How Health Status Affects Progress and Performance in School

A Population-based Study

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ABSTRACT

Objective: To assess the effects of health status at birth and health status in the preschool years on educational outcomes to age 9 in a population-based birth cohort.

Methods: Administrative data were used to follow all children born to Winnipeg mothers in 1990, and remaining in Manitoba until September 2004 (N=5,873). A structural equation model was used, incorporating latent variables to represent Health Status at Birth, Major Illness and Minor Illness during the preschool years. The model also included the child's sex and exact age, along with a number of social, economic, and demographic characteristics of the child's family. The outcome was a combination of marks on Grade 3 Standards Tests and enrolment in the appropriate grade for age.

Results: Major Illness in the preschool years had a significant influence on progress and performance in school ($p=0.0003$), predicting 1.26% of the variation in the outcome. Minor Illness was weaker but still significant ($p<0.01$). Health Status at Birth was not directly related to the outcome; its effect was mediated by Major and Minor Illness in childhood. Overall, the strongest predictors were the child's age and the area-level income, followed by the mother's age, family receipt of income assistance, the sex of the child, breastfeeding initiation (all $p<0.0001$), and Major Illness.

Conclusions: Health status plays a statistically significant but substantively small role in explaining progress and performance in school among a population-based cohort. Major Illness was more important than Minor Illness, and these two factors completely mediated the influence of Health Status at Birth on the outcome. The strength of the social, economic, and demographic variables underscores the importance of the broader factors that affect both health and educational outcomes.

Key words: Child health; health status; health services; social determinants; health policy

La traduction du résumé se trouve à la fin de l'article.

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Educational outcomes for young children are known to be affected by many factors, including a variety of psychological, educational, and sociological characteristics of the child, the family, the school system, and the environment in which the child is being reared. However, the influence of health status on educational outcomes has not been extensively documented.

Studies of 'general' health status and school achievement have shown consistent but relatively weak associations.¹⁻⁴ Similarly, numerous investigators have reported statistically significant but substantively modest associations between birthweight or gestational age and subsequent cognitive performance.⁵⁻¹¹ Other investigators focused on health status later in childhood,¹²⁻¹⁶ or specific diseases,¹⁷⁻²⁰ and reported mixed results.

No published studies have incorporated longitudinal measures of health status, so could not assess whether health status at birth and health status later in childhood have independent or overlapping effects. Furthermore, previous studies have not distinguished between levels of illness severity, and few have been conducted in Canada.

The objective of this study was to address those gaps, while including key social, economic and demographic factors known to affect both health and educational outcomes. The null hypothesis is that health status at birth and through the preschool years does not significantly influence educational outcomes. This study used a uniquely rich and comprehensive provincial data system to assess these relationships within a contemporary Canadian context.

METHODS

This study used a historical prospective design, in which a birth cohort was followed using de-identified person-level administrative data housed at the Manitoba Centre for Health Policy, a research unit within the Faculty of Medicine, University of Manitoba. The data system is comprehensive and universal, and its quality and validity have been described.²¹ The project was approved by the Health Research Ethics Board of the University of Manitoba (H2005:113) and by the Health Information Privacy Committee of Manitoba Health (2005/06-11).

Population-based study group

All singletons born to Winnipeg mothers in 1990 (N=8,903) were followed to June 1999 for outcomes at the end of the Grade 3 year, along with progression to Grade 9 entry in September 2004. The only exclusions were children who died (n=86), moved out of the city (n=2,862), or had missing data (n=82). The final analysis was based on 5,873 children.

Explanatory variables

Three health constructs were developed as latent variables, each derived from several related measures. Health Status at Birth was comprised of birthweight, gestational age, length of hospital stay at birth, and use of intensive care during birth hospitalization. Major Illness included the number of days in hospital between birth discharge and the child's fifth birthday, use of Intensive Care Units in that period, and the sum of annual assignments to Major Adjusted Diagnostic Groups (ADGs; using the Johns Hopkins grouper^{22,23} on each child's physician visit and hospitalization records). Minor Illness combined the number of physician visits from birth discharge to fifth birthday and the sum of annual assignments to Minor ADGs. Details regarding these constructs (loadings, etc.) are contained in the Technical Appendix.

Both Major Illness and Minor Illness were conceptualized as constructs which could have direct effects on the outcome, and possibly mediate the relationship between Health Status at Birth and the outcome.

Each child's sex and exact age (to the day) were also entered into the model, along with the following social, economic and demographic characteristics: the number of children in the family as of the study child's 8th birthday; the mother's age at the birth of her first child; whether breastfeeding was initiated before discharge from hospital; whether there was any indication that the child's mother experienced depression during the child's preschool years (as recorded in physician claims or hospital abstract diagnoses); whether the family ever received Income Assistance; the number of times the family moved by the child's 8th birthday; the mother's marital status as of the child's 5th birthday; and the average household income of the Census Enumeration Area

TABLE I

Descriptive Statistics for Study Group and Those Lost to Follow-up

	Study Group	Movers	Deaths	Missing Data
Number of children	N = 5873	n = 2862	n = 86	n = 82
Variable	Mean (S.D.)	Mean (S.D.)	Mean (S.D.)	Mean (S.D.)
Health Status at Birth				
Preterm birth (% <37 weeks)	5.02	5.17	46.5*	24.3*
Low birthweight (% <2500 g)	4.54	4.75	43.0*	17.6*
Long stay in hospital (%)	5.94	5.97	24.4*	9.46
3+ days in Intensive Care Unit (%)	4.44	4.57	18.6*	5.41
Major Illness in Childhood				
2+ Major Adjusted Diagnostic Group-years (%)	8.41	N/A	N/A	N/A
6+ days in hospital (%)	4.05	N/A	N/A	N/A
Admitted to Intensive Care Unit (%)	1.29	N/A	N/A	N/A
Minor Illness in Childhood				
Number of physician visits	38.27 (19.6)	N/A	N/A	N/A
Above 90% Minor Adjusted Diagnostic Group-years (%)	8.1	N/A	N/A	N/A
Social, Economic and Demographic Variables				
Age of child on test day (years)	8.9 (.28)	N/A	N/A	N/A
Area-level average household income	\$43,614 (17,323)	\$40,434* (16,251)	\$39,532 (15,768)	\$35,772* (15,290)
Mother's age at first birth (years)	25.3 (5.09)	23.8* (4.97)	23.3 (5.58)	22.7* (5.43)
Family received Income Assistance (%)	13.6	N/A	N/A	N/A
Sex of child (% male)	51.4	51.9	54.7	44.6*
Breastfeeding initiated at birth (%)	75.2	75.1	33.7*	56.7*
Family has 5+ children (%)	3.93	N/A	N/A	N/A
Maternal depression (%)	26.1	N/A	N/A	N/A

* significantly different from Study Group (p<0.01)
N/A = data not available

where the child's family lived on the child's 5th birthday.

Outcome variable: Progress and performance in school

The outcome variable combined marks on mandatory Standards Tests in Grade 3 Mathematics and Language Arts with information from school enrolment records, because not all children were in Grade 3 and completed the tests. To keep all children in the analysis, a LOGIT transformation was used to generate an outcome score for each child on a single, continuous scale. Details of this transformation are provided in the Appendix.

Statistical analysis

Structural equation modeling (SEM) was used, to allow incorporation of the latent variables and the longitudinal design. All of the social, economic and demographic factors (except child age) were also tested for mediation effects acting through the Major and Minor Illness constructs. The analysis was performed in SAS Version 9, using PROC CALIS. Details of the final model are contained in the Appendix.

RESULTS

Table I shows the descriptive characteristics for the study group and the excluded groups. Children whose families moved before complete data could be obtained were not statistically different from study children on Health Status at Birth. Children who died or had missing data were less healthy at birth than the study group, but represent less than 1.9% of the birth cohort.

The final model

The final structural equation model provided excellent fit to the data and explained 18.6% of the variance in the outcome measure. Most of the explanatory variables entered in the analysis were significant predictors of the outcome, as shown in Figure 1.

Influence of health-related factors

The Major Illness construct alone explained 1.26% of the variation in progress and performance in school (p=0.0003). Minor Illness was also independently related to the outcome, though weaker, explaining 0.15% of the outcome

Figure 1. Conceptual model with results from final analysis

Numbers above lines are standardized coefficients from final structural equation model. Variables significantly related to the outcome are numbered 1-9 in order of strength of direct association with the outcome.

* $p < 0.01$ ** $p < 0.001$

($p < 0.01$). Health Status at Birth was not directly related to the outcome; its influence was completely mediated by Major Illness and Minor Illness in the preschool years.

Influence of social, economic and demographic factors

Almost all of the social, economic and demographic factors were significant predictors of progress and performance in school, and most were more strongly related to the outcome than were the health factors. Better outcomes were related to the following characteristics, in order of importance: children who were older (born earlier in the year); those living in higher income areas; children born to older mothers; those in families which never received income assistance; girls; children breastfed at birth (all $p < 0.0001$); and those in smaller families ($p < 0.01$). Conversely, residential mobility, mother's marital status and maternal depression were not significantly related to the outcome directly.

Maternal depression, the sex of the child, family receipt of income assistance

and area-level income also had influences on the outcome mediated through Minor Illness (see Figure 1).

DISCUSSION

The results of this study suggest that early health status, particularly experience with a Major Illness, is significantly associated with progress and performance in school. This is consistent with the findings of previous studies using either health status at birth⁵⁻¹¹ or health status later in childhood.^{1,12-16} However, the results show that the role of Health Status at Birth is completely mediated by Major Illness and Minor Illness. This means that poor Health Status at Birth is related to later cognitive outcomes only because of its association with Major and Minor Illness later in childhood, rather than having a direct relationship with the outcome, as implied by previous research. This finding underscores the importance of incorporating longitudinal measures of health status in the analysis.

The 18.6% of outcome variance explained by the final model is comparable

to the 21% explained by the multilevel model developed by Tremblay et al.²⁴ analyzing Grade 3 performance in Ontario, which incorporated student, classroom, teacher and school-level influences. These relatively modest figures suggest that both studies were missing important variables affecting student outcomes (for example, each student's cognitive ability). Other investigators have reported similar effect sizes,²⁵⁻²⁷ which in Cohen's categorization would qualify as a 'medium' effect.²⁸

In our results, older children (those born earlier in the year) had better outcomes than younger children, which is consistent with previous research.²⁹⁻³² The importance of household income is also consistent with previous reports,^{18,24,25,33,34} though this may be more related to characteristics of the environment in which the child is reared, particularly parenting practices and behaviours,³⁵⁻³⁹ rather than an effect of income *per se*. The significance of the mother's age is also consistent with previous findings (see review by Elfenbein & Felice⁴⁰), as is family receipt of Income Assistance benefits.^{18,41-45} In this study, as

in most studies of early child development, girls had slightly better outcomes than boys.^{24,46-48} Finally, the importance of Major Illness is consistent with findings from smaller and clinical studies suggesting that children with disabilities or neurological disorders have the poorest outcomes in terms of later cognitive and educational performance.^{6,15,49,50} The results of this study extend these findings to a large, population-based study group.

Rather than defining the analysis group as children with Standards Test scores, this study used a birth cohort with few exclusion criteria. As Brownell et al. reported, a significant portion of children do not reach Grade 3 'on time', especially among those living in disadvantaged areas.⁴⁸ The inclusion of all births strengthens the analysis because it incorporates the likelihood that a child's absence, exemption from the test, or failure to progress to Grade 3 on time might have been related to their health status.

Limitations

There are several limitations of this study. The use of administrative data provides population coverage, but limits the availability of relevant variables; for example, each child's cognitive ability and motivation. Recording bias in health service records may also be present, potentially affecting several measures (e.g., mother's use of health services for Depression may not always be recorded as such). The use of area-level instead of household-specific income level is a weaker limitation, because the relationships have been shown to be similar,⁵¹ and the Income Assistance variable was family-specific. Furthermore, the aggregate measure may be capturing true area-level influences. Confounding always remains a potential threat, as variables not included in the analysis may be responsible for the reported relationships. Finally, because this study was limited to singleton births, the relationships may differ for children of multiple births.

CONCLUSIONS

Health status in the preschool years has a statistically significant but substantively small effect on progress and performance in school, except that children experiencing Major Illness are at significantly higher

risk. The strong linkage between Major Illness and Health Status at Birth suggests that many of these children could be identified early. The overwhelming strength of the social, economic and demographic factors underscores the continuing need to address the broader social determinants of health and educational outcomes, including the development of a comprehensive program for early child health and development.

REFERENCES

- Powney J, Malcolm H, Lowden K. *Health and Attainment: A Brief Review of Recent Literature*. Report No: 101. Edinburgh: Scottish Council for Research in Education, 2000.
- Bloch A. Chronic illness and its impact on academic achievement. *Pediatrician* 1986;13(2-3):128-32.
- Schlieper A. Chronic illness and school achievement. *Dev Med Child Neurol* 1985;27(1):75-79.
- Bailey-Britton AM. The relationship between health and academic performance in school-age children. *Issues Compr Pediatr Nurs* 1987;10(5-6):273-89.
- Record RG, McKeown T, Edwards JH. The relation of measured intelligence to birth weight and duration of gestation. *Ann Hum Genet* 1969;33(1):71-79.
- Drillien CM, Thomson AJ, Burgoyne K. Low-birthweight children at early school-age: A longitudinal study. *Dev Med Child Neurol* 1980;22(1):26-47.
- Lagerstrom M, Bremme K, Eneroth P, Janson CG. School marks and IQ-test scores for low birth weight children at the age of 13. *Eur J Obstet Gynecol Reprod Biol* 1991;40(2):129-36.
- Seidman LJ, Buka SL, Goldstein JM, Horton NJ, Rieder RO, Tsuang MT. The relationship of prenatal and perinatal complications to cognitive functioning at age 7 in the New England Cohorts of the National Collaborative Perinatal Project. *Schizophr Bull* 2000;26(2):309-21.
- Matte TD, Bresnahan M, Begg MD, Susser E. Influence of variation in birth weight within normal range and within sibships on IQ at age 7 years: Cohort study. *Br Med J* 2001;323(7308):310.
- Richards M, Hardy R, Kuh D, Wadsworth ME. Birth weight and cognitive function in the British 1946 birth cohort: Longitudinal population based study. *Br Med J* 2001;322(7280):199.
- Jefferis BJMH, Power C, Hertzman C. Birth weight, childhood socioeconomic environment, and cognitive development in the 1958 British birth cohort study. *Br Med J* 2002;325(7359):305.
- Fowler MG, Johnson MP, Atkinson SS. School achievement and absence in children with chronic health conditions. *J Pediatr* 1985;106(4):683-87.
- Wolfe BL. The influence of health on school outcomes. A multivariate approach. *Med Care* 1985;23(10):1127-38.
- Fowler MG, Cross AW. Preschool risk factors as predictors of early school performance. *J Dev Behav Pediatr* 1986;7(4):237-41.
- Cadman D, Walter SD, Chambers LW, Ferguson R, Szatmari P, Johnson N, McNamee J. Predicting problems in school performance from preschool health, developmental and behavioural assessments. *CMAJ* 1988;139(1):31-36.
- Denton K, West J. *Children's Reading and Mathematics Achievement in Kindergarten and First Grade*. Washington, DC: National Center for Education Statistics, 2002.
- Bender BG. Are asthmatic children educationally handicapped? *School Psychology Q* 1995;10(4):274-91.
- Byrd RS, Weitzman M. Predictors of early grade retention among children in the United States. *Pediatrics* 1994;93(3):481-87.
- McCarthy AM, Lindgren S, Mengeling MA, Tsalikian E, Engvall J. Factors associated with academic achievement in children with type 1 diabetes. *Diabetes Care* 2003;26(1):112-17.
- Hagen JWB. Intellectual functioning and strategy use in children with insulin-dependent diabetes mellitus. *Child Dev* 1990;61(6):1714.
- Roos LL, Gupta S, Soodeen R, Jebamani L. Data quality in an information-rich environment: Canada as an example. *Can J Aging* 2005;24(Suppl 1):153-70.
- Starfield B, Weiner J, Mumford L, Steinwachs D. Ambulatory care groups: A categorization of diagnoses for research and management. *Health Serv Res* 1991;26(1):53-74.
- Weiner JP, Starfield BH, Steinwachs DM, Mumford LM. Development and application of a population-oriented measure of ambulatory care case-mix. *Med Care* 1991;29(5):452-72.
- Tremblay S, Ross N, Berthelot J-M. *Factors Affecting Grade 3 Student Performance in Ontario: A Multilevel Analysis*. Report No: 81-003. Statistics Canada, 2001.
- White KR. The relation between socioeconomic status and academic achievement. *Psychol Bull* 1982;91(3):461-81.
- Ma X, Klinger DA. Hierarchical linear modelling of student and school effects on academic achievement. *Can J Educ* 2000;25(1):41-55.
- Caldas SJ, Bankston III C. Effect of school population socioeconomic status on individual academic achievement. *J Educ Res* 2001;90(5):269-77.
- Cohen J. *Statistical Power Analysis for the Behavioral Sciences*, second edition. Hillsdale, NJ: L. Erlbaum Associates, 1988.
- Sweetland JD, DeSimone PS. Age of entry, sex, and academic achievement in elementary school children. *Psychology in the Schools* 1987;24(4):406-12.
- Breznitz Z, Teltsch T. The effect of school entrance age on academic achievement. *Psychology in the Schools* 1989;26(1):62-68.
- Morrison FJ, Griffith EM, Alberts DM. Nature-nurture in the classroom: Entrance age, school readiness, and learning in children. *Dev Psychol* 1997;33(2):254-62.
- Elkin L. *Class of 1979 Project: Longitudinal Implications of School Entry Variability in Readiness*. Regina, SK: University of Regina, 2001.
- Wang MC, Haertel GD, Walberg HJ. Toward a knowledge base for school learning. *Rev Educ Res* 1993;63(3):249-94.
- Suter LE. Is student achievement immutable? Evidence from international studies on schooling and student achievement. *Rev Educ Res* 2000;70(4):529-45.
- Hoff-Ginsberg E. Mother-child conversation in different social classes and communicative settings. *Child Dev* 1991;62(4):782.
- Hart BJ, Risley TR. *Meaningful Differences*. Baltimore, MD: Paul H. Brookes Publishing, 1995.
- Huttenlocher J. Language input and language growth. *Prev Med* 1998;27(2):195-99.
- Yeung WJ, Linver MR, Brooks-Gunn J. How money matters for young children's development: Parental investment and family processes. *Child Dev* 2002;73(6):1861-79.
- Linver MR, Brooks-Gunn J, Kohen DE. Family processes as pathways from income to young chil-

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Technical Appendix

Preliminary analyses

Before the main structural equation modeling was initiated, a number of preliminary analyses were performed on several of the explanatory variables.

Latent Variables for Health Status

The initial conceptual model for this study contained only one latent variable representing health status in the preschool period, which was related to all five manifest variables listed below. These measures of health service use were used as indicators of health status, in accordance with previous research,^{22,52-54} and based on their demonstrated validity in the data repository at MCHP.²¹

Manifest Variables

- the number of physician visits from birth discharge until the child's 5th birthday
- the number of hospital days from birth discharge through 5th birthday
- use of intermediate or intensive care units (at any time)
- the number of Minor ADG-years for that child, from birth through 5th birthday*
- the number of Major ADG-years for that child, from birth through 5th birthday.*

However, a preliminary factor analysis revealed that these five measures loaded onto two distinct factors, one labelled Minor Illness, and the other Major Illness. The loading values for these constructs and the 'Health Status at Birth' construct were all above the recommended value of 0.4, and most were above 0.6, as shown in Table A1.

Table A1: Loading Values of Manifest Variables on Latent Constructs

Manifest Variable	Health Status at Birth	Minor Illness	Major Illness
Preterm birth	.7258		
Low birthweight	.6763		
ICU use (birth)	.7605		
Long hospital stay at birth	.7075		
Physician visits		.8250	
Minor ADGs		.6731	
Major ADGs			.5007
Hospital days			.4834
ICU use (preschool)			.4268

Social, Economic, and Demographic Variables

A number of variables were available to describe the environment within which each child was being reared. For several variables, values could be specified at any time during childhood. Therefore, those for which it made most sense to measure total cumulative exposure from birth were measured as of the child's 8th birthday: the number of children born to the child's mother; the number of residential moves recorded for the child's family; and whether the mother was diagnosed with depression during any physician visits or hospitalizations. Those for which effects were hypothesized to require a period of time to have an effect on educational outcomes were measured as of the child's 5th birthday: the average household income of the area where the child's family lived; and the mother's marital status. Data indicating whether the family received income assistance were only available for the period January 1995 through December 1998. Therefore, a variable was created to indicate whether the child's family ever received income assistance from the child's 5th through his or her 8th birthday. Mother's age at the birth of her first child was a constant. A factor analysis was performed to reduce the number of variables required in the final model, but revealed inadequate correlations among the variables to create a small number of strong factors. Therefore, all these variables were entered into the final models as separate variables.

Outcome measurement

The main outcome variable combined information from school enrolment records and results from mandatory Standards Tests in Grade 3 Mathematics and Language Arts. Most of the children (4,821/5,873) completed the standards tests, and their outcome value was the average of their two test scores (after transformation as described below). The remaining children were either exempt from writing (n=391 children, primarily with cognitive disabilities), enrolled in Grade 2 or lower (n=275), or started but did not complete the tests (n=386). It was important to include these children in the analysis, to determine whether their school performance was related to health problems. A single outcome score was generated for each child using a LOGIT transformation.^{55,56}

The LOGIT transformation provided a valid method to combine students who had test scores with students who did not. Groupings of students were

* For the ADG measures, each child was assigned to Major and Minor ADGs for each of the first five years of life. The sum of these assignments was used to calculate the number of Minor ADG-years and the number of Major ADG-years for each child from birth through 5th birthday.

created based on the subcategories of the groups listed above (e.g., there were several subcategories of exemptions), and using decile groupings for those with tests scores (e.g., 0-10%, 11-20%, etc.). The groups were then ranked according to the proportion of students in each group who enrolled in Grade 9 by September 2004 as expected (except those exempted for cognitive disabilities, who were designated as the lowest outcome group). All groups were then 'placed' into a bell curve in proportion to their size, thus filling in the area under the curve which represented all 5,873 children in the analysis. This distribution then provided standardized scores for each child. For example, children exempted due to cognitive disabilities were all assigned the z score of -2.27; children in Grade 2 received a score of -1.42; those who averaged 70% on the tests received a score of +1.81, and those who averaged 100% received a score of +2.79.

Relationships among explanatory variables and outcome

Table A2 shows the results of regression models between each explanatory variable and the final outcome. Virtually all explanatory variables demonstrated significant correlations, emphasizing the need for multivariate analysis to sort out the independent and overlapping effects of these variables.

Table A2: Univariate Regressions Between Each Predictor Variable and Progress and Performance in School

Variable	Coefficient	Std Error	Standardized Coefficient	R ² (%)
<i>Health-related constructs</i>				
Major Illness	-.79334	.10231	-.10069	1.01
Minor Illness	-.34071	.04409	-.10033	1.00
Health Status at Birth	-.40378	.07763	-.06773	0.46
<i>Social, economic, and demographic variables</i>				
Family receipt of income assistance	-.74568	.03430	-.27297	7.45
Area-level income (in \$10,000 units)	.12187	.00567	.26989	7.28
Mother's age at birth of first child (yrs)	.04847	.00231	.26409	6.97
Family moved 5+ times in 8 years	-.70739	.05198	-.17487	3.06
Mother registered as married	.35963	.02643	.17485	3.06
Age of child (months)	.04240	.00357	.15300	2.34
Breastfeeding initiated at birth	.31188	.02798	.14398	2.07
Sex of child (0=female, 1=male)	-.23146	.02424	-.12365	1.53
Family had 5+ children	-.59202	.06234	-.12301	1.51
Mother depressed	-.15868	.02773	-.07446	0.55
p<0.0001				

The final structural equation model

The final model was created using the widely recommended two-step process developed by Anderson and Gerbing,⁵⁷ which involves creation and refinement of a measurement model, followed by the final causal model. Maximum likelihood estimation was used, and the requirement for multivariate normality was satisfied (value = 1.73). Covariances were specified among several pairs of variables to address large residuals. The final model provided excellent fit to the data: Bentler's Comparative Fit Index value was 0.9767 (above recommended minimum 0.95, as were all other fit index values); the Root Mean Square Residual was .0023, and the Root Mean Square Error of Approximation was .0274 (both recommended to be under 0.10). The model explained 18.6% of the total variation in the outcome measure, thus qualifying as a 'Medium' effect in Cohen's classical definition.²⁸

Mediation test

The mediating role of Major and Minor Illness is confirmed by the result for Health Status at Birth in Table A2. That is, without the Major and Minor Illness variables in the model, Health Status at Birth displayed a highly significant direct association with the outcome (p<0.0001). However, in the final model, which included Major and Minor Illness, the direct association between Health Status at Birth and the outcome was not significant (p>0.75). The relationships between Health Status at Birth and both Major and Minor Illness were significant (p<0.0001), and those variables were both significantly related to the outcome, indicating that the relationship between Health Status at Birth and progress and performance in school is completely mediated by Major and Minor Illness in the preschool years.

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dren's development. *Dev Psychol* 2002;38(5):719-34.

40. Elfenbein DS, Felice ME. Adolescent pregnancy. *Pediatr Clin North Am* 2003;50(4):781-800.

41. Duncan GJ, Brooks-Gunn J, Klebanov PK. Economic deprivation and early childhood development. *Child Dev* 1994;65(2 Spec No):296-318.

42. Haveman R, Wolfe BL. The determinants of children's attainments: A review of methods and findings. *J Econ Lit* 1995;33(4):1829-78.

43. Brooks-Gunn J, Duncan GJ. The effects of poverty on children. *Future Child* 1997;7(2):55-71.

44. Klebanov PK, Brooks-Gunn J, McCarton C, McCormick MC. The contribution of neighborhood and family income to developmental test scores over the first three years of life. *Child Dev* 1998;69(5):1420-36.

45. Smith JR, Brooks-Gunn J, Kohen D, McCarton C. Transitions on and off AFDC: Implications for parenting and children's cognitive development. *Child Dev* 2001;72(5):1512-33.

46. Willms JD. *Indicators of Mathematics Achievement in Canadian Elementary Schools*. Ottawa: Statistics Canada, 1996.

47. Van de gaer E, Pustjens H, Van Damme J, De Munter A. Effects of single-sex versus co-educational classes and schools on gender differences in progress in language and mathematics achievement. *Br J Sociol Educ* 2004;25(3):307-22.

48. Brownell M, Roos NP, Fransoo RR, Guevremont A. Is the class half empty? A population-based perspective on socioeconomic status and educational outcomes. *IRPP Choices* 2006;12(5):1-30.

49. Calame A, Fawer CL, Claeys V, Arrazola L, Ducret S, Jaunin L. Neurodevelopmental outcome and school performance of very-low-birth-weight infants at 8 years of age. *Eur J Pediatr* 1986;145(6):461-66.

50. McGrath M, Sullivan M. Birth weight, neonatal morbidities, and school age outcomes in full-term and preterm infants. *Issues Compr Pediatr Nurs* 2002;25(4):231-54.

51. Mustard CA, Derksen S, Berthelot J-M, Wolfson MC. Assessing ecologic proxies for household income: A comparison of household and neighbourhood-level income measures in the study of population health status. *Health and Place* 1999;5(2):157-71.

52. Starfield B, Hankin J, Steinwachs D, Horn S, Benson P, Katz H, Gabriel A. Utilization and morbidity: Random or tandem? *Pediatrics* 1985;75(2):241-47.

53. Diaz C, Starfield B, Holtzman N, Mellits ED, Hankin J, Smalky K, Benson P. Ill health and use of medical care. Community-based assessment of morbidity in children. *Med Care* 1986;24(9):848-56.

54. Gissler M, Hemminki E, Louhiala P, Jarvelin MR. Health registers as a feasible means of measuring health status in childhood – A 7-year follow-up of the 1987 Finnish birth cohort. *Paediatr Perinat Epidemiol* 1998;12(4):437-55.

55. Mosteller F, Tukey JW. *Data Analysis and Regression: A Second Course in Statistics*. Reading, MA: Addison-Wesley, 1977.

56. Willms JD. Social class segregation and its relationship to pupils' examination results in Scotland. *Am Sociol Rev* 1986;51(2):224-41.

57. Anderson JC, Gerbing DW. Structural equation modeling in practice: A review and recommended two-step approach. *Psychol Bull* 1988;103:411-23.

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RÉSUMÉ

Objectif : Évaluer les effets de l'état de santé à la naissance et au cours des années préscolaires sur les résultats pédagogiques jusqu'à 9 ans au sein d'une cohorte de naissance représentative.

Méthode : À l'aide de données administratives, nous avons suivi tous les enfants nés de mères vivant à Winnipeg en 1990 et habitant encore au Manitoba en septembre 2004 (N=5 873). Nous avons utilisé un modèle d'équations structurelles incorporant des variables latentes pour représenter l'état de santé à la naissance, et les maladies graves et bénignes contractées durant les années préscolaires. Le modèle indiquait aussi le sexe et l'âge exact de l'enfant, ainsi que certaines caractéristiques sociales, économiques et démographiques de sa famille. Le résultat final était la combinaison des notes obtenues aux examens standardisés de la 3^e année et de l'inscription dans une classe correspondant à l'âge de l'enfant.

Résultats : Les maladies graves contractées au cours des années préscolaires avaient une influence significative sur le cheminement et le rendement scolaires ($p=0,0003$), en prédisant 1,26 % de l'écart dans le résultat final. L'influence des maladies bénignes était plus faible, mais encore significative ($p<0,01$). L'état de santé à la naissance n'était pas directement lié au résultat; son effet était atténué par les maladies graves et bénignes durant l'enfance. Globalement, les prédicteurs les plus forts étaient l'âge de l'enfant et le revenu dans la région, suivis de l'âge de la mère, du fait que la famille touche une aide au revenu, du sexe de l'enfant, de l'allaitement maternel (tous ces facteurs, $p<0,0001$) et de l'existence d'une maladie grave.

Conclusion : L'état de santé jouait un rôle significatif, mais tout de même assez faible, dans le cheminement et le rendement scolaires au sein d'une cohorte représentative. L'effet des maladies graves était plus important que celui des maladies bénignes, et ces deux facteurs compensaient entièrement l'influence de l'état de santé à la naissance sur le résultat. La force des variables sociales, économiques et démographiques souligne l'importance des facteurs généraux qui touchent à la fois la santé et les résultats pédagogiques.

Mots clés : santé de l'enfant; état de santé; services de santé; déterminants sociaux; politiques de santé