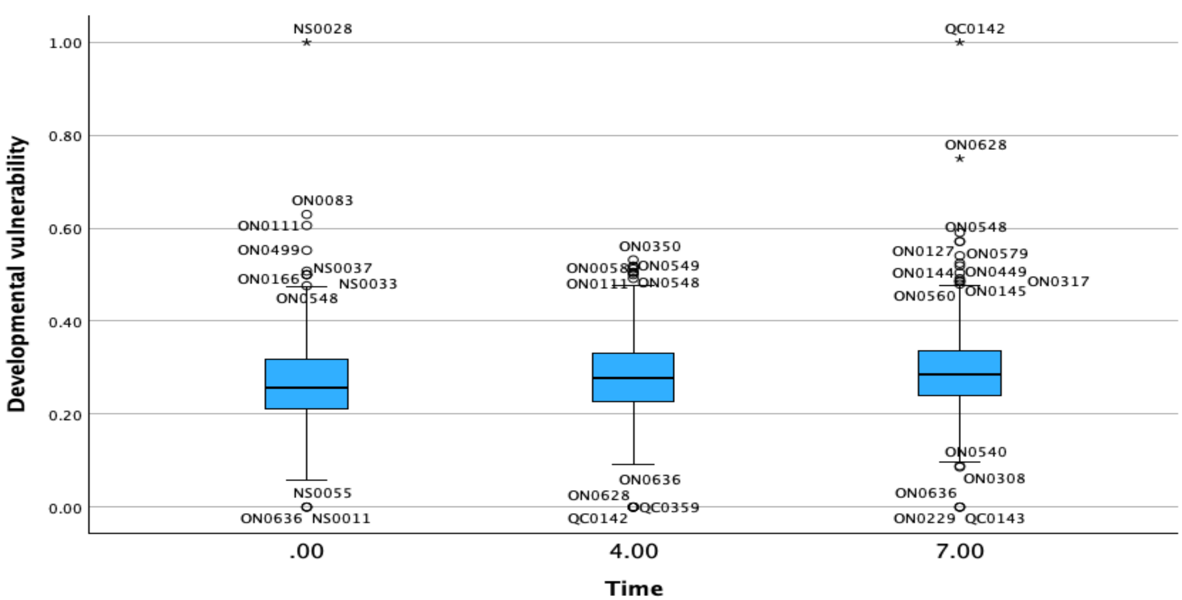


Figure A7

Scatter Plot of Special Needs Status Across Time in Manitoba

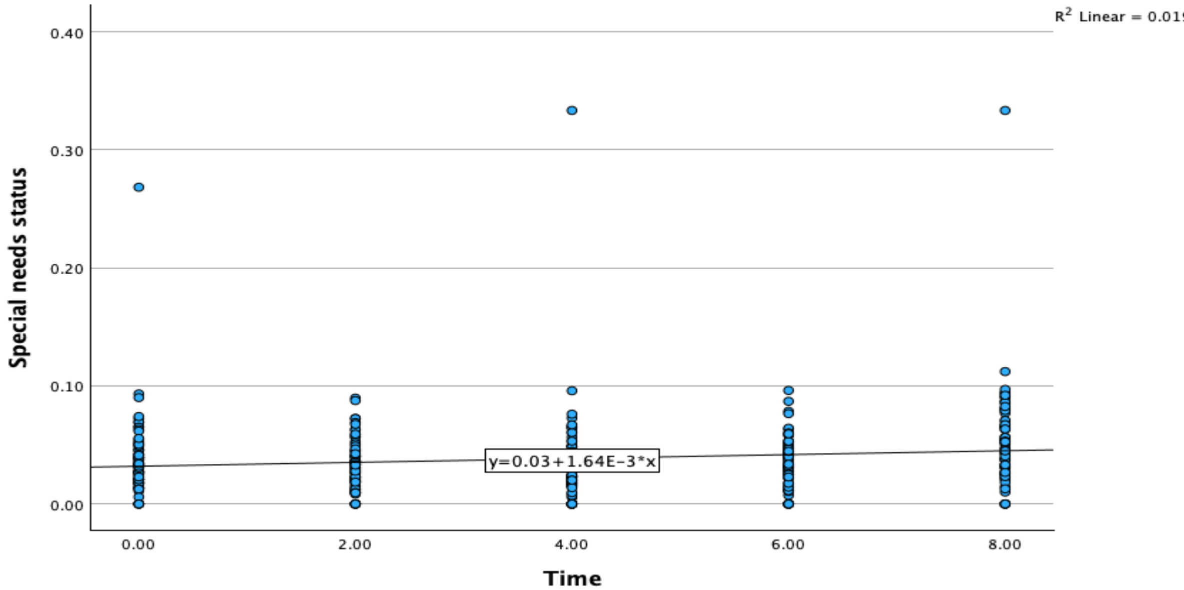


Figure A8

Scatter Plot of Neurodevelopmental Disorder Across Time in Manitoba

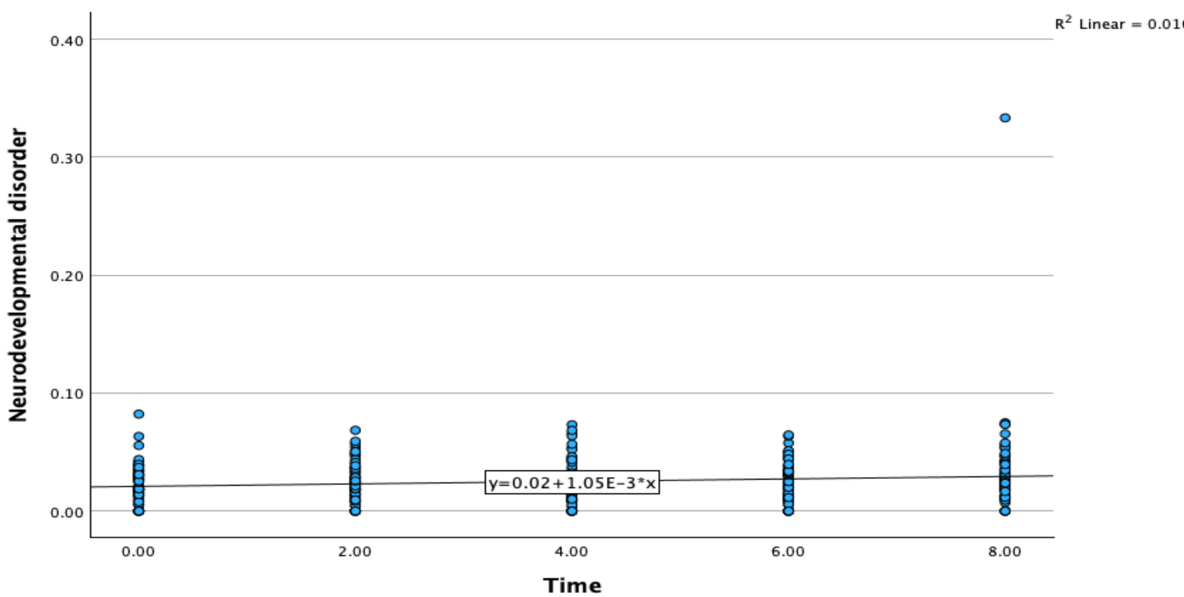


Figure A9

Scatter Plot of Developmental Vulnerability Across Time in Manitoba

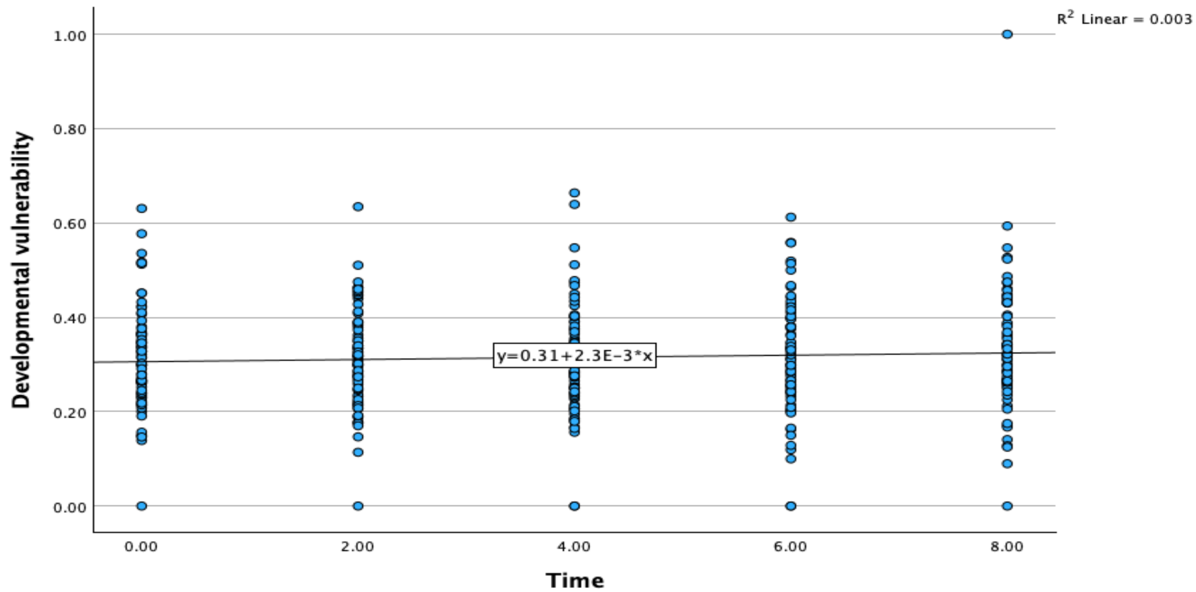


Figure A10

Box and Whisker Plot of Special Needs Status Across Time in Manitoba

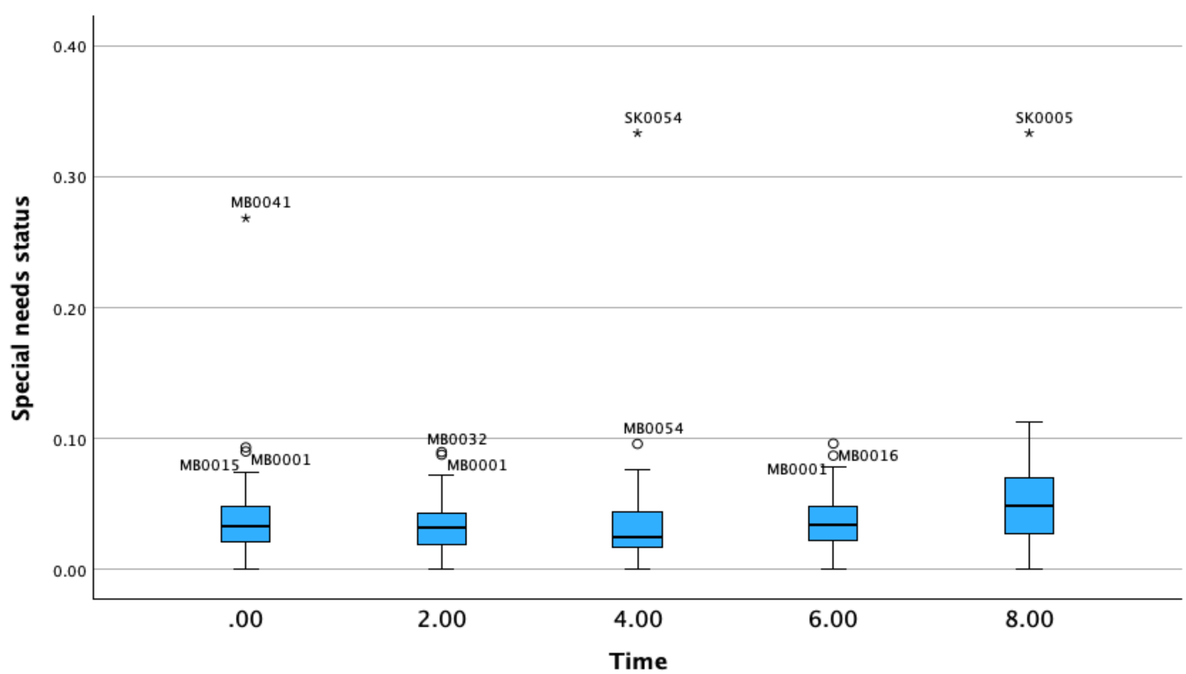


Figure A11

Box and Whisker Plot of Neurodevelopmental Disorder Across Time in Manitoba

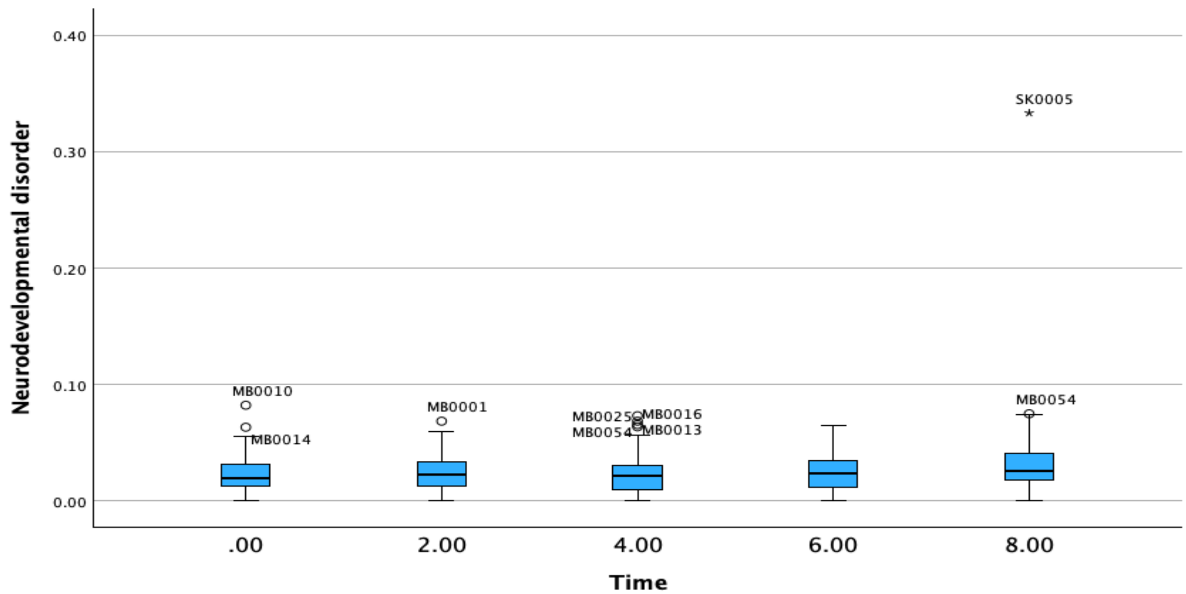
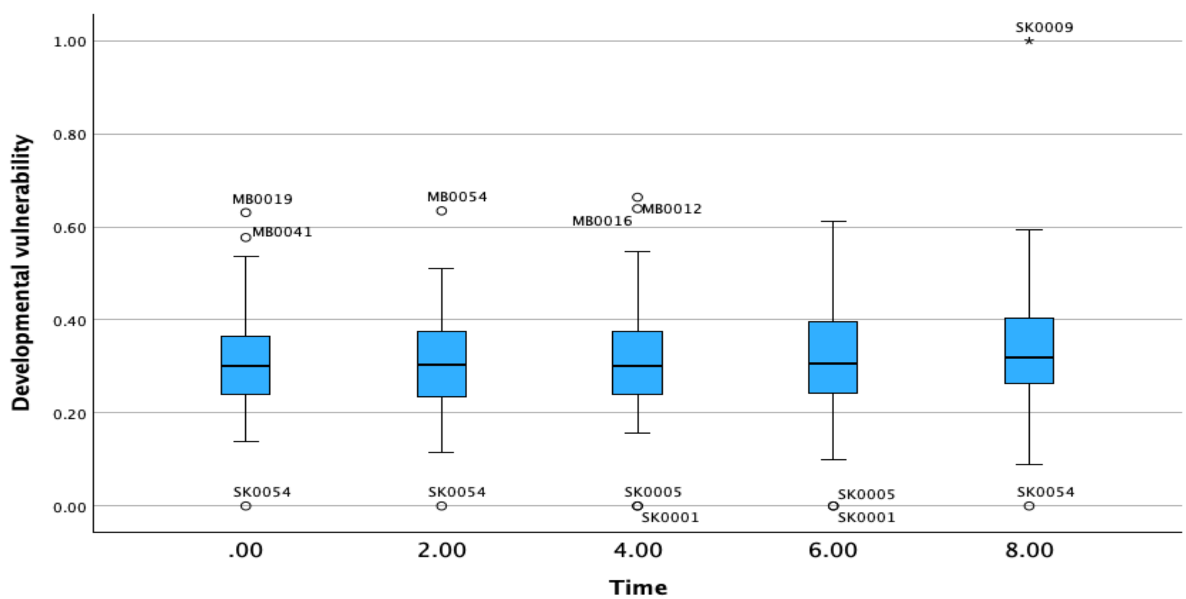


Figure A12

Box and Whisker Plot of Developmental Vulnerability Across Time in Manitoba



Appendix 2

Final Models Testing Interaction of SES And Time

Table A1

Type III Tests of Fixed Effects[a]

Source	Numerator df	Denominator df	F	Sig.
Intercept	1	1621.580	2898.522	< .001
Time	1	2270.959	52.162	< .001
Sex	1	2348.273	10.022	.002
Age	1	2172.991	37.387	< .001
Impairment	1	2346.933	563.837	< .001
English French Language Learner	1	2265.377	28.534	< .001
SES	1	1736.102	0.125	.724
Time * SES	1	2271.266	3.377	.066
a. Dependent Variable: Special needs status in Ontario.				

Table A2

Estimates of Fixed Effects[a]

Table A2: Estimates of Fixed Effects[a]							
Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Intercept	0.041	0.001	1621.580	53.838	< .001	0.039	0.042
Time	0.001	0.000	2270.959	7.222	< .001	0.001	0.002
Sex	-0.025	0.008	2348.273	-3.166	.002	-0.040	-0.009
Age	0.051	0.008	2172.991	6.115	< .001	0.034	0.067
Impairment	0.222	0.009	2346.933	23.745	< .001	0.204	0.240
English French Language Learner	0.024	0.005	2265.377	5.342	< .001	0.015	0.033

SES	0.000	0.001	1736.102	-0.353	.724	-0.002	0.001
Time * SES	0.000	0.000	2271.266	-1.838	.066	-0.001	2.025E-5
a. Dependent Variable: Special needs status in Ontario.							

Table A3

Estimates of Covariance Parameters[a]

Parameter		Estimate	Std. Error	Wald Z	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Residual		0.000	1.703E-5	27.740	< .001	0.000	0.001
Intercept + Time + Impairment + English French Language Learner [subject = neighbourhood]	Variance	2.339E-6	5.489E-7	4.261	< .001	1.476E-6	3.705E-6
a. Dependent Variable: Special needs status in Ontario.							

Table A4

Type III Tests of Fixed Effects[a]

Source	Numerator df	Denominator df	F	Sig.
Intercept	1	803.646	538.235	< .001
Time	1	831.299	19.055	< .001
Sex	1	2192.654	13.048	< .001
Age	1	2368.960	6.964	.008
Impairment	1	1853.073	204.041	< .001
English French Language Learner	1	1428.982	7.929	.005
SES	1	863.103	4.862	.028
Time * SES	1	802.864	0.095	.758

a. Dependent Variable: Neurodevelopmental disorder in Ontario.

Table A5

Estimates of Fixed Effects[a]

Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Intercept	0.023	0.001	803.646	23.200	< .001	0.021	0.025
Time	0.001	0.000	831.299	4.365	< .001	0.000	0.001
Sex	-0.026	0.007	2192.654	-3.612	< .001	-0.040	-0.012
Age	0.022	0.008	2368.960	2.639	.008	0.006	0.039
Impairment	0.120	0.008	1853.073	14.284	< .001	0.103	0.136
English French Language Learner	0.012	0.004	1428.982	2.816	.005	0.004	0.020
SES	-0.002	0.001	863.103	-2.205	.028	-0.004	0.000
Time * SES	-5.752E-5	0.000	802.864	-0.308	.758	0.000	0.000
a. Dependent Variable: Neurodevelopmental disorder in Ontario.							

Table A6

Estimates of Covariance Parameters[a]

Parameter	Estimate	Std. Error	Wald Z	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound

Residual		0.000	1.545E-5	19.785	< .001	0.000	0.000
Intercept + Time [subject = neighbourhood]	UN (1,1)	0.000	3.933E-5	11.904	< .001	0.000	0.001
	UN (2,1)	-8.218E-5	7.183E-6	-11.441	< .001	-9.626E-5	-6.811E-5
	UN (2,2)	1.540E-5	1.532E-6	10.057	< .001	1.268E-5	1.872E-5
a. Dependent Variable: Neurodevelopmental disorder in Ontario.							

Table A7

Type III Tests of Fixed Effects[a]

Source	Numerator df	Denominator df	F	Sig.
Intercept	1	287.073	174.717	< .001
Time	1	303.802	7.234	.008
Quadratic time	1	280.209	13.407	< .001
Sex	1	354.466	2.106	.148
Age	1	365.443	4.137	.043
Impairment	1	325.246	96.606	< .001
English French Language Learner	1	219.052	0.900	.344
SES	1	305.275	0.020	.887
Time * SES	1	257.010	1.121	.291
a. Dependent Variable: Special needs status in Manitoba.				

Table A8

Estimates of Fixed Effects[a]

Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Intercept	0.039	0.003	287.073	13.218	< .001	0.033	0.045

Time	-0.005	0.002	303.802	-2.690	.008	-0.008	-0.001
Quadratic time	0.001	0.000	280.209	3.662	< .001	0.000	0.001
Sex	-0.025	0.017	354.466	-1.451	.148	-0.059	0.009
Age	-0.050	0.025	365.443	-2.034	.043	-0.099	-0.002
Impairment	0.247	0.025	325.246	9.829	<.001	0.198	0.297
English French Language Learner	0.014	0.015	219.052	0.949	.344	-0.015	0.043
SES	0.000	0.002	305.275	-0.142	.887	-0.005	0.004
Time * SES	-0.001	0.001	257.010	-1.059	.291	-0.002	0.000
a. Dependent Variable: Special needs status in Manitoba.							

Table A9

Estimates of Covariance Parameters[a]

Parameter		Estimate	Std. Error	Wald Z	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Residual		0.001	6.311E-5	11.740	< .001	0.001	0.001
Intercept + Time + Impairment + English French Language Learner [subject = neighbourhood]	Variance	2.835E-6	1.767E-6	1.604	.109	8.356E-7	9.621E-6
a. Dependent Variable: Special needs status in Manitoba.							

Table A10

Type III Tests of Fixed Effects[a]

Source	Numerator df	Denominator df	F	Sig.
Intercept	1	293.761	174.510	< .001
Time	1	272.847	6.561	.011
Sex	1	356.456	2.000	.158
Age	1	366.744	4.007	.046
Impairment	1	321.368	92.924	< .001
English French Language Learner	1	214.497	1.235	.268
SES	1	306.128	0.028	.867
Time * SES	1	262.275	1.131	.289
a. Dependent Variable: Special needs status in Manitoba.				

Table A11

Estimates of Fixed Effects[a]

Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Intercept	0.033	0.003	293.761	13.210	< .001	0.028	0.038
Time	0.001	0.001	272.847	2.561	.011	0.000	0.002
Sex	-0.025	0.017	356.456	-1.414	.158	-0.059	0.010
Age	-0.050	0.025	366.744	-2.002	.046	-0.100	-0.001
Impairment	0.246	0.026	321.368	9.640	< .001	0.196	0.296
English French Language Learner	0.016	0.015	214.497	1.112	.268	-0.013	0.045
SES	0.000	0.002	306.128	-0.167	.867	-0.005	0.004

Time * SES	-0.001	0.001	262.275	-1.063	.289	-0.002	0.000
a. Dependent Variable: Special needs status in Manitoba.							

Table A12

Estimates of Covariance Parameters[a]

Parameter		Estimate	Std. Error	Wald Z	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Residual		0.001	6.562E-5	11.761	< .001	0.001	0.001
Intercept + Time + Impairment + English French Language Learner [subject = neighbourhood]	Variance	2.612E-6	1.783E-6	1.465	.143	6.854E-7	9.953E-6
a. Dependent Variable: Special needs status in Manitoba.							

Table A13

Type III Tests of Fixed Effects[a]

Source	Numerator df	Denominator df	F	Sig.
Intercept	1	309.904	172.245	< .001
Time	1	175.513	5.507	.020
Sex	1	338.928	7.885	.005
Age	1	351.341	9.581	.002
Impairment	1	367	52.162	< .001
English French Language Learner	1	328.737	0.877	.35

SES	1	316.983	0.572	.45
Time * SES	1	174.819	0.809	.37
a. Dependent Variable: Neurodevelopmental disorder in Manitoba.				

Table A14

Estimates of Fixed Effects[a]

Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Intercept	0.021	0.002	309.904	13.124	< .001	0.018	0.024
Time	0.001	0.000	175.513	2.347	.020	0.000	0.002
Sex	-0.033	0.012	338.928	-2.808	.005	-0.055	-0.010
Age	-0.052	0.017	351.341	-3.095	.002	-0.086	-0.019
Impairment	0.130	0.018	367	7.222	< .001	0.094	0.165
English French Language Learner	-0.010	0.011	328.737	-0.936	.35	-0.032	0.011
SES	0.001	0.002	316.983	0.756	.45	-0.002	0.004
Time * SES	0.000	0.000	174.819	-0.900	.37	-0.001	0.000
a. Dependent Variable: Neurodevelopmental disorder in Manitoba.							

Table A15

Estimates of Covariance Parameters[a]

Parameter	Estimate	Std. Error	Wald Z	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Residual	0.000	2.609E-5	11.837	<.001	0.000	0.000

Intercept + Time + Impairment + English French Language Learner [subject = neighbourhood]	Variance	5.529E-6	1.429E-6	3.869	< .001	3.332E-6	9.176E-6
a. Dependent Variable: Neurodevelopmental disorder in Manitoba.							

Table A16

Type III Tests of Fixed Effects[a]

Source	Numerator df	Denominator df	F	Sig.
Intercept	1	301.105	2417.769	< .001
Time	1	99.685	0.139	.710
Sex	1	311.115	1.396	.238
Age	1	323.671	0.575	.449
Impairment	1	351.889	93.436	< .001
English French Language Learner	1	359.108	9.601	.002
SES	1	306.463	17.330	< .001
Time * SES	1	101.506	2.652	.107
a. Dependent Variable: Developmental vulnerability in Manitoba.				

Table A17

Estimates of Fixed Effects[a]

Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Intercept	0.314	0.006	301.105	49.171	< .001	0.301	0.326
Time	0.001	0.002	99.685	0.373	.710	-0.003	0.005
Sex	-0.055	0.046	311.115	-1.181	.238	-0.146	0.037

Age	0.052	0.068	323.671	0.758	.449	-0.082	0.186
Impairment	0.712	0.074	351.889	9.666	< .001	0.567	0.857
English French Language Learner	0.144	0.047	359.108	3.099	.002	0.053	0.236
SES	-0.026	0.006	306.463	-4.163	<.001	-0.038	-0.014
Time * SES	-0.003	0.002	101.506	-1.628	.107	-0.007	0.001
a. Dependent Variable: Developmental vulnerability in Manitoba.							

Table A18

Estimates of Covariance Parameters[a]

Parameter		Estimate	Std. Error	Wald Z	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Residual		0.005	0.000	11.038	<.001	0.004	0.006
Intercept + Time + Impairment + English French Language Learner [subject = neighbourhood]	Variance	0.000	4.371E-5	3.846	<.001	0.000	0.000

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Chapter 5

Conclusions

This dissertation set out to determine the health and social outcomes of children with NDD and examine child neurodevelopmental identification and intervention services to support healthy child development in Canada. With the data gathered and analyzed in these studies, this dissertation looked at how aspects of social structures can influence early development at the individual level, between neighbourhoods over time, and at the system level. Using several methodologies, individual- and neighbourhood-level child developmental health patterns and profiles were explored. The measures and methodologies used enabled the use of both categorical (diagnostic) and dimensional (components of functioning/ability) approaches to examining child developmental health.

The bioecological systems theory (Bronfenbrenner, 1995) was utilized as a guiding framework to look at the influence of micro- and meso- systems such as individual characteristics and neighbourhoods (Chapters 2 and 4), family relationships (Chapter 3), and educational, social service, and healthcare systems (Chapters 2, 3, and 4) on children's developmental health at school entry in three distinct but interrelated studies. The dimension of time (chronosystem) was considered when examining social determinants of health and developmental outcomes over multiple time periods (Chapters 2 and 4). This research connects evidence across the traditional silos of health, education, and social aspects of health to answer the overarching research questions: 1) What is the impact of NDD on academic achievement and developmental health trajectories over time, given other sociodemographic characteristics? (Chapters 2 and 4); and 2) What are the service pathways to early identification and intervention for families and children vulnerable to neurodevelopmental concerns? (Chapter 3).

Main Findings

In the first, quantitative study, kindergarten developmental outcomes were linked to the assessment participation outcomes of students in Grade 3 and Grade 6 in Ontario. The association between a diagnosis of ASD or another NDD in kindergarten and the likelihood of completing standardized assessments in Grades 3 and 6, and meeting test expectations were explored using a linked dataset of the EDI and Grades 3 and 6 literacy and mathematics assessments. The contribution of sociodemographic characteristics (e.g., sex, language, special needs, or immigrant status), early development (scores on the EDI), were explored to understand the determinants of optimal pathways to academic achievement. The empirical findings in this study provide unique evidence of the low participation rates and that developmental vulnerability, impairments, and other factors in kindergarten affect children's academic progress. The results of the logistic regression analysis showed that children with other NDD were less likely to participate in assessments than children with ASD. Assessment participation rates may be improved by modifying assessments, health services, and educational supports beginning in the early years. The results of the study reinforce the need for support of children with NDD to be able to complete academic assessments to the best of their ability given how strongly educational attainment predicts future wellbeing. It is also possible there are behavioural and biological differences between NDD subtypes that result in greater needs, and more services are made available such as early intervention programs or access to special education services and accommodations based on the individual's needs, between kindergarten and into Grade 3 and 6 that help some, but not all, children participate in traditional standardized assessments. Policy recommendations include consideration of modification of existing assessments and accommodations, of restrictions on who is granted accommodations, and re-evaluating whether mainstream and/or special education services are adequate to meet the needs of students. There may be downsides to entry to special education services. There may be insufficient resources to provide enough students with enough support to make meaningful differences in their educational journeys, discordance in learning plans going between mainstream and special education classes, and lack of sustainability or scalability with differentiation and accommodations in larger mainstream classrooms where help from educational assistants is not guaranteed. This research also opens opportunities to review the adequacy of specially designed instruction or special education services as lack of participation may be partly attributed to the tools available to teach and measure academic abilities.

The second study was a qualitative review of published articles and websites which explored similarities, differences, barriers, and facilitators to the various child neurodevelopmental policies and programs in Ontario and Manitoba. Wide-ranging school, family, home-based, and clinical programs for assessment and community and parenting supports were reviewed. Curricula in the two provinces focused on child and family skill development in addition to consistent and accessible programming supported healthy child development. The programs identified assist in understanding how to improve child development services for children, families, and educational or healthcare professionals. The importance of collaborative and transparent policy environments for decision-making, as well as collaborative and connected healthcare, education, and social systems that provide professionals with up-to-date training and knowledge on how to assess, refer, or treat children with NDD or vulnerable to atypical development can be drawn from the present study. Several practical implications emerged from this review that policymakers, healthcare professionals, and service providers can consider when choosing what services to offer and to whom. First, health/social care can be improved in both provinces by targeting barriers in family circumstances and service limitations in waitlists, service caps, eligibility, fragmented resources, and clinical training. Next, ample professional training would ensure care providers can better identify concerns, educate caregivers, and refer families to appropriate services. Third, proactive policies and programs starting at prenatal to postpartum periods, or in early childhood can provide families and children with the support, material conditions, and services they need to succeed and thrive developmentally.

The third, quantitative study was designed to compare changes in developmental outcomes at kindergarten in Manitoba and Ontario neighbourhoods over a 10-year period. A multilevel modelling approach using EDI data allowed us to compare large samples of children with formal diagnoses and other special health needs. Several sociodemographic factors were associated with increased neighbourhood prevalence rates of special needs status, developmental vulnerability, and neurodevelopmental disorders. There was a consistent and mostly increasing change over time in the prevalence rates in these neighbourhoods over time. Initial prevalence rates in 2011 of SN, NDD, and developmental vulnerability in Ontario were 4.1%, 2.3%, and 28.4%. Compounded, rates of growth represent roughly 19%, 34%, and 3% increases over the course of a decade. Initial prevalence rates in 2011 of SN, NDD, and developmental vulnerability in Manitoba were 3.9%, 2.1%, and 31.4%. Compounded, rates of growth represent roughly 20%, 38%, and 2.5% increases over the course of a decade. Decisionmakers in both provinces need to re-evaluate current healthcare, education, and social service capacities.

The current study adds to the growing body of literature on the increasing rate of change in the proportion of developmental vulnerability, which was found to be associated with increases in social factors (e.g., family instability, mental illness, lower neighbourhood income), medical factors (e.g., neonatal issues, hospitalizations, birth outcomes) (Saunders et al., 2021), and exposure to maternal depression before age 5 (Wall-Wieler et al., 2020). While this study could not identify the causes increasing change over time in prevalence of SN, NDD, or developmental vulnerability, one can speculate on the plausible, non-mutually exclusive reasons for this pattern: 1) increased awareness of typical and atypical development and identification of needs, 2) broadening of the definitions and diagnostic criteria, or 3) actual increases in prevalence because of unmeasured changes in social, environmental, or biological exposures. The study provides additional evidence of differences in developmental health which may be attributed to differences in psychosocial, material, and socioeconomic conditions early in life that shape trajectories over the life course (Keating & Hertzman, 1999; Hertzman & Power, 2004). Therefore, a key policy priority should be to address social determinants of health and to increase the capacities of the education, social service, and healthcare systems to be able to support children with neurodiversity. Specifically, there should be increased funding efforts to incorporate more educational, identification, and treatment services for children with NDD, in addition to targeting of programs towards harder-to-reach populations such as those residing in more rural/remote areas, low-income areas, or with lower education status. Moreover, strengthening the evidence base and clinical guidelines for healthcare providers on the assessment/screening, navigation, and other interventional services for children with NDD may improve diagnostic accuracy, confidence, and clinical capacity. Successful programs and policies can be broken down further to target these stakeholder categories: 1) Families/children with NDD, whose health & wellbeing can be influenced by greater promotion of programs, removal of barriers related to access to care, and a life course approach to supporting families from pre-natal to early childhood periods and beyond; 2) Providers, who can be influenced through professional training and knowledge on identification and intervention strategies, holistic methods of care, and financial incentives to facilitate care; 3) Schools and community organizations, who require human and financial resources to implement seamless child development and special education services; and 4) Systems and decision makers, to finance programs, measure change over time in relevant outcomes, and maintain public accountability in the performance management and cost-effectiveness of education, social, and health care systems.

Relationship Between the Studies and Main Contributions

This dissertation extends knowledge of how access to both material and social supports vary geographically, by individual and neighbourhoods, and how they may impact health outcomes. It also contributes to existing knowledge on how early diagnoses and identification of NDD and other developmental concerns not only improve access to support and services, but impact health and educational outcomes. The findings of Chapter 2 showed that there were sociodemographic factors which may be associated with differential developmental and academic outcomes for children with NDD in one province. This prompted questions about if or how trajectories differ in other provinces and whether health/education services, policies, or other factors contribute to differential health and education outcomes. Chapter 3 synthesized literature on various services, policies, and programs that Ontario and Manitoba offer their residents to facilitate entry to early identification/intervention and contribute to differential child developmental outcomes. In turn, the findings of Chapter 3 informed the development of Chapter 4 to compare how developmental health outcomes have changed over time in a ten-year period in these two provinces, with visualizations of positive and negative outlier neighbourhoods. The outcomes/predictors, and results in each study showcase a small piece of a complex web of relationships and interactions between people, environments, and social systems. The studies highlight where and how stakeholders and policy leaders can leverage material and human resources in ways children, neighbourhoods, and families are likely to be responsive to and benefit from, with the overall aim of reducing health inequities.

Chapter 2 and 4 provide an understanding of how individuals and neighbourhoods in ON/MB are vulnerable to (dis)-advantages in early life/entry to school that could affect (future) quality of life and educational experiences. In comparison, Chapter 3 considers characteristics of interventions and systems involved in shaping children's early capacities in a holistic manner, including cognitive and non-cognitive domains of development and interactions between systems in the context of relevant sociodemographic traits also explored in Chapters 2 and 4. Each chapter explores the impact or influence of social determinants and social systems involved in shaping children's development over time with the underlying ecological systems theory woven throughout the interpretation of the results. The three studies focused on a few of the ecological system layers in isolation – 1) the relationships between education and health, 2) relationships between people, processes, contexts, and time, and 3) the interactions between time and the immediate environment or microsystem. Using the developmentally and/or academically vulnerable groups identified in the three studies can help policymakers utilize targeted strategies (such as the programs reviewed in Chapter 3) to influence educational & developmental journeys for children (or neighbourhoods) with developmental challenges, before and after entry to school. Special consideration must be paid when implementing programs for equity-deserving or underserved groups, such as Indigenous communities, rural/remote contexts, and linguistically or culturally diverse populations. Culturally and developmentally appropriate early intervention programs are more likely to be utilized by caregivers (Ramey & Ramey, 1998). Underserved groups such as those who are non-verbal, female, ethnic minorities, from disadvantaged backgrounds, or have severe comorbidities should be closely monitored throughout their care journey as they may face barriers to early identification and diagnosis (Lord et al., 2022); they are more likely to experience challenges with access, transitions, complexity of care, and communication. But by targeting social determinants and processes that cause health disparities such as neighbourhood economic deprivation, segregation, community/individual psychological stress, inadequate healthcare infrastructure, or by reducing the reliance on individual resources (Gee & Payne-Sturges, 2004), health disparities can be reduced and the rate of change in SN, NDD, and developmental vulnerability can be decelerated.

Policy And Service Implications

The studies have reinforced the importance of investments in early intervention programs given these challenges in the education system and changes over time in prevalence of developmental health indicators. With this information, modifying existing programs or adding new programs can address social inequities in health and education alongside the promotion of child development services that are likely to engage families and produce benefits in both cognitive and non-cognitive domains of children's development. However, with current funding, training, and staffing challenges, improvements to such programs may not be feasible.

Some policy considerations may include the costs to provide targeted strategies (e.g., neighbourhoods, certain demographics) compared to universal strategies that people can access with fewer administrative or diagnostic hurdles. Policymakers should continue to target mechanisms such as increasing trust in system and providers, confidence in parental abilities, knowledge transfer, open dialogue channels, convenience and ease of access when choosing and implementing programs that are evidence-based. This will require additional funding dedicated to children with other NDD. Communities with sustained improvements in developmental health in British Columbia from 2001-2009 have been characterized by strong intersectoral leaderships, shared resources, long term policy commitments, community planning and programming focused on EDI outcomes, and strong alignment with the school system (Hertzman, 2010).

Taken together, the findings of this dissertation reinforce needs for 1) greater collaboration between health and education sectors to support children in their learning and development; 2) addressing the social determinants of child developmental health through effective policies and programs; and 3) expanding universal child development services and more targeted services to neighbourhoods vulnerable to negative health outcomes. Various policy strategies to tackle determinants of child developmental health may be to conduct universal developmental screenings, provider training, enhance provider confidence, and promote interagency communication and intersectoral action between the education and health systems (Moore et al., 2017). Public and social policy approaches to address social determinants of child developmental health can include income redistribution policies, education and job security policies, improvement in psychosocial/material circumstances that mediate the socioeconomic gradient (e.g., nutrition, housing, social support, positive lifestyle behaviours) and providing lower SES groups with access to high-quality curative healthcare (Solar & Irwin, 2010). Greater parental concern and higher SES may be related if parents have less financial stress and a greater ability to be actively involved in their child's life and notice any concerns with development (Loubersac et al., 2021). Therefore, targeted income redistribution policies may have a positive impact on family-child-system relationships and interactions.

Policymakers should prioritize early interventions as they can reduce the negative social, educational, and vocational impacts of commonly co-occurring mental disorders like anxiety or depression (Munir, 2016). Interventions should consider the needs of both family and child and recognize the higher levels of stress that families experience so that the supports suggested are feasible (Head & Abbeduto, 2007). Diagnostic assessments should include an assessment of the family's overall well-being, the family home environment, their ability to cope and participate in interventions, and their interactions with the child (Head & Abbeduto, 2007). This will require continued collaboration between health, education, and social service sectors with the aim of reducing health disparities within and between provinces and across different types of NDD.

Future Research Directions

The studies reinforce the proven capacity of the EDI to be used to track and predict children's health and education outcomes. The use of the EDI, along with administrative databases, enabled the inclusion of a smaller proportion of children with diverse developmental profiles into population-level research using aggregate methods. The methods of this dissertation could be replicated to explore health and social outcomes in remaining Canadian provinces, both quantitatively using the EDI and qualitatively using existing research on policies and programs nationally. A natural progression of this work would be to interview stakeholders on how they use research to inform child health policy decisions. Key informants could include service providers, such as early childhood educators, clinical professionals in charge of referrals and diagnoses (e.g., family doctors, clinical psychologists, speech language pathologists), and government policymakers. Continuing with a multi-provincial investigation will allow for a pan-Canadian and comparative approach, which is relevant, as health and educational policies are governed at the provincial level, resulting in interprovincial variation in childhood outcomes and available services. For example, service use data from the EDI were briefly described at the individual level in Manitoba and Ontario, looking at whether a child had received school-based support, received further assessment, needed assessment, was on a waitlist, or had attended an early intervention program. A multi-provincial investigation of service use data using the EDI, or other instruments could be expanded at individual or neighbourhood levels to analyze whether provinces are meeting the needs of children with NDD or children who are vulnerable to developing NDD. Chapter 4 could be expanded by separating the effects of within-neighbourhood changes and the effects of between-neighbourhood differences. Other analytical methods, such as within-cluster centring of predictors could be applied, which would represent only how changes in the predictors within a neighbourhood relate to changes over time in developmental outcomes.

Conclusions

The overall dissertation supports the evidence that inequities in health begin at an early age but can be addressed and minimized through targeting social determinants of health using health policy directives. The delivery of appropriate and high-quality services and supports for children vulnerable to NDD in addition to support for parents to improve the experiences children have in their environments (Irwin et al., 2007) should be a priority for provincial and municipal governments and supported by federal funding. Continued efforts to target inequitable distributions of material resources and psychosocial stressors (WHO Commission on Social Determinants of Health, 2008) will enhance health equity during critical periods of a child's development and promote more positive health outcomes throughout the life course.

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