

**Applied Research Branch  
Strategic Policy  
Human Resources Development Canada**

**Ten Hypotheses about Socioeconomic Gradients and  
Community Differences in Children's Developmental  
Outcomes**

**- 01 -**

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## Abstract

The term “socioeconomic gradient” is often used to describe the relationships between social outcomes and SES. This paper defines socioeconomic gradients and suggests a standardised method for presenting them. It sets out ten hypotheses about socioeconomic gradients and community differences, describes the statistical models for testing them, and discusses their implications for social policy. In accomplishing these goals, the hypotheses are tested using data describing children’s early literacy skills, based on data from two Canadian surveys – the National Longitudinal Survey of Children and Youth (NLSCY) and Understanding the Early Years (UEY). The paper concludes with a discussion of the implications of these findings for public policy and further research.

### Keywords

1. Socioeconomic status
2. Socioeconomic gradients
3. Early Childhood Outcomes
4. Community Differences
5. Multilevel models
6. Child development
7. Performance indicators
8. Social policy

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### 1. Introduction

Children whose parents have low incomes and low levels of education, or are unemployed or working in low-prestige occupations, are more likely to exhibit behaviour problems and have poor cognitive development during the early years than children growing up in families with high socioeconomic status (SES) (Hertzman, 1994; Hertzman & Weins, 1996; Willms, 2002a). When these children enter school, their problems tend to worsen: they are less likely to do well in academic pursuits, or be engaged in curricular and extra-curricular school activities (Datcher, 1982; Finn & Rock, 1997; Johnson, Crosnoe, & Elder, 2001; Voelkl, 1995). In the longer term they are prone to leaving school early (Cairns, Cairns, & Neckerman, 1989; Crane, 1991; Ensminger & Slusarcick, 1992; Janosz et al., 1997; Rumberger, 1995) and their relatively poor literacy skills makes it difficult to successfully enter the labour market or pursue post-secondary training (Raudenbush & Kasim, 1998). Adolescents who are from low SES families are more likely to be obese (Willms, Tremblay, & Katzmarzyk, 2002), and to participate in a range of activities such as smoking, drug use, and unsafe sexual practices that can compromise their later health status (Duffy, 2000; Elliott, 1993; Jessor, 1992; Raphael, 1996). Adults who have relatively poor socioeconomic circumstances are more likely to experience mental and physical health problems, and ultimately die at a younger age (Hertzman, 1999; Kunst & Mackenbach, 1992; Marmot, *et al.*, 1991; Power, Manor & Fox, 1991; Wilkinson, 1992; 1996). There is clearly a relationship between SES and a wide range of social outcomes, which are evident at birth and persist throughout the life cycle.

The study of the relationships between children's outcomes and the SES of their parents has a long tradition in the sociology of education (White, 1982). One strand of this research has been concerned with whether certain kinds of schools or school programs are successful in educating children with differing family circumstances (Murphy, 1985; Raudenbush & Willms, 1995). Another strand has been concerned with individuals' academic and occupational attainment, and the extent to which these are determined by the socioeconomic positions of their parents (e.g. Bielby, 1981; Sewell & Hauser, 1975). The relationship between health outcomes and SES also has a long

history. Much of the interest was focused initially on the effects of income, or more generally on the effects of poverty and poor living conditions (Deaton, 2002; Gordon & Townsend, 2000), but in the past two decades researchers have emphasized other aspects of socioeconomic status, especially social class. The celebrated study of Whitehall civil servants in the United Kingdom found that illness and mortality were related to occupational grade, and that better health was associated with each successive increase in social status (Marmot *et al.*, 1991). The term "gradient" is used to describe the relationships between social outcomes and SES, as it emphasizes the notion that the relationship is gradual and increases across the range of SES (Adler *et al.*, 1994; Marmot, 2002).

The focus of policy research in child development, education, and population health is on identifying the underlying processes that give rise to socioeconomic gradients, and how these are shaped and constrained by institutions and the wider communities in which people live. Researchers have strived to identify *risk* and *protective* factors that mediate or moderate the socioeconomic gradient, or have effects on social outcomes in addition to the effects associated with SES. One can describe socioeconomic gradients with simple descriptive statistics, such as the correlation between a social outcome and SES, or the difference in percentages of people from low and high SES groups who experience a particular social outcome. However, the strength of socioeconomic gradients and their functional form (e.g., linear or curvilinear) depends on the unit of analysis used to estimate the gradient (e.g., the individual or the community) and much more can be learned about the underlying processes that affect social outcomes through a careful examination of gradients at each level of analysis.

This paper has four aims. The first is to define socioeconomic gradients and suggest a standardised method for presenting them. This could make it easier for researchers and the policy community to compare gradients across studies and monitor changes over time. The second aim is to set out ten hypotheses about socioeconomic gradients and community differences, describe the statistical models for testing them, and discuss their implications for social policy. The third aim is to provide examples of the tests of these hypotheses using data describing children's early literacy skills, derived from two Canadian surveys – the National Longitudinal Survey of Children and Youth (NLSCY)

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and Understanding the Early Years (UEY). Although the focus of the paper is largely expository, the substantive results have important policy implications. Therefore, the fourth aim of this paper is to discuss the policy implications of these findings specifically, and more generally the implications of findings pertaining to the ten hypotheses.

## 2. What is a Socioeconomic Gradient?

A socioeconomic gradient depicts *the relationship between a social outcome and socioeconomic status for individuals in a specific community*. The *social outcome* can be any measurable trait. In research on child development it is typically a measure describing cognitive ability, health, behaviour, social skills, or personality traits. The measure can be continuous, such as a test score, or dichotomous, such as whether a child has a chronic health condition. It can also be the growth trajectory for a child (Bryk & Raudenbush, 1987; Boyle & Willms, 2001); for example, the focus can be on the extent to which children with differing family SES are progressing in their reading skills at different rates. The formal definition of *socioeconomic status*, commonly referred to as SES, is the relative position of a family or individual on an hierarchical social structure, based on their access to, or control over, wealth, prestige, and power (Mueller & Parcel, 1981). It is usually operationalised as a composite measure of income, level of education, and occupational prestige (Dutton & Levine, 1989; Mueller & Parcel, 1981). The *community* can be any unit in which individuals are clustered, including geographically defined units such as a country, province or state, city, census tract, or neighbourhood. The community can also be a social or organisational unit such as a school, hospital, or workplace. The definition states “individuals” in a community, to emphasize the importance of using individual data to define a gradient. One could also describe the relationship between average outcome scores for some units, such as mean test scores for a set of schools, and the average levels of SES for these units, such as school mean SES. However, this does not adequately describe the outcome-SES relationship for a population. Later in this paper it will be shown that it is possible to decompose the socioeconomic gradient for a community into within-unit and between-unit components for units at a lower level of an organizational hierarchy.

## Ten Hypotheses about Socioeconomic Gradients and Community Differences

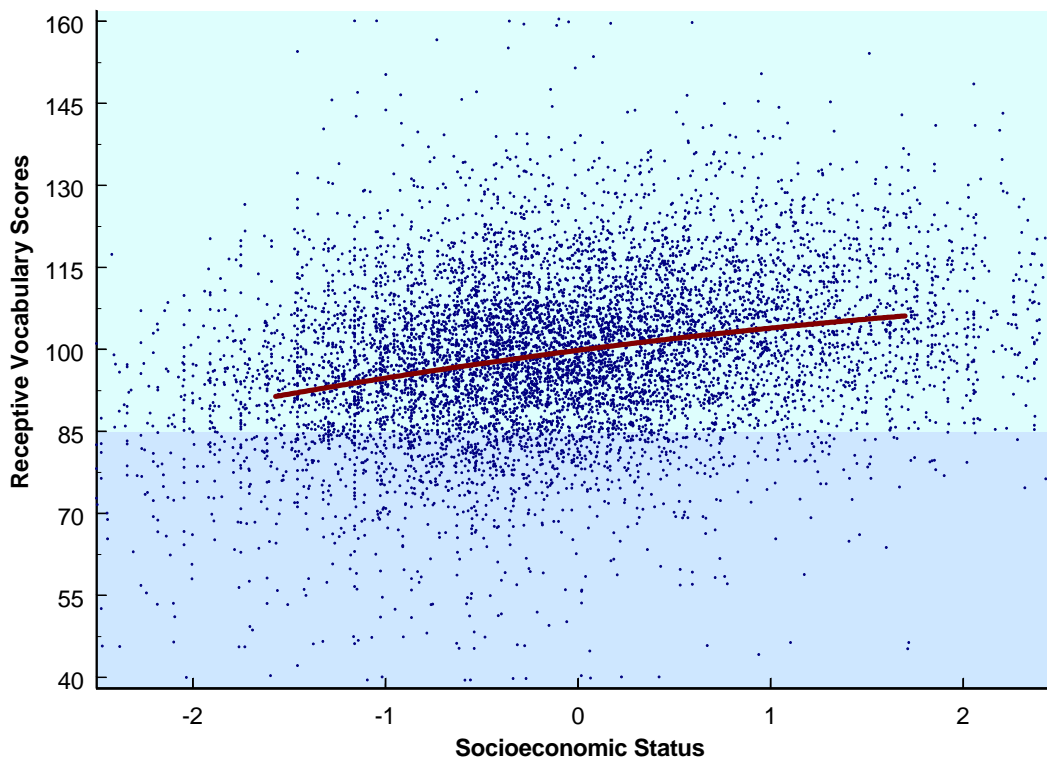


Figure 1. **Socioeconomic gradient for Children's Receptive Vocabulary**  
Source: NLSCY, Cycle 3

### 2.1 An Example

Figure 1 shows the socioeconomic gradient for children's receptive vocabulary scores at ages 4 to 6, based on data for 8275 children from the 1998-99 cycle of the National Longitudinal Study of Children and Youth (NLSCY). Receptive vocabulary test scores were assessed with the Peabody Picture Vocabulary Test (PPVT-R)<sup>1</sup>, an individually administered test which has a correlation of about 0.70 with intelligence quotients (both full-scale and verbal) based on the widely-used Wechsler Intelligence Scale (Dunn & Dunn, 1997). SES is a composite measure derived from measures of family income,

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<sup>1</sup> Correlations of PPVT scores with academic achievement tests range from .33 to .80 with tests of academic achievement (Williams & Wang, 1997). The reliability of the test for four- and five-year-old children ranges from .93 to .95 (both alternate forms reliability and Cronbach's alpha). The PPVT scores were standardized to have a mean of zero and a standard deviation of 15, using data for two-month age groups, for the first cycle of the NLSCY. A French version of the test, Échelle de Vocabulaire en Images Peabody (EVIP), was also developed and normed separately for children who took the test in French.

mothers' and fathers' occupational status, and mothers' and fathers' education (Willms, 2001b). It was scaled to have a mean of zero and a standard deviation of one for all families that participated in the 1998 cycle of the NLSCY.

Socioeconomic gradients comprise three components: their level, their slope, and the strength of the outcome-SES relationship.

The *level* of the gradient is defined as the expected score on the outcome measure for a child with average SES. The level of a gradient for a community is an indication of the overall performance of a community, after taking account of children's family background. The level for the socioeconomic gradient in Figure 1 is 99.87.

The *slope* of the gradient is an indication of the extent of inequality attributable to SES. Steeper gradients indicate a greater impact of SES on childhood outcomes – that is, greater inequality – while gradual gradients indicate a lower impact of SES – that is, less inequality. The slope for the gradient in Figure 1 is 4.57, which indicates that children's vocabulary scores increase by about 4.6 points for each one standard deviation increase in SES.<sup>2</sup>

The *strength* of the gradient refers to how much individual scores vary above and below the gradient line. If the relationship is strong, then a considerable amount of the variation in the outcome measure is associated with SES, whereas a weak relationship indicates that relatively little of the variation is associated with SES. The most common measure of the strength of the relationship is a statistic called R-squared, which is the proportion of variance in the outcome measure explained by the predictor variable. For the gradient in Figure 1, 8.8 percent of the variation in vocabulary scores is associated with SES.

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<sup>2</sup> The gradient in Figure 1 was based on an ordinary least squares regression of PPVT scores on SES and the square of SES. The coefficients were 99.863 (intercept), 4.572 (SES), and -0.513 (SES-squared). Because the quadratic term, SES-squared, was statistically significant, the slope of the gradient varies across levels of SES. In this case, the slope of 4.572 is an estimate of the slope evaluated at the centre of the data; that is, for a child in a family with nationally average SES.

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The gradient is drawn from the 5<sup>th</sup> to 95<sup>th</sup> percentiles of SES, to provide an indication of the range of SES scores in the sample. This is a useful device when comparing sub-groups of the population, such as racial and ethnic groups or various communities, as it shows the range of SES within each group.

### **2.2 A Composite Measure versus Constituent Components**

Deaton (2002) argues that a socioeconomic gradient is a useless concept for thinking about policy, as there are no policy instruments that simultaneously act upon income, education, and social class (Deaton, 2002). However, income, education, and social class are all proxy factors for an underlying global construct – the relative position of a family or individual on an hierarchical social structure – and that the composite is useful for gaining an understanding of the underlying causal processes. Because of the pervasive effect of SES on a wide range of factors, it is useful to be able to compare SES gradients for various outcomes, across communities and over time. As a policy instrument, it has proven to be a useful device for communicating the extent of inequalities in a society. As Deaton (2002) argues, however, one also needs to examine separately the effects of the constituent components, as this can improve our understanding of the causal mechanisms and direct attention to particular kinds of interventions. In examining the relationship between literacy skills and SES for the Programme for International Student Assessment (PISA; Organisation for Economic Cooperation and Development, 2001), for example, the SES gradients were estimated separately for each participating country, and then examined the separate effects of the constituent components. These cross-sectional comparisons of socioeconomic gradients provide a clear policy message: the aim of school policy must be to “raise and level the bar”, but how each country achieves these aims depends on the relationships between literacy skills with income, parents’ education, and parents’ occupational status, and a range of other family, school, and community factors (Willms, 2002b).

Another issue is whether one should include in the composite well-known correlates of SES, such as the age of the mother when the child was born, ethnicity, or family structure (e.g., single vs. two-parent family, and family size). Generally, it is preferable



not to include such variables in the construct for at least three reasons: they are not part of the formal definition of SES; their meaning varies across societies and cultures to a much greater extent than does income, education or social class; and their effects on various outcomes is not as consistent across a wide range of social outcomes. Thus, a reasonable way to proceed is to examine socioeconomic gradients using a composite measure of socioeconomic status, and then examine the relationship between outcomes and the constituent components of SES as well other factors such as ethnicity, maternal age, and family structure.

### 3. Ten Hypotheses about Socioeconomic Gradients and Community Differences

#### 3.1 The Hypothesis of a Socioeconomic Gradient

*There is a significant relationship between social outcomes and socioeconomic status.*

The most basic hypothesis about socioeconomic gradients is that there is a significant bivariate relationship between a particular social outcome and SES. This can be tested in a straightforward manner using ordinary least squares regression for continuous outcomes, or logistic regression analyses for dichotomous outcomes. For example, the relationship between children's receptive vocabulary and SES is statistically significant – the slope is 4.57, which is greater than zero ( $p < 0.05$ ). However, usually the interest is in the gradients for individual communities within a larger unit, such as cities or health regions within a state or province, or schools within a school district. The national gradient for children's vocabulary shown in Figure 1 can be decomposed into a within-community gradient and a between-community gradient. The relative strength of these components has implications for social policy which will be discussed later.

**3.1.1 An example.** Figure 2 shows the socioeconomic gradients for children's receptive vocabulary for 18 Canadian cities (red lines) and five UEY "communities" (blue lines), based on data from the NLSCY and the UEY surveys. The 18 cities were selected because they had sample sizes of at least 80 children, and included at least one city from each of the ten Canadian provinces. The five UEY communities were the first five communities to participate in the UEY survey. They included a rural community in Southwest Newfoundland; Prince Edward Island; children served by a school district in the inner city of Winnipeg, Manitoba; Prince Albert, Saskatchewan; and an area of Coquitlam, British Columbia. The measures of children's vocabulary and socioeconomic status are the same as in Figure 1, with the national scaling for the NLSCY applied to the five UEY communities.

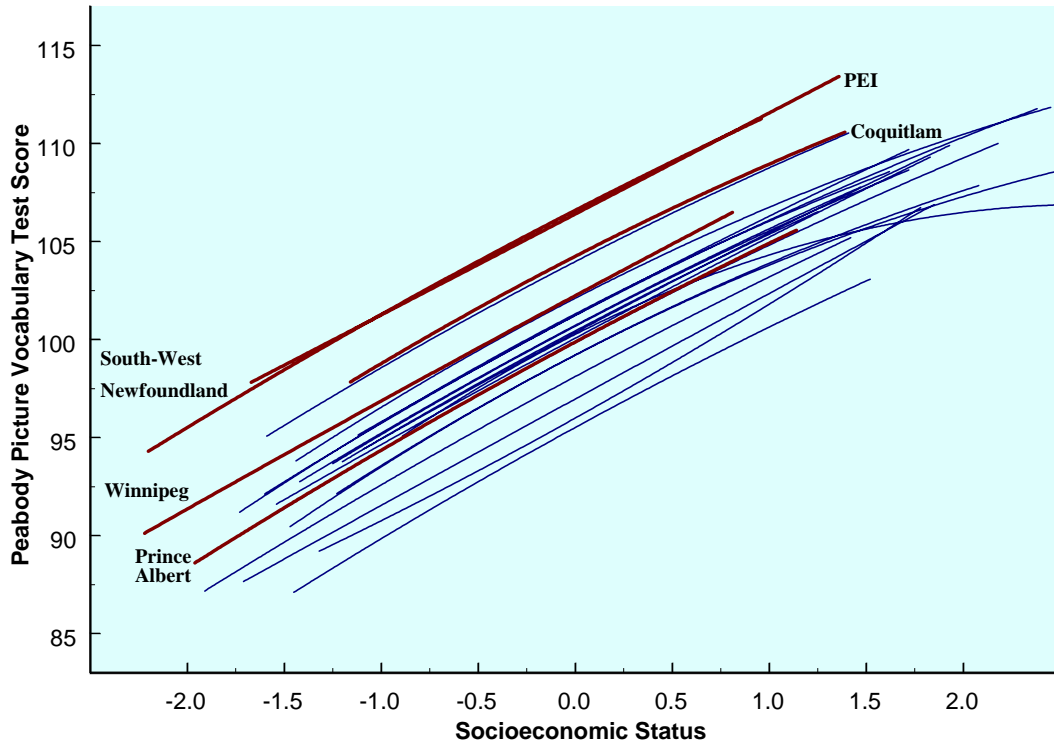


Figure 2. **Within-community gradients for children’s receptive vocabulary**

Source: NLSCY, Cycle 3 and UEY

**Note.** Gradients for the UEY communities are shown in red, and gradients for other communities, based on NLSCY data, are shown in blue.

**3.1.2 Statistical Analysis.** In a multilevel framework, a separate regression equation is fit to the data for each community:

$$Y_i = \beta_0 + \beta_1 X_i + r_i \quad \text{Within-Community Equation (1)}$$

where  $Y_i$  is a person’s outcome score,  $X_i$  is their score on the SES measure. The intercept,  $\beta_0$ , is the expected outcome score for a person who has a score of zero on  $X_i$ . In most multilevel models,  $X_i$  is “centred” on a particular value, such as the national mean, so that a value of zero on  $X$  refers to a hypothetical person with particular characteristics. In the example, SES is centred on the 1998 national mean, and thus the  $\beta_0$  for each community is the *level* of gradient. The parameter  $\beta_1$  is the *slope* of the socioeconomic gradient. It is

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an estimate of the expected change in the outcome score  $Y_i$  for a one-unit change in  $X_i$ . The parameters,  $r_i$ , are the residuals; that is, the deviation of people's scores from the regression line. The *strength* of the gradient, as gauged by the proportion of variance in the outcome measure explained by SES (i.e.,  $R^2$ ), is the difference between the variance in  $Y_i$  and the variance of the residuals expressed as a fraction of the variance in  $Y_i$ .

With  $j$  communities (in the example,  $j = 23$ ) one can write  $j$  such equations:

$$Y_{ij} = \beta_{0j} + \beta_{1j} X_{ij} + r_{ij} \quad \text{A Set of Within-Community Equations (2)}$$

where the subscript  $j$  has been added to each element of equation 1. Therefore, one now have  $j$  different  $\beta_0$ 's, one for each community, and  $j$  different  $\beta_1$ 's. The  $\beta_0$ 's are the levels of the socioeconomic gradients, and the  $\beta_1$ 's are the slopes of the socioeconomic gradients for the set of communities. The  $\beta_0$ 's can be expressed as an average  $\beta_0$ , called gamma ( $\gamma$ ), plus the deviation of each community's  $\beta_0$  from the average:

$$\beta_{0j} = \gamma_{00} + u_{0j} \quad \text{Among-Community Equation for Levels of the Gradients (3)}$$

where  $\gamma_{00}$  is the grand mean, or the mean of the community means, and  $u_{0j}$  is the deviation from each community's mean from the grand mean. Similarly, the slopes of the gradients vary among communities, and can be expressed as an average slope plus a deviation from the average slope:

$$\beta_{1j} = \gamma_{10} + u_{1j} \quad \text{Among-Community Equation for Slopes of the Gradients (4)}$$

where  $\gamma_{10}$  is the mean of the community slopes, and  $u_{1j}$  is the deviation from each community's slope from the mean slope.

The *Gradient Hypothesis* is that the average socioeconomic gradient across the communities is statistically significant; that is, that  $\gamma_{00}$  is significantly different from zero:

$$H_0: \gamma_{10} = 0$$

The Gradient Hypothesis (5)

$$H_1: \gamma_{10} \neq 0$$

which is assessed with a t-test with  $j-1$  degrees of freedom. Note that in this case, the slopes were allowed to vary; that is, there is a different slope for each community.

## 3.2 The Hypothesis of Community Differences

*Communities vary in their social outcomes even after taking account of individual's socioeconomic background.*

This hypothesis arises from research on school effectiveness where researchers are interested in whether the outcomes of students with differing family backgrounds vary in their achievement scores across schools (Raudenbush & Willms, 1995). In the first instance, one can simply compare the mean vocabulary scores across the 23 communities. They indeed vary substantially: among the 18 cities from 97.8 for Vancouver to 105.2 for Quebec, and among the five UEY communities from 94.5 for Prince Albert to 105.5 for PEI. The analysis of within-community gradients also allows one to determine whether communities differ in their outcomes after taking account of the socioeconomic status of the children's families. One can draw a vertical line at an SES value of zero. The point at which the line intersects a community's gradient is the expected outcome score for a child with average socioeconomic characteristics; that is, the *levels* of the socioeconomic gradients. In this example, the expected scores vary from 95.5 (Vancouver) to 104.0 (Quebec) among the cities, and from 99.9 (Prince Albert) to 106.4 (PEI) among the UEY communities. A formal test of the "hypothesis of community differences" can be tested within a multilevel framework. In this example, the community differences in their outcomes are statistically significant, even after taking account of SES.

**3.2.1 Statistical Analysis.** The statistical model described by equations 2 to 4 are also used to test this hypothesis. The *Hypothesis of Community Differences* holds that the levels of the gradients vary significantly, which is equivalent to stating that the variance of the

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$u_{0j}$ 's is greater than zero. This between-community variance is referred to as tau ( $\vartheta$ ), and the hypothesis is:

$$H_0: \text{Var}(u_{0j}) = \tau_0 = 0$$
$$H_1: \tau_0 > 0$$

Hypothesis of Community Differences (6)

It is easier conceptually to formulate multilevel models as separate within- and between-community equations, as specified in equations 2 to 4. However, the estimation of these models entails the substitution of equations 3 and 4 into equation 2 to yield a model with both within- and between-community residuals. These can be easily estimated with available software such as HLM (Raudenbush, Bryk, Cheong, & Congdon, 2001) or MLN (Goldstein *et al.*, 1998). Estimation of the model represented by equations 2 and 3 for the example yielded a grand mean, ( $\mu_0 = 100.41$  (s.e. = 0.79), and  $\vartheta = 10.87$ . The test of whether  $\vartheta$  is greater than 0 is assessed with a chi-square ( $\chi^2$ ) test, with  $j-1$  degrees of freedom. For the example, the null hypothesis that  $\vartheta$  is equal to zero is rejected, and therefore one can conclude that these communities differ in their level of receptive vocabulary scores, even after taking account of family SES.

### 3.3 The Hypothesis of Diminishing Returns

*The relationship between social outcomes and socioeconomic status is weaker at higher levels of socioeconomic status.*

This hypothesis holds that the gradient rises steadily with increasing levels of SES, but gradually tapers off at a higher level of SES. This is an important hypothesis, because if there are diminishing returns above some level of SES, it would suggest that one could improve social outcomes for the least advantaged through policies which reduced inequalities in SES. For example, if one examined the separate components of SES – income, education, and occupation – and found that there was a curvilinear income gradient, with diminishing returns above a certain income, it would suggest that one could reduce inequalities through policies that redistributed wealth. This appears to be the case for certain health outcomes, at least in the U.S. Among US adults who earn less than

\$20,000, an increase in income is associated with markedly better health outcomes. However, above that threshold, increasing income has only a marginal effect on health status (Epelbaum, 1990; House *et al.*, 1990; Mirowsky & Hu, 1996; Rogot *et al.*, 1992). Similar research in Canada on health outcomes generally support the hypothesis, but the extent of curvilinearity is not as marked (Boyle & Willms, 1999; Wolfson *et al.*, 1999), such that one can not easily identify an income threshold. The relationship between life expectancy and Gross National Product (GNP) at the level of countries is also curvilinear, with diminishing returns at levels above \$5,000 (World Bank, 1993).

The hypothesis of diminishing returns has not received much attention with respect to children's cognitive or behavioural outcomes. Willms (2002a) reported small but statistically significant curvilinear income gradients for receptive vocabulary skills at ages 4 and 5, and for mathematics skills in the primary grades, but the extent of curvilinearity was negligible. The results of PISA for the reading scores of 15-year old youth suggest that there is slight curvilinearity supporting the diminishing returns hypothesis in a few countries, but in most countries the gradient is decidedly linear (OECD, 2001).

Willms and Somers (2001) found that the parental education gradients for children's reading and mathematics scores were curvilinear in several Latin American countries, but the curve increased with increasing levels of parental education. It appears that there is some minimum level of parental education necessary for children to benefit from elementary schooling in these countries. Similar findings for youth's reading performance were found for Mexico and Brazil in the PISA, but these may be attributable to a "floor effect" on the reading test.

In the example describing children's vocabulary skills, the national socioeconomic gradient is slightly curvilinear, indicating a diminishing return relationship (see Figure 1). The socioeconomic gradients for most of the communities are quite linear (see Figure 2). However, the socioeconomic gradient for Ottawa-Hull is also a good example – the slope of the gradient becomes increasing more gradual as SES increases, such that there is virtually no relationship for families with SES scores above 1.0.

**3.3.1 Statistical Analysis.** The most common approach to testing this hypothesis is simply to add a quadratic term for SES into the within-community model:

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$$Y_{ij} = \beta_{0j} + \beta_{1j} X_{ij} + \beta_{2j} X_{ij}^2 + r_{ij} \quad \text{Within-Community Equations}$$

with Curvilinear Term (7)

where the  $\beta_{2j}$ 's are the curvilinear terms for the socioeconomic gradients. These can be expressed as an average effect,  $\gamma_{20}$ , and the deviation of each community from the average effect:

$$\beta_{2j} = \gamma_{20} + u_{2j} \quad \text{Among-Community Equation for Curvilinear Gradients (8)}$$

where  $\gamma_{20}$  is the mean of the curvilinear effects, and  $u_{2j}$  is the deviation of each community's curvilinear effect from the mean effect. One can test whether the mean effect is statistically significant:

$$H_0: \gamma_{20} = 0$$
$$H_1: \gamma_{20} \neq 0$$

Hypothesis of Diminishing Returns (9)

which is assessed with a t-test with  $j-1$  degrees of freedom (in this case, with the slopes allowed to vary). One can also test whether the curvilinear effect varies significantly among communities:

$$H_0: \text{Var}(u_{2j}) = \tau_2 = 0$$
$$H_1: \tau_2 > 0$$

Hypothesis of Varying Diminishing Returns (10)

The hypothesis of diminishing returns does not hold for the data describing the 18 Canadian communities. The coefficient for SES-squared is -.272, which is not statistically significant ( $p = 0.17$ ). Also, the coefficients for SES-squared did not vary significantly ( $p = 0.20$ ) across the 18 communities. Thus, a model with only the linear component of SES provides a better fit to these data.

### 3.4 The Hypothesis of Converging Gradients



*Variation among communities in their social outcomes decreases with increasing levels of socioeconomic status.*

This hypothesis also has important implications for policy analysis. If socioeconomic gradients converge at higher levels of SES, it suggests that successful communities are those that have been successful in bolstering the social outcomes of their least advantaged citizens. At the national or provincial and state levels, evidence of converging gradients would suggest that jurisdictions with low and steep socioeconomic gradients should emphasize policies that are targeted at improving the outcomes of people from lower socioeconomic backgrounds, while those with high and gradual socioeconomic gradients should emphasize more universal interventions aimed at increasing levels of performance for all citizens.

An analysis of youth literacy skills based on data from the International Adult Literacy Study (IALS) revealed a marked pattern of converging gradients, not only among OECD countries, but also among provinces and states in Canada and the US (Willms, 1999a). Also, for the US, the analysis found that the literacy skill gaps between African American and white youth, and between Hispanic and white youth, were smaller in some states than in others, and the states that had high overall levels of literacy skills were those that had been successful in closing the achievement gap between minority and non-minority youth.

The converging gradient hypothesis was tested for a set of 31 elementary schools in one school district in British Columbia (Willms, 2001c), for which longitudinal data on children's achievement were available covering the period from grade 3 through to the end of grade 7, as well as data on children's general cognitive ability at the end of grade 3. The hypothesis also held for "ability" gradients on the *rate* at which children acquired literacy skills during the elementary years: children with high levels of cognitive ability tended to increase their cognitive skills at a relatively fast pace in all schools, whereas children with low cognitive ability tended to learn at a fast pace in some schools but not in others. The schools which were most successful, as gauged by the rate at which children acquired skills, were those that were successful with the least able pupils. These school-level results, although not based on a nationally representative sample, are important vis-à-vis the macro-level IALS results because they were based on children's

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growth trajectories in literacy skills over a five-year period, rather than on their level of skills at some particular point during their schooling careers.

However, the pattern of grade 3 and 4 reading and mathematics skills for Latin America, based on the UNESCO-OREALC study, do not support the converging gradient hypothesis (Willms & Somers, 2001). The analysis indicated that gradients were relatively low and gradual in most countries (Bolivia, Columbia, Dominican Republic, Honduras, Paraguay, Peru, and Venezuela) and somewhat higher but with steep slopes in other countries (Argentina, Brazil, and Chile, and to some extent Mexico). Cuba stood alone with a high, gradual socioeconomic gradient. This pattern was also evident for the PISA data – Brazil and Mexico had relatively low but gradual gradients compared with the OECD countries participating in the study (OECD, 2001). It may be that as countries develop their education systems, the performance levels of high SES students increase first, either because of uneven investments in the public sector or because of a growing private sector. Later, as the systems develop further, they are able to achieve relatively high levels of performance for all pupils, as demonstrated by the success of Cuba.

The results presented in Figure 2 for the SES gradients of receptive vocabulary skills across Canadian cities also do not support the converging gradients hypothesis. Indeed, the slopes are nearly parallel, and do not vary significantly across the 18 communities. The correlation between the levels of performance and the slopes is -0.26, which is not statistically significant.

**3.4.1 Statistical Model.** The model described by equations 2, 3, and 4 above are fitted to the data to test this hypothesis. The estimation of this model entails estimation also of the variance of the gradient levels [i.e.,  $\text{Var}(\mathbf{u}_{0j})$ ], the variance of the gradient slopes [i.e.,  $\text{Var}(\mathbf{u}_{1j})$ ], and the covariance of the levels and slopes [i.e.,  $\text{Cov}(\mathbf{u}_{0j}, \mathbf{u}_{1j})$ ]. In the first instance, one tests whether the slopes vary significantly among communities:

$$H_0: \text{Var}(u_{1j}) = \tau_1 = 0$$

$$H_1: \tau_1 > 0$$

Hypothesis of Variable Slopes (11)

Assuming the slopes vary significantly among communities, one then wants to test also whether the covariance between levels and slopes is statistically significant:

$$H_0: Cov(u_{0j}, u_{1j}) = \tau_{01} = 0$$

$$H_1: \tau_{01} > 0$$

Hypothesis of Converging Gradients (12)

### 3.5 The Hypothesis of Contextual Effects or Double Jeopardy

*The average level of socioeconomic status of a community has an effect on social outcomes over and above the effects associated with individuals' socioeconomic status.*

The presence of a socioeconomic gradient indicates that there is a relationship between social outcomes and SES. However, there is often an additional effect, called a “contextual effect”, associated with the SES of the community. Research in the sociology of education has been concerned with contextual effects for at least twenty-five years, because they are directly relevant to issues concerning the manner in which students are allocated to schools, classrooms and instructional groups. This research has provided convincing evidence that there are contextual effects associated with the demographic characteristics of a classroom or school, over and above the effects associated with an individual’s family background. The research indicates that when children are segregated, either *between schools* through residential segregation or the “creaming” of the most able pupils into selective schools (Brookover *et al.*, 1978; Henderson, Mieszkowski, & Sauvageau, 1978; Rumberger & Willms, 1992; Shavit & Williams, 1985; Willms, 1986), or *between classes* through tracking or streaming (Gamoran, 1991, 1992; Kerckhoff, 1986), children from advantaged backgrounds do better, while those from disadvantaged backgrounds do worse. This is called the “hypothesis of double jeopardy” because it suggests that children from low SES families tend to be disadvantaged because of their circumstances at home, but when they are also segregated into low SES schools they are likely to fare even worse.

In most studies of school effects, the data are not sufficient for testing whether contextual effects are stronger for children with differing levels of SES, because it

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requires sufficiently large samples within groups to achieve accurate estimates of the slopes of the gradients for each school. The hypothesis is that contextual effects tend to be stronger for minority students or children from low SES backgrounds, which could be called the “hypothesis of triple jeopardy”. The interactions between family SES and group mean SES may favour advantaged students because when high SES families are confronted with unfavourable contexts, they are able to draw on other resources (e.g., extra tutoring or more help with homework) to ensure their child does not suffer. Contextual effects were evident for every country examined in the PISA study (OECD, 2001). Moreover, they tended to be slightly larger for males and for youth from lower SES backgrounds. Similar results were found for the educational attainment of school-leavers for a small sample of Scottish schools (Willms, 1985).

There has been very little research aimed at uncovering the causal mechanisms associated with contextual effects. The early research argued that contextual effects were a proxy for peer effects that occur when bright and motivated students work together (Heath, 1984). However, schools or classrooms with high social-class or high ability intakes tend to have several advantages associated with their context (Willms, 1986; Willms & Somers, 2001; OECD, 2001): they are more likely to attract and retain talented and motivated teachers, and on average they are more likely to have greater support from parents, fewer disciplinary problems, and generally an atmosphere conducive to learning. Also, there has been relatively little research on the contextual effects for communities other than schools or classrooms, or for social outcomes other than school achievement. In research on health outcomes, the hypothesis would hold that people who are poor are more likely to have health problems, but suffer double jeopardy if they also live in a poor community. A few recent studies suggest there are contextual effects associated with neighbourhood deprivation (Sloggett & Joshi, 1998; Yen & Kaplan, 1999).

**3.5.1 Statistical Model.** The hypothesis of double jeopardy is tested in a multilevel analysis by asking whether school mean SES is related to the SES-adjusted level of outcomes. The model is identical to that described by equations 2 to 4, except that equation 3 is extended to include the mean level of SES as a predictor of the levels of the community gradients:

$$\beta_{0j} = \gamma_{00} + \gamma_{01} \bar{X}_{\cdot j} + u_{0j} \quad \text{Hypothesis of Double Jeopardy (13)}$$

where  $\gamma_{00}$  is the mean of the community means adjusted for both individual level SES and the mean level of SES of the community,  $\gamma_{01}$  is the contextual effect associated with the mean SES of the community, and  $\bar{X}_{\cdot j}$  is the mean SES of the community. In estimating such models, it is common practice to estimate  $\bar{X}_{\cdot j}$  with individual-level data aggregated to the group level. However, in many cases it would be preferable to use census data, or reliable data from other sources. Moreover, one can also estimate the effects of other variables describing group context, such as the percentage of minorities in the community. The level of aggregation is also an issue. In studies of school effects, the school and classroom are appropriate levels for assessing contextual effects. In studies of child development, the local neighbourhood may be a more appropriate level.

The hypothesis that the contextual effect varies depending on the level of SES of the individual is tested as a “cross-level interaction”, that is the slopes of the gradients are regressed on group mean SES:

$$\beta_{1j} = \gamma_{10} + \gamma_{11} \bar{X}_{\cdot j} + u_{1j} \quad \text{Hypothesis of Triple Jeopardy (14)}$$

For the data in the example, the effect of mean SES is -5.30, which is statistically significant ( $p < .01$ ). The direction of the contextual effect is opposite to the double jeopardy hypothesis, as it indicates that low SES children have better early vocabulary skills in low SES communities. In this instance, the negative contextual effect may be essentially an urban-rural effect, whereby children living in rural areas, which tend to have a lower SES, develop more quickly than would be expected given their family SES. The hypothesis pertaining to triple jeopardy cannot be tested with these data, as the results indicated that the slopes did not vary significantly across communities.

### 3.6 The Hypothesis of Relative Deprivation

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*Communities that are relatively homogeneous in their socioeconomic status tend to have superior social outcomes than those that are relatively heterogeneous in their socioeconomic status.*

This hypothesis stems mainly from research on health outcomes, particularly the work by Wilkinson (1992, 1996, 2000). He observed that the relationship between life expectancy and income was much weaker across countries than within them, and concluded that what matters most is a person's relative status or position within a society. He showed that a country's life expectancy was related more closely to the extent of income inequality, not its absolute level of income. This finding was supported by analyses of adults' life expectancy across states in the US, which also uncovered a strong relationship between mortality and income inequality (Kaplan et al., 1996; Kennedy, Kawashi, & Prothrow-Stith, 1996). Similar findings have been observed for US cities (Lynch et al., 1998), and local authorities in the UK (Ben-Schlomo, White & Marmot, 1996).

However, these findings have been based on aggregate data, and therefore subject to criticism. The principal argument is that the relationship between mortality and income in many jurisdictions is curvilinear, with income having a stronger impact among poor people than among rich people, and because jurisdictions with greater income inequality have disproportionately more people at the extremes of the income distribution, societies with greater income inequality will on average have higher mortality rates (Gravelle, 1998). Deaton and Lubotsky (2001) have shown that a measure of racial inequality accounts for the effects of income inequality on mortality among US cities and states.

The argument underlying the relative deprivation hypothesis is that relative status is related to health because it is proxy for people's autonomy: those with a low sense of control over their lives suffer more stress which in turn affects their health (Marmot *et al.*, 1997; Syme, 1996). The relative deprivation argument is supported by smaller-scale studies, including the Whitehall study (Marmot, *et al.*, 1991), that have examined people's relative status. Ross et al. (2000) observed a weaker relationship between income inequality and mortality among Canadian cities compared with the US. They maintain that the relationships between income inequality and health stem mainly from an inadequate provision of goods and services to meet the needs of the poor in US cities.

However, the extent of income inequality in Canadian cities is much smaller than most US cities, and the range in income inequality is much less. Thus, the Canada-US comparisons do not provide any purchase on the causal mechanisms contributing to the observed effect of income inequality.

These debates call attention to the need for analyses of socioeconomic gradients using individual and community-level data in a multilevel framework. In the first instance one needs individual-level data for cities, such that the within-city socioeconomic (and income) gradients can be estimated. These analyses would furnish estimates of the health outcomes of people at differing levels of SES. It is then possible to enter SES (or income) inequality at the city level, and estimate its effect. One could also discern whether the effect of inequality varied for people with differing levels of SES. Finally, one could enter other individual- and city-level factors, such as sense of control or service provision, to determine the extent to which they mediated the outcome-inequality relationship, or operated as independent factors.

**3.6.1 Statistical Model.** The hypothesis of relative deprivation is tested in a multilevel analysis by adding into the second level a term describing the within-group variation of SES:

$$\beta_{0j} = \gamma_{00} + \gamma_{01} \overline{X}_{\bullet j} + \gamma_{02} Z_j + u_{0j} \quad \text{Hypothesis of Relative Deprivation (15)}$$

where  $\gamma_{02}$  is the effect associated with SES inequality.  $Z_j$  is a measure of SES inequality, such as the standard deviation of SES. There are several measures of income inequality, and they tend to yield similar results in analyses of health outcomes (Kennedy et al., 1996). It is preferable to include also a measure of the mean level of SES, as in equation 14. This is not essential if the measure of relative deprivation is uncorrelated with the mean level of SES, but in most cases the theory underlying the analysis would call for it.

For the example pertaining to children's early vocabulary, a measure of the standard deviation SES was used as an indicator of inequality. The standard deviation of SES is negatively related to receptive vocabulary scores ( $\gamma_{02} = -6.80$ ,  $se = 8.36$ ), which is consistent with the hypothesis of relative deprivation. However, the effect is not statistically significant ( $p=0.43$ ).

### 3.7 The Hypothesis of SES by Group Status Interactions

*The gradients for low-status groups tend to be lower and steeper than the gradients for high-status groups.*

**3.7.1 Moderators and Mediators.** Before discussing this hypothesis, it would be useful to discuss the concepts of moderator and mediator with respect to socioeconomic gradients. In psychological and health research, the term “moderator” has been used to indicate that the magnitude of an effect varies across levels of another variable, whereas the term, “mediator” refers to variables which explain how or why one variable is related to another (Baron & Kenny, 1986; Chaplin, 1991; Rothman & Greenland, 1998). However, the distinction between moderators and mediators can be confusing, as it depends largely on whether one can maintain there is a causal relationship between the predictors and the social outcome, or at least specify the temporal sequence of the variables (Kraemer, Stice, Kazdin, Offord, & Kupfer, 2001). Kraemer *et al.* (2001) have brought some precision to the terms moderator and mediator by distinguishing them from proxy, overlapping, and independent risk factors, and by clarifying the role of each kind of factor in data analysis. With respect to socioeconomic gradients, these terms are as follows:

(a) A *proxy risk factor* would be a strong correlate of SES, which has a relationship with a social outcome mainly through its association with SES. The proxy factor may or may not precede SES temporally, and generally the strength of the SES relationship with the outcome would dominate that of the proxy factor. For example, in many large-scale educational surveys, data are collected on “possessions in the home” as an indicator of wealth. Whether a family “owns a dish-washer” may be related to a child’s achievement score, but this only occurs because of its correlation with SES. One is not usually interested in such factors, unless they are used in a composite scale to represent income when direct assessment is impossible.

(b) An *over-lapping risk factor* would be one that is correlated with SES, and occurs contemporaneously with SES (or at least the temporal sequence cannot be determined or is irrelevant to the causal link between SES and the outcome). Thus, it has the same status



as SES as a potential risk factor. Ethnicity, family structure and maternal age could be considered as over-lapping risk factors, and treated in analysis as factors which are correlated with SES, and have effects that overlap with SES.

(c) An *independent risk factor* is one that also occurs contemporaneously with SES, or is at least irrelevant with respect to the causal link, and is uncorrelated with SES. The child's gender is a good example, as family SES does not cause gender, and SES and gender are uncorrelated. Gender is a risk factor for many childhood outcomes, favouring girls in some cases, and boys in others.

(d) A *moderator* is a factor which affects the relationship between another variable and the social outcome. With respect to gradients one is concerned with whether SES is a moderator. One could conceive of two sub-populations, for example, children from high SES and low SES families. If some other factor of interest, for example "positive parenting", has a different relationship with the social outcome for the two sub-populations, one would say that SES *moderates* the effects of positive parenting. This is an important kind of interaction, because if certain factors are risk factors for high SES groups but not low SES groups, or vice versa, one is closer to understanding the underlying causal mechanisms. Kraemer et al. (2001) require that for SES to be a moderator, it must precede the moderated risk factor, and be uncorrelated with it.

(e) A *mediator* is a factor which is influenced by SES directly, and helps to explain why there is a relationship between SES and the social outcome. For example, parents' income, education, and occupational status may have an effect on parents' ability to be warm and nurturing parents, to be engaged with their child, or to function as a cohesive family unit. They may also affect the mental health of the parents. If so, one would expect to observe a correlation between SES and these factors. Based on previous research, one would also expect them to be significantly related to many childhood outcomes. One would say that these variables — positive parenting, engagement, family functioning, and parental depression — *mediated* the socioeconomic gradient if (i) they were significantly related to the social outcome, (ii) they were correlated with SES, and (iii) they either partially or totally accounted for the SES-outcome relationship.

The *hypothesis of SES-by-group-status interactions* maintains that there is an interaction between SES and group status in their effects on social outcomes, and more

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specifically that the gap in social outcomes between high- and low-status groups is greater at lower levels of SES. Previously, one might have considered SES as a moderator of the group status effect, but as Kraemer et al. (2001) point out, this concept is not useful when SES does not precede the factor of interest. In their sense, then, this hypothesis is about the dominance or co-dominance of two over-lapping factors. Generally, one wants to discern whether there are significant interactions between SES and gender, SES and ethnicity, and SES and other factors describing group status.

The hypothesis of SES-by-group-status interactions has been stated in a specific direction, positing that low-status groups are likely to have especially poor social outcomes if they are of low SES. The argument is that children from low-status groups often experience racial and ethnic prejudice, which has a negative effect on their social outcomes. This effect is likely to be greater in families with low SES, as they do not have the economic and social capital to help their children overcome these effects. Research on sector differences in literacy skills between Catholic and Protestant youth supports this hypothesis: Catholic youth had poorer literacy skills than Protestant youth, and the gap was greater for youth with lower SES backgrounds (Willms, 1998). Generally, however, one is interested in whether there is an interaction, whatever its direction.

**3.7.2 Statistical Model.** The hypothesis of SES by group-status interactions is tested by adding to the level 1 model (equation 3) a dummy variable denoting group status, and a variable constructed as the product of SES times group status:

$$Y_{ij} = \beta_{0j} + \beta_{1j} X_{1ij} + \beta_{2j} X_{2ij} + \beta_{3j} X_{1ij} X_{2ij} + r_{ij} \quad (16)$$

where  $X_{1ij}$  is SES,  $X_{2ij}$  is a dummy variable denoting group status (e.g., minority = 1; non-minority = 0), and  $X_{1ij} X_{2ij}$  is the SES by group-status interaction. The  $\beta_{2j}$ 's can be expressed as an average minority gap,  $(\beta_{20})$ , plus the deviation of each community's  $\beta_{2j}$  from the average; and similarly the  $\beta_{3j}$ 's can be expressed as an average interaction,  $(\beta_{30})$ , plus the deviation of each community's  $\beta_{3j}$  from the average. The hypothesis of SES by group-status interactions is then:

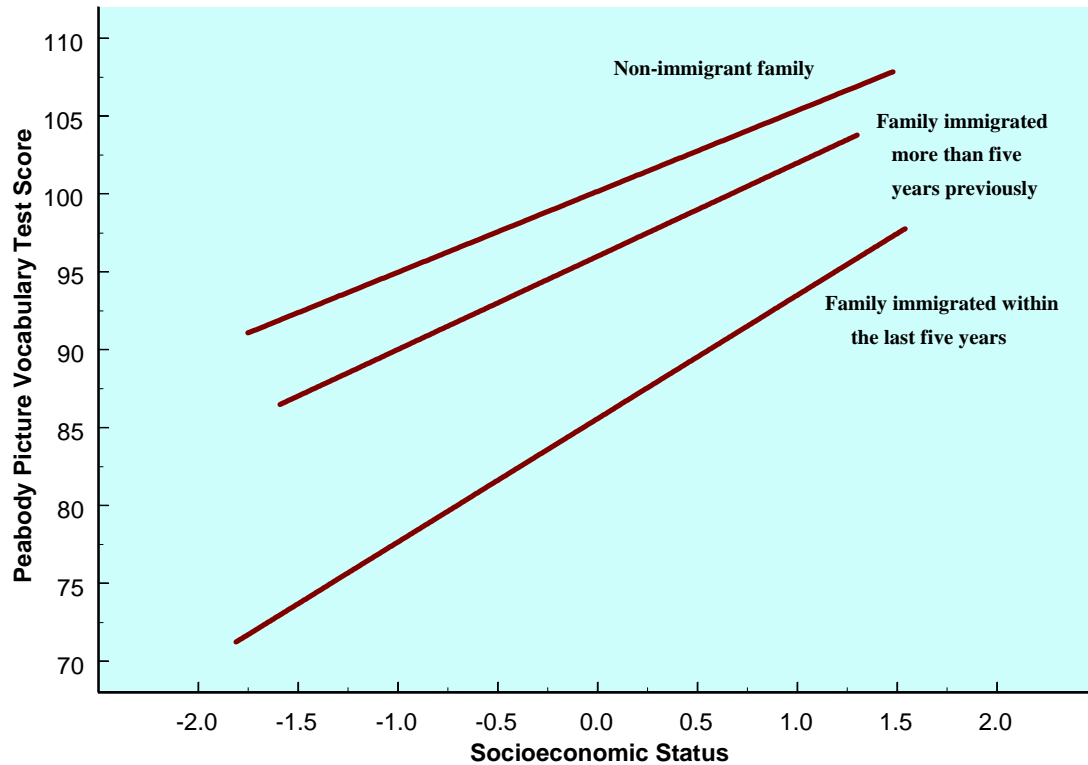
$$H_0: \gamma_{30} = 0$$

$$H_1: \gamma_{30} \neq 0$$

Hypothesis of SES by Group-Status Interactions (17)

**An Example.** For the example in this study, the analysis examined whether children whose parents had immigrated to Canada within the previous five years, and children whose parents had immigrated more than five years previously, had lower vocabulary skills than those whose parents were non-immigrants. The analysis indicated that on average, within communities, the vocabulary scores of children of recent immigrants were 14.6 points lower, and those of established immigrants were 4.2 points lower, than non-immigrants. Figure 3 displays the average within-community gradients for the two groups. Note that the range of SES is truncated at the 5<sup>th</sup> and 95<sup>th</sup> percentiles of SES for each group. The estimate of the SES-by-immigrant interactions were 2.7, which is in the direction hypothesized, but not statistically significant ( $p = 0.06$ ), and 0.8 (also non-significant).

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**Figure 3** Socioeconomic gradients for receptive vocabulary for recent immigrants and non-immigrants

Source: UY-1

### 3.8 The Hypothesis of Family- and Community-Level Mediators

*Variation within and among communities in their social outcomes is attributable to the independent actions of individuals. Variation among communities is also attributable to features of the community which direct and shape individuals' actions.*

Coleman (1988) describes two dominant approaches to research in the social sciences, which are evident in the study of childhood development. One approach, commonly taken by psychologists and economists, emphasizes the independent actions of individuals, particularly parents. It assumes that parents make independent decisions to achieve what they perceive to be best for their family – what economists call “maximizing utility”. Research on child development has strived to identify “risk factors”, such as poverty or inadequate parenting, that are associated with undesirable

childhood outcomes. Another approach, more characteristic of the work of sociologists, stresses the importance of social context in shaping, constraining, and redirecting individuals' actions. Researchers following this line of inquiry maintain that people's individual choices depend on the norms of their immediate community, and the kind of social support available to them. Until recently, most of the research on how social context affects children's development has been at the micro-level. There has been relatively little work concerned with the effects of community factors, and much of it has been directed at understanding the effects of neighbourhood poverty (see Brooks-Gunn, Duncan, & Aber, 1997).

The application of hierarchical models to the study of gradients and community differences provides a means for researchers to bring these two approaches together. The approach is straightforward: one simply introduces potentially mediating individual-level factors into the (level 1) model describing within-community relationships (equation 3), and community-level factors into the (level 2) model describing between-community relationships (equation 4).

**3.8.1 Statistical Model.** The hypothesis of an individual-level mediator is tested by adding the potential mediator to the level 1 model (equation 3):

$$Y_{ij} = \beta_{0j} + \beta_{1j} X_{1ij} + \beta_{2j} X_{2ij} + r_{ij} \quad (18)$$

where  $X_{1ij}$  is SES,  $X_{2ij}$  is the potentially mediating factor. The  $\beta_{2j}$ 's can be expressed as an average effect across all communities, ( $\gamma_{20}$ ), plus the deviation of each community's  $\beta_{2j}$  from the average,  $U_{2j}$  (as per equation 4). The primary criterion for a mediator is that it be related to the outcome, even after controlling for SES:

$$\begin{aligned} H_0: \gamma_{20} &= 0 \\ H_1: \gamma_{20} &\neq 0 \end{aligned} \quad \text{Hypothesis of Individual-Level Mediator (19)}$$

The hypothesis of a community-level mediator is tested by adding the potential mediator to the second-level equation for the  $\beta_{0j}$ 's:

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$$\beta_{0j} = \gamma_{00} + \gamma_{01}Z_j + u_{0j} \quad (20)$$

where  $\gamma_{00}$  is the mean of the *adjusted* community means, and  $u_{0j}$  is the deviation from each community's adjusted mean from the grand mean. One is primarily interested in the magnitude and statistical significance of the coefficient,  $\gamma_{01}$ :

$$\begin{aligned} H_0: \gamma_{01} &= 0 \\ H_1: \gamma_{01} &\neq 0 \end{aligned} \quad \text{Hypothesis of Community-Level Mediator (21)}$$

**3.8.2 An Example.** For the NLSCY and UEY data there are four individual-level factors that are potential mediators of the socioeconomic gradient. They include measures describing positive parenting practices and family functioning, which were scaled to range from zero to 10; a measure of the amount of time parents spent reading to their child, measured in occasions per week; and a dichotomous measure denoting whether the mother suffered from depression. The potential community-level mediators include measures of social support, the quality of the neighbourhood, and stability of the neighbourhood. Support and quality were also measured on scales which ranged from 0 to 10 at the individual level. Neighbourhood stability is the average number of years the people in the neighbourhood had lived at their current address. The model also included a measure of the mean SES of the community, as in the contextual effects model described above. The results are displayed in Table 1.<sup>3</sup>

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<sup>3</sup> The community-level indicators of social support, neighbourhood quality, and stable neighbourhood were measured at the level of enumeration area (EA), which is a geographical unit comprising on average about 400 families. Consequently, the analysis for this example required a three-level hierarchical model (communities, EAs, and children). This is not particularly relevant to the expository aspect of this paper, and therefore to avoid distracting the reader from the central issue, the three sets of equations are not specified. These can be seen in Bryk and Raudenbush (2002, Chapter 8).

**Table 1**  
**The Relationship Between Children's Receptive Vocabulary and Socioeconomic Status and Family and Community Factors**

	Model I	Model II	Model III
<i>Child's Sex and Family Background</i>			
Socioeconomic Status	<b>4.85</b>	<b>4.87</b>	<b>4.20</b>
Female		0.65	0.49
Number of Brothers and Sisters		<b>-1.83</b>	<b>-1.74</b>
Single Parent Family		0.19	0.62
Immigrated within Last Five Years		<b>-13.10</b>	<b>-12.43</b>
<i>Family Processes</i>			
Positive Parenting Practices			-0.24
Reads to the Child			<b>0.62</b>
Family Functioning			<b>0.41</b>
Maternal Mental Health			-0.34
<i>Community Factors</i>			
Mean Socioeconomic Status	<b>-3.46</b>	<b>-3.52</b>	<b>-3.76</b>
Social Support			<b>0.70</b>
Neighbourhood Quality			0.27
Neighbourhood Stability			<b>0.14</b>

**Note.** Figures in bold text are statistically significant at  $p < .05$ .

Model I is the contextual effects model, which includes only SES and the mean level of SES at the city level. It provides an estimate of the average within-community SES slope, which is 4.85. The effect associated with mean SES is -3.46, which indicates that each one standard deviation increase in SES is associated with about a 3.5 point decrease in average receptive vocabulary scores.<sup>4</sup>

Model II includes variables denoting the child's sex, the number of siblings the child has, whether it is a single or two-parent family, and whether the family had immigrated within the past five years. The number of brothers and sisters has a large and significant negative relationship with receptive vocabulary scores: each additional sibling is associated with a decrease in scores of about 1.8 points. Also, as was evident in Figure 3 above, children from immigrant families have somewhat lower receptive vocabulary

<sup>4</sup> This estimate differs from the results of the two-level model presented in the section on contextual effects presented above, because the information contained in the EA level data accounts for some of the contextual effect.

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scores than their non-immigrant counterparts. The gap is about 13 points. The results also indicate that girls scored slightly higher than boys, but the difference was not statistically significant. The effects of living in a single parent family were negligible.

Model III introduces the seven factors describing family processes and community factors. The results indicate that reading to the child is an important determinant of receptive vocabulary scores: an increase of one extra reading session per week is associated with a 0.62 point increase in receptive vocabulary. Also, a one-point increase on the family functioning scale is associated with a 0.41 point increase in receptive vocabulary scores. The effects of maternal depression and positive parenting practices were not statistically significant. The effect associated with social support, measured at the community level, was also large and statistically significant: each one-point increase on the ten-point scale was associated with an increase of 0.70 points in receptive vocabulary. The effects of neighbourhood quality were not as large, and the effect was not statistically significant ( $p = 0.08$ ). The effects of neighbourhood stability were also large and statistically significant: an increase of one year in the average time people had lived at their current address was associated with a 0.14 increase in receptive vocabulary scores.

The coefficient for SES when these seven potential mediating variables were not in the model was 4.87 (s.e. = 0.24). The SES effect was reduced to 4.20 (s.e. = 0.21) after inclusion of these variables. This is a statistically significant reduction in the slope of the SES gradient, and therefore one can claim that these factors *partially* mediated the SES gradient. However, the extent of mediation is slight – less than 20 percent – and therefore one could conclude that these factors operate largely as independent risk factors.

### 3.9 The Hypothesis of Spatial Auto-Correlation

*Successful communities tend to be in close proximity to other successful communities.*

This hypothesis holds that the level of a socioeconomic gradient for a community is correlated with the levels of socioeconomic gradients for neighbouring communities. This is called spatial auto-correlation (Cliff & Ord, 1973; Haining, 1997). The same hypothesis would hold for the slopes of the gradients. For example, suppose a school



were successful in its mathematics achievement, given the SES of its pupils; that is, the level of its gradient were relatively high compared with other schools in the province. One might expect that neighbouring schools would also be relatively effective for several reasons. The students attending the school would likely be living in areas with similar socioeconomic circumstances to students in neighbouring areas. There may be a “diffusion of best practice” because teachers at the school discuss practices with teachers in neighbouring schools. The students’ parents might share similar attitudes towards schooling as the parents of students in neighbouring schools. However, despite the potential for school results to be spatially related, there are no studies in the literature on school effectiveness that examines these relationships. Indeed, one of the assumptions underlying models for estimating school effects (e.g., Raudenbush & Willms, 1995) is that the school-level residuals are independent (e.g., the  $\mathbf{u}_{oj}$  in equation 3). If there is spatial auto-correlation, this assumption is violated, and the model will yield biased estimates.

A simple test for the presence of spatial auto-correlation can be conducted as follows: (1) Determine which communities are “neighbours” for each community with available data. In the case of schools, this could be defined as, say, the three closest schools, or perhaps all schools within a certain radius of a school. For communities, it is common practice to consider all communities that are geographically contiguous to a community to be its “neighbours”. This is called the first level of contiguity. One could also consider as neighbours all the first-level contiguous communities and those communities that were contiguous with them – this is called the second level of contiguity. (2) Estimate the socioeconomic gradients for each community, applying the techniques described above. (3) For each community, estimate the average level and the average slope for its neighbouring communities. (4) Estimate the correlation of the levels of the gradients with the average levels for neighbouring communities. Do the same for the slopes. If the hypothesis of converging gradients holds, the correlations would be positive and statistically significant.

If there is auto-correlation, one might try to “fix” it. There are a number of spatial regression approaches which incorporate spatial information, with the aim of producing unbiased estimates of the desired coefficients (Cliff & Ord, 1973; Ord, 1975).

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However, one can also view the auto-correlation as symptomatic of a mis-specified model (Miron, 1984). Taking the schooling example above, one could introduce measures of neighbourhood socioeconomic characteristics, schooling practices, and parents' attitudes, and examine the extent to which these variables accounted for the spatial auto-correlation. If these covariates were themselves spatially correlated, and related to the social outcome of interest, they would reduce the extent of auto-correlation among the levels and slopes of the gradients. From this perspective, spatial auto-correlation is welcome, as it opens up the possibility of identifying new risk and protective factors, and testing hypotheses about causal mechanisms in a more powerful way. Some of the most important factors related to social outcomes may have explicit spatial characteristics, such as a family's proximity to a neighbourhood park, or the distance a child must travel to a local school. One of the assumptions underlying the relative deprivation hypothesis in population health research is that an individual's feeling of being relatively deprived, and the accompanying feelings of lacking control over one's life (Syme, 1996) or being socially isolated (House, Williams, & Kessler, 1987), contribute to the relative deprivation effect. If this is the case, then one could also test hypotheses about the effects of relative deprivation measured locally (Gatrell, 1997); for example, by estimating the effects of a measure of the difference between the SES of a community and the average SES of its neighbouring communities. It is these kinds of analyses that are required to resolve the relative deprivation debate discussed above.

**3.9.1 An example.** For the example used in this study, it is not particularly interesting to examine the spatial auto-correlation hypothesis with respect to the location of the 23 communities. However, the UEY data provide an opportunity to examine the hypothesis as it pertains to local neighbourhoods. For these data, the enumeration area (EA) where each child resided was available. The EA is a geographical unit which on average comprises about 400 families. For each of the five UEY sites, the extent of auto-correlation among the levels of the socioeconomic gradients was estimated, following the procedures above. (There were insufficient data within each EA to obtain accurate estimates of the within-EA slopes, and thus these were treated as fixed effects.) The correlations between estimated levels (the  $\beta_0$ 's of equation 3) and the average of the estimated levels of the contiguous EAs for each community were as follows: Southwest

Newfoundland: -0.043; Prince Edward Island: 0.018; children served by a school district in the inner city of Winnipeg, Manitoba: 0.050; Prince Albert, Saskatchewan: -0.049; and the area of Coquitlam, British Columbia: -0.038. In all cases, the correlation coefficients were not statistically significant. These rather disappointing findings are discussed in the concluding section.

### 3.10 The Hypothesis of Stable Gradients

*Socioeconomic gradients tend to be stable over time.*

This hypothesis is that societies establish certain *tolerable equilibria* for inequalities in social outcomes, which are maintained by powerful economic and political forces. Research on the relationship between health outcomes and wealth has shown that certain diseases, including lung cancer, heart disease, and HIV infection, were initially diseases of the rich, but over time became diseases of the poor, with a socioeconomic gradient consistent with other diseases (Deaton, 2002; Preston, 1974). Research on schooling suggests that there are similar forces at play which result in a stability of socioeconomic gradients. Heath (1990) argued that the gap in educational attainment in Britain had been relatively constant throughout the twentieth century. However, McPherson and Willms (1986) showed that the comprehensive school reforms of the late 1960s and early 1970s, which called for the abolishment of selective schooling in favour of comprehensive schools, had the effect of raising and flattening socioeconomic gradients. The analyses were based on longitudinal data for Scotland where the reform was embraced by all local educational authorities (McPherson & Willms, 1986). Despite the success of comprehensive reforms, the Thatcher Government introduced parent choice of schools in 1980 which allowed parents to choose schools outside their designated catchment areas. They observed that middle class parents were more likely to exercise choice, and that they disproportionately chose schools with high social-class intake (Echols, McPherson, & Willms, 1990; Willms & Echols, 1992). This may well have pulled socioeconomic gradients back towards the equilibria described by Heath.

An assessment of the stability of socioeconomic gradients requires data describing the same communities over time (see Willms & Raudenbush, 1989). For example, school

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districts often collect achievement data annually or biennially for all students at particular grade levels. Similarly, it will be possible to assess changes in socioeconomic gradients for school performance for countries participating in the OECD PISA, as comparable data are being collected triennially (OECD, 2001).

**3.10.1 Statistical Analysis.** The statistical analysis for data collected at two time points is straightforward. One simply creates a dummy variable at the individual level denoting whether the individual was sampled at time 1 or time 2. One then simply stacks the data for the two cohorts, with the appropriate community-level identifier to link data by community. At the individual level, one then sets out a model similar to equation 15:

$$Y_{ij} = \beta_{0j} + \beta_{1j} X_{ij} + \beta_{2j} W_{ij} + \beta_{3j} X_{ij} W_{ij} + r_{ij} \quad (21)$$

where  $X_{ij}$  is SES,  $W_{ij}$  is a dummy variable denoting year (e.g., base year = 0; follow-up = 1), and  $X_{ij} W_{ij}$  is the SES-by-year interaction. The  $\beta_{2j}$ 's represent the changes in the *level* of the gradient from baseline to follow-up, and are expressed as an average increase (or decrease),  $(\beta_{20})$ , plus the deviation of each community's  $\beta_{2j}$  from the average. The  $\beta_{3j}$ 's represent the changes in the *slope* of the socioeconomic gradient, and are expressed as an average change,  $(\beta_{30})$ , plus the deviation of each community's  $\beta_{3j}$  from the average. The hypothesis of stable gradients is then:

$$\begin{aligned} H_0: \gamma_{20} &= 0 \\ H_1: \gamma_{20} &\neq 0 \end{aligned} \quad \text{Hypothesis of Stable Levels (22)}$$

and

$$\begin{aligned} H_0: \gamma_{30} &= 0 \\ H_1: \gamma_{30} &\neq 0 \end{aligned} \quad \text{Hypothesis of Stable Slopes (23)}$$

When data for three or more successive cohorts are available, one can introduce cohort as a level in the analysis, such that one has children within communities, communities

over time, and communities. These models can afford very powerful tests of the effects of community level factors, as one can then estimate whether *changes* in community-level factors are related to *changes* in childhood outcomes. These models are discussed by Willms & Raudenbush (1989). An example of the test for stable gradients based on the NLSCY data is provided by Willms (2001d).

## 4. Summary and Discussion

This report suggests a definition of socioeconomic gradients, and sets out ten hypotheses about gradients and community differences relevant to policy research in the areas of child development, education, and population health. Weaved within the discussion of the ten hypotheses is a presentation of a set of analyses concerning children’s vocabulary development, based on analyses of data from Canada’s National Longitudinal Study of Children and Youth and the Understanding the Early Years survey. The findings of these analyses have implications for social policy, and for future academic research. The principal findings are summarised in Table 2, and discussed further below:

**Table 2. Ten Hypotheses regarding Socioeconomic Gradients for Children’s Receptive Vocabulary**

Hypothesis	Accepted or Rejected?	Comments
Socioeconomic Gradient	Accepted	Strong evidence
Community Differences	Accepted	Strong evidence
Diminishing Returns	Accepted	Statistically significant, but a weak relationship
Converging Gradients	Rejected	Inconsistent with research on youth literacy skills
Double Jeopardy	Rejected	Needs to be examined further with smaller units of analysis
Relative Deprivation	Rejected	Needs to be examined with spatially-related measures
SES by Group-Status Interactions	Accepted	Results apply only to immigrants versus non-immigrants; needs to be examined further with other measures of group status
Family and Community-Level Mediators	Accepted	Family and community factors mediate the relationship between vocabulary skills and SES, but largely operate as independent factors
Spatial Auto-Correlation	Rejected	Needs to be examined further with a wide range of outcomes and covariates
Stable Gradients	Not tested	Related research suggests gradients are relatively stable, but can be altered through public policy and the people’s efforts

**(1) Children’s receptive vocabulary is related to socioeconomic status.** On average, across 23 Canadian communities, the slope is 4.57. This means that a child of low SES (e.g., with a family SES score at -1.0, or about the 16<sup>th</sup> percentile) would have an expected score that was about 9 points lower than a high

SES child (e.g., with a family SES score of 1.0, or about the 84<sup>th</sup> percentile.) This is a large difference — a difference of 9 points in receptive vocabulary could have a substantial effect on children’s skills upon entry to school.

Although there is a strong relationship, a child’s socioeconomic status is far from being deterministic of a child’s receptive vocabulary. For the full NLSCY sample, which is representative of all Canadian children, SES explains less than 9% of the variation in children’s vocabulary scores. Figure 1 shows that while there are many children living in low SES families with low scores, the majority of them have scores above 85, which is commonly seen as a vulnerability cut-off score. Similarly, there are several children from high SES families whose scores are quite low. Indeed, the majority of children with scores below 85, are from average and above-average SES families. These results emphasize the need for universal interventions aimed at improving the early literacy skills of all children, rather than targeted interventions aimed particularly at low SES families. (See also Willms, 2002a).

- (2) There are large and statistically significant differences among Canadian communities in the level of children’s vocabulary skills.** The gap in vocabulary scores between the lowest and highest scoring communities was more than 10 points. This difference is not simply attributable to sampling error, as there were sufficiently large samples in each community to achieve accurate estimates. Moreover, a difference of about the same magnitude remained after controlling for SES and sampling error (see Figure 2).

These differences among communities are very large, and as with differences associated with SES, a difference of this magnitude could have substantial effects on children’s learning during the schooling years. The analyses which follow in the paper explain some of these differences, but overall there is not a good explanation about why communities differ to this extent. These findings call for further research that examines children’s outcomes across a range of outcomes, at differing ages, and across time.

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- (3) **Socioeconomic gradients are linear in nearly all communities.** The average socioeconomic gradient for these communities was slightly curvilinear, supporting the hypothesis of diminishing returns. However, the relationship was weak, such that it is not possible to identify a low SES threshold that could be used to target certain families for interventions. Moreover, the relationship between vocabulary scores and SES was also linear in nearly all communities.
- (4) **The gradients do not converge at higher levels of SES.** Although analyses of literacy skills for youth have indicated a pattern of converging gradients, the gradients for early vocabulary skills are remarkably parallel. Thus, one cannot identify communities which have particularly low early literacy scores for low SES children but not high SES children, or vice-versa.
- (5) **There is no evidence of double jeopardy in children's early vocabulary skills.** The hypothesis was that children from low SES families who also lived in low SES communities would have lower vocabulary scores than comparable children living in high SES communities. This hypothesis did not hold; in fact, the effect of community SES was in the opposite direction, indicating that on average children's vocabulary scores, after adjusting for SES, were higher in low SES communities than in high SES communities.
- (6) **There is no evidence of a relative deprivation effect for children's early vocabulary scores.** Children's vocabulary scores were not related to the amount of variation in SES within each community. This relationship could be examined further, with measures of deprivation assessed using spatial techniques at the local level.
- (7) **Children whose families had immigrated within the past ten years scored on average about 13.7 points lower than children in non-immigrant families.** This is a substantial gap, which could result in some children having a relatively slow start during the first few years of elementary school. The findings suggest



that the gap may be greater for low SES families, but the interaction term was not statistically significant. This is a case which calls for a targeted intervention, and many school districts have special programs for children whose first language is not the language of instruction.

- (8) The four most important family and community factors related to children's early vocabulary skills, aside from SES and number of siblings, were the amount that parents read to their child, the extent to which the family functioned as a cohesive unit, the degree of social support in the neighbourhood, and the stability of the neighbourhood.** These factors operated mainly as independent factors, alongside SES; that is, they only partially mediated the SES gradient. They also show that it is not possible to identify a single factor that can be the focus of social policy at the municipal, provincial, or national levels. Rather there are several factors which by themselves have a fairly small effect, but taken together can have a rather substantial effect on children's vocabulary.
- (9) There is no evidence of spatial auto-correlation at the neighbourhood level, after accounting for SES.** One might expect that there are factors such as effective literacy or parenting practices that are diffused from one neighbourhood to its neighbouring communities, which would result in a strong observed auto-correlation. However, this was not the case. The results suggest that neighbourhoods operate largely independent of one another. It may be that the neighbourhood, defined using enumeration areas, is the wrong unit of analysis. At a more macro-level, such as provinces, there is certainly a spatial correlation for many childhood outcomes (Willms, 2002a). Further analyses are required which take a more macro approach to examining spatial variation across communities and provinces.

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**(10) Gradients are not immutable; they can be altered through policy and reforms, and through the efforts of families and children.** This paper did not examine longitudinal trends in SES gradients. However, gradients can be altered through public policy and reform, and through the efforts of concerned citizens. In New Brunswick for example, the provincial government launched a comprehensive program of early childhood reforms, including: prenatal screening and intervention; postnatal screening and intervention; preschool clinics at 3.5 years of age; home-based early intervention services; integrated daycare services; social work prevention services; and home economic services. A detailed analysis of *changes* in socioeconomic gradients for children's developmental outcomes in New Brunswick indicated that the prevalence of low birth weight, prenatal complications, and the motor and social development of New Brunswick's babies decreased during the first few years of the program (Willms, 2000). The analyses in this report point to several factors that are related to the level and slope of socioeconomic gradients, suggesting that it is feasible to direct social policy for children at raising and leveling gradients, at local, provincial, and national levels.

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