Variation in cerebral palsy profile by socio-economic status

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ABBREVIATIONS

DAG	Directed acyclic graph
MACS	Manual Ability Classification System
REPACQ	Registre de la Paralyse Cérébrale de Québec
SES	Socio-economic status

AIM Socio-economic differences in maternal and child health are well recognized, but the role of individual-level and area-level determinants in cerebral palsy (CP) phenotypes is debated. We set out to examine (1) the association between area-level and individual-level measures of socio-economic deprivation and CP phenotype among children, including subtype, severity, and comorbidities; and (2) the direct effect of area-level deprivation not mediated through individual-level deprivation.

METHOD Regional data from a provincial CP register were analyzed. The outcome of interest was CP phenotype. The area-level exposure was measured using the Pampalon Deprivation Index. Individual-level socio-economic status (SES) was determined using maternal education. We conducted multiple regression models, stratified by preterm birth, controlling for key covariates, and a mediation analysis of area-level deprivation on the association between individual SES and CP phenotype.

RESULTS A socio-economic gradient in mobility was seen in our cohort, above and beyond differences in maternal and perinatal factors. The added direct effect of area-level deprivation was seen only in children whose mothers were educated to a higher level, suggesting no additional contribution of area-level deprivation in children of mothers with a lower level of education.

INTERPRETATION Contextual socio-economic factors can impact the severity of CP. These findings indicate important areas for potential community-level or area-level public health intervention (i.e. neighborhood reinvestment, preventive measures), and suggest that neighborhood-level research in maternal and perinatal health should continue to be pursued.

Cerebral palsy (CP) is one of the most common motor disabilities in childhood, affecting approximately 2 per 1000 children, creating an important health burden for affected children, their families, and their communities.[1] Biological risk factors for CP include placental abnormalities, major and minor birth defects, and preterm delivery.[2] Beyond these, few studies have examined the social determinants of CP. A recent systematic review[3] found an association between area-level and, to a lesser degree, individual-level socio-economic status (SES) and risk of CP. Socio-economic differences in maternal and child health are well recognized,[4] but their role in CP remains debated. It is unclear if the distribution of CP cases and case severity is associated with environmental exposures.

We hypothesize that there exist both individual-level and area-level socio-economic determinants of CP severity. At an individual level, maternal SES is recognized as a robust predictor of child health.[5,6] Studies to date suggest that children with CP, born to disadvantaged families, have more severe phenotypes as defined by spastic quadriparesis,[7] poor mobility,[8–10] and cognitive impairment.[7] We hypothesize that, beyond individual-level SES factors, socio-economic indicators related to families' areas of residence may also affect CP outcomes,[11] with areas associated with chronic exposure to socio-economic stressors (e.g. inadequate nutrition and lack of health resources, housing, or areas for physical activity) being associated with more severe outcomes. Researchers have shown that, even after adjusting for individual-level risk factors, exposure to neighborhood social or material deficits is associated with poorer child and adolescent health outcomes.[12,13] The two existing theories explaining this relationship are that neighborhoods can either act as stressors that trigger or worsen health symptoms or that neighborhood environments mediate the social connections that are necessary for ensuring resiliency and health promotion throughout the life course.[12] A better understanding of the impact of such contextual factors on children with CP is needed to inform

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health services and targeted interventions, and ultimately to reduce the health burden of CP in the population.

In the present study, data from a provincial regional CP register were used to examine (1) the association between area-level and individual-level socio-economic deprivation measures and CP phenotype including subtype, severity, and comorbidities; and (2) the direct effect of area-level deprivation not mediated through individual-level deprivation.

What this paper adds

- A socio-economic gradient in mobility was seen in our study population, above and beyond differences in maternal and perinatal factors.
- A direct effect of area-level deprivation was seen only in children of mothers with a higher education level, with no additional risk added to children of mothers with lower education already at risk.
- Contextual factors can affect the severity of cerebral palsy.

METHODS

Setting and participants

Children with CP born between 1 January 1999 and 31 December 2010 were identified from the Registre de la Paralyse Cérébrale de Québec (REPACQ). Utilizing the framework of the regionalization of pediatric rehabilitation service delivery, children with CP were enrolled in six of the province's 17 administrative health regions. Children are enrolled at the age of 2 years, when the diagnosis is initially made, and are followed up at 5 years to update diagnosis, functional status, and comorbidities. Ethics permission for the registry's establishment and its implementation was obtained from the local host institution (McGill University Health Center Research Institute) and each participating pediatric rehabilitation center. CP was defined, in accordance with recent consensus statements, as 'a non-progressive motor impairment of early onset, that is presumably cerebral in origin, which may or may not be associated with developmental delays, cognitive disability, language impairment, epilepsy, sensory (auditory or visual) loss, orthopedic abnormalities, or behavioral difficulties.'[14] Details of the registry's ascertainment strategy have been described elsewhere.[15] This regional registry captures nearly all children with CP living in these regions, with a calculated prevalence of 1.84 per 1000 children aged 8 to 10 years.

Measures of socio-economic status

Both an individual-level and an area-level indicator of SES were explored as predictors, as they capture different aspects of a family's SES.

Individual-level socio-economic status

Individual-level SES data available from the REPACQ registry included maternal age (in years), maternal and paternal education, and ethnicity, as obtained through self-report. Maternal education was chosen a priori as the individual-level SES indicator, as other studies have supported the notion that maternal education is strongly correlated with broad indicators of maternal and child health.[6]

Area-level socio-economic status

Area-level SES data were obtained using the material and social deprivation index developed by Pampalon et al.[16–18] The deprivation index is based on the dissemination areas, which are the smallest available geographic units from the national census for which data are available from Statistics Canada, with a population varying between 400 and 700 people. These dissemination areas are considered relatively homogeneous in socio-economic composition and were linked to the six-digit postal codes available in the registry using the postal code conversion file from Statistics Canada. The deprivation index is derived from six indicators, three for material, and three for social components. The material component is composed of (1) the proportion of the population aged 15 years and over without a high school diploma or equivalent, (2) the employment-to-population ratio for the population, and (3) the average income of the population aged 15 years and over. The social component is composed of (1) the proportion of individuals aged 15 years and older living alone, (2) the proportion of the population aged 15 years and over who are separated, divorced, or widowed, and (3) the proportion of single-parent families. Five of these six indicators are adjusted for age and sex, except for the proportion of single-parent families indicator. The deprivation indices provide deprivation scores for each dissemination area. These scores are divided into quintiles, with quintile 1 (Q1) representing the most privileged group and Q5 representing the most disadvantaged group. This deprivation index was used as the final area-level measure of socio-economic status. For the regression models, we dichotomized area-level deprivation into two exposure categories: least deprived areas (i.e. highest SES) were formed by Q1 and Q2 and most deprived areas (i.e. lowest SES) were formed by Q4 and Q5, excluding the middle Q3 category from these comparisons.

Covariates

The following clinical variables were extracted from the CP registry: sex, subtype of CP (spastic quadriparesis, spastic diplegia, spastic hemiplegia, dyskinetic), severity of motor function impairment (defined according to the Gross Motor Function Classification System [GMFCS] and the Manual Ability Classification System [MACS]),[19,20] and comorbidities (epilepsy, visual impairment, hearing impairment, cognitive impairment, feeding difficulty, communication impairment). Depending on their level of motor function, participants were categorized in a binary fashion as ambulant (GMFCS levels I–III) or non-ambulant (GMFCS levels IV and V). Pregnancy factors extracted included parity, the presence of gestational diabetes mellitus, gestational hypertension, and pre-eclampsia, and smoking status. Perinatal factors extracted included gestational age in weeks, birthweight in grams, Apgar scores, and first blood gas pH.

Analysis

SPSS version 20.0 (PASW, Chicago, IL, USA) was used for data entry and analysis, and Stata version 12.0 (StataCorp LP, College Station, TX, USA) was used for regression analyses. Descriptive bivariate analysis and comparisons among clinical variables and deprivation scores were conducted using χ^2 tests or Fisher's exact test for categorical variables. We estimated crude and adjusted risk ratios (RRs) using log-binomial models. RRs generate the most valid and conservative measures of association given the frequency of the study outcomes. We produced crude RRs of a priori chosen CP outcomes (MACS levels IV–V poor bimanual ability, GMFCS levels IV–V non-ambulant, CP subtype spastic quadriparesis, presence of any comorbidities) by maternal education and deprivation index quintile.

The effect estimate measures the probability of the outcome among the exposed (least educated/most deprived) relative to the unexposed (most educated/least deprived). We fitted multivariable models to adjust for a priori confounders that are known to be associated with both exposures of interest, namely individual-level and area-level SES, and the outcome of CP. Figure S1, online supporting information, shows the a priori model directed acyclic graph (DAG) used in the multivariable analysis. We selected the minimum set of covariates that we felt were essential to all models and adjusted for age, parity, maternal and paternal ethnicity, and paternal education. As we wanted to assess whether or not the effect was different in term and preterm infants (which was not included in multivariable models as gestational age is part of the causal pathway), we stratified all of our analyses by preterm birth status (≥37wks vs <37wks). This allowed us to observe the effect of SES separately among preterm and term infants, which may provide clues to the potential mechanism or pathways involved. To separate the effect of neighborhood deprivation from that of maternal education, we used mediation analysis.[21] Through this effort, we estimated the controlled direct effect of area-level socio-economic deprivation that is not mediated through individual-level SES.[22] Figure S2, online supporting information, shows the a priori model DAG used in the mediation analysis.

RESULTS

A total of 499 children were identified in the registry in 2012, and a deprivation index score could be accessed for 483 of these children. For 16 children a deprivation index score could not be calculated because a valid six-digit postal code was not available. These 16 children were excluded from our analyses. The parental sociodemographic and pregnancy characteristics of the sample children are outlined in Table I. There was no significant difference in distribution of children across quintiles, with 18.2% in Q1, 21.9% in Q2, 18.8% in Q3, 18.4% in Q4, and 22.6% in Q5. There were significant differences in maternal age across deprivation index quintiles, with a higher proportion of both younger (<22y, p=0.009) and older (>37y, p=0.029) mothers living in the most deprived areas. There were also significant differences in maternal and paternal education across deprivation index quintiles, with a greater proportion of parents with over 14 years of schooling in the least deprived areas (for each, p<0.001). A significant difference across deprivation index quintiles was also seen in both

Table I: Maternal and paternal characteristics by combined area-level deprivation index

Characteristic	Q1 (richest) (%) (n=88)	Q2 (%) (n=106)	Q3 (%) (n=91)	Q4 (%) (n=89)	Q5 (%) (n=109)	Total (%) (n=483)	p
Maternal age (y)[a]							
<22	4.5	10.7	15.1	10.3	21.1	12.7	0.009
≥37	5.7	11.7	9.3	11.5	20.2	12.1	0.003
Maternal education (y)[a]							
<11	3.4	4.9	20.7	5.8	19.8	11.1	<0.001
≥14	49.4	38.2	19.5	29.1	23.6	31.8	<0.001
Paternal education (y)[a]							
<11	4.7	12.0	28.2	12.3	21.1	15.7	<0.001
≥14	43.0	34.0	11.8	25.9	25.3	28.2	<0.001
Maternal ethnicity[a]							
White	90.9	86.8	76.9	68.5	62.4	76.8	<0.001
Black	2.3	2.8	8.8	9.0	11.9	7.0	0.028
Other	6.8	10.4	14.3	22.5	25.7	16.1	NS
Paternal ethnicity[a]							
White	90.9	85.8	72.5	67.4	60.6	75.2	<0.001
Black	1.1	2.8	9.9	9.0	11.9	7.0	NS
Other	8.0	11.3	17.6	23.6	27.5	17.8	NS
Primiparous	37.6	34.3	28.1	26.4	34.0	32.2	NS
Maternal smoking	13.6	15.1	22.0	18.0	19.3	17.6	NS
Gestational hypertension	10.5	18.8	17.2	12.9	14.0	14.8	NS
Pre-eclampsia	4.5	11.3	4.4	4.5	8.3	6.8	NS
Gestational diabetes mellitus	9.3	7.8	18.4	13.1	11.3	11.8	NS

In Quebec, maximum attendance at high school lasts 11 years and completion results in a high school diploma. Attendance for less than 11 years results in no diploma; education for 12 to 13 years indicates education at CEGEP (pre-university college) or vocational school (more than high school diploma), and education for 14 years or more indicates some university education. [a]Significantly different among the five quintiles (χ^2 test, p<0.05). Q, quintile; NS, non significant.

maternal and paternal ethnicity, with a greater proportion of white parents living in the least deprived areas (for each, $p<0.001$). There were no significant differences in pregnancy characteristics between quintiles, such as pregnancy parity, maternal smoking, gestational hypertension, pre-eclampsia, and gestational diabetes mellitus.

The perinatal characteristics of the sample children are outlined in Table II. Children living in the least deprived areas were significantly more likely to be born at term ($p<0.001$) and be of normal birthweight (>2.5kg, $p=0.001$). There were no differences across deprivation index quintiles in sex, Apgar scores, and first blood gas pH. Table III describes CP outcomes for both term-born and preterm infants. A non-ambulant GMFCS status (levels IV and V) was seen in 27%, a poor non-functional bimanual ability (MACS levels IV and V) in 29%, spastic quadriparesis subtype in 32%, and the presence of at least one comorbidity in 78% of the total sample of children. Presence of any comorbidity was more common in term-born children (81% vs 71%, $p=0.003$).

The crude and adjusted RRs of CP outcomes are shown in Table IV, with stratification by preterm and term-born infants. The adjusted model includes maternal age, parity, maternal and paternal ethnicity, and paternal education as covariates chosen a priori. Gestational age and birthweight were comparable among preterm children living in least deprived areas and most deprived areas. Similarly, gestational age and birthweight were comparable among term-born children living in the least deprived areas and most deprived areas. Children in the most deprived group were more likely than children in the least deprived areas to have non-ambulatory gross motor function in univariable analyses (RR 1.5, 95% confidence interval [CI] 1.0–2.1), and their risk increased in models adjusting for individual sociodemographic variables (RR 1.7, 95% CI 1.1–2.7). This difference in mobility was seen only in the stratum of preterm children (adjusted RR 4.2, 95% CI 1.3–14.2). There were no significant differences between children in the most and least deprived areas with respect to bimanual ability or spastic quadriplegia subtype on univariable analysis. Multivariable analysis showed that only among children born preterm were those living in the most deprived areas more likely to have spastic quadriplegia subtype (RR 2.2, 95% CI 1.2–3.9). There were no differences in comorbidities between groups.

Children whose mothers did not have a high school diploma were also more likely to have a non-ambulatory status in univariable analyses (RR 1.9, 95% CI 1.3–3.0). This difference between groups was seen only among the children born preterm (RR 2.7, 95% CI 1.3–5.5). In multivariable analyses, children whose mothers did not complete high school were also more likely to be non-ambulant (RR 2.7, 95% CI 1.6–4.4), with the difference also seen among children born at term (RR 2.5, 95% CI 1.03–5.9). Bimanual ability was more severely affected among children whose mothers did not complete high school in both univariable (RR 1.9, 95% CI 1.2–3.1) and multivariable analysis (RR 2.7, 95% CI 1.6–4.4). The difference in bimanual ability was significant among preterm children in unadjusted models (RR 3.6, 95% CI 1.4–8.8), but CIs shifted to

Table II: Perinatal characteristics by combined area-level deprivation index

Characteristic	Q1 (*n*=88)	Q2 (*n*=106)	Q3 (n=91)	Q4 (*n*=89)	Q5 (*n*=109)	Total (*n*=483)	*p*
Gestational age (wk)[a]							
Mean (SD)	37.4 (3.8)	35.2 (5.1)	33.9 (5.0)	35.3 (5.2)	35.0 (5.3)	35.3 (5.0)	<0.001
<37wks (%)	23.4	42.4	64.4	41.9	45.8	43.5	
Birthweight (kg)*							
Mean (SD)	3.01 (0.89)	2.59 (1.07)	2.30 (0.98)	2.54 (1.06)	2.46 (1.07)	2.58 (1.04)	0.001
<2.5kg (%)	20.8	42.2	53.4	43.1	46.4	41.3	
Sex							
Male (%)	61.4	59.4	52.7	53.9	49.5	55.3	NS
Apgar score <5 (%)							
At 1min	21.3	28.0	24.3	27.1	23.7	24.9	NS
At 5min	8.0	14.6	11.3	8.6	12.1	11.1	NS
At 10min	7.1	9.1	4.1	6.7	10.2	7.7	NS
Cord pH <7.0 (%)	5.4	10.6	7.4	4.0	4.6	6.5	NS

[a]Significantly different among the five quintiles (χ^2 test, *$p<0.05$). Q, quintile; NS, non significant.

Table III: Selected CP outcomes

Outcome	Total sample (%)	Preterm group (<37wks) (%)	Term-born group (≥37wks) (%)	*p*
GMFCS levels IV and V	108/395 (27)	44/170 (26)	64/225 (28)	NS
MACS levels IV and V	92/312 (29)	37/139 (27)	55/173 (32)	NS
Spastic quadriparesis	129/407 (32)	62/177 (35)	67/230 (29)	NS
Any comorbidities[a]	309/411 (75)	122/171 (71)	187/232 (81)	0.03

[a]$p=0.003$. GMFCS, Gross Motor Function Classification Scale; MACS, Manual Ability Classification System; NS, non significant.

Table IV: Crude and adjusted risk ratios of cerebral palsy (CP) outcomes by deprivation index quintile and maternal education, in preterm and term-born children with CP

Outcome	Total sample, RR (95% CI)	Preterm group (<37wks), RR (95% CI)	Term-born group (≥37wks), RR (95% CI)
GMFCS levels IV and V (non-ambulant) (reference category GMFCS levels I–III [ambulant])			
Deprivation index Q1–2 (poorest) versus Q4–5 (richest)			
Crude	1.5 (1.0–2.1)	2.3 (1.1–5.1)	1.2 (0.9–1.9)
Adjusted	1.7 (1.1–2.7)	4.2 (1.3–14.2)	1.5 (1.0–2.4)
Maternal education no high school diploma versus high school or higher			
Crude	1.9 (1.3–3.0)	2.7 (1.3–5.5)	1.5 (0.8–2.8)
Adjusted	2.7 (1.6–4.4)	3.1 (0.9–10.4)	2.5 (1.0–5.9)
MACS levels IV and V (reference category MACS levels I–III)			
Deprivation index Q1–2 (poorest) versus Q4–5 (richest)			
Crude	1.1 (0.8–1.7)	1.7 (0.8–3.7)	1.0 (0.6–1.6)
Adjusted	1.4 (0.8–2.4)	3.1 (0.9–10.5)	1.0 (1.0–1.0)
Maternal education no high school diploma versus high school or higher			
Crude	1.9 (1.2–3.1)	3.6 (1.4–8.8)	1.3 (0.7–2.7)
Adjusted	2.5 (1.3–4.7)	2.8 (0.7–10.8)	2.1 (0.6–7.5)
CP subtype spastic quadriparesis (reference category all other subtypes [spastic diplegia, spastic hemiparesis, dyskinetic, ataxic])			
Deprivation index Q1–2 (poorest) versus Q4–5 (richest)			
Crude	1.2 (0.8–1.6)	1.3 (0.8–2.3)	1.0 (0.7–1.5)
Adjusted	1.0 (0.7–1.5)	2.2 (1.2–3.9)	0.9 (0.6–1.4)
Maternal education no high school diploma versus high school or higher			
Crude	1.7 (1.1–2.6)	1.8 (0.9–3.6)	1.7 (0.9–2.9)
Adjusted	1.4 (0.7–2.8)	1.0 (0.3–2.8)	2.8 (1.4–5.3)
Presence of any comorbidities (reference category having no associated comorbidities [seizures, vision, hearing, communication, feeding, cognitive impairments])			
Deprivation index Q1–2 (poorest) versus Q4–5 (richest)			
Crude	1.0 (0.9–1.2)	0.9 (0.7–1.2)	1.0 (0.9–1.2)
Adjusted	–	–	–
Maternal education no high school diploma versus high school or higher			
Crude	1.1 (1.0–1.3)	1.3 (1.0–1.7)	1.1 (0.9–1.3)
Adjusted	–	–	–

Adjusted models includes maternal age, maternal ethnicity, paternal ethnicity, paternal education, and parity. GMFCS, Gross Motor Function Classification Scale; MACS, Manual Ability Classification System.

cross the null once covariates were entered into the model. Spastic quadriplegia subtype was seen more often in children whose mother did not complete high school in univariable models (RR 1.7, 95% CI 1.1–2.6), with no difference on multivariable analysis or among preterm or term-born infants. Among term-born infants, spastic quadriplegia subtype was seen more often among children of mothers of lower education level in the adjusted model. There were no differences between groups in the presence of comorbidities in univariable analyses. We were not able to generate any appropriately powered results for the adjusted analyses, as the sample size was too small.

In our mediation analysis, when the mediator was set to low maternal education, there was no direct effect of socio-economic deprivation index on the GMFCS level (RR 0.6, 95% CI 0.3–1.4). This would suggest that the increased risk of non-ambulant functional outcome in the offspring of mothers of lower education level (without a high school diploma) is not further modified by living in a lower SES neighborhood. However, when the mediator was set to high maternal education, there was a strong direct effect of socio-economic deprivation index (RR 2.3, 95% CI 1.1–4.3) on the GMFCS level. This suggests that living in a deprived neighborhood confers additional risk of non-ambulant GMFCS status only on the children of females with a higher level of education.

DISCUSSION

In our study, we observed a socio-economic gradient in prematurity and low birth weight. These findings replicate those previously reported in the literature.[23–25] A socio-economic gradient for both individual and area-level measures was seen in our cohort in mobility, despite a lack of differences in maternal and perinatal factors. Our mediation analysis suggests that the direct effect of neighborhood deprivation is seen only in the children of females with higher educational attainment. Our findings are consistent with those of previous studies exploring the relationship between CP phenotype or severity and SES. In Ireland, a retrospective population-based study found a socio-economic gradient in non-ambulant children with CP, with more disadvantaged children being found at greater risk.[8] That study also found a socio-economic gradient in children with hemiplegic or diplegic subtypes of CP, but not other subtypes. In England, a retrospective population-based study found a socio-economic gradient in children with the bilateral spastic subtype of CP (which would include both spastic diplegia and spastic quadriparesis) as well as with CP with a severe intellectual impairment.[7] Two retrospective population-based studies in the USA[9,26] have explored the possible relationship between race and risk of CP and found that the risk of CP was higher among black children than white children; a similar association was found for risk of severe CP, as determined by the GMFCS level. A recent study in Brazil showed that SES influences functional mobility and the use of assistive mobility devices in children with CP.[10]

Our study population is from the province of Quebec, where a universal healthcare system has been in place since 1971. Differences in functional mobility in the absence of differences in maternal and neonatal factors would suggest a role of SES through an unmeasured variable. One hypothesis is access, or lack of, to early or more intensive rehabilitation services may impact CP outcomes. Unfortunately, this factor was not measured in our study. Although rehabilitation services are covered by universal healthcare, there is often a significant delay in being admitted to community-based rehabilitation programs. Many families turn to private therapy to supplement services offered by the province. However, private services are not universally accessible across the socio-economic spectrum. Regular and rigorous rehabilitation therapy, such as passive stretching exercises, is important in the management of spasticity. Lack of rehabilitation exercises can worsen permanent contractures, which in turn can reduce a child's eventual functional mobility. The ideal time to start such services as well as their optimal frequency, remain undetermined. It is possible that more privileged children have greater access to additional private rehabilitation services, receiving these either earlier and/or more frequently than their less privileged peers. Navigating the healthcare system can also be more challenging for families of lower SES owing to a lack of discretionary time, linguistic or cultural barriers, and limited education. 'Health literacy' requires a complex group of reading, listening, analytical, and decision-making skills and the ability to apply these skills to health situations.[27] Social deprivation can have dire consequences on early child development.[28] However, this socio-economic gradient was seen only in the preterm group, within which gestational age and birthweight were comparable. It is possible that the type of pathology in the preterm group is more sensitive to differences in SES. It was not unexpected that spastic diplegia was more commonly seen in the preterm group. Children born preterm are more likely to have other medical difficulties, such as respiratory or feeding issues, which can place an additional burden of care on their families. Perhaps this additive effect can account for the apparent susceptibility of preterm children to differences in SES.

Although our study objectives and methodology did not aim to determine the effect of SES on CP prevalence, the families of children with CP in our registry were evenly distributed across deprivation index quintiles. This suggests that, in our population, there may not be a socio-economic gradient in CP prevalence; however, further studies specifically designed to explore this question are needed. Certain limitations of our study should be noted. First, the area-level deprivation index used was calculated based on the residence at time of registration at 2 years. It is possible that families moved either during pregnancy or after registration, leading to potential misclassification. Second, because of the nature of our data, we are not able to comment on the causal inference of the observed associations. We did not have access to pre-pregnancy family data and were not able to identify whether social characteristics (i.e. living alone, being separated or divorced) were consequences of, rather than risk factors for, CP. We suggest that future studies in this area access life course information of study respondents, and attempt to disentangle these relationships. Finally, although a large number of variables were available in the registry, the use and frequency of use of rehabilitation services were not included in our models. These will be important mediating factors to measure in future research.

Despite the above limitations, our study has several strengths. First of these is the representativeness of our study sample. Almost all children with CP in these administrative health regions were captured.[15] Second, the deprivation index used is well established in Canadian epidemiological and public health research. The Pampalon Index has been used in multiple peer-reviewed articles, and in a variety of cohorts.[25,29] The use of this index thus improves the generalizability and comparability of our findings.

CONCLUSION

CP in children has various causes, manifestations, and comorbidities. The highest health burden of CP is felt by children who are non-ambulatory.[30,31] Further study is needed to better understand the relationship between SES and functional mobility in children with CP. The Canadian CP Registry is currently collecting data on use of rehabilitation services in these children, which will help address one of our proposed hypotheses. In a universal healthcare system, health inequities should be minimized. In this study, we aimed to identify potential factors that, if modified, may reduce inequalities in health among children and their families. We identified that area-level deprivation may be one such modifiable factor. Future research will benefit from an exploration of targeted interventions to reduce the health burden of CP among vulnerable populations.

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SUPPORTING INFORMATION

The following additional material may be found online:

Figure S1: A priori model DAG used in the multivariable analysis.

Figure S2: A priori model DAG used in the mediation analysis.

REFERENCES

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