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From Kindergarten readiness to fourth-grade assessment: Longitudinal analysis with linked population data

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ABSTRACT

Early child development (ECD) – the development of physical, social–emotional, and language–cognitive capacities in the early years – is a foundation of health, well-being, learning, and behaviour across the life course. Consequently, the capacity to monitor ECD is an important facet of a modern society. This capacity is achieved by having in place an ongoing flow of high-quality information on the state of early child development, its determinants, and long-term developmental outcomes. Accordingly, there remains a considerable need for research that merges community-centred, longitudinal, and linked-data approaches to monitoring child development. The current paper addresses this need by introducing one method of summarising and quantifying the developmental trajectories of British Columbian children at the neighbourhood- or district-level: computing the *Community Index of Child Development (CICD)* for each geographic area. A simple index that describes change in children's developmental trajectories at the aggregate level, the *CICD* is computable because of our capacity to conduct individual-level linkage of two population data sets: the *Early Development Instrument (EDI)*, a holistic measure of children's readiness for school which is administered at Kindergarten, and the British Columbia Ministry of Education's *Foundation Skills Assessment (FSA)*, a Grade 4 measure of academic skills. In this paper, we demonstrate: (a) wide variation in the *CICDs* according to the children's district of residence in Kindergarten; (b) an association of the *CICDs* with an indicator of the socioeconomic character of the neighbourhoods; and (c) contrasting patterns of neighbourhood convergence and divergence in two different school districts – such that, in some areas, children from high vulnerability neighbourhoods tend to catch up between Kindergarten and Grade 4 whereas, in other areas, they tend to fall further behind.

Introduction

Early child development (ECD) – the development of physical, social–emotional, and language–cognitive capacities in the early years – is now recognized as a social determinant of health (World Health Organisation, 2007). ECD is influenced strongly by early life social circumstances and has profound life-long effects on health, well-being, behaviour, and skill acquisition (Keating & Hertzman, 1999; Kershaw, Irwin, Trafford, & Hertzman, 2005). According to McCain, Mustard, and Shanker (2007), population-based research on ECD is necessary for understanding the capacity of our future population, and warrants the commitment of government, institutions, service providers, and individuals. The capacity to monitor ECD over time and by location is fundamental to this endeavour, and is achieved by having in place an ongoing flow of high-quality information on the state of early child development, its determinants, and long-term developmental outcomes. The most desirable

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approach, argues Hertzman (2008), would be to "create a coordinated 'system of early child development statistics' that is population-based, person-specific, and longitudinal in character. Moreover, it would need to be linkable at the level of the individual, and at the level of the group, to data on the social environments encountered by the developing child" (p. 3).

Regrettably, there remains a considerable need for research that merges community-centred, longitudinal, and linked-data approaches to monitoring early child development (Hertzman, 1999, 2008; Lloyd, 2008). A *community-centred* approach is one in which the social ecology of children's early environments is viewed as being important for understanding ECD. A *longitudinal* approach is one in which information is collected at regular intervals so as to best capture the dynamic nature of ECD and long-term outcomes. Finally, a *linked-data* approach is one in which administrative records from multiple sources are merged, making population-based research on multiple domains of human experience feasible and cost-effective, minimising loss to follow-up, and reducing volunteer bias.

With an eye towards addressing this need for research that combines multiple approaches to monitoring ECD, the current paper introduces a method for reporting on the developmental trajectories of British Columbian children at the neighbourhood and school district level. In particular, this paper:

1. describes the process of linking, at the level of the individual child, two population-based databases: the *Early Development Instrument (EDI)*, a holistic measure of children's physical, social, emotional, language, and communication skills development administered at Kindergarten, and the British Columbia Ministry of Education's *Foundation Skills Assessment (FSA)*, a Grade 4 measure of numeracy, reading comprehension, and writing skills;
2. introduces the *Community Index of Child Development (CICD).* A simple index of change we have created by individually linking Early Development Instrument and Foundation Skills Assessment records, the *CICD* may be used to describe the developmental trajectories of British Columbian children, at the neighbourhood (or district) level, from Kindergarten to Grade 4; and
3. uses data from our record linkage activities to illustrate the extent of variation in Kindergarten to Grade 4 developmental trajectories across actual (rather than synthetic or administratively defined) units of aggregation.

The *Community Index of Child Development* is a useful aggregate level descriptor of change for several reasons. For example, the *CICD*: (a) provides a means to summarise children's longitudinal development, rather than simply making comparisons of cross-sectional data comprising different sets of children; (b) allows us to separate "vulnerable" children (those at developmental risk) from "non-vulnerable" children (those not at risk), thereby removing determinants of differential vulnerability; (c) serves as a useful outcome measure in future studies of the influence of community characteristics on children's development (e.g., socioeconomic, cultural/ethnic/immigration, social capital/civil society, community governance, and institutional performance); (d) provides a means to represent and quantify unexpected school success (better-than-expected school trajectories) or unexpected school failure (worse-than-expected school trajectories) at the aggregate level, as children move from Kindergarten to Grade 4; and arguably most important (e) provides a convenient and straightforward means to communicate to different audiences – such as policy-makers, parents, researchers, and educators – findings that merge community-centred, longitudinal, and linked-data approaches to monitoring child development. We are currently unaware of any other communication tool designed for this purpose.

Important to note at the outset is that, because both the Early Development Instrument (at Kindergarten) and the Foundation Skills Assessment (at Grade 4) are population-based, the longitudinal trajectories created by linking them together are not subject to volunteer bias nor to other sample selection effects. As time goes on, results of school testing in higher grades and school completion data will be available, allowing us to assess the prospects for health selection in educational success, using the EDI as a baseline health measure. Moreover, given the implications of ECD for long-term health, we will be able to assess how the socioeconomic characteristics of the neighbourhoods in which children reside matter for health trajectories across the life course.

Also important to note is that the physical, socioemotional, language/cognitive, and communication domains of school readiness measured by Kindergarten's EDI, although moderately correlated, are distinct from one another. Only the physical scale can be construed as a direct measure of health, traditionally defined. However, many of the items on the other scales – physical aggression, helpfulness, understanding the language of the classroom, and being able to make oneself understood – relate directly to well-being. In recent years, social epidemiological approaches to the life course and health (Kuh & Ben-Shlomo, 1997) have begun to be complemented by a human development approach, which emphasises the role of early developmental trajectories as determinants of health over the life course (Schoon, Sacker, & Bartley, 2003). Early physical, socioemotional, and language/cognitive development has been shown to be associated with mid-life health and well-being through a mixture of latent, pathway, and cumulative effects (Hertzman & Power, 2005; Hertzman, Power, Matthews, & Manor, 2001). Thus, each scale of the EDI has been shown to be a predictor of health and well-being over the life course and early child development can be construed as a determinant of future health and well-being.

Method

Participants

We at the Human Early Learning Partnership (HELP) obtained from the British Columbia Ministry of Education the *Foundation Skills Assessment (FSA)* scores (described in a later section) for each individual British Columbian child for whom the *Early Development Instrument (EDI)* was

completed in Kindergarten. Written approval from both the University of British Columbia's Behavioural Research Ethics Board and the British Columbia Ministry of Education was received in order to conduct this research. The identity of individual children was not known to the researchers, and strict data confidentiality and security guidelines were followed closely. Table 1 describes the EDI participant counts across school years.

So as to describe our population-based data collection in British Columbia as comprehensively as possible, Table 1 describes the record counts for five annual EDI cohorts; however, it should be noted that, because of a current lack of longitudinal data availability for Cohorts 3, 4, and 5 (explained in a later section), only the *first two* Kindergarten cohorts (1999/2000 and 2000/2001) are followed in this study.

Because the EDI has been designed as a population-based measure, we at HELP have carefully planned our EDI data collection such that each EDI cohort represents more than 95% of the children who reside in a given catchment area. As such, each EDI cohort may be considered representative of 'all Kindergarten children'.

Kindergarten instrument: The Early Development Instrument (EDI)

In British Columbia, Canada, the transition year from preschool to school is called Kindergarten, which begins in September of the year the child turns 5 years old. In February of the Kindergarten year, teachers complete the Early Development Instrument (EDI) on behalf of all of the children in their classrooms.

The EDI combines several areas that have been identified as relevant to children's readiness for school (Doherty, 1997; Duncan et al., 2007; Janus et al., 2007; Kagan, 1992; Lemelin et al., 2007): physical health and well-being, social competence, approaches to learning, emotional maturity, language development, cognitive development, communication skills, and general knowledge.

As Janus et al. (2007) and Janus and Offord (2007) describe, the three primary purposes of the EDI are to: (1) report on populations of children in different communities, (2) monitor populations of children over time, and (3) predict how children will do in elementary school, both academically and socially. Designed to take 20 minutes per child to complete, the EDI consists of 104 questions designed to tap five scales of early childhood development (Janus & Offord, 2007). These five scales include:

Physical health and well-being. The physical scale includes items that assess children's gross and fine motor skills, pencil holding, running on the playground, motor coordination, energy levels for classroom activities, independence in looking after own needs, and daily living skills.

Social knowledge and competence. The social scale includes items about children's curiosity about the world, eagerness to try new experiences, knowledge of standards of acceptable behaviour in a public place, ability to control own behaviour, appropriate respect for adult authority, cooperation with others, following rules, and ability to play and work with other children.

Emotional health and maturity. The emotional scale assesses children's abilities to reflect before acting, balance between too fearful and too impulsive, abilities to deal with feelings at age-appropriate levels, and empathic responses to other people's feelings.

Language and cognitive development. The language scale includes items designed to tap children's reading awareness, age-appropriate reading and writing skills, age-appropriate numeracy skills, board game performance, abilities to understand similarities and differences, and ability to recite back specific pieces of information from memory.

Communication skills and general knowledge. Finally, the communication scale includes items that assess children's skills to communicate needs and wants in socially appropriate ways, symbolic uses of language, story telling, and age-appropriate knowledge about the life and world around them. In particular, it is sensitive to the challenges of those who have English as a second language.

Schedule and scope of the EDI administration. The EDI has been, or is currently being, administered in several provinces across Canada – namely the provinces of British Columbia, Manitoba, Québec, and Ontario. In addition, the EDI is being piloted and/or administered in several jurisdictions outside of Canada, including Australia, Chile, Jamaica, Kosovo, and the United States. Given the scope of the EDI administration, it should be reiterated that this paper focuses solely on British Columbia's EDI administration.

HELP's current funding allows us to collect EDI scores from Kindergarten children in a given school district on a triennial basis – that is, every 3 years. Therefore, it is important to clarify that, although we do indeed collect EDI data from around the province of British Columbia on an *annual* basis, EDI data for any *one* particular school district only occurs every *3 years*. It should also be noted that our data collection includes children in schools that are privately funded (e.g., independent schools) and federally funded (e.g., Aboriginal band schools). Therefore, as described earlier, the EDI collection represents a near-census of British Columbian students' records.

The BC Ministry of Education has divided the province's jurisdictions into 59 geographic school districts. As Table 2 illustrates, 27 neighbourhoods nested within two school districts participated in the 1999/2000 EDI data collection (Vancouver district: 23 neighbourhoods; Howe Sound district: 4 neighbourhoods) and 36 neighbourhoods within two different school districts in 2000/2001 (Abbotsford district: 15 neighbourhoods; Coquitlam: 21 neighbourhoods). Although not the focus of the current paper, there were 10, 45, and 34 school districts involved in the 2001/2002, 2002/2003, and 2003/2004 EDI data collections, respectively. By 2003/2004, all school districts had

Table 1
Count of British Columbian EDI records per school year

Kindergarten school year	Count of EDI records
1999/2000 (Cohort 1)	4267
2000/2001 (Cohort 2	3643
2001/2002 (Cohort 3)	4008
2002/2003 (Cohort 4)	27,506
2003/2004 (Cohort 5)	5374
All EDI Years	44,798

Table 2
Scope of EDI data collection in British Columbia

Kindergarten school year	Count of school districts in which EDI data were collected (total *N* of school districts = 59)	Count of neighbourhoods within each school district
1999/2000 (Cohort 1)	2	Vancouver: 23, Howe Sound: 4
2000/2001 (Cohort 2)	2	Abbotsford: 15, Coquitlam: 21
2001/2002 (Cohort 3)	10	n/a
2002/2003 (Cohort 4)	45	n/a
2003/2004 (Cohort 5)	34	n/a

participated at least once and several had participated two times or more. The reason for the marked increase in the number of school districts between 2001/2002 and 2002/2003 is because this is when the program was transformed from a pilot project to systemic program in British Columbia.

Defining neighbourhood sizes and boundaries. Kershaw et al. (2005, p. 6) describe how we define EDI neighbourhood boundaries in British Columbia:

> *[We] worked closely with communities to benefit from local knowledge in determining neighbourhood boundaries that more accurately reflect the experience of a diverse range of people who reside in the area. Local [early childhood development] coalition representatives were invited to draw lines on maps of their area to signal the presence of perceived divides in their community. While some local coalitions opted to maintain the Census or another existing boundary system, others opted for dramatically different breakdowns than those employed for survey data collection.*

In this paper, we compute *Community Index of Child Development* scores only for neighbourhoods with 40 children or more, thereby ensuring statistical stability and anonymity in the results. It should also be noted that we compute results according to the neighbourhood of residence – rather than the Census unit, school catchment area, or school attended. Given that the primary focus of the EDI work is to reflect upon the quality of children's "early experiences", describing the trajectories of children according to where they live at Kindergarten, rather than some other point in time, serves this purpose best (Hertzman, Kershaw, Irwin, Trafford, & Wiens, 2008).

The four school districts in Cohorts 1 (EDI in 1999/2000) and 2 (EDI in 2000/2001). As described above, two school districts participated in the 1999/2000 EDI data collection (Vancouver, Howe Sound) and two different districts participated in 2000/2001 (Abbotsford, Coquitlam). It is these four school districts for which we could obtain two-wave/longitudinal data and, hence, compute *Community Index of Child Development* scores. In this section, we describe each district more fully, thus providing a lens through which to interpret the *CICD* scores presented in a later section.

1. *School district 39 Vancouver (EDI in 1999/2000)*: The Vancouver school district covers an urban core area of approximately 600,000 residents with a high degree of socioeconomic stratification and cultural diversity. The district serves 56,000 students in elementary and secondary schools, 3000 adult students in adult basic education and over 40,000 students in continuing education classes. Approximately 1.9% of the region's students are Aboriginal, 36.9% of the population is identified as a visible minority (British Columbia Statistics, 2006a), and over 50% of district's children speak English as a second language (Vancouver School Board, n.d.). The Vancouver district contains 23 neighbourhoods, each comprising between 44 and 472 children (mean count of children per neighbourhood = 165, median = 105, SD = 135).
2. *School district 48 Howe Sound (EDI in 1999/2000)*: The Howe Sound district is a semi-rural school district comprising 70,000 residents. The population is concentrated in three major centres: Squamish (North and South), Whistler, and Pemberton. Squamish, along a highway corridor, is a traditional sawmill town that is being transformed into a bedroom community for Vancouver, for the international skiing village of Whistler, and for the traditional mining and Aboriginal town of Pemberton which, in turn, is being transformed into a bedroom community for Whistler. It should be noted that whereas the proportion of Aboriginal children in this region (11.2%) is higher than in Vancouver (1.9%), its proportion of persons identified as being a visible minority (9.7%) is far lower than in Vancouver (36.9%) (British Columbia Statistics, 2006b). The district's four neighbourhoods each comprises between 44 and 132 children (mean count of children per neighbourhood = 90, median = 91, SD = 45).
3. *School district 34 Abbotsford (EDI in 2000/2001)*: Traditionally a farming community, Abbotsford is growing rapidly as a result of its becoming a bedroom community for Vancouver. Located in British Columbia's Fraser Valley, semi-rural Abbotsford is BC's fifth largest municipality. Comprising Abbotsford, Clearbook, Matsqui, and Huntington neighbourhoods, approximately 4.9% of the district's students are Aboriginal, while 12.5% of the population is identified as a visible minority (British Columbia Statistics, 2006c). The Abbotsford district contains 15 neighbourhoods, each comprising between 43 and 166 children (mean count of children per neighbourhood = 92, median = 83, SD = 36).
4. *School district 43 Coquitlam (EDI in 2000/2001)*: The Coquitlam district serves the cities of Coquitlam, Port Coquitlam, and Port Moody (the "tri-cities"), as well as the villages of Anmore and Belcarra. Located approximately 30-minutes drive outside of Vancouver, the school district covers an area of 120 km^2 and serves a total student population of 31,000, making it the third largest school district in British Columbia. Part of the same regional (not school) district as Vancouver, approximately 1.9% of the region's students are Aboriginal, 36.9% of the population is identified as a visible minority (British Columbia Statistics, 2006a). The Coquitlam district contains 21 neighbourhoods, each comprising between 47 and 180 children (mean count of children per neighbourhood = 92, median = 93, SD = 31).

Grade 4 instrument: The Foundation Skills Assessment (FSA)

The FSA, a three-part annual assessment test administered by the British Columbia Ministry of Education, is designed to measure the numeracy, reading comprehension, and writing skills of fourth- and seventh-grade children throughout British Columbia. The FSA is administered in public and in funded independent schools across the province in late April/early May of each year. Approximately 40,000 children per grade level write the FSA each year.

The FSA relates to what children learn in the classrooms in two important ways. First, the FSA measures:

> *critical skills that are part of the provincial curriculum. FSA represents broad skills that all students are expected to master. FSA only addresses skills that can be tested in a limited amount of time, using a pen-and-paper format. FSA does not measure specific subject knowledge or many of the more complex, integrated areas of learning* (British Columbia Ministry of Education, 2003, p. 20).

Second, the FSA tests are designed to measure cumulative learning. This means that when, for example, fourth-grade children complete their version of the FSA, they are expected to use skills gained from Kindergarten to Grade 4 (British Columbia Ministry of Education, 2003).

The British Columbia Ministry of Education and the school districts use FSA results to: (a) report the results of child performance in various areas of the curriculum; (b) assist in curriculum improvement; (c) facilitate discussions on child learning; and (d) examine the performance of various child populations to determine if any require special attention. Schools use FSA data primarily to assist in the creation and modification of various school growth plans (e.g., plans for academic improvement).

Procedure

The Kindergarten EDI and Grade 4 FSA records were individually linked in a two-step process:

Linking the EDI to the Ministry's Provincial Education Number. In the first step, individual children's EDI records were linked probabilistically (via a combination of gender, date of birth, school number, and home postal code flags) to their respective Ministry of Education Provincial Education Numbers (PENs). The PEN is a nine-digit identification number assigned to each individual child when he or she enters the British Columbia education system, and follows the child permanently through their K-12 education in BC. This number is used for several purposes including (a) the distribution of funding to schools, (b) transition analysis between schools, districts and post secondary education, (c) exams, and (d) student reporting (British Columbia Ministry of Education, n.d.).

As Table 3 describes, the linkage rate between EDI and PEN records was very high across all school years, even though it is only the *first two cohorts* that are the focus of the current paper:

- 95% for the 1999/2000 EDI administration (4044 out of 4267),
- 94% for 2000/2001 (3411 out of 3643),
- 85% for 2001/2002 (3416 out of 4008),
- 96% for 2002/2003 (26,502 out of 27,506), and
- 94% for 2003/2004 (5076 out of 5374).

It should be noted that the 2001/2002 EDI administration yielded a smaller than average PEN linkage rate (85%) because one district neglected to collect children's day of birth, thus hindering slightly the probabilistic linkage of the EDI to the PEN and, in turn, the FSA.

Although EDI records could be linked to their PENs across all EDI administrations, there are three EDI years for which FSA records are not yet available, temporally speaking: 2001/2002, 2002/2003, and 2003/2004. Kindergarten children in 2001/2002, 2002/2003, and 2003/2004 do not generally reach Grade 4 until 2005/2006, 2006/2007, and 2007/2008, respectively. Therefore, for children in the most recent three EDI administrations, FSA data are either not yet ready for dissemination from the Ministry or have simply not yet been collected.

Also, as stated earlier, the FSA has three subtests: numeracy, reading comprehension, and writing. Whereas the reading comprehension and numeracy subtests are generally comprised of multiple-choice items, the writing subtest follows an essay format. Therefore, due to the comparatively subjective nature of the writing subtest's marking relative to that of the other two subtests, it was decided to exclude writing linkage rates or results from this paper.

Linking the EDI to the FSA. Once a unique PEN was identified for each child, the second step in the data linkage process involved linking the EDI records to the FSA database (which is separate from the Ministry's PEN database). As Table 3 also describes, the linkage rate between EDI scores in Kindergarten and FSA scores in Grade 4 was high across the available school years (EDI Cohorts 1999/2000 and 2000/2001):

Table 3
EDI-to-PEN-to-FSA data linkage rates

Kindergarten school year	Count of EDI records (Kindergarten)	Records for which PEN was found	FSA record found (Grade 4)	
			Numeracy subtest	Reading subtest
1999/2000 (Cohort 1)	4267	4044 (95%)	3782 (89%)	3783 (89%)
2000/2001 (Cohort 2)	3643	3411 (94%)	3173 (87%)	3172 (87%)
2001/2002 (Cohort 3)	4008	3416 (85%)	Not yet available	Not yet available
2002/2003 (Cohort 4)	27,506	26,502 (96%)	Not yet available	Not yet available
2003/2004 (Cohort 5)	5374	5076 (95%)	Not yet available	Not yet available

- 89% for the 1999/2000 EDI administration:
  - 3782 (3783) out of 4267 EDI records were linked to FSA numeracy (reading) scores 4 years later;
- 87% for the 2000/2001 EDI administration:
  - 3173 (3172) out of 3643 EDI records were linked to FSA numeracy (reading) scores 4 years later.

Although high across available school years, reasons why the EDI-to-FSA linkage rates are slightly lower than those of the EDI-to-PEN linkage may include a child's moving out of province prior to Grade 4, a child having died prior to Grade 4, and so forth. Unfortunately, the Ministry does not have in place a systematic large-scale flagging process to explain why a given Kindergarten child's FSA record does or does not appear in the FSA database 4 years later. Although beyond the scope of this paper, the missing data appear to neither be systematic nor representative of any one particular subgroup of children.

Unpacking 'vulnerability'

The computation of the *Community Index of Child Development* for a given neighbourhood requires first identifying the neighbourhood's individual children as being either "vulnerable" or "not vulnerable" not only on the EDI, but also on the FSA. Here, a child is "vulnerable" on the EDI if *any one* of his or her scale scores (social, emotional, physical, language, or communication) falls below the scale-specific provincial cut-off score – a fixed score corresponding to the bottom 10% of the provincial distribution of scale-specific Wave 0/1 EDI data. Conversely, a child is identified as "not vulnerable" on the EDI if *none* of his or her scale scores falls below the scale-specific cut-off score, meaning the child is, on average, not likely to be limited in any area of his/her development. Readers are referred to the work of the EDI's lead creators, Magdalena Janus and Dan Offord (e.g., Janus et al., 2007; Janus & Offord, 2007), for the specific rationale for selecting a standard 10% vulnerability cut-off.

In this paper, we use this omnibus "ever vulnerable" (vulnerable on one or more scales) flag when calculating of the *Community Index of Child Development* scores, because it is this flag that is reported most commonly across Canadian jurisdictions implementing the EDI, because this flag taps into multiple EDI scales, and because it has been lamented that many studies of child development attend only to select developmental domains (Kershaw, Forer, Irwin, Hertzman, & Lapointe, 2007). For more about the "ever vulnerable" flag, please refer to Janus et al. (2007).

A child's FSA "vulnerability" on either the numeracy or reading comprehension subtest is due to his or her score being "below provincial expectations" (a label assigned by the Ministry to the child's ordinal subtest score of 1) or to the child's not completing the test. Both other ordinal scores – specifically "met provincial expectations" (score = 2) and "exceeded provincial expectations" (score = 3) – are collectively identified as "not vulnerable".

It should be noted that we chose slightly different language to describe children's FSA "vulnerability" or "non vulnerability", so as to preserve the rather more academic nature of the Ministry's assessment: "not passed" and "passed", respectively. "Passed" here refers to children who "met" or "exceeded" provincial expectations, whereas "not passed" refers to children who were "below" provincial expectations, or did not complete the test. This issue is described in more detail in a later section.

Four EDI-to-FSA 'pathways'

It is possible to classify children's development from Kindergarten to Grade 4 in four ways. As Table 4 describes, children who are *not vulnerable* on any of the five scales of the EDI at Kindergarten, and also *passed* the FSA at Grade 4 can be thought of as following *Pathway A* (a positive trajectory over time). Even more promising than *Pathway A* is when children follow *Pathway C*: *vulnerable* on one or more scales of the EDI at Kindergarten and nonetheless *passed* the FSA 4 years later (a positive deflection over time).

In contrast, children who are *vulnerable* on one or more scales of the EDI at Kindergarten and *did not pass* the FSA at Grade 4 are thought to follow *Pathway D* (a negative trajectory over time). Arguably the least promising of the four patterns, *Pathway B* describes those children who are *not vulnerable* on any of the five scales of the EDI at Kindergarten, yet *did not pass* the FSA 4 years later (a negative deflection over time).

The Community Index of Child Development (CICD)

By using the EDI data in concert with the Ministry data, we gained the ability to flag each neighbourhood's individual children as following Pathway *A*, *B*, *C*, or *D*. Once each child's record was flagged as *A*, *B*, *C*, or *D*, an aggregate *Community Index of Child Development* score was then calculated for the 63 neighbourhoods nested within the four school districts across British Columbia for which longitudinal (two-wave) data were available.

An aggregate index of child growth and development, the *Community Index of Child Development* is calculated as described in Eq. (1):

$$CICD = [C/(C+D)]/[B/(A+B)] \quad (1)$$

where A = count of children who were "not vulnerable" on any one scale of the EDI in Kindergarten and who "passed" the FSA in Grade 4 (a positive trajectory); B = count of children who were "not vulnerable" on any one scale of the EDI, yet who "did not pass" FSA (a negative deflection); C = count of children who were "vulnerable" on any one scale of the EDI, yet who "passed" the FSA (a positive deflection); and D = count of children who were "vulnerable" on any one scale of the EDI, and who "did not pass" the FSA (a negative trajectory).

Table 4
The Four EDI-to-FSA pathways

	FSA (Grade 4)	
	"Passed"	"Did not pass"
EDI (Kindergarten)		
"Not vulnerable"	Pathway A	Pathway B
"Vulnerable"	Pathway C	Pathway D

The numerator of the *CICD* [i.e., $C/(C+D)$] represents the rate of *positive* pathways/deflections in a given aggregate unit over time, whereas the denominator [i.e., $B/(A+B)$] represents the rate of *negative* pathways/deflections. Taken together, the *CICD* depicts the *ratio of positive to negative* EDI-to-FSA pathways/deflections in a given aggregate unit. Hence, the larger the *CICD* in a given neighbourhood or district, the better the children's trajectories over time.

Results

CICD scores by school district

We computed two sets of *Community Index of Child Development* scores for each of the 63 neighbourhoods (one set for the FSA numeracy outcome, and a separate set for the FSA reading outcome). Here, for the purpose of brevity, we present the range of neighbourhood-level *CICDs* aggregated to the more-macro level of the school district.

Table 5 illustrates the great variation in the *CICDs* in the respective numeracy and reading *Community Index of Child Development* scores across the four British Columbia districts. Two notable findings include:

- The *Vancouver* school district (Cohort 1) shows the greatest variation in *CICD* scores, relative to the three other school districts: a point spread of 20.13 (numeracy) and 24.43 (reading). In addition, Vancouver yields the highest *CICD* scores (23.36 numeracy, 25.88 reading), compared to the maximum scores of the other three districts; and
- The *Howe Sound* school district (Cohort 1) shows the smallest range of *CICD* scores, relative to the three other school districts: a point spread of only 2.5 (numeracy) and 2.09 (reading), though this finding is likely related to the small number of neighbourhoods that comprise this district.

Additional exploratory analyses (only some of which are presented here for the purpose of brevity) reveal that, as would perhaps be expected, higher *CICDs* (relatively high ratio of positive to negative deflections) are generally found in neighbourhoods with the lowest risk of vulnerability and those that are the richest socioeconomically, whereas the lowest *CICDs* (relatively low ratio of positive to negative deflections) are found in neighbourhoods with the highest risk of vulnerability and those that are the poorest socioeconomically.

Various characteristics of the neighbourhood environments in which young children reside have been shown to associate strongly with children's well-being and later developmental outcomes. Such characteristics include, but are not limited to, the availability, accessibility, affordability, and quality of neighbourhoods' learning; recreational, and social activities; child care; schools; medical facilities; and employment opportunities (Leventhal & Brooks-Gunn, 2000). Other characteristics include neighbourhoods' relative socioeconomic disadvantage, which relates to the quality of the area's social and structural environment, and levels of social capital, an umbrella term that encompasses constructs such as informal social control, norms of reciprocity, social engagement, participation, cohesion, and trust (Brooks-Gunn, Duncan, Klebanov, & Sealand, 1993; Carpiano, 2006; Drukker, Kaplan, Schneiders, Feron, & van Os, 2006; Putnam, 2001).

Recognising the importance of paying close attention to neighbourhood-level SES when exploring children's school readiness (Kershaw et al., 2005) while simultaneously gathering evidence of the *CICDs'* criterion validity, we opted to compute the ecological correlation between one relatively standard neighbourhood-specific indicator of socioeconomic status with the 63 neighbourhoods' respective numeracy and reading *Community Index of Child Development* scores. After carefully considering various neighbourhood-level SES variables to which we had access, we decided to select the 2001 Statistics Canada census' "percentage of adults without high school graduation" as the criterion variable. A neighbourhood-level variable that represents the proportion of the population aged 20 years or higher without high school completion, we argue that this particular variable provides the most *direct* measure of the educational climate of the neighbourhood. Furthermore, we posit that a neighbourhood's academic precedent is associated more with education, than with income or occupation.

Results revealed a relatively strong negative correlation between the percent of adults without high school graduation, by neighbourhood, and each set of *CICD*

Table 5
Community Index of Child Development scores by neighbourhood within school district

	FSA subtest	Mean	SD	Median	Minimum	Maximum	Range
Cohorts 1 and 2: All four districts	Numeracy	6.75	4.10	5.40	2.87	23.36	20.49
	Reading	4.94	4.33	3.57	1.45	25.88	24.43
Cohort 1: Vancouver	Numeracy	7.46	5.12	5.40	3.23	23.36	20.13
and Howe Sound	Reading	5.36	5.73	3.34	1.45	25.88	24.43
Cohort 1: Vancouver Only	Numeracy	7.87	5.38	5.41	3.23	23.36	20.13
	Reading	5.74	6.06	3.69	1.45	25.88	24.43
Cohort 1: Howe	Numeracy	4.76	1.26	4.95	3.42	5.92	2.50
Sound Only	Reading	2.79	1.05	2.92	1.68	3.77	2.09
Cohort 2: Abbotsford	Numeracy	6.30	3.28	5.49	2.87	17.60	14.73
and Coquitlam	Reading	4.67	3.20	3.63	1.86	15.59	13.73
Cohort 2: Abbotsford only	Numeracy	5.83	2.67	5.04	3.23	13.00	9.77
	Reading	4.03	2.30	3.46	1.86	10.83	8.97
Cohort 2: Coquitlam only	Numeracy	6.59	3.65	5.74	2.87	17.60	14.73
	Reading	5.07	3.66	3.83	1.95	15.59	13.64

scores: $r = -0.441$, $p < .001$ (numeracy) and $r = -0.537$, $p < .001$ (reading). As would perhaps be expected, these results suggest that as the percentage of "adults without high school graduation" increases in a given neighbourhood, there is a commensurate decrease in the average *Community Index of Child Development* score. Therefore, to facilitate understanding of the *CICDs* to a greater degree, it is useful to have a socioeconomic criterion (or several criteria) against which comparisons in *CICDs* can be made.

Community Index of Child Development scores by Neighbourhood: Scenarios of Divergence and Convergence

Figs. 1 and 2 present contrasting patterns of neighbourhood-level *CICD* for the two school districts administered the EDI in 1999/2000: Vancouver and Howe Sound. Fig. 1 maps the *Community Index of Child Development* scores for each of the 23 neighbourhoods in the Vancouver school district. The background of each neighbourhood is coloured green to brown, according to the proportion of Kindergarten children who were vulnerable on one or more scales of the EDI (green = low vulnerability, brown = high vulnerability). In the foreground each neighbourhood has two semi-circles, the left-hand one representing the numeracy *CICD* and the right hand semi-circle representing the reading *CICD* for the children who were in Kindergarten while resident in those neighbourhoods. The size of each semi-circle is proportional to the *CICD*, such that larger semi-circles indicate larger *CICDs*. Thus, examination of Fig. 1 shows that, in general, the *CICDs* for numeracy and reading are larger in the lower vulnerability neighbourhoods. In other words, Vancouver is a scenario of *divergence*, wherein children from higher vulnerability neighbourhoods also tend to fall further behind those from lower vulnerability neighbourhoods, over the 4-year period of time.

Fig. 2 (Howe Sound) shows a contrasting pattern of *Community Index of Child Development* scores. Although there are only four neighbourhoods in the district, there is a clear pattern of *convergence* wherein the largest *CICDs* (for both numeracy and reading) are in the highest vulnerability neighbourhoods. Thus, Howe Sound is a scenario of Kindergarten children from higher vulnerability neighbourhoods tending to catch up with children from lower vulnerability neighbourhoods between Kindergarten and Grade 4.

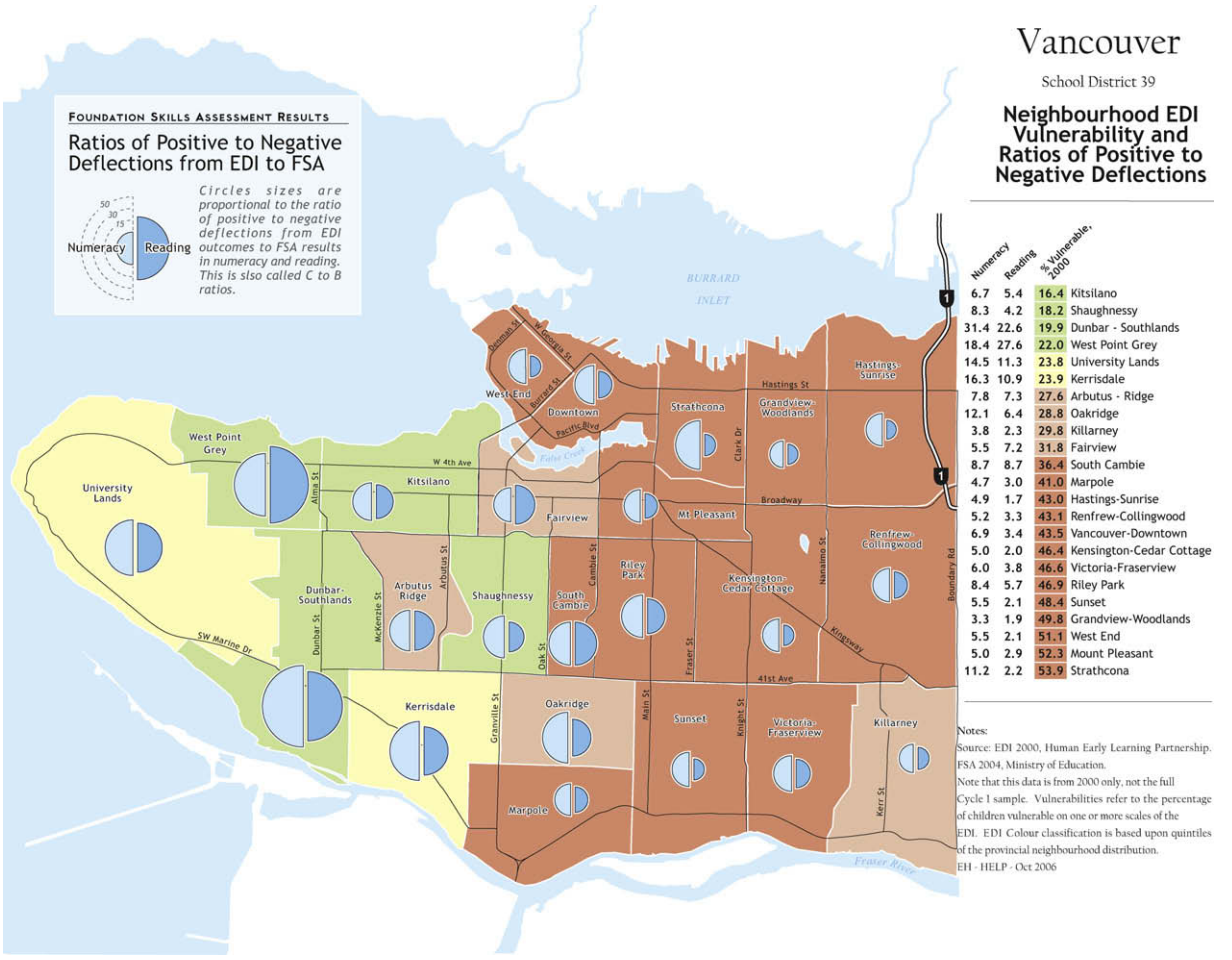

Fig. 1. Numeracy and reading Community Index of Child Development scores, by neighbourhood, for the Vancouver school district.

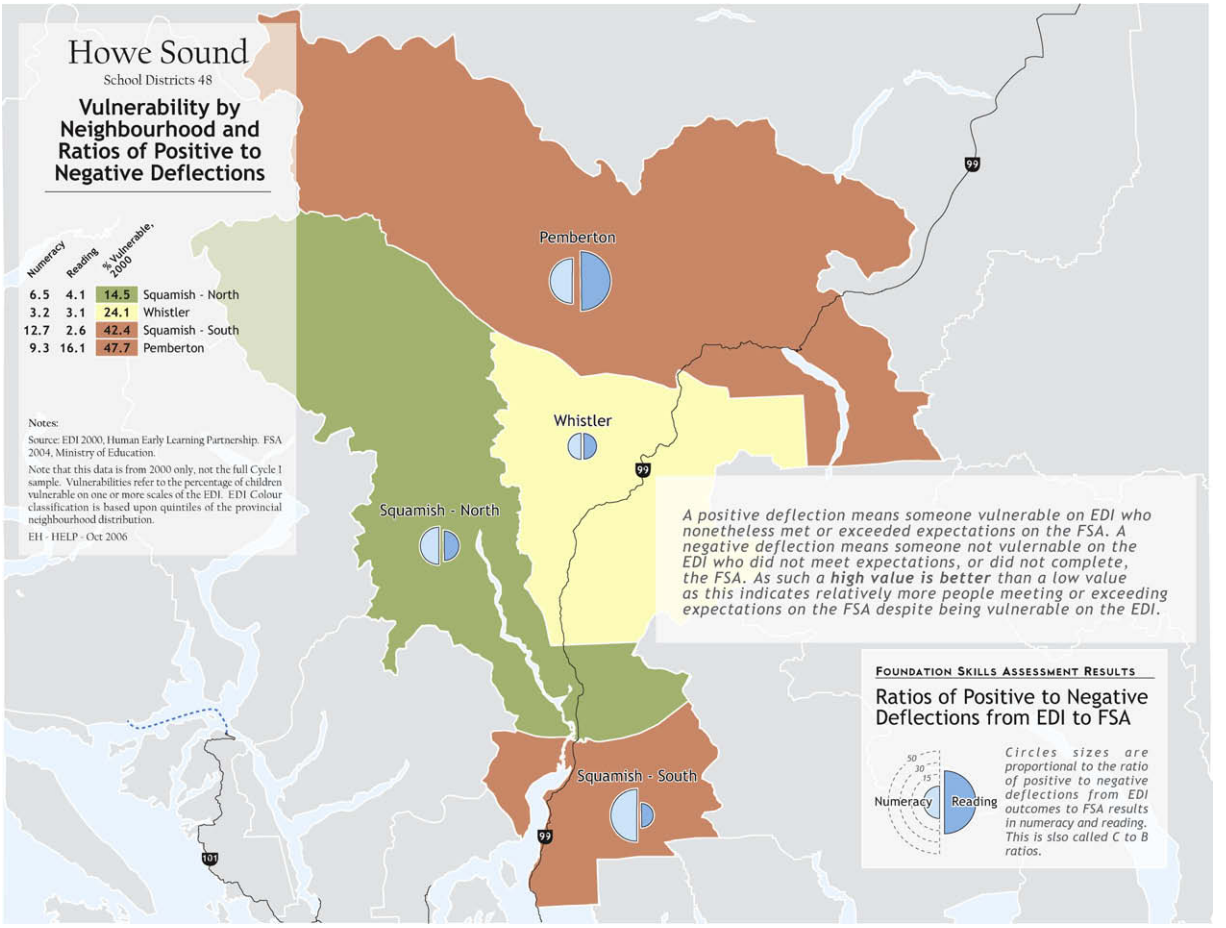

Fig. 2. Numeracy and reading Community Index of Child Development scores, by neighbourhood, for the Howe Sound school district.

Discussion and Conclusions

In this paper, we explored the early childhood developmental trajectories of British Columbian children by linking, at the level of the individual child, two population data sets: the *Early Development Instrument (EDI)*, a measure of children's readiness for school administered in children's Kindergarten year, and the British Columbia Ministry of Education's *Foundation Skills Assessment (FSA)*, a Grade 4 measure of numeracy, reading comprehension, and writing skills. We summarised children's trajectories between EDI and FSA using the *Community Index of Child Development*, allowing us to identify patterns of change from Kindergarten to Grade 4 at the aggregate level.

In particular, we demonstrated: (a) wide variation in the *CICDs* according to the children's district of residence in Kindergarten; (b) an association of the *CICDs* with an indicator of the socioeconomic character of the neighbourhoods; and (c) contrasting patterns of neighbourhood convergence and divergence in two different school districts – such that, in some areas, children from high vulnerability neighbourhoods tend to catch up between Kindergarten and Grade 4 (Howe Sound's convergence), whereas, in other areas, they tend to fall further behind (Vancouver's divergence).

The finding from Vancouver that the development of children from high vulnerability neighbourhoods, over time, falls behind that of children from low vulnerability neighbourhoods is consistent with the work of Schneiders et al. (2003, p. 699) who assert, "If [neighbourhood socioeconomic disadvantage] plays a causal part, we would expect children living in disadvantaged neighbourhoods to show increasing problems as they get older".

Perhaps more puzzling is the finding from Howe Sound that the development of children living in high vulnerability neighbourhoods, over time, tends to catch up with children from low vulnerability neighbourhoods. In an effort to explain this pattern of convergence, it would perhaps be helpful to know something about the residential histories of the area's residents. As Robert (1999) suggests, such knowledge would perhaps allow us to unpack the potential relationship between childhood development and their changing neighbourhood socioeconomic context as it varies over time, rather than considering only one snapshot of a neighbourhood's context. Robert also suggests that, in order to determine whether a neighbourhood's socioeconomic context has independent effects on the development of its children, research needs to use information about both the socioeconomic position of individual children's families and of

the larger socioeconomic context of the neighbourhood. This issue is raised again below.

In addition to knowing something about the residential histories of the Howe Sound's residents, it would also be helpful to know more about the temporal dimension of the area's socioeconomic characteristics. As Duncan, Brooks-Gunn, and Klebanov (1994) observe in their study of economic deprivation and child development, studies of the patterns of childhood poverty show great diversity, with much poverty being short-term but some being longer-term. These findings raise "questions about the sensitivity of developmental outcomes to both the duration and the timing of poverty" (p. 297). Further research must be devoted to exploring these crucial issues in more detail.

Strengths of the current research

As mentioned at the outset, the *Community Index of Child Development* is a useful neighbourhood-level descriptor of change for several reasons. First, the *CICD* provides a convenient and straightforward means by which to communicate to different audiences findings that merge various approaches to monitoring child development. Such audiences may include policy-makers, parents, researchers, and educators alike.

Second, the *CICD* provides a means by which to summarise children's longitudinal development, rather than simply making comparisons of cross-sectional data comprising different sets of children. The vast majority of studies aimed at exploring the relationship between such neighbourhood characteristics and children's development have followed cross-sectional designs, thus hindering the ability to make conclusive inferences about the neighbourhood effects. It is for this reason that Drukker et al. (2006), Schneiders et al. (2003), and Sellström and Bremberg (2006) recommend the use of longitudinal studies that explore the impact of neighbourhood effects on children's development – the hypothesis being that associations between neighbourhood environment and health-related quality of life are dynamic, and that changes in quality of life through childhood are linked inextricably to the neighbourhood environment. Further support for the implementation of longitudinal designs that include neighbourhood-level predictors is offered by Boyle, Georgiades, Racine, and Mustard (2007), who note that, because the majority of longitudinal investigations of child development examine the influences of individual-level variables only, "we know much less about the potential of neighbourhoods and families to exert effects" (p. 168).

Third, the calculation of the *CICD* allows us to separate "vulnerable" children from "non-vulnerable" children, thereby removing determinants of differential vulnerability. In particular, the *CICD* provides a means by which to represent and quantify unexpected school success (better-than-expected school trajectories) or unexpected school failure (worse-than-expected school trajectories) at the aggregate level, as children move from Kindergarten to Grade 4. As a result, the *CICD* provides "starting place" for investigations of the determinants of unexpected school success or better-than-expected school performance trajectories.

Fourth, the *CICD* serves as a useful outcome measure for future studies that explore community influences on children's development – whether those influences be socioeconomic, cultural/ethnic/immigration, social capital/civil society, community governance, or institutional performance in nature.

Fifth, by simultaneously reporting such observations at the aggregate level and providing context for such observations, we highlight the notion that we should increasingly consider child development as an issue of neighbourhood-wide concern – and not just a private issue for parents (early child development) or an institutional issue for schools (literacy and numeracy skills).

Finally, by focussing this research on population-based data, we avoid various problems outlined by Kershaw et al. (2007) that commonly afflict studies of ECD – each of which was addressed in earlier sections of the paper. These problems include the tendency to rely on small samples of children, to focus solely on high-risk populations, to use census neighbourhood boundaries, and to attend only to select developmental domains.

Limitations and issues to consider

First, both the EDI and the FSA have limitations as individual assessments that remain even after they are joined together in developmental trajectory analyses. The EDI, for example, is holistic, covering five key scales of early development: physical, social, emotional, language, and communications (Janus et al., 2007). An individual child can be flagged as "ever vulnerable" if any *one* of his/her EDI scale scores is below the scale-specific 10% provincial cut-off. Imagine, for example, a child who is physically "vulnerable" on the EDI, but "not vulnerable" on the social, emotional, language, and communication scales: for reporting purposes, even though this child is "not vulnerable" on four of the five scales, his/her record is classified as "vulnerable on one or more scales" for the purpose of this paper. As such, "ever vulnerability" on the EDI can be driven by vulnerability on only *one* scale, potentially masking interesting differences across children and neighbourhoods.

Related to this point, it may be the case that higher percentages of "adults without high school graduation" are correlated with the *CICD* scores simply due to the way that Pathway *C* is defined. Recall that children in this category are "vulnerable" on at least one scale of the Kindergarten's EDI, but nonetheless pass Grade 4's FSA. Some of these *C* children are "vulnerable" on only one or two scales of the EDI, while other *C* children presumably fare poorly on multiple (if not all) scales. Furthermore, it may be the case that *C* children from higher income neighbourhoods are more likely to have only *marginally* met the criterion for "ever vulnerability" and that it is *these* children that are more likely to pass Grade 4's FSA. Taken together, it may be the case that the lack of differentiation between differing levels of vulnerability on Kindergarten's EDI influences the correlation between the *CICDs* and the "adults without high school graduation" criterion variable.

Second, one may argue that, of the five developmental scales that the EDI covers, the FSA at Grade 4 taps only the scales of language and communications, making it possible

for children who lack basic literacy skills to score more poorly on the FSA than the EDI. At first glance, these seemingly differing scopes of the EDI (the arguably more holistic measure) and the FSA (the arguably more cognitive measure) may *appear* to suggest that the constructs tapped by each assessment are perhaps non-commensurable and, hence, their scores are inappropriate for inclusion in trajectory analyses (Lloyd & Zumbo, 2007; Lloyd, Zumbo, & Siegel, in press).

As Lloyd (submitted for publication) posits, however, it may be possible to assess longitudinal measures' commensurability using evidence of *predictive validity* – which refers to the degree to which a given measure's data can predict scores on a relevant criterion (comparison) measure at a later time (American Educational Research Association, American Psychological Association, & National Council on Measurement in Education, 1999). In other words, if scores in a given wave are deemed to be considerably predictive of scores in a later wave/later waves, then it may be the case that the measures are sufficiently comparable for inclusion in trajectory analysis. A similar argument has been made by Boivin et al. (2008), who observe that the validity of ECD indicators should be based on their predictive accuracy with respect to short-, medium-, and long-term outcomes. In this sense, they state that early school achievement may be seen as an ecologically valid outcome of ECD indicators, such as the EDI.

Recent work by Hertzman (2006) [which is also described by McCain et al. (2007)] reveals that children's performance on the FSA can be predicted reliably by the EDI 4 years earlier. He demonstrates that the gap between the percentage *failing to meet expectations on the Grade 4 FSA* (i.e., the percent of children who failed to meet provincial expectations on the FSA, compared to the total number of children who wrote the FSA) and the percentage *not passing the Grade 4 FSA* (percent of children who failed to meet provincial expectations on the FSA, compared to the total number of children who should have written the FSA but did not because of illness, truancy, or because of being held back in a lower grade) grows as the number of vulnerabilities on the Kindergarten EDI also grows. For example, of the children with *zero* vulnerabilities on any of the five EDI scales, 7.5% fail to meet FSA numeracy expectations and 12.3% do not pass the FSA numeracy subtest. In contrast, of the children with *four or five* vulnerabilities on the EDI, 27.5% fail to meet FSA numeracy expectations and 55.6% do not pass the FSA numeracy subtest. More compellingly, of the children with *zero* vulnerabilities on the EDI, 13.6% fail to meet FSA reading expectations and 17.8% do not pass the FSA reading subtest. In contrast, of the children with *four or five* vulnerabilities on the EDI, 48.4% fail to meet FSA reading expectations and 68.3% do not pass the FSA reading subtest.

Similar findings have been revealed by Lemelin et al. (2007) and by Lesaux, Vukovic, Hertzman, and Siegel (2007), who demonstrate that school-level literacy scores are related to the physical, social, and emotional development of the Kindergarten population, as measured by the EDI. Taken together, there is robust evidence that joining the EDI and FSA together in trajectory analyses is statistically and conceptually defensible.

Third, the *Community Index of Child Development scores* presented in this paper are based upon the place of residence of children in Kindergarten only, given that our primary interest was to reflect upon the quality of children's "early experiences". The *CICD* can, however, also be calculated for place of residence at Grade 4, or in ways that would segregate children who have moved among neighbourhoods between Kindergarten and Grade 4. Although the scope of this paper does not allow us to show these analyses, the basic messages of this paper are unchanged when *CICDs* are handled in these ways.

Fourth, a large literature on child development shows that proximal-level factors – those child- or family-level variables that describe the more intimate environments in which children are reared – can exert as strong, if not stronger, an influence on the development of children as neighbourhood- or district-level factors (Duncan et al., 1994; Janus & Duku, 2007; Kershaw et al., 2005). Such child-level factors include, but are certainly not limited to, development of language skills, emotional–behavioural regulation, social competence (Boyle et al., 2007), levels of stress, and cortisol regulation (Cicchetti & Rogosch, 2001). Such family-level factors include: income, education, race/ethnicity, parental unemployment, family poverty, dependence on social assistance, living in rental accommodations, lone-parent family status, teen parenthood/maternal age at birth, family structure, and large family size (Boyle et al., 2007; Leventhal & Brooks-Gunn, 2000).

Given the importance of such proximal variables in understanding child development – more specifically, the importance of understanding the dynamic interplay between proximal variables with neighbourhood factors (Bronfenbrenner, 1979) – it may be the case that the aforementioned patterns of divergence (Vancouver) and convergence (Howe Sound) could be more easily interpreted if we could incorporate such data into our large-scale reporting.

Related to this point, Leventhal and Brooks-Gunn (2000) argue that studies that do not include controls for proximal-level factors, particularly those related to the family, cannot be used to estimate true neighbourhood effects because it is family (and individual) characteristics that often define neighbourhoods. For example, there is a tendency for families to reside in neighbourhoods in which neighbours have similar incomes. As a result, unmeasured characteristics associated with neighbourhood residence – whether they be individual, family, or neighbourhood in nature – might account for some (or all) of observed neighbourhood effects. It is therefore worth stressing that the current paper does not claim to involve an investigation of neighbourhood effects; rather this paper provides one means by which to complement, not replace, research that explores the multi-level effect of individual-, family-, and neighbourhood-level characteristics on early child development

Future directions and conclusions

One future direction of this research involves mapping the *CICDs* for various subgroups of children, namely for Aboriginal children, by gender, for children whose language

is not English, and for children with other sociodemographic characteristics such as residential and school transience. This direction is particularly important given the social and cultural diversity that exists in British Columbia and, specifically, the Greater Vancouver region.

Second, whereas the current paper reports the *CICDs* at the neighbourhood-level, it is equally possible to compute the ratio scores at various other levels of aggregation. For example, preliminary analysis of the school-level data suggests that the level of school variation is greater than the neighbourhood or district variation. This preliminary finding, we posit, is an important element of "bringing schools back in" to the data analytic fold, and raises questions about possible reasons for high versus low *CICD* schools. The eventual aim will be to create best-fit models that account for neighbourhood and school differences in the ratios, and to identify neighbourhoods/schools that are outliers from best-fit models – all the while considering their special characteristics.

Recall from an earlier section that it may be the case that the lack of differentiation between differing levels of vulnerability on Kindergarten's EDI influences the correlation between the *CICDs* and the "adults without high school graduation" criterion variable. To this end, a third direction involves computing separate *CICDs* for each of the five scales of the EDI, as well as exploring the factors associated with variation in *C* by itself, in *B* by itself, in addition to focussing on the ratio of positive to negative deflections.

A growing literature shows that children's developmental trajectories begin at birth (or even before), not simply at school age, and such trajectories traverse both health and education domains (Drukker et al., 2006). Therefore, our fourth aim is to marry our community-centred, longitudinal, and linked-data approach with a life course approach to monitoring children's development. To this end, we are applying for access to birth and health services records from BC's Ministry of Health. Whereas our current data holdings follow children from Kindergarten to Grade 4, the inclusion of the children's health records will allow us to better understand the Birth-Age 5 time period and, in turn, its influence not only on children's readiness for school at Kindergarten but also on educational outcomes at Grade 4. Furthermore, 2006/2007 marks the first year in which we can obtain Grade 7 FSA data for our 1999/2000 cohort of EDI writers. By using EDI data in concert with both retrospective health and prospective education records, it will be possible to examine more thoroughly – and achieve new insights into – the developmental trajectories of British Columbian children.

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References

American Educational Research Association, American Psychological Association, & National Council on Measurement in Education. (1999). *Standards for educational and psychological testing*. Washington, DC: AERA, APA, NCME.

Boivin, M., Lemelin, J.-P., Forget-Dubois, N., Dionne, G., Seguin, J., & Tremblay, R. E. (2008). Early child development and early school achievement: The EDI in question, results from the Québec Longitudinal Study of Child Development. In J. E. V. Lloyd (Ed.), *Bringing it together: Merging community-based, life-course, linked data, and social indicator approaches to monitoring child development*. Proceedings from the Early Childhood Learning Knowledge Centre's monitoring committee workshop (pp. 35–40). Toronto, ON: Early Childhood Learning Knowledge Centre, Available from: http://www.ccl-cca.ca/NR/rdonlyres/A926804D-EA69-4C70-A2E4-224A734C0410/0/BringingItTogetherEN.pdf. Accessed 17.10.08.

Boyle, M. H., Georgiades, K., Racine, Y., & Mustard, C. (2007). Neighbourhood and family influences on educational attainment: Results from the Ontario Child Health Study follow-up 2001. *Child Development, 78*(1), 168–189.

British Columbia Ministry of Education. (2003). *Interpreting and communicating British Columbia Foundation Skills Assessment results 2002*. Available from: http://www.bced.gov.bc.ca/assessment/fsa/02interpret.pdf. Accessed 08.12.03.

British Columbia Ministry of Education (n.d.). General information. Available from: http://www.bced.gov.bc.ca/pen/geninfo.htm. Accessed 11.07.08.

British Columbia Statistics. (2006a). *Regional district 15 – Greater Vancouver: Statistical Profile*. Available from: http://www.bcstats.gov.bc.ca/DATA/sep/rd/Rd_15.pdf. Accessed 06.07.07.

British Columbia Statistics. (2006b). *Regional district 31 – Squamish Lillooet: Statistical Profile*. Available from: http://www.bcstats.gov.bc.ca/DATA/sep/rd/Rd_31.pdf. Accessed 06.07.07.

British Columbia Statistics. (2006c). *Regional district 9 – Fraser Valley: Statistical Profile*. Available from: http://www.bcstats.gov.bc.ca/DATA/sep/rd/Rd_9.pdf. Accessed 06.07.07.

Bronfenbrenner, U. (1979). *The ecology of human development*. Cambridge, MA: Harvard University Press.

Brooks-Gunn, J., Duncan, G. J., Klebanov, P. K., & Sealand, N. (1993). Do neighborhoods influence child and adolescent development? *The American Journal of Sociology, 99*(2), 353–395.

Carpiano, R. M. (2006). Toward a neighborhood resource-based theory of social capital for health: Can Bourdieu and sociology help? *Social Science & Medicine, 62*, 165–175.

Cicchetti, D., & Rogosch, F. A. (2001). Diverse patterns of neuroendocrine activity in maltreated children. *Development and Psychopathology, 13*, 677–693.

Doherty, G. (1997). *Zero to six: the basis for school readiness*. (Report #R-97-8E). Ottawa: Human Resources Development Canada.

Drukker, M., Kaplan, C., Schneiders, J., Feron, F. J. M., & van Os, J. (2006). The wider social environment and changes in self-reported quality of life in the transition from late childhood to early adolescence: A cohort study. *BMC Public Health, 6*(133), 1–11.

Duncan, G. J., Brooks-Gunn, J., & Klebanov, P. K. (1994). Economic deprivation and early childhood development. *Child Development, 62*(2), 296–318.

Duncan, G. J., Dowsett, C. J., Claessens, A., Magnuson, K., Huston, A. C., Klebanov, P., et al. (2007). School readiness and later achievement. *Developmental Psychology, 43*(6), 1428–1446.

Hertzman, C. (1999). Population health and human development. In D. Keating, & C. Hertzman (Eds.), *Developmental health and the wealth of nations* (pp. 21–40). New York: The Guilford Press.

Hertzman, C. (2006). Seven uses of the EDI: The case of British Columbia. Paper presented at the Measuring Early Child Development conference, Vaudreuil, Québec, Canada.

Hertzman, C. (2008). Purpose of the workshop. In J. E. V. Lloyd (Ed.), *Bringing it together: merging community-based, life-course, linked data, and social indicator approaches to monitoring child development*. Proceedings from the Early Childhood Learning Knowledge Centre's monitoring committee workshop (pp. 3–5). Toronto, ON: Early Childhood Learning Knowledge Centre, Available from: http://www.ccl-cca.ca/NR/rdonlyres/A926804D-EA69-4C70-A2E4-224A734C0410/0/BringingItTogetherEN.pdf. Accessed 17.10.08.

Hertzman, C., Kershaw, P., Irwin, L. G., Trafford, K., & Wiens, M. (2008). Four uses of the EDI: The case of British Columbia. In J. E. V. Lloyd (Ed.), *Bringing it together: merging community-based, life-course, linked data, and social indicator approaches to monitoring child development*. Proceedings from the Early Childhood Learning Knowledge Centre's monitoring committee workshop (pp. 27–34). Toronto, ON: Early Childhood Learning Knowledge Centre, Available from: http://www.ccl-cca.ca/NR/rdonlyres/A926804D-EA69-4C70-A2E4-224A734C0410/0/BringingItTogetherEN.pdf. Accessed 17.10.08.

Hertzman, C., & Power, C. (2005). A life course approach to health and human development. In J. Heymann, C. Hertzman, M. L. Barer, & R. G. Evans (Eds.), *Healthier societies: from analysis to action* (pp. 83–106). New York: Oxford University Press.

Hertzman, C., Power, C., Matthews, S., & Manor, O. (2001). Using an interactive framework of society and life course to explain self-rated health in early adulthood. *Social Science & Medicine, 53*, 1575–1585.

Janus, M., Brinkman, S., Duku, E. K., Hertzman, C., Santos, R., Sayers, M., et al. (2007). *The Early Development Instrument: Population-based measure for communities. A handbook on development, properties, and use*. Hamilton, Ontario: Offord Centre for Child Studies.

Janus, M., & Duku, E. (2007). The school entry gap: socioeconomic, family, and health factors associated with children's school readiness to learn. *Early Education and Development,, 18*(3), 375–403.

Janus, M., & Offord, D. (2007). Development and psychometric properties of the Early Development Instrument (EDI): A measure of children's school readiness. *Canadian Journal of Behavioral Science, 39*(1), 1–22.

Kagan, S. L. (1992). Readiness past, present, and future: Shaping the agenda. *Young Children* 48–53.

Keating, P., & Hertzman, C. (1999). *Developmental Health and the Wealth of Nations: Social, Biological, and Educational Dynamics*. New York: Guilford Press.

Kershaw, P., Irwin, L. G., Trafford, K., & Hertzman, C. (2005). *The British Columbia atlas of child development* (1st ed.). Victoria, BC: Western Geographic Press.

Kershaw, P., Forer, B., Irwin, L. G., Hertzman, C., & Lapointe, V. (2007). Toward a social care program of research: A population-level study of neighborhood effects on child development. *Early Education and Development, 18*(3), 535–560.

Kuh, D. L., & Ben-Shlomo, Y. (1997). *A life course approach to chronic disease epidemiology: Tracing the origins of ill health from early to adult life*. Oxford: Oxford University Press.

Lemelin, J.-P., Boivin, M., Forget-Dubois, N., Dionne, G., Séguin, J. R., Brendgen, M., et al. (2007). The genetic-environmental etiology of cognitive school readiness and later academic achievement in early childhood. *Child Development, 78*(6), 1855–1869.

Lesaux, N. K., Vukovic, R. K., Hertzman, C., & Siegel, L. S. (2007). Context matters: The interrelatedness of early literacy skills, developmental health, and community demographics. *Early Education and Development, 18*(3), 497–518.

Leventhal, T., & Brooks-Gunn, J. (2000). The neighborhoods they live in: The effects of neighbourhood residence on child and adolescent outcomes. *Psychological Bulletin, 126*(2), 309–337.

Lloyd, J. E. V. (Ed.). (2008). *Bringing it together: Merging community-based, life-course, linked data, and social indicator approaches to monitoring child development*. Proceedings from the Early Childhood Learning Knowledge Centre's monitoring committee workshop. Toronto, ON: Early Childhood Learning Knowledge Centre. Available from: http://www.ccl-cca.ca/NR/rdonlyres/A926804D-EA69-4C70-A2E4-224A734C0410/0/BringingItTogetherEN.pdf. Accessed 17.10.08.

Lloyd, J.E.V. On the quantitative analysis of individual change: Unpacking "change" and "commensurability", submitted for publication.

Lloyd, J. E. V., & Zumbo, B. D. (2007). The non-parametric difference score: A workable solution for analysing two-wave change when the measures themselves change across waves. *Journal of Modern Applied Statistical Methods, 6*, 413–420.

Lloyd, J.E.V., Zumbo, B.D., & Siegel, L.S. When measures change over time: A workable solution for analysing change and growth across multiple waves. *Journal of Educational Research & Policy Studies*, in press.

McCain, M. N., Mustard, J. F., & Shanker, S. (2007). *Early years study 2: Putting science into action*. Available from: http://www.councilecd.ca/cecd/home.nsf/pages/EYS2. Accessed 25.10.07.

Putnam, R. D. (2001). Foreword. In S. Saegert, J. P. Thompson, & M. R. Warren (Eds.), *Social capital and poor communities* (pp. xv–xvi). New York: Russell Sage Foundation.

Robert, S. A. (1999). Socioeconomic position and health: The independent contribution of community socioeconomic context. *Annual Review of Sociology, 25*, 489–516.

Schneiders, J., Drukker, M., van der Ende, J., Verhulst, F. C., van Os, J., & Nicolson, N. A. (2003). Neighbourhood socioeconomic disadvantage and behavioural problems from late childhood into early adolescence. *Journal of Epidemiology and Community Health, 57*, 699–703.

Schoon, I., Sacker, A., & Bartley, M. (2003). Socio-economic adversity and psychosocial adjustment: A developmental-contextual perspective. *Social Science & Medicine, 53*, 1001–1015.

Sellström, E., & Bremberg, S. (2006). The significance of neighbourhood context to child and adolescent health and well-being: A systematic review of multilevel studies. *Scandinavian Journal of Public Health, 34*, 544–554.

Vancouver School Board (n.d.). District information. Available from: http://www.vsb.bc.ca/districtinfo/default.htm. Accessed 11.07.08.

World Health Organisation. (2007). *The World Health Report 2007 – A safer future: Global public health security in the 21st century*. Geneva, Switzerland: WHO.