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ORIGINAL ARTICLE

Associations of Birth Factors and Socio-Economic Status with Indicators of Early Emotional Development and Mental Health in Childhood: A Population-Based Linkage Study

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Abstract
Using a linked population-based database established on healthcare, socio-economic, and survey datasets in British Columbia, Canada, we examined how biological, socio-demographic, and socio-economic status (SES) factors at birth related to children's emotional development and mental health. One analysis examined teacher-rated anxiety, hyperactivity, and aggression for kindergarten children (M_{age} = 5.7; n = 134,094). Another analysis examined administrative healthcare records comprising of physician-assigned diagnostic codes for mental health conditions (conduct disorder, attention deficit hyperactivity disorder, anxiety disorder and depression) from ages 5 through 15 (n = 89,404). Various factors at birth, including gestational age, birthweight, and maternal demographics, were related to emotional development and mental health in childhood. Across outcomes, low SES indicated detrimental associations with various aspects of children's emotional development and mental health (e.g., adjusted odds of mental health conditions were 25–39% higher for children of low income families versus others). Findings reinforce evidence that poverty (reduction) is a primary public health issue.

Keywords Birth factors · Perinatal · Mental health · Children · Socio-economic status

Introduction

The early years of life are pivotal and can set the stage for developmental trajectories [1]. Biological and social factors can have varying effects on health during childhood and throughout life. The World Health Organization [2] states that there can be "no health without mental health." Accordingly, there have been recent attempts to better characterize child mental health to help inform health promotion programming and policies.

Mental health conditions experienced throughout life commonly manifest symptoms before adulthood: about half of common mental health conditions (e.g., mood, anxiety, and impulse-control disorders) display symptoms before age 14 [3, 4]. Childhood mental health conditions often impose lasting negative influences on children's lives, as well as on those of their family members, and their broader communities, with considerable social and economic burdens [5]. Such conditions are often linked to impaired development, including lower physical health and poor academic performance [6].

Mental health conditions encompass a large subset of conditions. Among children and youth, anxiety disorders, behaviour disorders (including attentional deficient hyperactivity disorder (ADHD) and conduct disorder), and mood disorders (including depression) are the most prevalent childhood and youth mental health conditions in North America [4, 7]. Approximately 20% of youth in Canada (ages 5–14) experience a mental illness [8].

Recently, there has been a movement toward assessing and monitoring indicators of children's mental health in the early years, as mental health at a very young age is associated with certain developmental social, health, and educational trajectories [9]. In Canada, a widely used tool for assessing children's developmental outcomes, including outcomes in the emotional domain, is the Early Development Instrument (EDI; [10]). The EDI is a teacher-report measure, administered during the kindergarten year, which has been used at population levels in Canada and Australia,

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and at regional levels in other countries [11]. Scores are not used as a diagnostic basis for individuals but are used only at aggregate levels (e.g., for schools, districts, neighbourhoods; see https://edi.offordcentre.com/for further details on use of the EDI). EDI ratings of emotional development relate to well-being and mental health conditions in childhood and early adolescence [12, 13]. Population-level monitoring of children's early emotional development may be useful for informing our thinking about intervention, treatment, and implementation of support services that address factors detrimental to children's early emotional health and wellbeing [14].

A promising avenue for facilitating prevention of childhood mental health conditions is the identification of early life risk factors. Our study aims to jointly examine how multiple factors at birth relate to indicators of children's early emotional development and mental health outcomes, by drawing from population-wide birth cohort data linkages. To contextualize our study in the field, we will therefore review related studies in this area.

Biological Birth Factors Related to Child and Youth Mental Health

Various factors at birth have been found to be associated with mental health outcomes. Regarding sex, for instance, internalizing disorders (e.g., anxiety) are more prevalent among girls, whereas the reverse occurs for externalizing disorders (e.g., conduct disorders). This may partly be due to socialization; when presented with vignettes of boys and girls presenting similar symptoms of hyperactivity, teachers and mental health practitioners are more likely to refer boys for externalizing conditions [15, 16].

Factors such as delivery mode may also impact childhood mental health as individuals born via caesarean section have their gut seeded through contact primarily with the mother's skin rather than through the birth channel [17]. This process can adversely affect gut microbiota, which chemically affects the central nervous system and in turn can impact cognitive and emotional factors such as response to stressors and temperament in childhood [18]. Another factor, small birthweight for gestational age, may relate to neural and socio-cognitive vulnerability [19]. Similarly, preterm birth can evoke neural changes implicating cognitive and socio-emotional functioning [20], alterations that may heighten vulnerability (e.g., ineffective management of stress [21]). Finally, lower Apgar scores may indicate poor adjustment to birth stress, and may reflect a biological vulnerability to life stressors [22].

Socio-Demographic Birth Factors Related to Child and Youth Mental Health

Younger (especially teenage) maternal age is associated with a host of social/socio-economic challenges that can adversely impact offspring mental health [23]. In addition to being a socio-demographic factor, maternal age is also a biological factor. Older motherhood may present higher risks of offspring experiencing physical conditions, such as abnormalities [24] or small birthweight and/or early gestational age, that may impact neural functioning, which may hamper optimal cognitive and socio-emotional functioning. Immigrant status may also impact child mental health through acculturation stress, discrimination/stigma, and differential health service utilization [25]. In Canada, children growing up in single parent households have a poverty rate of 43%, compared to the overall poverty rate of 10% [26]. Beyond socio-economic adversity, a single parent/caregiver may also be confronted with challenges to care for their child(ren) without the emotional and social supports that may be provided by a second caregiver [27].

Socio-Economic Status (SES) and Child and Youth Mental Health

Low SES (e.g., lower educational attainment, lower income levels) is a well-established risk for adverse child mental health outcomes [28]. In Canada, prevalence of mental health conditions among children was consistently higher for children belonging to families receiving income-based subsidy relative to those unsubsidized [29]. SES gradients of mental health outcomes have been found in Canadian contexts [30, 31] and internationally [28]. Children from low SES families are less likely to receive positive parental support and are more likely to be exposed to environmental/contextual stressors such as pollution, financial insecurity, and unsafe neighbourhoods [32]. Low-SES neighbourhoods are associated with worse birth outcomes (e.g., preterm birth and low birthweight; [33]), factors associated with adverse youth mental health. Epigenetic research indicates challenging environments associated with low SES may heighten risk of expressing genetic predispositions (e.g., enhanced stress reactivity) associated with negative mental health [34].

The Present Study

In Canada, empirical work relating multiple SES and birth factors to child mental health is scarce. Jutte et al. [35] examined how biologic (Apgar score, birthweight) and social (SES, lone parenthood, maternal age) factors at birth were associated with school exam failure and hospitalization. SES

more strongly related to the outcomes than did biological factors. The role of non-biological birth factors as potential risk factors for healthy child development has commonly been overshadowed by a heavy emphasis on biologic variables among pediatric medical communities (e.g., [36]). Regarding children's and early adolescents' emotional development and mental health, however, we are unaware of any representative analyses that jointly examined biologic, socio-demographic, and socio-economic factors at birth.

This study aimed to quantify the relationship of biologic, socio-demographic, and SES factors with indicators of mental health in childhood using a population-based data linkage. We hypothesized that: (a) our data would replicate previous patterns of associations between biological, socio-demographic, and socio-economic factors at-birth and both (i) teacher-rated emotional development in kindergarten and (ii) physician-assessed mental health conditions during childhood, and: (b) SES would, relative to biological birth risk factors, show stronger associations with both teacher-rated emotional development in kindergarten and physician-assessed mental health conditions up to early adolescence.

Method

Data Sources

Data were obtained from linked population-based vital statistics (birth records), administrative health, aggregate census, and child survey data, in British Columbia (BC), Canada. Emotional development was measured via kindergarten teacher-ratings on the EDI [10]. Indicators of children's mental health outcomes were obtained from fee-for-service physician claims files, as recorded in Medical Services Plan (MSP; [37]) datafiles. These files comprised billing, diagnostic codes, and service dates pertaining to public services provided by health care practitioners (about two-thirds were general practitioners) in clinics and hospital sites during patient interactions, as well as insurance subsidy data (reflecting families' income level). Hospitalizations were obtained from the Discharge Abstract (DADs) Hospital Separation File [38]. EDI data and MSP and DADs data were linked to BC's provincial Vital Statistics database [39], containing birth data for children born in BC, and aggregate census data on neighborhood, block-level income quintile data.

BC's Ministry of Health granted permission to link EDI data to health insurance records. Individual linkage between survey and administrative data was completed by Population Data BC using personal health numbers and probabilistic–deterministic linkage [40]. Data analyses were approved by the Ministry of Health and the Human Early Learning Partnership Data Stewards. All inferences, opinions, and conclusions drawn in this article are those of the authors, and do not reflect the opinions/policies of the Data Steward(s). Ethics approval for this study was granted by the University of British Columbia Behavioural Research Ethics Board under application H09-0192 ("Developmental Trajectories").

Study Samples

The EDI sample (n = 134,094) included children with data on birth, census, and EDI datafiles, born in BC between 1993 and 2005, and who attended public kindergarten in the 1999/2000 to 2010/11 school years. In BC, children can begin full-day kindergarten in the September of the calendar year in which they turn 5; attendance is optional, but over 90% of eligible children attend [41]. EDI participation rates were high: ~ 80% of children attending public kindergarten in school districts participating in EDI data collection were captured in our file for corresponding years.

The mental health conditions sample comprised individuals with data on birth, census, and MSP datafiles, and who were born in BC between 1993 and 1995, and were registered on MSP for ≥ 275 days/year in each year after their birth year through age 15 (n = 89,404), a criterion to indicate annual presence in BC [42, 43]. MSP registration information was obtained from the BC Ministry of Health Consolidation File [44]. Under the Medicare Protection Act [45], BC residents (and their spouses and children aged < 18) must enroll in MSP after 3 months of residence. Certain subpopulations are not included in MSP records: undocumented children, those who lived in BC for < 3 months of a calendar year, and children with Federal health coverage (i.e., children within Aboriginal, military, and refugee families).

Measures

Biological Birth Factors

Sex was a binary variable: male or female. Mode of delivery was categorized as: 'Spontaneous/vaginal', 'Vacuum-assisted', 'Breech', or 'Caesarean section'. Birthweight adjusted for gestational age was employed, as it indicates whether an infant was born of a smaller-/larger-than-average birthweight after accounting for gestational age. This variable was categorized into weights that were 'Small' (< 10th percentile for their gestational age), 'Normal' (10th–90th percentile for their gestational age), and 'Large' (> 90th percentile for their gestational age) [46, 47]. Five term groupings were used: 'Early preterm' (20–33 weeks), 'Late preterm' (34–36 weeks), 'Early term' (37–38 weeks), 'Term' (39–41 weeks), and 'Post term' (42–43 weeks). The Apgar score is a widely-used composite score indicating colour, pulse rate, reflex irritability, activity, and respiratory effort.

Infants are scored on each measurement with a 0, 1, or 2, yielding a sum score from 0 to 10. Higher scores indicate better neonatal outcomes [48, 49]. We chose 1-min Apgar scores, as they show greater variability than 5-min scores [48]. Scores were grouped as < 5, 5–7, and > 7.

SES at Birth

Two SES proxies were used. Families with a low household income (the cut-off increased incrementally from $19,000 in 1993 to $28,000 in 2005) can apply for MSP payment subsidies from the Ministry of Health. Children were categorized as 'On subsidy' if they received subsidized MSP within two years of their birth year.

The second SES variable was derived from block-level census data on income quintiles, derived from the equivalized disposable income within dissemination areas (DA). Data were linked to the DA of the children's earliest recorded family residence postal code. DAs resemble neighbourhood blocks in urban areas, and larger areas in rural regions, typically comprising 400–700 residents. Representative studies for the Canadian context [50] found that census income data aggregated at DA-levels are a reasonable proxy for family income in population-based analyses.

EDI Mental Health Outcome

We used three subdomains of the EDI's Emotional Maturity domain, which correspond to behavioural patterns related to common internalizing and externalizing symptoms, as indicators of emotional development: 'Aggressive behaviour' (seven items), 'Hyperactivity and inattentive behaviour' (seven items), and 'Anxious and fearful behaviour' (eight items). EDI data collection is provincially funded in BC, and occurs in waves (i.e., school districts participate once over a 2- or 3-year period). Data collection is voluntary for teachers and schools, and employs passive consent procedures for parents [51]. Teachers select a category that describes each child's behaviour over the previous 6 months (the EDI is administered in spring to ensure teachers have sufficient experience with each child's behaviour). Teachers rate statements (e.g., 'Would you say that this child seems to be unhappy, sad, or depressed?'; 'is inattentive?') on a 3-point scale—Never or not true, Sometimes or somewhat true, Often or very true. Aligned with previous EDI scoring methods [10], we reverse-coded and dichotomized subdomain scores, using the lowest decile as the cut-off (e.g., lowest decile = high aggressive behavior).

Evidence from numerous studies supports the EDI's validity [10, 52–54]. Prior work employed the emotional health EDI domain to indicate behavioural problems [55, 56], and lower scores on the Emotional Maturity domain relate to lower child-rated well-being at age 10 [12], and higher odds of physician visits for mental health conditions by age 14 [13].

Mental Health Conditions

We used health insurance billing codes for depression, anxiety disorders, conduct disorders, and ADHD as indicators of children's mental health. In BC, for our study years, ICD-9 codes were used to record diagnoses in physician claims, whereas ICD-9 and ICD-10 were used to record hospital diagnoses (hospitalizations). ICD-9 296.2-296.36 and those beginning with 311 pertained to depression, those beginning with 300 to anxiety, those with 312 to conduct disorder, and those with 314 to ADHD. ICD-10 was introduced in Canada in 2001–2004. ICD-10 F32-F39 pertained to depression, F40-F43 to anxiety, F91 to conduct disorders, and F90 to ADHD. Individuals were assigned a mental health condition code if they had at least one clinic contact or hospitalization billed according to the ICD-9 or ICD-10 codes for the select mental health conditions (hereafter, "physician visits" denote such instances). Operationalization of these four mental health conditions was not necessarily exclusive (i.e., children with any physician-visits for depression were identified as such—regardless of whether they had visits for any of the other mental conditions also). Accuracy of MSP billings for very young children may be low due to difficulty in assessing mental health condition symptoms and emotional maturity [57], so diagnoses were limited to those occurring at age 5–15.

Analytic Approach

Using Stata 15 [58], multivariable logistic regression was employed. One set of analyses assessed associations of factors at birth with adverse emotional development (within the lowest decile) on the three EDI subdomains in kindergarten. Another set of analyses examined associations of factors at birth with physician visits (any/none) for each of the four select mental health conditions.

Results

Sample Characteristics

Detailed proportions and counts for variable categories are presented in Tables 1 and 2. In the EDI sample (n = 134,094), mean age at assessment was 5 years, 7 months; 51% were boys; 64% were born vaginally; 80% were born at normal birthweight for gestational age; 92%

Table 1 Adjusted odds ratios for poor EDI—Emotional Development subdomain scores for the analytic sample (n = 134,094), associated with birth factors

Birth factor (reference group)	Anxious and fearful behaviour	Aggressive behaviour	Hyperactive and inattentive behaviour
Biological (aOR range 0.64–3.66)			
Child's sex (female; n = 65,112)			
Male (n = 68,982)	**1.09** (1.05, 1.13)	**2.93** (2.82, 3.04)	**3.66** (3.51, 3.82)
Birth delivery (Spontaneous/vaginal; n = 85,226)			
Caesarean (n = 34,689)	1.01 (0.97, 1.06)	**1.10** (1.05, 1.14)	**1.12** (1.08, 1.17)
Vacuum (n = 6429)	0.99 (0.91, 1.08)	1.05 (0.97, 1.14)	1.04 (0.95, 1.13)
Breech (n = 574)	**0.72** (0.53, 0.98)	0.81 (0.60, 1.08)	0.82 (0.60, 1.11)
Forceps (n = 7176)	0.98 (0.90, 1.06)	1.00 (0.93, 1.08)	0.95 (0.88, 1.04)
Birthweight adjusted for gestational age (10th–90th Percentile; n = 107,841)			
Small: < 10th percentile (n = 11,062)	**1.19** (1.12, 1.26)	**1.13** (1.06, 1.20)	**1.31** (1.23, 1.39)
Large: > 90th percentile (n = 15,191)	1.03 (0.98, 1.09)	1.00 (0.94, 1.05)	1.01 (0.95, 1.07)
Gestational period (Term: 39–41 weeks; n = 94,412)			
Early preterm (20–33 weeks; n = 1981)	**1.32** (1.15, 1.51)	0.97 (0.84, 1.11)	**1.50** (1.32, 1.71)
Late preterm (34–36 weeks; n = 6715)	**1.19** (1.10, 1.29)	0.99 (0.92, 1.07)	**1.11** (1.02, 1.20)
Early term (37–38 weeks; n = 29,353)	**1.15** (1.11, 1.21)	1.00 (0.95, 1.04)	**1.11** (1.07, 1.17)
Post term (42–43 weeks; n = 1633)	0.96 (0.81, 1.13)	1.01 (0.87, 1.18)	0.88 (0.74, 1.04)
Apgar score at 1-min (8–10; n = 105,082)			
1–4 (n = 6379)	0.94 (0.86, 1.03)	1.02 (0.94, 1.10)	**1.08** (1.00, 1.18)
5–7 (n = 22,633)	1.02 (0.97, 1.07)	1.03 (0.98, 1.07)	**1.10** (1.05, 1.16)
Age at EDI assessment (per 1-year increase; n = 134,094)			
	0.64 (0.60, 0.68)	**0.93** (0.88, 0.98)	**0.69** (0.64, 0.73)
Maternal age at child birth (25–30 years; n = 42,117)			
< 20 years (n = 5508)	1.07 (0.98, 1.17)	**1.45** (1.34, 1.57)	**1.44** (1.33, 1.57)
20–24 years (n = 28,137)	1.01 (0.95, 1.06)	**1.19** (1.14, 1.25)	**1.16** (1.10, 1.22)
31–35 years (n = 39,746)	**1.07** (1.02, 1.12)	0.99 (0.94, 1.03)	0.99 (0.94, 1.04)
36–40 years (n = 16,187)	**1.08** (1.02, 1.15)	1.01 (0.95, 1.08)	**1.06** (1.00, 1.13)
> 40 years (n = 2399)	**1.20** (1.05, 1.37)	1.13 (0.99, 1.29)	**1.25** (1.09, 1.43)
Socio-demographic (aOR range 0.80–1.89)			
Mother's birthplace (Canada; n = 95,978)			
Outside Canada (n = 38,116)	**0.92** (0.88, 0.96)	**0.92** (0.88, 0.95)	**0.80** (0.76, 0.84)
Parental marital status (married; n = 91,674)			
Divorced (n = 2489)	1.11 (0.98, 1.26)	**1.51** (1.35, 1.70)	**1.47** (1.30, 1.67)
Separated (n = 2262)	**1.22** (1.12, 1.32)	**1.84** (1.65, 2.06)	**1.89** (1.68, 2.13)
Widowed (n = 119)	0.89 (0.48, 1.66)	1.35 (0.79, 2.29)	1.13 (0.62, 2.06)
Never married (n = 24,215)	**1.21** (1.15, 1.28)	**1.52** (1.45, 1.59)	**1.46** (1.39, 1.54)
Other (n = 6665)	**1.22** (1.12, 1.32)	**1.48** (1.37, 1.59)	**1.51** (1.39, 1.63)
Unknown (n = 6670)	**1.10** (1.01, 1.19)	**1.28** (1.18, 1.38)	**1.25** (1.15, 1.35)
Socio-economic status (aOR range 1.08–1.44)			
Family MSP status (unsubsidized; n = 86,840)			
Subsidized (n = 47,254)	**1.26** (1.21, 1.31)	**1.37** (1.31, 1.42)	**1.44** (1.38, 1.50)
Neighbourhood block-level income quintile (Q1/highest; n = 29,232)			
Q5/lowest (n = 21,754)	**1.40** (1.32, 1.49)	**1.35** (1.27, 1.43)	**1.40** (1.31, 1.49)
Q4 (n = 26,008)	**1.24** (1.17, 1.32)	**1.20** (1.13, 1.27)	**1.25** (1.17, 1.33)
Q3 (n = 27,826)	**1.17** (1.09, 1.24)	**1.11** (1.04, 1.17)	**1.16** (1.08, 1.24)
Q2 (n = 29,274)	1.03 (0.96, 1.10)	1.03 (0.97, 1.10)	**1.08** (1.01, 1.15)

Bolded values represent significant odds ratios relative to the reference category (< 0.05)

MSP Medical services plan—British Columbia's universal public health insurance

Table 2 Adjusted odds ratios of having a physician visit for a common mental health condition between age 5–15 for the analytic sample (n = 89,404), stratified by type of disorder

Birth factor (reference group)	Depression	Anxiety	Conduct	ADHD
Biological (aOR range 0.77–2.82)				
Child's sex (Female; n = 45,776)				
Male (n = 43,638)	**0.77** (0.73, 0.81)	**0.90** (0.85, 0.94)	**2.26** (2.14, 2.39)	**2.82** (2.66, 2.98)
Birth delivery (Spontaneous/vaginal; n = 61,184)				
Caesarean (n = 18,462)	1.05 (0.98, 1.12)	**1.12** (1.06, 1.19)	**1.07** (1.01, 1.15)	**1.08** (1.01, 1.15)
Forceps (n = 680)	0.83 (0.56, 1.11)	0.81 (0.60, 1.08)	1.19 (0.89, 1.58)	1.25 (0.96, 1.64)
Breech (n = 9078)	0.99 (0.90, 1.08)	1.06 (0.98, 1.15)	1.19 (0.89, 1.58)	1.25 (0.96, 1.64)
Birthweight adjusted for gestational age (appropriate: 10th–90th Percentile; n = 71,761)				
Small: < 10th percentile (n = 8244)	0.95 (0.86, 1.04)	1.06 (0.98, 1.15)	1.08 (0.99, 1.18)	**1.17** (1.08, 1.27)
Large: > 90th percentile (n = 9399)	1.09 (1.00, 1.18)	1.03 (0.96, 1.11)	0.93 (0.85, 1.02)	0.93 (0.85, 1.01)
Gestational period (term: 39–41; weeks n = 64,297)				
Early preterm (20–33 weeks; n = 1286)	0.84 (0.65, 1.03)	1.17 (0.98, 1.41)	**1.32** (1.09, 1.61)	1.10 (0.90, 1.34)
Late preterm (34–36 weeks; n = 3869)	**0.87** (0.76, 0.99)	**1.12** (1.00, 1.25)	**1.18** (1.04, 1.33)	**1.16** (1.04, 1.30)
Early term (37–38 weeks; n = 16,661)	0.98 (0.91, 1.04)	**1.06** (1.00, 1.13)	1.04 (0.98, 1.12)	**1.05** (0.99, 1.12)
Post term (42–43 weeks; n = 3291)	0.92 (0.79, 1.05)	0.89 (0.78, 1.01)	1.05 (0.92, 1.20)	0.97 (0.84, 1.10)
Apgar score at 1-min (8–10; n = 69,996)				
1–4 (n = 4243)	1.11 (0.97, 1.24)	1.07 (0.96, 1.19)	1.09 (0.97, 1.22)	**1.13** (1.01, 1.26)
5–7 (n = 15,165)	**1.09** (1.01, 1.16)	1.00 (0.94, 1.07)	1.07 (1.00, 1.15)	**1.09** (1.02, 1.17)
Maternal age at child birth (25–30 years; n = 31,109)				
< 20 years (n = 3237)	**1.32** (1.15, 1.49)	1.09 (0.96, 1.23)	**1.44** (1.27, 1.63)	**1.37** (1.22, 1.55)
20–24 years (n = 19,312)	**1.11** (1.03, 1.19)	1.03 (0.96, 1.10)	**1.15** (1.07, 1.24)	1.06 (0.99, 1.14)
31–35 years (n = 25,881)	1.01 (0.94, 1.08)	1.05 (0.99, 1.12)	0.95 (0.89, 1.02)	1.02 (0.95, 1.09)
36–40 years (n = 8792)	**1.21** (1.10, 1.33)	**1.14** (1.05, 1.24)	1.08 (0.98, 1.19)	**1.10** (1.00, 1.20)
> 40 years (n = 1073)	1.25 (0.96, 1.55)	**1.41** (1.16, 1.72)	**1.35** (1.07, 1.70)	1.21 (0.96, 1.52)
Socio-demographic (aOR range 0.58–1.82)				
Mother's birthplace (Canada; n = 64,075)				
Outside Canada (n = 25,329)	**0.58** (0.54, 0.62)	**0.74** (0.70, 0.78)	**0.62** (0.58, 0.66)	**0.60** (0.56, 0.64)
Parental marital status (married; n = 69,274)				
Divorced (n = 1675)	**1.72** (1.45, 1.99)	**1.47** (1.27, 1.71)	**1.52** (1.31, 1.76)	**1.60** (1.38, 1.86)
Separated (n = 1117)	**1.39** (1.10, 1.67)	**1.41** (1.18, 1.69)	**1.45** (1.22, 1.72)	**1.72** (1.45, 2.04)
Widowed (n = 84)	2.07 (0.82, 3.32)	**1.82** (1.01, 3.30)	1.66 (0.89, 3.09)	1.70 (0.89, 3.24)
Never married (n = 11,326)	**1.37** (1.26, 1.48)	**1.26** (1.17, 1.36)	**1.38** (1.28, 1.47)	**1.51** (1.41, 1.62)
Other (n = 2534)	**1.23** (1.05, 1.41)	1.13 (0.99, 1.30)	**1.15** (1.01, 1.30)	**1.41** (1.24, 1.60)
Unknown (n = 3394)	**1.22** (1.06, 1.38)	1.06 (0.94, 1.20)	**1.17** (1.02, 1.33)	**1.26** (1.12, 1.43)
Socio-economic status (aOR range 1.10–1.39)				
Family MSP status (unsubsidized; n = 58,628)				
Subsidized (n = 30,776)	**1.36** (1.28, 1.44)	**1.25** (1.19, 1.32)	**1.39** (1.31, 1.47)	**1.38** (1.30, 1.46)
Neighbourhood block-level income quintile (Q1/highest; n = 14,965)				
Q5/lowest (n = 18,260)	1.08 (0.99, 1.18)	0.97 (0.89, 1.04)	1.03 (0.95, 1.13)	**1.10** (1.01, 1.20)
Q4 (n = 19,355)	1.04 (0.96, 1.14)	0.98 (0.91, 1.06)	1.01 (0.93, 1.10)	1.08 (0.99, 1.17)
Q3 (n = 18,883)	1.04 (0.95, 1.13)	0.94 (0.87, 1.01)	0.93 (0.85, 1.01)	1.02 (0.94, 1.11)
Q2 (n = 17,941)	1.00 (0.92, 1.10)	0.93 (0.86, 1.00)	0.93 (0.85, 1.02)	1.01 (0.93, 1.10)

Bolded values represent significant odds ratios relative to the reference category (< 0.05)

MSP Medical services plan—British Columbia's universal public health insurance

were born at term (37–42 weeks of gestation); 61% were born to mothers aged 25–35; 68% were born to married parents; and 35% were from low-income families (subsidized). For the mental health conditions (MSP billing) sample (n = 89,404), 49% were boys; 68% were born vaginally; 80% were born at normal birthweight for gestational age;

64% were born to mothers aged 25–35; 78% were born to married parents; and 34% were of families on subsidized MSP (i.e., low income). The proportion of children who had any physician visits (while aged 5 through 15) for the following conditions was: 6.7% for depression, 8.8% for anxiety, 7.1% for conduct disorder, and 7.8% for ADHD.

Biological Factors at Birth Related to Child and Youth Mental Health

Sex and Age at EDI Assessment

Relative to girls, boys had several-fold higher odds of teacher-rated aggressive and hyperactive behaviours (aORs: 2.93, 3.66 respectively) and slightly higher odds of anxious behaviours (aOR: 1.09). Boys had higher odds of physician visits for conduct disorder and ADHD (aORs: 2.26, 2.82, respectively), whereas girls had higher odds of physician visits for depression and anxiety (higher adjusted odds of 23% and 10%, respectively). Among the EDI sample, each 1-year increase in age at the time of teacher-assessment was related to lower adjusted odds of teacher-rated anxious, aggressive, and hyperactive behaviours (lower odds of 36%, 7%, and 31% respectively).

Delivery Mode

Being born via caesarean section was related to higher odds of teacher-rated aggressive and hyperactive behaviours, relative to vaginal delivery mode. Also, breech delivery mode was associated with lower odds (aOR: 0.77) of teacher-rated anxious behaviours than vaginally-born children. Regarding visits for mental conditions in childhood, compared to children delivered vaginally, those born via caesarean section had higher odds of physician visits for anxiety, conduct disorder, or ADHD (aORs ranged: 1.07–1.12).

Birthweight

Children born at a small birthweight adjusted for gestational age had higher odds of teacher-rated anxious, hyperactive, and aggressive behaviours relative to those born at appropriate birthweight for their gestational age. Higher odds of physician visits for ADHD occurred for children with a small birthweight for their gestational age (aOR: 1.17).

Gestational Age

Relative to those born at term (39–41 weeks of gestation), earlier gestational age related to higher odds of teacher-rated anxious (aOR: 1.32 for early preterm, 1.19 for late preterm, 1.15 for early term) and hyperactive behaviours (aOR: 1.50 for early preterm, 1.11 for late preterm and for early term). Earlier gestational age was associated with higher odds of physician visits for anxiety (aOR: 1.12 for late preterm, 1.06 for early term), conduct disorder (aOR: 1.32 for early preterm, 1.18 for late preterm), as well as for ADHD (aOR: 1.16 for late preterm, 1.05 for early preterm). One inverse association between gestational age and mental health outcomes was observed whereby those born at late preterm had 13% lower odds of physician visits for depression.

Apgar Score

Lower Apgar score (1–4 and 5–7) was associated with higher odds of teacher-rated hyperactivity (aOR 1.08 and aOR 1.10, respectively). Relative to children born with an Apgar score > 7, lower Apgar score was associated with higher odds of physician visits for depression (aOR for score 5–7: 1.09) and ADHD (aOR: 1.13 for score 1–4, 1.09 for score 5–7).

Socio-Demographic Factors at Birth Related to Child and Youth Mental Health

Maternal Age

In comparison to children born to mothers aged 25–30, younger maternal age related to higher odds of teacher-rated aggressive behaviours (aOR: 1.45 for < 20 years) and hyperactive behaviours (aOR: 1.44 for < 20 years), and higher odds of physician visits for depression (aOR: 1.32 for < 20 years), conduct disorder (aOR: 1.44 for < 20 years), and ADHD (aOR: 1.37 for < 20 years). Older maternal age also related to higher odds of adverse teacher-rated outcomes as well as physician visits for mental conditions; specifically for teacher-assessed anxious behaviours (aOR: 1.20 for > 40 years) and hyperactive behaviours (aOR: 1.25 for > 40 years), and physician visits for depression, anxiety, conduct disorder, and ADHD (with aORs ranging from 1.1 to 1.4 for the 36–40 years and/or > 40 years groups).

Parental Marital Status

Having parents who were unmarried was related to higher odds of teacher-assessed anxious behaviours, with relatively high aORs for aggressive behaviours (aORs: 1.51 for divorced, 1.84 for separated, 1.52 for never married), and hyperactive behaviours (aORs: 1.47 for divorced, 1.89 for separated, 1.46 for never married). A similar pattern emerged for physician visits, as children of divorced, separated, or never married parents had elevated odds of physician visits for depression, anxiety, conduct, and ADHD (with aORs ranging from 1.26 to 1.72).

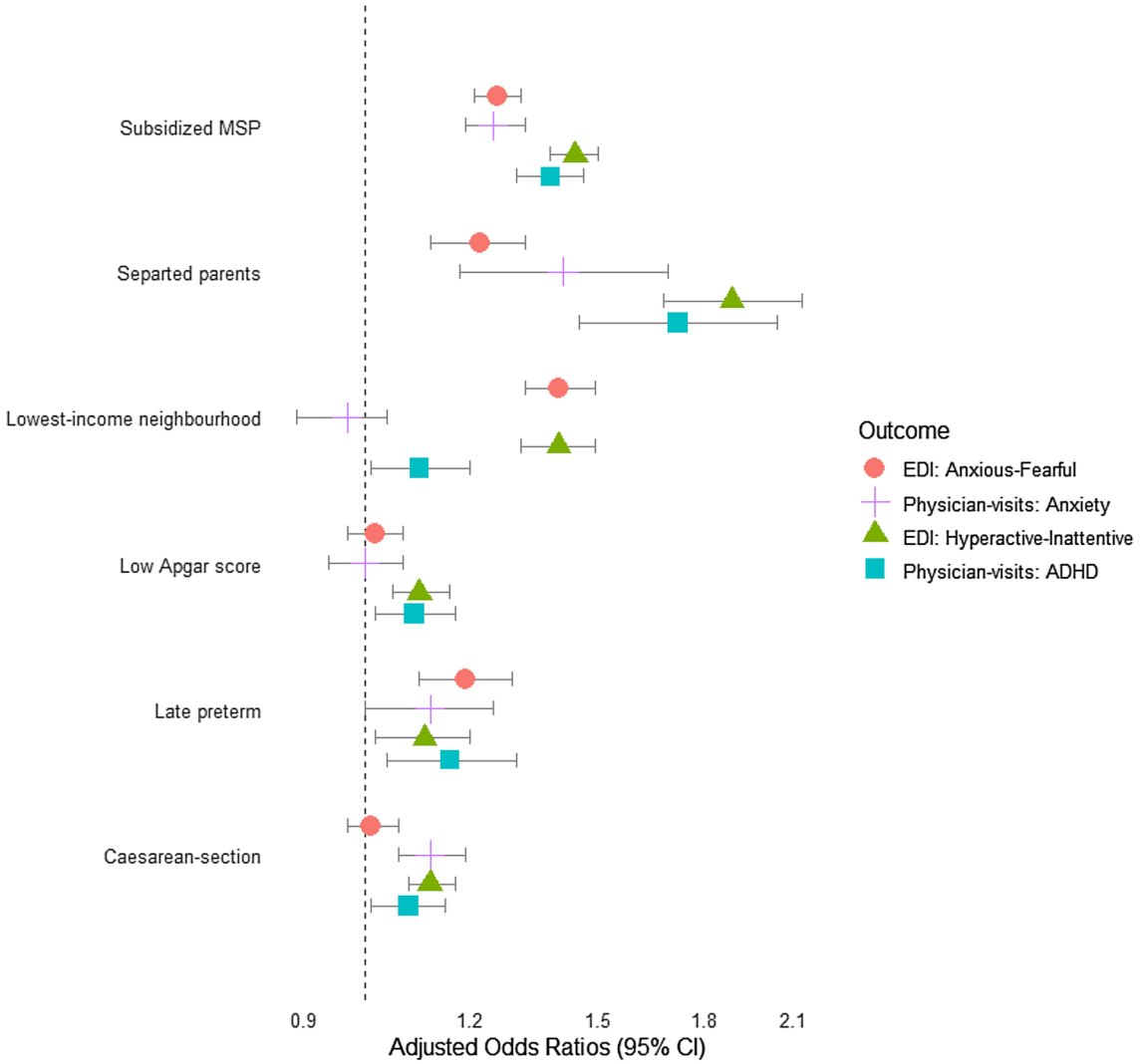

Fig. 1 Associations of select birth and SES factors with teacher-rated and physician-assessed indicators of children's mental health outcomes. Note. X-axis is on a logarithmic scale (log10). *EDI* Early Development Instrument, *MSP* Medical services plan—British Columbia's universal public health insurance

Immigrant Background

Relative to children of Canadian-born mothers, those of foreign-born mothers had somewhat lower aORs (ranging from 0.80 to 0.92) for teacher-rated anxious, aggressive, and hyperactive behaviours, whereas the aORs were considerably lower for physician visits for depression, anxiety, conduct disorders, and ADHD (ranging from 0.58 to 0.74).

Socio-Economic Factors at Birth Related to Child and Youth Mental Health

Children belonging to families on low-income (MSP) subsidy within two years of their birth had higher aORs for teacher assessed anxious, aggressive, and hyperactive behaviours (aORs ranged from 1.26 to 1.44), and physician visits for depression, anxiety, conduct, and ADHD (aORs range 1.25–1.39). Relative to children residing in neighbourhoods of the highest income quintile (Q1), those in lower income quintiles had incrementally higher odds of teacher-rated anxious behaviours (aORs: 1.40 for Q5 [the lowest income quintile], 1.24 for Q4, 1.17 for Q3), aggressive behaviours, and hyperactive behaviours (with almost identical aORs patterns). Interestingly, for the mental health-related physician visits, the same pattern was not observed. To illustrate the pattern of results, we created Fig. 1, which displays aORs relating several birth factors and SES variables with anxiety and ADHD/inattentive behaviours as measured via EDI kindergarten teacher ratings and administrative records of physician visits.

Discussion

This study examined relationships of biological, socio-demographic, and socio-economic factors at birth with indicators of children's mental health outcomes. Results demonstrated that several factors at birth related to both teacher-rated emotional development and physician visits for mental health conditions in childhood. Interestingly, the most consistent patterns of association were observed between the indicators of children's mental health and variables indicative of the presence (or absence) of resources that may affect the upbringing of children—that is, the poverty proxy (insurance subsidy status) and the lone-parent proxies (separated, divorced, never married). The pattern corroborates previous evidence that social and socio-economic factors that impede access to resources (money, time, support) are adversely related to children's health across a broad range of outcomes [35]. The patterns of associations for some of the biological factors were, however, more varied. In the following, we relate our predictor-specific findings to previous empirial research, and conclude with some implications for informing mental health strategies by population health approaches and a social determinants of health perspective.

Biological Factors at Birth Related to Child and Youth Mental Health

Sex

Regarding EDI ratings, boys had substantively higher odds of aggressive and hyperactive behaviours, and slightly higher odds of anxious behaviours. However, odds of having a physician visit for internalizing conditions (depression and anxiety) were higher for girls, whereas the reverse was observed for externalizing conditions (ADHD and conduct). Various Canadian studies have observed similar sex-based developmental patterns [59, 60] to those observed in the present study.

Delivery Mode

Caesarean birth delivery was related to poorer teacher-rated aggressive and hyperactive/inattentive behaviours, and physician visits for anxiety, conduct disorder and ADHD. Previous research also found that birth via caesarean section was associated with poor mental health outcomes, including higher levels of ADHD-related symptoms [61] and higher levels of EDI scores on anxiety, aggression, and hyperactivity [62]—but our finding has particular implications given that the adverse associations occurred even after adjustment for diverse additional biological and socio-economic birth-related factors.

Birthweight

Small birthweight adjusted for gestational age related to poor teacher-rated anxiety, aggression, and hyperactivity, and physician visits for ADHD. Razaz et al. [60] also found that small birthweight for gestational age was associated with poorer EDI-assessed emotional development, however, the present analyses adjusted for a wider range of social and biological perinatal factors—and hence suggested small birthweight adjusted for gestational age may reflect unique vulnerabilities for several emotional outcomes in childhood.

Gestational Age

Early gestational age (< 39 weeks) was associated with teacher-rated anxious and hyperactive-inattentive behaviours, and physician-assessed anxiety, conduct, and ADHD. However, an inverse association was found with physician-assessed depression. Nevertheless, these findings generally agree with studies linking earlier gestational ages to internalizing and externalizing conditions in childhood [63, 64].

Apgar Score

Lower Apgar scores were related to teacher-rated hyperactive-inattentive behaviours in kindergarten, and physician visits for depression and ADHD—similar to previous studies finding that low Apgar scores relate to poor teacher-rated emotional development in kindergarten [60], ADHD in childhood [48], and internalizing conditions in childhood [49, 65]. Future work may unpack the mechanisms by which perinatal vulnerabilities indexed by low Apgar scores can impact emotional health in childhood, especially hyperactive and depressive/internalizing symptoms.

Age at EDI Assessment

Younger age at assessment was associated with higher odds of teacher-rated anxious, hyperactive-inattentive, and aggressive behaviours. Such a pattern may simply reflect relative developmental immaturity of the younger children's social-emotional competencies compared to the older children in the classrooms. This coheres with recent findings suggesting that prevalence of pediatric ADHD was highest among the relatively youngest compared to the oldest children within kindergarten classes, with age differences

between the youngest and oldest being nearly one year [66]. Hence, the observed elevated emotional health symptoms in kindergarten associated with younger age at EDI assessment may be reflective of age-related variance in emotional maturity.

Socio-Demographic Factors at Birth Related to Child and Youth Mental Health

Maternal Age

Younger maternal age was associated with teacher-rated aggressive and hyperactive/inattentive behaviours as well as physician visits for depression, conduct disorders, and ADHD. Literature consistently indicates adverse associations of younger maternal ages with children's mental health [63, 67]. Other work finds that children born of teenage mothers (age < 20) had higher odds of health service use and educational challenges relative to children not born of teenage mothers [35]. Another Canadian study found that children who are born to a teenage mother had worse EDI emotional development scores [62].

Children born to *older* mothers (> 35 years) had higher odds of teacher-assessed anxious and hyperactive behaviours as well as physician visits for all four mental health conditions relative to those born of mothers aged 20–34. This pattern corroborated work suggesting older maternal ages may be related to adverse impacts on child mental health, independent of SES [23]. Conversely, numerous studies have found protective associations of older maternal age with mental health [67]. Older maternal age is commonly associated with higher income, higher educational attainment, better preparedness regarding pregnancy/motherhood, and supportive/nurturing parenting behaviours—yet also possible biological risks [24]. The growing shift of delaying pregnancy in numerous high-income nations due to various reasons [68] warrants thorough examination of implications on developmental outcomes.

Parental Marital Status

Non-married parental marital status was related to poorer emotional development and mental health outcomes, replicating a Canadian study whereby children of non-married parents had lower EDI emotional development scores, after adjusting for sex, SES, and maternal age [62]. Adverse associations of children's emotional development and mental health with the variable 'unmarried parent', which to a large extent represents a proxy of lone motherhood, may be interpreted in light of the Canadian social spending policy landscape. In Canada, lone motherhood presents a serious poverty risk [69]; in BC, the context of our study, almost half of children in lone-parent households live in poverty [26], and over 80% of lone-parent households are female-led. Furthermore, lone mothers face institutionalized societal challenges in raising children, given that Canada—in international comparison—has been spending relatively little on child care, income assistance, and maternity-leave employment insurance. Consequently, single motherhood commonly presents a double-jeopardy whereby single parents have fewer social and practical resources to raise a family, are likely to struggle financially, and cannot rely on social services (e.g., childcare) to support them [70–72]. These stresses are, in turn, likely to affect the day-to-day experiences and behaviors of their children [73] and may contribute to higher levels of, for example, anxiety.

Immigrant Background

Children with foreign-born mothers had less anxious, aggressive, and hyperactive teacher-ratings in kindergarten and, especially, lower odds of physician visits for mental health conditions. The latter association may partially reflect under-utilization of healthcare services by immigrants [74] rather than better mental health outcomes per se. Regarding emotional development in kindergarten, a comparable pattern was observed by Guhn et al. [75], whereby children of some immigrant language backgrounds (e.g., Punjabi) in British Columbia had higher EDI-rated emotional functioning than their English language peers—such a pattern may reflect bilingual socio-cognitive advantages and/or cultural influences that may promote emotional development for at least some immigrant groups.

Socio-Economic Factors at Birth Related to Child and Youth Mental Health

For virtually all the outcomes we examined, the most consistent pattern of associations with negative mental health outcomes pertained to markers of low SES: subsidized MSP, lower block-level income, teenage motherhood, and non-married parents. Such a pattern agreed with compelling evidence underscoring the detrimental impacts of lower SES on mental health [28]. Also, the aORs tended to be higher for some of the SES indicators (subsidy as proxy for poverty; non-married parents as proxy for lone mother status) than for the birth risk factors (e.g., Apgar scores, birthweight, gestational age). Similar patterns were observed in a population-based study from Manitoba—pointing to fundamental importance of considering population-level *social determinants of health*, such as poverty and lone parent status, as critical leverage points within mental health prevention and promotion strategies [35].

Limitations and Strengths of the Present Study

The use of physician visits rather than clinical scores/symptoms to infer psychiatric conditions was a limitation. Nevertheless, ICD-10 diagnoses of depression have been shown to have a Positive Predictive Value (PPV) of 75% based on diagnosis from a clinical interview; the PPV was 83% for severe forms of depression [76].

Regarding the association of older maternal age and hyperactivity symptoms (via EDI and mental health conditions), a potential confounder that was unavailable in this study was information on developmental delay. Future work may further unpack this association and consider the role of developmental delay in the relationship of maternal age to ADHD.

Although health insurance is universal in BC, the billing format differs based on the service provider; our files did not document individuals receiving healthcare from providers who did not use MSP billing. In BC, psychiatrists typically use MSP billing, whereas counsellors' and psychologists' services may not be covered via MSP billing (some supplemental health insurance plans may cover/subsidize psychologists' fees; [77]). Also, MSP captured *public* healthcare services—whereas visits/contact with private professionals were absent from our datafile. Aboriginal persons would not have been captured in the MSP dataset as they are on a federal healthcare plan. Generally speaking, however, most Canadian families do access public rather than private healthcare services [78], and initial points of contact for health concerns are commonly family physicians or walk-in clinics/centres.

Across the study years, the EDI was assessed for kindergarteners only in public schools in BC. As independent/private schools tend to include children of higher SES, the generalizability of findings may be unclear for this subgroup of children. Regarding SES, as a binary variable, MSP subsidy indicated only if a household income was below a low income threshold, rather than a gradient. Also, BC-specific economic analyses suggest approximately one quarter of households eligible for MSP subsidy fail to receive it; a reality that is possible because low-income residents of BC are required to actively apply for the program [79]. Block-level income as a proxy for household SES has limitations since within-block variability may have been masked.

The population-based linkage provided representative longitudinal evidence on how numerous biological, sociodemographic, and SES factors at birth related to different indicators of children's mental health, assessed at two developmental phases. Our indicators of various aspects of children's emotional development and mental health (both internalizing and externalizing) were assessed via teacher-ratings in early childhood and via physician visits for mental health conditions from age 5 to 15, complimenting the strengths and weaknesses of each assessment mode. Parallel associations of the same set of birth factors with indicators of children's mental health in two distinct phases of childhood provided a unique opportunity to document commonalities regarding factors related to child mental health (e.g., low SES related to worse outcomes in both studies). Few prior studies of birth factors and child mental health have had such a diverse set of independent/exposure variables.

Summary

The present investigation highlighted the potential of population-based data linkages for studying child development outcomes. A key finding was the strong detrimental association between low SES and the different indicators of children's mental health across childhood. This pattern corroborates the notion that specific socio-economic/-demographic subgroups may be particularly vulnerable for psychological challenges in early and middle childhood. This study yielded population-based evidence suggesting that social and economic factors have a unique impact on childhood mental health, independent of the impact of a host of birth risk and biological factors. From a public health viewpoint, this is critical insofar as any initiatives that target mental health outcomes during the early years may need to focus on social spending—not (solely) medical spending—because social spending may affect *how many* children will end up requiring medical support [80, 81]. For instance, promising recent evidence in Canada found an unconditional prenatal income supplement to low SES mothers helped ameliorate developmentally important outcomes (lower levels of low birthweight and preterm birth, and higher levels of breastfeeding initiation) [82]. Moreover, Canadian evidence [81] suggests that investing in social services can improve health outcomes, and may present better leverage for improving population health than investments solely in health care.

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Compliance with Ethical Standards

Conflict of interest The authors have no conflicts of interest to declare.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The University Research Ethics Board approved this study.

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