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Risk factors for developmental vulnerability: Insight from population-level surveillance using the Early Development Instrument

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Abstract

Objectives: Population-level studies may elucidate the most promising intervention targets to prevent negative outcomes of developmental vulnerability in children. This study aims to bridge the current literature gap on identifying population-level developmental vulnerability risk factors using combined social and biological/health information.

Methods: This study assessed developmental vulnerability among kindergarten children using the 2016 Early Development Instrument (EDI) and identified risk factors of developmental vulnerability using EDI data cross-linked to a population-wide administrative health dataset. A total number of 23,494 children aged 5–6 were included (48% female). Prenatal, neonatal, and early childhood risk factors for developmental vulnerability were investigated, highlighting the most important ones contributing to early development.

Results: The main risk factors for developmental vulnerability were children with a history of mental health diagnosis (risk ratio = 1.46), biological sex–male (risk ratio = 1.51), and poor socioeconomic status (risk ratio = 1.58).

Conclusion: Our study encompasses both social and health information in a populational-level representative sample of Alberta, Canada. The results confirm evidence established in other geographic regions and jurisdictions and demonstrate the association between perinatal risk factors and developmental vulnerability. Based on these results, we argue that the health system should adopt a multilevel prevention and intervention strategy, targeting individual, family, and community together.

Keywords

Early child development, Early Development Instrument, vulnerability, risk factors

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Introduction

In the area of determinants of health and disease (DOHaD) there is a growing body of knowledge that can inform policy and action plans to increase the human potential for a healthy life.[1] Early childhood development from birth to 8 years old is multifaceted, including physical, socioemotional, cognitive, and motor development.[2] The prenatal period and the first 5 years of a child's life are especially important due to rapid brain development, which is

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sensitive to biological and environmental influences. Prenatal and postnatal care, and early detection and treatment of health concerns are important when considering children's developmental health. From both child development and economic perspectives, preventive strategies are most effective when they are proportionately tailored to specific risk factors and timing in the development.[3] In relation to health economics impact, there is an estimated doubling of return on investment to society for every dollar paid toward supporting healthy early childhood development.[3]

Understanding the most important risk and protective factors for child development is important to inform decisions and policy development for the deployment of programs and services to support vulnerable children and their families. Vulnerability in children can be broadly defined as the outcome of the interaction between biological and social factors that make children prone to certain risks in their development.[4] In utero exposure to substances, prenatal exposure to maternal diabetes,[5–8] and lack of essential nutrients during pregnancy[9] are examples that may negatively impair children's development, whereas breastfeeding during infancy is a well-known protective factor for children's optimal neurodevelopment.[10] However, based on our rapid literature review, among the studies focusing on understanding how early life events may shape children's development (N = 25), only around half of those (N = 12) focus on prenatal and neonatal risk/protective factors, while only a fifth (N = 5) investigated prenatal, neonatal, and early childhood determinants (Supplemental Table S1). Also, the 2019 Canadian Health Survey on Children and Youth reported a need for additional information for those individuals under the age of 12. This calls for more converging evidence for the potential prenatal, neonatal, and early childhood factors related to early childhood development.

Studies across Canada often use the Early Development Instrument (EDI) to assess developmental vulnerability by identifying children whose skills and behaviors are below the levels exhibited by most of their peers.[11–13] The EDI is a kindergarten-teacher-completed questionnaire that provides information about children's ability to meet age-appropriate developmental expectations, as shaped by their experiences in the first 5 years of their life.[14]

Studies using administrative health data already confirmed common risk factors of developmental vulnerability, yet individual studies are usually limited in scope, for example focusing only on social[15] or biological/health[7,13] information, or lack a population-level representative sample.[16,17] Linking data from different sources including both biological and social factors may help to reduce this current knowledge gap by generating evidence with enhanced external validity, providing a more comprehensive perspective of social economics and health utilization, which in turn can promote a better involvement of policymakers.[18] In this study, we sought to understand how prenatal, neonatal, and early childhood factors are associated with kindergarten-aged children's vulnerability in the Canadian province of Alberta and to compare these results with other provinces in Canada and other countries, within the broader context of known social and biological determinants of health.

The primary goal of the study is to bridge the knowledge gap in the literature by the development of a cross-linked dataset through linking multiple population-level province-wide health administrative databases to the 2016 collection of EDI data. A secondary goal is to confirm the association between the important prenatal, neonatal, and early childhood factors that contribute to early development specifically in the Alberta population, which have not been explored in the literature, and to enable comparison of the results to other jurisdictions in Canada and other countries. The study results may facilitate a better understanding of developmental vulnerability in Canada and other countries and could inform policymakers and guide vulnerability risk reduction and prevention.

Methods

Study population and variable extraction

The province-wide collection of EDI data for Alberta, sponsored by the Alberta Ministry of Education, was carried out in February and March 2016. This data collection process involved obtaining active consent from parents. During that period, Alberta had a total of 69,486 children aged 5 and 6 years old; 31,128 (44.8%) of them did not participate in the EDI data collection due to being homeschooled, living in remote areas, or due to school opt-outs. An additional 7677 questionnaires did not meet eligibility criteria (e.g. missing data, under 30 days in the classroom, parental consent was missing, incorrect completion of the questionnaire) and were excluded. Then, data from the EDI were linked with the administrative databases from the Ministry of Health, Government of Alberta based on identifiable information (i.e. name, biological sex, and date of birth) and unique provincial health number, resulting in a cohort size of 28,952. Eight databases were linked with EDI data, including Alberta Health Care Insurance Plan Physician Claims, the National Ambulatory Care Reporting System, the Canadian Institute of Health Information–Discharge Abstract Database, the Alberta Health Care Insurance Plan Population Registry Database, Alberta Pharmaceutical Information Network database and Alberta Human Services Drug Supplement Plan database, Alberta Notice of Live Birth or Stillbirth database, Statistics Canada Census Data (2016). For a description of the databases, please see Supplemental material. Only linked records were used in the study.

Finally, we retrieved neonatal and prenatal information from the Alberta Notice of Live Birth or Stillbirth

records. Children not born in Alberta do not have records from this database and were excluded from the analysis. The final analytical study sample consisted of 23,494 children (mean age = 5.68 years and $SD = 0.33$; 48.0% females). The flowchart of the sample exclusions is shown in Figure 1.

This study was approved by the Health Research Ethics Board—Health Panel at the University of Alberta (Pro00104650_REN1). Informed consent was waived by the institutional review board due to the secondary analysis nature of the study. Given the anonymization of the data, the researcher's access to it presents minimal risks.

Outcome measures

The EDI's validity, reliability, and consistency have been reported, showing a high degree of consistency across several countries.[19] The questionnaire includes 103 items grouped into five relevant developmental domains: physical health and wellbeing, social competence, emotional maturity, language and cognitive development, and communication and general knowledge.[14] Each child's domain summary scores were derived by averaging scores from domain-specific questions with a range from 0 to 10, where a higher score indicates a higher developmental status. Each domain score was then categorized as "developmentally vulnerable" when the range for a specific domain fell on or below the 10th percentile of the distribution in that domain, which indicates risk for difficulties (for more details, please visit https://edi.offordcentre.com/resources/edi-cohort-reports/). Children who score in the "developmentally vulnerable" range in one or more domains are considered vulnerable overall. This was the study's main outcome measure, as it encompasses all areas of development and is strongly predictive of poor academic and behavior outcomes in later grades,[15] often more so than a domain-specific vulnerability.[20] As most of the research published using EDI data uses the same Canadian baseline threshold (i.e. 10th percentile of the Canadian normative distribution), it is reasonable to compare them among different locations. Analyses using domain-specific outcomes were also conducted and are presented in the supplementary material (Supplemental Tables S6-S10).

Study predictors

To facilitate study interpretation and reduce multicollinearity bias, raw variables with duplicated meanings, or moderately and highly correlated ($r > 0.5$) were excluded from the study. A total of 28 variables were included as predictors (see Supplemental Tables S2 and S11). They included biological factors, such as sex assigned at birth and child's and mother's chronic and mental conditions, and socioenvironment factors, such as history of health services utilization, mother's drug and multivitamin use, socioeconomic status (SES) as measured by whether the child was part of a subsidy group, and community sociodemographic characteristics. For a complete list of variables included in the regression model and details on the predictor variables please refer to the Supplemental materials.

Statistical analysis

Alberta-born cohort characteristics were compared between the vulnerable and nonvulnerable children across several selected variables with Chi-square tests (Table 1). See Supplemental Table S4 for comparison of all variables. Likewise, we compared children for whom EDI data were available (n = 28,952) with those without EDI data (n = 40,534) to investigate whether these groups had similar demographic characteristics and patterns of health service utilization (see Supplemental Table S3).

Multivariate logistic models were used to identify risk factors associated with vulnerability in children using SAS, version 9.4. Statistical tests with p-values lower than 0.05 were considered statistically significant. This analysis was performed for Alberta-born children with vulnerability in one or more domains and with vulnerability in each of the five domains as outcomes. Numeric variables with highly skewed distributions were converted to binary equivalents (1 = high risk, 0 = low risk) to ease the interpretation of results. The cut-offs for these dichotomous variables were chosen at the 90th percentile to code the high-risk groups as 1, and the cut-offs were sometimes rounded to facilitate interpretation (for more details, see Supplemental Table S2).

Odds ratios from logistic regression models tend to overestimate the relative risks when the outcome is common (e.g. > 10%).[21] For more accurate relative risk interpretation, risk ratios were computed[22] to assess the effects risk factors had on the vulnerability risk in conjunction with adjusted p-values (using false discovery rate 0.05). Dichotomous variable categories were selected such that the reference group did not undergo any intervention (e.g. breastfeeding = "No," preterm pregnancy = "No"). Due to the high number of variables included in the regression model, only those variables that reached statistical significance were reported in the results. All variables are reported in Supplemental materials (see Supplemental Table S5).

Among all data sources, biological data collected via the administrative health data Alberta Notice of Live Birth or Stillbirth form at the child's birth in a hospital had the highest proportions of missing data. To explore the risk factor potential of those data, missing values were replaced via imputation methods either based on medians (for continuous variables) or modes (for categorical variables), when <30% of the original variable was missing. Logistic models were applied to the data after imputation.

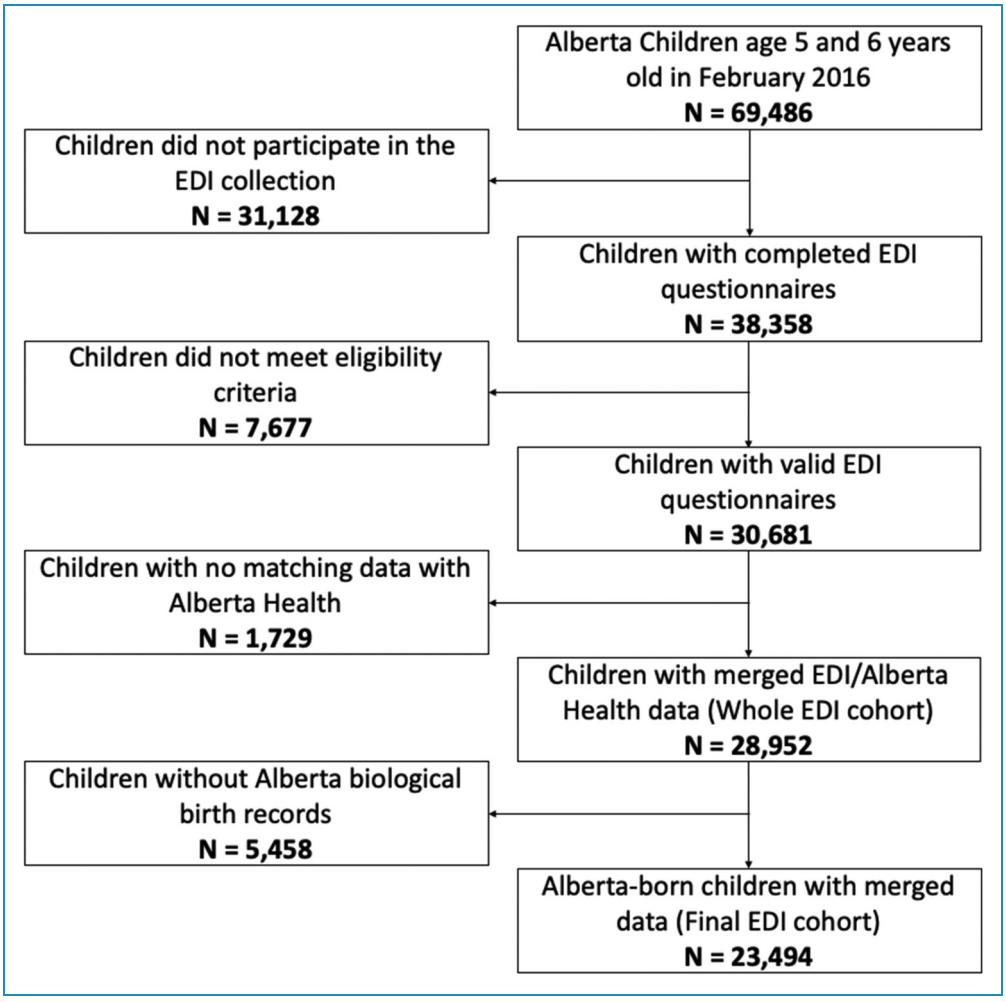

Figure 1. Study cohort flow chart.

Results

Descriptive statistics

Our analyses found statistically significant differences between the group of children with EDI data (whole EDI cohort) and the group of children without EDI data (non-EDI) in SES/subsidy and mental health utilization in physician claims (Supplemental Table S3). Children that did not participate in the EDI assessment have a higher rate of subsidy (12.43%) than children that did take part in the survey (8.33%). We found a slightly higher proportion of children without EDI data had mental health utilization in physician claims (88.9%, compared to 88.2% of children with EDI data). No statistically significant between-group differences were found in demographic characteristics and patterns of health service utilization.

A total of 6702 children (28.5%) were developmentally vulnerable. Relative to nonvulnerable children (n = 16,792), a higher proportion of the vulnerable children were males (21% of girls were vulnerable compared to 35% of boys), belonged to a subsidy group (54% of those who received subsidy were vulnerable), and were part of a drug benefit plan for at least 1 year (51% of children that were part of the plan were vulnerable). The results for all variables can be seen in Table 1 and Supplemental Table S4. Definitions of all variables are in Supplemental Table S2.

Vulnerable versus nonvulnerable children

The results of the logistic regression examining the contribution of potential risk factors to vulnerability are presented in Table 2 (see Supplemental Table S5 for the results for all variables). Overall, children who experienced socioeconomic adversity had 1.58 times the risk of being vulnerable than nonsubsidy children. Similarly, after adjusting for other risk factors, the risk for vulnerability among males relative to females is 1.51 times higher, 1.30 times higher for prenatal exposure to nicotine, and 1.46 times higher for every additional year of mental health diagnosis.

Table 1. Characteristics of the study cohort by vulnerability in one or more domains.

Variable name	Variable label	Nonmissing −N	Nonvulnerable children (n = 16,792)−N (%)	Vulnerable children (n = 6702)−N (%)	p-Value[#]
Age−mean (SD)	Years	23,494	5.70 (0.32)	5.63 (0.34)	<0.001
Child's biological sex	Female	23,494	8869 (52.8%)	2420 (36.1%)	<0.001
	Male		7923 (47.2%)	4282 (63.9%)	
Socioeconomic/subsidy status (Child)	Subsidy	23,339	900 (5.4%)	1042 (15.7%)	<0.001
	No Subsidy		15,800 (94.6%)	5597 (84.3%)	
Mother's smoker status	Yes	18,689	1237 (9.1%)	1014 (19.7%)	<0.001
	No		12,304 (90.9%)	4134 (80.3%)	
Years child had human service drug benefit plan enrollment	0	23,494	15,776 (93.9%)	5674 (84.7%)	<0.001
	1		498 (3.0%)	405 (6.0%)	
	2		281 (1.7%)	322 (4.8%)	
	3		237 (1.4%)	301 (4.5%)	
Preterm pregnancy	Yes	23,494	1066 (6.4%)	610 (9.1%)	<0.001
	No		15,726 (93.6%)	6092 (90.9%)	
Breastfeeding status	Yes	18,603	13,014 (96.2%)	4745 (93.4%)	<0.001
	No		510 (3.8%)	334 (6.6%)	
Years child had asthma	0	23,242	15,147 (91.0%)	5874 (89.0%)	<0.001
	1		239 (1.4%)	107 (1.6%)	
	2		248 (1.5%)	109 (1.6%)	
	3		1006 (6.1%)	512 (7.8%)	
Child's chronic disease status	Yes	23,339	2327 (13.9%)	1536 (23.1%)	<0.001
	No		14,373 (86.1%)	5103 (76.9%)	
Years child had mental health diagnosis	0	23,243	14,481 (87.0%)	4667 (70.7%)	<0.001
	1		1590 (9.5%)	1081 (16.4%)	
	2		462 (2.8%)	551 (8.3%)	
	3		108 (0.7%)	303 (4.6%)	
Child's emergency visits	ED visits ≥ 4	23,242	2010 (12.1%)	1127 (17.1%)	<0.001
	ED visits<4		14,630 (87.9%)	5475 (82.9%)	

(continued)

Table 1. Continued.

Variable name	Variable label	Nonmissing −N	Nonvulnerable children (n = 16,792)−N (%)	Vulnerable children (n = 6702)−N (%)	p-Value#
Not speaking English or French−mean proportion (SD)	Proportion of individuals	23,477	1.6 (1.6)	1.9 (1.8)	<0.001
Individuals with higher education −mean proportion (SD)	Proportion of individuals	23,477	65.1 (11.3)	61.5 (10.8)	<0.001

Note: # χ^2 Test was used for categorical variables. T-test was used for continuous variables.

Breastfeeding at birth was associated with a 13% less risk of vulnerability compared to children who were not breastfed. Further, a 4% reduction of risk was observed for every additional year the child had asthma. Finally, a 1% increase in the proportion of individuals in the community with higher education reduced the risk of vulnerability by 1%.

Follow-up analyses explored the association of these risk factors on vulnerability in each EDI domain (Supplemental Tables S6–S10). Increased risk of vulnerability in each domain was associated with the child's socioeconomic/subsidy group, years of mental health diagnosis, and prenatal exposure to smoking and other addictive substances. There were no substantial differences in terms of the identified risk factors between Alberta-born children and all children cohorts.

Discussion

In this comprehensive, population-level linked dataset including perinatal and birth data as well as child development at school entry in the Canadian province of Alberta, we confirmed the universality of key risk factors associated with the highest risk of vulnerability: SES, biological sex, and children's mental health. Studies including such a broad range of perinatal, neonatal, and early childhood variables, both biological and social, as predictors of child development outcomes are rare, and so far, come only from a few in Canada[13,23–30] and Australia.[31] By conducting our study in the Canadian province of Alberta, we both confirm the previous findings and add a unique contribution of extended universality to this body of knowledge. These results call for further research and practical guidelines in diminishing the negative impact of mental diseases and poor SES on child development and focusing on sex-specific developmental vulnerability.

Biological sex at birth might be indicative of vulnerability as our analysis shows that boys have a 50% greater risk of being developmentally vulnerable than girls. Similar results were found in other studies in Canada[26,27,32] and Australia.[30,32–34] Dea et al.[32] reported almost twice the risk for developmental vulnerability in boys when compared to girls by using the EDI data in Quebec, Canada. Using different data sources, Cabaj et al.[26] and Mughal et al.[27] reported that boys have a higher risk of problem behaviors at age 8 and are more prone to develop communication and personal-social delays at age 3, respectively. In Australia, previous reports showed that male children are at higher risk of developmental vulnerability, motor gross delay, and executive function difficulties at age 5.[30]

Several components of SES were associated with vulnerability, as previously reported by studies using the EDI data in Canada[24,32,35] and the Australian version data (Australian Early Development Census, AEDC).[32,34,36] Our results suggest that living in an area with a higher proportion of people with higher education was a protective factor for child vulnerability. This finding is consistent with the known compounding effect of low SES and education,[30,34] where children from low SES families are more likely to demonstrate poor outcomes, with limited exposure to a stimulating environment and the lack of family resources to stimulate education suggested as a possible mechanism[35,37] which can later affect their school attendance and transfer to high school.[38] Relatedly, we identified a higher proportion of individuals who do not speak English/French in the child's neighborhood. This higher proportion may contribute to poor outcomes in education and is associated with higher vulnerability risks.

The present study showed an association between a child's poor mental health and school readiness difficulties (i.e. children's ability to successfully engage in the task demands of school). By analyzing the AEDC data, Green et al.[39] showed that childhood developmental vulnerability indicators at age 5 are a major contributor to children's mental illness at age 13. Together, these findings add insights to the current knowledge of the association between mental health issues at early ages and increased psychiatric diagnosis and symptom severity later in life.[40] Interestingly, maternal and paternal mental illness is also associated with developmental vulnerability of children. Saunders et al.,[24] Wall-Wieler et al.,[13] and Bell et al.,[41] all of them using the EDI data or the Australian version data (AEDC) showed that exposure to parents with a

Table 2. Logistic regression model results for children with 1-or-more vulnerabilities at ages 5 and 6 (n = 23,494).

Predictors	Risk ratio	Standardized estimate	p-Value*
Biological factors			
Child's biological sex (Male)	1.51	0.18	<0.001
Child's chronic disease status	1.13	0.04	<0.001
Mother's diabetes status	1.10	0.03	<0.001
Years child had asthma	0.96	−0.02	0.010
Years child had mental health diagnosis	1.46	0.20	<0.001
Social and environmental factors			
Breastfeeding status	0.87	−0.02	0.021
Child's emergency visit	1.01	0.03	0.001
Individuals with higher education	0.99	−0.09	<0.001
Living in rented dwellings	1.01	0.01	<0.001
Mother's pregnancy history count	1.04	0.03	<0.001
Mother's smoker status	1.30	0.07	<0.001
Mother's drug use status	1.18	0.02	0.046
Not speaking English or French	1.05	0.07	<0.001
Preterm pregnancy	1.16	0.03	0.001
Socioeconomic/subsidy status (Child)	1.58	0.10	<0.001
Years child had human service drug benefit plan enrollment	1.16	0.07	<0.001

Note. *Adjusted p-value based on false discovery rate correction at 0.05. All p-values presented in this table are significant at $p < 0.05$, see Supplemental Table S5 for the full table.

psychiatric diagnosis increases the risk of developmental vulnerability, difficulties in social competence, physical health and wellbeing, and emotional maturity. In addition to the psychiatric diagnosis of parents, the mental health history in children also had a similar impact on vulnerability. Mental illness is one of the global leading causes of years lived with disability (YLDs; i.e. years of life lost due to time lived in states of less than full health), accounting for almost 15% of global YLDs.[42] The burden due to mental disorders is seen across all age groups and emerges even before five years of age.[42] This highlights the need for early identification and intervention to support children in their mental health, particularly as young individuals with psychiatric disorders often face challenges in obtaining an accurate diagnoses.[43]

We also identified other risk factors for children's vulnerability, confirming previous studies in the field. For example, exposure to tobacco, opioids, and other substances during pregnancy are contributors to poor developmental outcomes in children.[6–8,34,44] In addition, in utero exposure to these substances can result in preterm birth,[6,8] further contributing negatively to early childhood development as shown by previous studies.[24] On the other hand, breastfeeding and multivitamin and folic acid intake showed a significant trend ($p = 0.050$, see Supplemental Table S5) and are associated with lower risks for childhood development. Those are important factors of neurodevelopment since many important brain formation events are dependent on folic acid and vitamins, such as proliferation and growth of glial and neuronal cells and the synthesis of

neurotransmitters.[45] Also, breastfeeding is beneficial for all infants as it has important nutrients that influence the development of cognitive and motor abilities, and socioemotional competencies in children.[10]

Despite many strengths, our study also has limitations. The EDI data privacy impact assessment did not allow us to link EDI scores with parent or family information. Due to this limitation, we did not have access to the original family environment or the parents' health status (chronic disease conditions and mental health issues), which are known to impact children's early development and their vulnerabilities.[11–13] Also, our final cohort covered approximately 30% of Alberta children due to the mandatory informed consent process and the options for school boards to opt out of the program, and EDI data were not collected for First Nation Band-operated schools. Thus, results need to be interpreted with caution due to a potential sample selection bias. The representativeness of the study sample is further impacted by reducing the cohort to Alberta-born children with valid EDI data. A sizable proportion of the sample (n = 5458) had missing Alberta Notice of Live Birth or Stillbirth form data, which may be due to the busy schedule of health providers in hospitals and the low priority for nurses to record answers thoroughly on the form, enforcing the use of imputation methods that could potentially underestimate variability due to repetition of the same value within variables. In addition, since we found a significant difference in the proportion of people receiving subsidies (Supplemental Table S3), in conjunction with imputing systematically missing data, it is likely there are group differences in other unmeasured factors between the study cohort and the larger EDI cohort. All considered, the study sample selection may have underestimated the proportion of vulnerable children. In addition, the study was designed to explore risk factors associated with vulnerability, not to establish causality. Thus, even though the dataset collected may imply causality, due to the temporal separation between variables and outcome, the modeling results should be interpreted with caution.[46–48]

Conclusion

The current findings from the analysis of a large cohort of Albertan children are a significant contribution to our body of knowledge concerning the vulnerability of Canadian children in the context of DOHaD. By linking data on child development at school entry with a variety of health administrative data including data collected from birth and by using a population-level sample from Alberta, we included both social and health information in a representative sample of Alberta, Canada. Our results are in line with existing findings that the mother's substance use, the child's chronic and mental disease status, male biological sex, and socioeconomic status are the main risk factors of developmental vulnerability, while breastfeeding and multivitamin with folic acid supplementation are associated with lower risk of developmental vulnerability. Our results confirm evidence established in other geographic regions and jurisdictions and demonstrate the association of perinatal risk factors for Alberta children. Although it is extremely important to know risk factors for policymakers and for prevention, our top risk factors may be challenging to address. It would take time to change at a population level, making it difficult to make informed decisions for developing programs and services aimed to support specifically vulnerable children and their families. The current health system is designed to treat diseases and to invest in procedural interventions instead of focusing on preventive care. Our results are in favor of long-term multilevel intervention, in which individuals, families, and communities are targeted together.

Contributorship: BC, AG, and MJ designed the study. DM and MW designed the analytical strategy and helped to interpret the findings. FT conducted the literature review and helped to write the first draft with YSL. All authors contributed to editing the first draft of the manuscript.

Disclaimer: This study is based in part on data provided by Alberta Health. The interpretation and conclusions contained herein are those of the researchers and do not necessarily represent the views of the Government of Alberta. Neither the Government nor Alberta Health express any opinion in relation to this study.

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References

1. Hoffman DJ, Reynolds RM and Hardy DB. Developmental origins of health and disease: current knowledge and potential mechanisms. *Nutr Rev* 2017; 75: 951–970.

2. Chan M, Lake A and Hansen K. The early years: silent emergency or unique opportunity? *The Lancet* 2017; 389: 11–13.
3. Heckman JJ. Skill formation and the economics of investing in disadvantaged children. *Science* 2006; 312: 1900–1902.
4. Schweiger G. Ethics, poverty and children's vulnerability. *Ethics Soc Welf* 2009; 3: 288–301.
5. Novak CM and Graham EM. Obstetric management, tests, and technologies that impact childhood development. *Dev Med Child Neurol* 2019; 61: 1002–1007.
6. Mackay DF, Anderson JJ, Pell JP, et al. Exposure to tobacco smoke in utero or during early childhood and risk of hypomania: prospective birth cohort study. *Eur Psychiatr* 2017; 39: 33–39.
7. Molino AR, Fidalgo TM, Ribeiro MV, et al. Maternal cigarette use during pregnancy and school readiness: An analysis of preschool age children in São Paulo, Brazil. *Early Hum Dev* 2020; 148: 105103.
8. Tobon AL, Habecker E and Forray A. Opioid use in pregnancy. *Curr Psychiatry Rep* 2019; 21: 1–10.
9. Schwarzenberg SJ and Georgieff MK and Nutrition CO. Advocacy for improving nutrition in the first 1000 days to support childhood development and adult health. *PEDIATRICS* 2018; 141. DOI: 10.1542/peds.2017-3716
10. Turner S, Mayumi Maruyama J, Matijasevich A, et al. Breastfeeding and the development of socio-emotional competencies: A systematic review. *Breastfeed Med* 2019; 14: 691–704.
11. Comaskey B, Roos NP, Brownell M, et al. Maternal depression and anxiety disorders (MDAD) and child development: A Manitoba population-based study. *PLoS One* 2017; 12. DOI: 10.1371/journal.pone.0177065
12. Singal D, Chateau D, Struck S, et al. In Utero antidepressants and neurodevelopmental outcomes in kindergarteners. *PEDIATRICS* 2020; 145. DOI: 10.1542/peds.2019-1157
13. Wall-Wieler E, Roos LL and Gotlib IH. Maternal depression in early childhood and developmental vulnerability at school entry. *PEDIATRICS* 2020; 146. DOI: 10.1542/peds.2020-0794
14. Janus M and Offord DR. Development and psychometric properties of the early development instrument (EDI): A measure of children's school readiness. *Can J Behav Sci/Revue Canadienne des Sciences du Comportement* 2007; 39: 1–22.
15. Toit M, Linde J and Swanepoel DW. Early childhood development risks and protective factors in vulnerable preschool children from low-income communities in South Africa. *J Community Health* 2020; 46: 1–9.
16. Page KA, Luo S, Wang X, et al. Children exposed to maternal obesity or gestational diabetes mellitus during early fetal development have hypothalamic alterations that predict future weight gain. *Diabetes Care* 2019; 42: 1473–1480.
17. Symington EA, Baumgartner J, Malan L, et al. Nutrition during pregnancy and early development (NuPED) in urban South Africa: A study protocol for a prospective cohort. *BMC Pregnancy Childbirth* 2018; 18. DOI: 10.1186/s12884-018-1943-6
18. Harron K, Dibben C, Boyd J, et al. Challenges in administrative data linkage for research. *Big Data Soc* 2017; 4: 2053951717745678.
19. Janus M, Brinkman SA and Duku EK. Validity and psychometric properties of the early development instrument in Canada, Australia, United States, and Jamaica. *Soc Indic Res* 2011; 103: 283.
20. Davies S, Janus M, Duku E, et al. Using the early development instrument to examine cognitive and non-cognitive school readiness and elementary student achievement. *Early Child Res Q* 2016; 35: 63–75.
21. Vieira AJ. Odds ratios and risk ratios: what's the difference and why does it matter? *South Med J* 2008; 01: 730–734.
22. Zhang J and Yu KF. What's the relative risk? A method of correcting the odds ratio in cohort studies of common outcomes. *JAMA* 1998;280:1690–1691.
23. Santos R, Brownell M, Ekuma O, et al. *The Early Development Instrument (EDI) in Manitoba: linking socioeconomic adversity and biological vulnerability at birth to children's outcomes at age 5*. Winnipeg, MB: Manitoba Centre for Health Policy, 2012.
24. Saunders NR, Janus M, Porter J, et al. Use of administrative record linkage to measure medical and social risk factors for early developmental vulnerability in Ontario, Canada. *Int J Popul Data Sci* 2021; 6: 1407.
25. Razaz N, Cnattingius S, Persson M, et al. One-minute and five-minute Apgar scores and child developmental health at 5 years of age: A population-based cohort study in British Columbia, Canada. *BMJ Open* 2019; 9: e027655.
26. Cabaj JL, McDonald SW and Tough SC. Early childhood risk and resilience factors for behavioural and emotional problems in middle childhood. *BMC Pediatr* 2014; 14: 166.
27. Mughal MK, Giallo R, Arnold PD, et al. Trajectories of maternal distress and risk of child developmental delays: findings from the All Our Families (AOF) pregnancy cohort. *J Affect Disord* 2019; 248: 1–12.
28. Cronin P and Goodall S. Measuring the impact of genetic and environmental risk and protective factors on speech, language, and communication development-evidence from Australia. *Int J Environ Res Public Health* 2021; 18. DOI: 10.3390/ijerph18084112
29. Grace T, Bulsara M, Robinson M, et al. Early life events and motor development in childhood and adolescence: A longitudinal study. *Acta Paediatr* 2016; 105: e219–e227.
30. O'Meagher S, Kemp N, Norris K, et al. Risk factors for executive function difficulties in preschool and early school-age preterm children. *Acta Paediatr* 2017; 106: 1468–1473.
31. Pearce A, Scalzi D, Lynch J, et al. Do thin, overweight and obese children have poorer development than their healthy-weight peers at the start of school? Findings from a South Australian data linkage study. *Early Child Res Q* 2016; 35: 85–94.
32. Dea C, Gauvin L, Fournier M, et al. Does place matter? An international comparison of early childhood development outcomes between the Metropolitan Areas of Melbourne, Australia and Montreal, Canada. *Int J Environ Res Public Health* 2019; 16. DOI: 10.3390/ijerph16162915
33. Veldman SL, Jones RA, Chandler P, et al. Prevalence and risk factors of gross motor delay in pre-schoolers. *J Paediatr Child Health* 2020; 56: 571–576.
34. Williamson A, Gibberd A, Hanly MJ, et al. Social and emotional developmental vulnerability at age five in Aboriginal

and non-Aboriginal children in New South Wales: A population data linkage study. *Int J Equity Health* 2019; 18: 120.
35. Lloyd JE and Hertzman C. From kindergarten readiness to fourth-grade assessment: longitudinal analysis with linked population data. *Soc Sci Med* 2009; 68: 111–123.
36. Dhamrait GK, Christian H, O'Donnell M, et al. Gestational age and child development at school entry. *Sci Rep* 2021; 11: 14522.
37. van Bergen E, van Zuijen T, Bishop D, et al. Why are home literacy environment and children's reading skills associated? What parental skills reveal. *Read Res Q* 2017; 52: 147–160.
38. Sheridan MA and McLaughlin KA. Neurobiological models of the impact of adversity on education. *Curr Opin Behav Sci* 2016; 10: 108–113.
39. Green MJ, Tzoumakis S, Laurens KR, et al. Latent profiles of early developmental vulnerabilities in a New South Wales child population at age 5 years. *Aust N Z J Psychiatry* 2018; 52: 530–541.
40. Luby JL, Gaffrey MS, Tillman R, et al. Trajectories of preschool disorders to full DSM depression at school age and early adolescence: continuity of preschool depression. *Am J Psychiatry* 2014; 171: 768–776.
41. Bell MF, Bayliss DM, Glauert R, et al. Children of parents who have been hospitalised with psychiatric disorders are at risk of poor school readiness. *Epidemiol Psychiatr Sci* 2019; 28: 508–520.
42. Collaborators GBDMD. Global, regional, and national burden of 12 mental disorders in 204 countries and territories, 1990-2019: A systematic analysis for the Global Burden of Disease Study 2019. *Lancet Psychiatry* 2022; 9: 137–150.
43. Reimherr JP and McClellan JM. Diagnostic challenges in children and adolescents with psychotic disorders. *J Clin Psychiatry* 2004; 65: 5–11.
44. Tzoumakis S, Carr VJ, Dean K, et al. Prenatal maternal smoking, maternal offending, and offspring behavioural and cognitive outcomes in early childhood. *Crim Behav Ment Health* 2018; 28: 397–408.
45. Valera-Gran D, García de la Hera M, Navarrete-Muñoz EM, et al. Folic acid supplements during pregnancy and child psychomotor development after the first year of life. *JAMA Pediatr* 2014; 168: e142611.
46. Hernán MA, Hsu J and Healy B. A second chance to get causal inference right: a classification of data science tasks. *CHANCE* 2019; 32: 42–49.
47. Shmueli G. To explain or to predict? *Stat Sci* 2010; 25: 289–310.
48. Westreich D and Greenland S. The table 2 fallacy: presenting and interpreting confounder and modifier coefficients. *Am J Epidemiol* 2013; 4: 292–298.