# Epilepsy, school readiness in Canadian children: Data from the National Longitudinal Study of Children and Youth (NLSCY)

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# Epilepsy, school readiness in Canadian children: Data from the National Longitudinal Study of Children and Youth (NLSCY)

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## ARTICLE INFO

## ABSTRACT

*Purpose:* Utilizing data from the National Longitudinal Survey of Children and Youth (NLSCY) we evaluated the association between childhood epilepsy and health impairments on measures of school readiness employed in the survey.
*Methods:* Standard scores on the Peabody Picture Vocabulary Test-Revised (PPVT-R) were employed in a regression analysis to compare scores in children with and without epilepsy. We also examined the effect of impairments in any of the 8 domains of the Health Utilities index (HUI) on test scores.
*Results:* A total sample size of 39,130 children (20,044 males, and 19,086 female were included in the analysis, 33,560 children were administered the PPVT-R at a mean age of 4.5 years. There were 70 children with epilepsy, 21 had a score of 1 on the HUI, 21 were assessed to have a HUI < 1 (signifying health impairments in one or more of the 8 domains). In the remainder, the PPVT scores were missing. Using the Ordinary Least Squares (OLS) regression for continuous outcomes model for PPVT-R scores as the outcome variable, females scored 1.1 points higher ($\beta$ = 1.1, 95%CI 0.755, 1.444, $p$ = 0.000), children without epilepsy and HUI score of <1 scored 3.84 points lower ($\beta$ = −3.843 95%CI −4.232, −3.452, $p$ = 0.000). Children with epilepsy and a HUI score of 1 scored 9.90 points lower ($\beta$ = −9.902, 95%CI −16.343, −3.461, $p$ = 0.003) while those with epilepsy and HUI < 1 scored 17.30 lower ($\beta$ = −17.308, 95%CI −23.776, −10.839, $p$ = 0.000).
*Conclusion:* The data provide objective evidence that children with epilepsy are at risk of scholastic underachievement at school entry, while those with additional health impairments as measured by the HUI are at greater risk of underachievement.

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## 1. Introduction

Epilepsy is a chronic neurological disorder that affects children worldwide, with a prevalence of 4.03–5.26 per 1000 in Canada.[1] It has been shown to be significantly associated with co-morbidities such as cerebral palsy, developmental delay and intellectual and learning disabilities, and attention-deficit/hyperactivity disorder in several population based studies.[2–5] The report of the Institute of Medicine (IOM) published in 2012 examines the public health dimensions of epilepsy, and lists amongst the priorities for research in epilepsy, a specific focus on using public health surveillance data and population health research.[6] Few data exist on objectively measured outcomes in population-based surveys of epilepsy.

We used data from Canada's National Longitudinal Survey of Children and Youth (NLSCY) to examine the association between epilepsy, and the impact of associated health limitations as measured by the Health Utilities Index (HUI) on school readiness.

## 2. Methods

### 2.1. Survey tools used

The NLSCY was developed to track extrinsic socioeconomic and intrinsic family and personal factors influencing child development in Canada.[7] The first cohort of children included a sample size of 22,831 with an age range of birth to 11 years. This group of children was surveyed subsequently every 2 years (biennially), for a total of 8

cycles, terminating in 2008–2009. New samples of children from 0 to 2 years of age were added to each cycle, allowing for cross-sectional studies up to cycle 4, and longitudinal analysis up to cycle 8. The respondents form a representative sample of children and youth from Canada's ten provinces when sampling or bootstrap weights are applied.[8]

Children with epilepsy were identified through two questions: (1) Does the child have any of the following long-term conditions: Epilepsy?; (2) Does he/she take the following prescription medication on a regular basis: anti-convulsants or anti-epileptic pills?[7] A previous study used these two questions to compare prevalence rates of epilepsy from the NLSCY to clinical studies and found the estimates were comparable.[1]

Ethics approval for this project was obtained from the Health Sciences Research Ethics Board, Western University as well as Social Sciences Research Ethics Board. Statistics Canada has reviewed and permitted release of the results of this analysis.

### 2.2. Participants

Participants in the NLSCY were randomly selected from Canada's national household sampling frame. For each selected household, typically only one or two children would be surveyed between the ages of 0 and 11. A question was asked to identify the Person Most Knowledgeable (PMK) about the child, to answer most questions in the survey.

### 2.3. Data collection

Data was collected from the PMK and child (where applicable) through an interviewer's visit to the home where the interviewer administered the Peabody Picture Vocabulary Test-Revised (PPVT-R).

#### 2.3.1. Description of tests administered

In order to study the association between epilepsy and school readiness, we selected results of the PPVT-R as a measure. We also considered the possibility of children with epilepsy as a chronic condition having additional limitations that could lead to their either missing the PPVT-R or affecting negatively the scores on the PPVT-R. There is evidence from previously conducted population based studies that a significant proportion of children with epilepsy (as high as 35%) report impairments that include another developmental disability (cerebral palsy, mental retardation, hearing and visual impairment).[2] Such limitations could affect the administered test response adversely or may even limit the ability of the child to take the test.

*PPVT-R*: The PPVT-R is a test of school readiness evaluating the receptive vocabulary acquisition in 4–5 year old children, who are asked to match a picture to a word read out by the test instructor. This test was originally developed by Lloyd and Leota Dunn

(University of Hawaii); a French adaptation was created by the authors as well as Claudia M. Thériault-Whalen (St. Thomas University, Fredericton).[9] The PPVT-R is considered to be a leading assessment tool for testing general verbal ability and has been used in national longitudinal surveys across the United States, Canada and other OECD (Organization of Economic Cooperation and Development) countries. The test was normalized on a nationally representative sample of children and youth in both the US and Canada. Raw scores, standardized scores (mean 100, standard deviation 15) and percentile scores are provided.

In the present analysis we used responses pooled across cycles 1 through 8 for the PPVT-R, as it was a single time-point in any child's survey, administered only once to four to 5-year-olds. PPVT_R scores may have shown up as missing if the individual was unable to take the test for health impairments that were severe enough to prevent participation or other reasons.

### 2.4. Health Utilities Index (HUI)

HUI is a measure that classifies an individuals 's functional ability in eight domains of health: vision, hearing, speech, ambulation, dexterity, cognition, emotion and pain. A composite score for the HUI is derived using scores given to the 8 domains using an algorithm based on population norms, scores ranging from 0 to 1where the score of 1 represents (full health) while 0 represents a condition akin to death. The HUI was reported only once for children aged 4 and older in the NLSCY.[10,11] In cycles 1 and 2 of the NLSCY, HUI2 was used, and all subsequent cycles HUI3 version was used. We anticipated that the relationship between HUI scores in children with epilepsy and the PPVT-R scores to be non-linear. It was therefore decided to recode the HUI scores into dichotomous variables to demonstrate the effect.

### 2.5. Statistical analysis

For the statistical analysis of the PPVT-R OLS regression coefficients and 95% confidence intervals were computed with SPSS® (IBM Corp. Released 2012. IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp.) and a series of 1000 bootstrap weights were applied (Stata 12, ®StataCorp LP 1996–2013). The HUI composite score was recoded as a dichotomous variable with a score of less than 1 indicating less than perfect health and 1 indicating perfect health.

*PPVT-R*: A total of 39,130 children were surveyed, representing a population of 5,069,005 children. Of these, 70 children (4–5 years) were identified with epilepsy pooled across the 8 cycles of the NLSCY. There were more males than females in the sample (M: F, 51.2%: 48.8%). Scores on the PPVT-R ranged from 50–160. OLS linear regression was centered on the mean age (4.5 years) and PPVT mean score of 100. Missing data in the survey was accounted for in the regression model. There were a total 8960 responses that

**Table 1**
PPVT scores in children with and without epilepsy and associated health impairments.

| Variable/descriptors | N | Proportion (%) | Mean scores for groups | S.D. | OLS regression coefficient $\beta$ | 95% CI lower limit | 95% CI upper limit | p Value |
|---|---|---|---|---|---|---|---|---|
| Total children in pooled sample | 39,130 | | | | | | | |
| Cycles 1–8 | M = 20,044 | 51.2 | | | | | | |
| | F = 19,086 | 48.8 | | | | | | |
| Children reporting epilepsy | 70 | | | | | | | |
| PPVT scores | 33,560 | | 100.01 | 15.38 | | | | |
| Children without epilepsy and HUI = 1 | 22,134 | 56.6% | 101.09 | 15.092 | | | | |
| Children without epilepsy and HUI < 1 | 7994 | 26.5% | 97.16 | 15.60 | −3.84 | −4.232 | −3.452 | 0.000 |
| Children with epilepsy and HUI = 1 | 21 | 0.1% | 91.36 | 14.07 | −9.902 | −16.34 | −3.461 | 0.03 |
| Children with epilepsy and HUI < 1 | 21 | 0.1% | 83.53 | 23.036 | −17.31 | −23.78 | −10.84 | 0.000 |

HUI = Health Utilities Index.

**Table 2**
Effect of associated health impairments on the ability to be administered the PPVT-R in children with epilepsy.

| | n | HUI scores available n | Mean HUI scores | SD | SEM | t Test for independent samples p value (2 tailed) | 95%CI of difference | |
|---|---|---|---|---|---|---|---|---|
| Group 1. Children with epilepsy who were administered PPVT-R | 52 | 43 | 0.86 | 0.22 | 0.34 | 0.000 | −0.486 | −187 |
| Group 2. Children with epilepsy who were not administered or missed the PPVT-R | 18 | 12 | 0.52 | 0.26 | 0.74 | | | |

were missing for PPVT scores and/or HUI, of these 5570 had a missing PPVT-R score, while 3390 missing the HUI as well.

There were 21 children with epilepsy and a perfect score of 1 on the HUI, and 21 children with epilepsy and a HUI score of <1 (Table 1).

A further analysis of the dataset was carried out looking at the differences in mean HUI scores between children with epilepsy who had been administered the PPVT-R in comparison to those who were not administered the test. Of the 70 children 43 of 52 children were identified as having been administered the PPVT-R (group1), and were also given a HUI score. In 12 of 18 children who were not administered the PPVT-R (group2), HUI scores were available. The mean scores were compared by a 2 tailed t test for independent samples) (Table 2).

## 3. Results

### 3.1. PPVT-R scores in children with and without epilepsy

In OLS model centered around a mean score of 100.0088, school readiness as measured through the PPVT-R revealed a gender effect favoring females who scored an average of 1.10 points higher than males ($\beta = 1.10$, 95%CI 0.75; 1.44) $p < 0.001$). Children with out epilepsy but carrying impairment as measured by a HUI score of <1, scored 3.8 points lower than their peers within a narrow 95%CI. Children with epilepsy but with no additional impairments (HUI = 1) scored averaging a total of 9.9 points lower on the PPVT-R than their peers ($\beta = -9.902$, 95%CI $-16.343$, $-3.461$, $p = 0.003$), while those with epilepsy and an associated health impairment measuring HUI < 1 scored even 17.3 points lower on the average with a wide confidence interval ($\beta = -17.308$, 95%CI $-23.776$, $-10.839$, $p = 0.000$).

### 3.2. HUI scores in children with epilepsy administered the PPVT-R (Group 1 vs Group2)

The differences in the mean HUI scores (Group1, Group2; 0.86, 0.52, $p < 0.000$ (2tailed t test) was found to be statistically significant. The results indicate significant health impairments in the group of children with epilepsy who were not administered the PPVT-R.

## 4. Discussion

The NLSCY data analysis provides objective evidence that children with epilepsy are at risk of scholastic underachievement at school entry, while those with additional health impairments as measured by the HUI are at greater risk of underachievement. Children with epilepsy with or without added health impairments show a great degree of variability in their standardized scores on the PPVT-R. Unfortunately, low sample sizes limited our ability to estimate the more detailed average decrease related to unit decreases in the HUI. However, a comparison of the mean HUI scores indicates that the HUI scores of children with epilepsy who were not administered the PPVT-R were significantly lower, further supporting the notion that some children with epilepsy

may carry significant health impairments or functional disabilities limiting their ability to take the test.

The PPVT-R is well established as a standardized measure of school readiness in the United States and Canada. PPVT-R scores have been found to be statistically strong predictors of later school success in reading. In addition, reading skills as measured on the PPVT-R and later measures in reading, and math assessments at ages 5–8 years and may even provide a measure of some degree of intelligence and achievement.[12,13] The Health Utilities index (HUI) is a multi-attribute index that provides comprehensive, reliable, responsive and valid measures of health status in a wide variety of chronic health conditions in national and international studies.[10] Even small differences in mean scores of 0.02–0.04 have been considered to be clinically important.[14] A relationship between low HUI scores and chronic conditions including epilepsy has been shown for adults using the Canadian Community Health Survey (CCHS) data for 2000–2001.[11]

In a smaller study of preschool children, those with epilepsy (partial, primary generalized, and unclassified) scored lower in a variety of domains tested; in auditory attention, short-term memory, narrative memory, and rapid word retrieval, along with slower processing, in comparison to peers.[15] Deficiencies in these domains may become a barrier to academic achievement in early childhood. These findings possibly may also account for the lower and highly variable PPVT-R scores seen in children with epilepsy in this sample.

Several explanations for this variation could be considered. For example, children who had outgrown or who had a milder form of epilepsy may have performed better, and on par with peers, while children with epilepsy that significantly impacted cognitive abilities could underperform on the tests. Secondly, it is very likely that different types of epilepsy may affect brain development and function to a variable extent. Future studies should explore this phenomenon.

In another study, Vanasse et al. also reported children with epilepsy underperformed in reading tests as comparison to their peers (functioning almost 2 years behind their grade level), and reported differences in reading and phonological processing amongst subtypes of epilepsy.[16] In the present study, it is not possible to comment on the effect of different subtypes of epilepsy on account of the relatively smaller sample size and the lack of specificity in the survey data on the nature of epilepsy and due to limited sample size.

The principal strengths of this study include use of a standardized test examining academic school readiness, a large population size comparator, and use of bootstrap weighting in the analysis. This analysis draws from a very large sample of Canadian children which allows for accurate population estimates of conditions with very low prevalence rates as well as simple models which indicate how comorbid conditions impact on school outcomes in children with epilepsy. There is an obvious discrepancy between cross sectional estimates of epilepsy published previously and the number of children with epilepsy in this study. After Cycle 4 the survey became longitudinal in nature, and it is conceivable that many children had achieved a spontaneous remission in later cycles and were not included in this

sample. By pooling the children across all the cycles, the sample size was a large one for comparison purposes.

While the longitudinal nature of the NLSCY survey would permit the development of models of causation, the results of this study are based on a cross sectional analysis of data limiting the ability to examine causation. The primary limitation of this study is that the participants in this study are relatively healthier, and hence there may be a self-selection bias. The analysis however allowed us to observe that there was a significant proportion of children among the group with epilepsy who were not administered the test. While one could speculate that the missing responses could be attributed to severity of epilepsy, the present study lacks sufficient power to draw definitive conclusions of this nature as medical records of these children were not available in a survey of this nature.

One must ask the question about the wider implications of these results. Other studies using carefully selected participants suggest that all children even those with controlled seizures and milder forms of epilepsy should be considered as vulnerable to learning disabilities. The authors of this study recommended screening for co-morbid conditions.[17]

The recently conducted "Priorities in Pediatric Epilepsy Research: Improving Children's Futures Today" workshop (October 23–24, 2012, Ann & Robert H. Lurie Children's Hospital of Chicago) brought together parents of children with epilepsy, health care providers (adult and pediatric neurologists and epileptologists, nurses), neuropsychologists, voluntary advocacy organizations, pharmaceutical with other stakeholders (industry representatives, health services, clinical, and translational science researchers, educators), to address needs in pediatric epilepsy research and care. The priorities in this workshop were found to be consistent with IOM report referred to earlier. The workshop identifying several measures needed to address gaps in our understanding of comorbidities, cognitive and behavioral outcomes and information that would improve parents and stakeholders in the wider circle of care for the child (educators, translational science researchers, individuals and agencies shaping health policy).[18] Population studies of this nature go some way toward helping the process of educational assessments, screening and interventional measures.

## 5. Conclusion

The findings of the present population based study lend further support to recommendations that children with epilepsy should not only be screened for their cognitive deficits by specific psychometric tests, but also be screened for associated health impairments that might influence testing results and outcomes. Only then can tailored and specific interventions and their impact on academic outcomes can be established.

## Conflict of interest statement

No conflicts of interest to disclose.

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