Neighbourhood Deprivation and Risk of Childhood Visual Impairment: A Nationwide Study from Sweden

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Abstract

The purpose of the study was to examine the association between neighbourhood deprivation and incidence of hospitalisation for childhood visual impairment (VI), after accounting for family- and individual-level socio-demographic characteristics. All residents in Sweden aged 2-11 years were followed between January 1, 2000 and December 31, 2010. Childhood residential addresses were geocoded and classified according to neighbourhood deprivation (an index of low education, low income, unemployment, and receipt of welfare assistance). Data were analysed by multilevel logistic regression, with family- and individual-level characteristics at the first level and level of neighbourhood deprivation at the second level. During the study period, among a total of 643,304 children, 1056 were hospitalised with childhood VI. Age-adjusted cumulative hospitalisation rates for childhood VI increased with increasing level of neighbourhood deprivation. In the study population, 1.5 per 1000 and 2.4 per 1000 children in the least and most deprived neighbourhoods, respectively, were hospitalised with childhood VI. The odds ratio (OR) for hospitalisation for childhood VI for those in low-deprivation neighbourhoods versus those in low-deprivation neighbourhoods was 1.49 (95% confidence interval (CI) =1.20–1.86). High neighbourhood deprivation remained significantly associated with higher odds of childhood VI after adjustment for family- and individual-level socio-demographic characteristics (OR=1.33, 95% CI=1.05–1.68, p=0.016). This study is the largest so far on neighbourhood influences on childhood VI. Our results suggest that neighbourhood is associated with incidence of hospitalisation for childhood VI independently of family- and individual-level socio-demographic characteristics.

Keywords: Childhood visual impairment; Neighbourhood-level deprivation; Incidence; Socio-demographic factors; Multilevel modelling

Introduction

Visual impairment (VI) (including blindness) occurs when any part of the optical system is defective, diseased, or malfunctions. VI is a major health risk in childhood affecting child’s psychological, educational and socioeconomic experiences [1]. According to the WHO estimates that 19 million children are affected with VI, while 1.4 million are blind [2]. Although 90% VI has been reported in developing countries, in developed countries, the childhood VI has increased trend [3]. The specific mechanisms behind childhood VI are largely unknown; some of the known risk factors include congenital abnormalities [4], injury [5], hereditary [6], and infections in earlier life [7]. There is widespread variation in the causes of VI and blindness. In developing or low income countries where much of the VI is related either to infection or nutrition, corneal scarring is the most common cause of blindness. However, the majority of VI is either preventable or treatable [2]. Efforts have therefore been made to study whether the socioeconomic environment is associated with the risk of VI [8,9]. Neighbourhood environments have been shown to be an important independent risk factor for many childhood health problems [10-17]. However, no previous studies have investigated whether neighbourhood deprivation is associated with childhood VI after accounting for family and individual factors.

The present study had the following two aims: 1) to determine whether the relationship between neighbourhood deprivation and risk of hospitalisation for childhood VI remains significant after adjusting for family- and individual-level socio-demographic factors; and 2) to examine possible cross-level interactions between individual-level socio-demographic factors and neighbourhood-level deprivation to determine whether neighbourhood-level deprivation has a differential effect on risk of childhood VI across subgroups of families and individuals (effect modification).

Methods

Data used in this study were retrieved from a national database, which contains longitudinal information on the entire population of Sweden. The dataset used contains nationwide information on parents and their offspring at the individual and neighborhood levels, including comprehensive demographic and socioeconomic data. The information in the present dataset comes from several Swedish national registers. The registries used in the present study were the Total Population Register, the Multi-Generation Register, the Hospital Discharge Register, and the Out-Patient Register. The Swedish nationwide population and health care registers have exceptionally high completeness and validity [18]. Individuals (children and their parents) were tracked using the personal identification numbers which are assigned to each resident of Sweden. These identification numbers were replaced with serial numbers to provide anonymity. The follow-up period ran from January 1, 2000 until hospitalisation/out-patient treatment for VI, death, emigration or the end of the study period on December 31, 2010. All residents in Sweden aged 2-11 years, a total of 643,304 children, were followed and there was no loss to follow-up due to use of the individual serial numbers.

Outcome variable: childhood VI

The outcome variable in this study was a hospital or out-patient treatment for VI, death, emigration or the end of the study period.
diagnosis of childhood VI (age at diagnosis 2 to 11 years) during the study period. Data on in-patient and out-patient diagnoses of VI for 2000–2010 were retrieved from the Hospital Discharge Register and Out-Patient Register, which contain information on all hospital visits, including diagnoses. We searched these two registers for the International Classification of Diseases (ICD)-10 codes H54 (Visual impairment including blindness), denoting VI as the main diagnosis during the study period. The serial numbers were used to ensure that each individual appeared only once in the dataset, for his or her first hospital diagnosis of VI during the study period.

Exclusion criteria: Children hospitalized for any kind of VI (including blindness) (ICD-9 369 and ICD-10 H54) in the 11 years before the start of the study period were excluded.

Neighbourhood-level deprivation

The home addresses of all Swedish individuals have been geocoded to small geographic units with boundaries defined by homogeneous types of buildings. These neighbourhood areas, called small area market statistics or SAMS, each contain an average of 1,000 residents and were created by the Swedish Government-owned statistics bureau Statistics Sweden, SAMS were used as proxies for neighbourhoods, as they were in previous research [19,20]. Neighbourhood of residence is determined annually using the National Land Survey of Sweden register.

A summary index was calculated to characterise neighbourhood-level deprivation. The neighbourhood index was based on information about female and male residents aged 20 to 64 because this age group represents those who are among the most socioeconomically active in the population (i.e. a population group that has a stronger impact on the socioeconomic structure in the neighbourhood than children, younger women and men, and retirees do). The neighbourhough index was based on four items: low education level (<10 years of formal education), low income (income from all sources, including interest and dividends, that is <50% of the median individual income), unemployment (excluding full-time students, those completing military service, and early retirees), and receipt of social welfare. The index of the year 2000 was used to categorise neighbourhood deprivation as low (more than one SD below the mean), moderate (within one SD of the mean), and high (more than one SD above the mean) [21].

Individual level socio-demographic variables

Sex of child: Male or Female.

Age ranged from 2 to 11 years and was divided into three categories: 2-4, 5-8, and 9-11-years. Because a poor antenatal and intrapartum environment is known to be a risk factor for VI in term newborns [4,7]. Children’s age was limited to ages over 1 year.

Maternal marital status was categorized as (1) married/cohabitating or (2) never married, widowed, or divorced. Family income was calculated as annual family income divided by the number of people in the family. The family income measure took into consideration the ages of the family members and used a weighted system whereby small children were given lower weights than adolescents and adults. The sum of all family members’ incomes was multiplied by the individual’s consumption weight divided by the family members’ total consumption weight. The final variable was calculated as empirical quartiles from the distribution.

Maternal and paternal education levels were categorised as completion of compulsory school or less (≤ 9 years), practical high school or some theoretical high school (10–12 years) and completion of theoretical high school and/or college (>12 years).

Maternal and paternal country of birth was categorised as Sweden, Western country (Western Europe, USA, Canada, Oceania), and other. Maternal urban/rural status: this variable was included because access to preventive antenatal care may vary according to urban/rural status. Mothers were classified as living in a large city, a middle-sized town, or a small town/rural area. Large cities were those with a population of ≥ 200,000 (Stockholm, Gothenburg and Malmö); middle-sized towns were towns with a population of ≥ 90,000 but <200,000; small towns were towns with a population of ≥ 27,000 and <90,000; and rural areas were areas with populations smaller than those of small towns. This classification yielded three equally-sized groups.

Maternal age at childbirth and paternal age at childbirth was classified as <30,30-39, and ≥ 40 years. Because VI is known to cluster in families, children were classified according to whether or not they had a family history (siblings) of VI.

Comorbidities: Hospitalization for perinatal complications was defined as hospitalization (within the first year of birth) for a main diagnosis of perinatal complication (ICD-10 P00-P99); Hospitalization for congenital malformations was defined as hospitalization (within 11 years and in follow-up period) for a main diagnosis of congenital malformation (ICD-9 740-759 and ICD-10 Q00-Q99).

Statistical analysis

The cumulative incidence for hospitalisation of VI was calculated for the total study population and for each subgroup after assessment of neighbourhood of residence for the children. Incidence was defined as first registration for childhood VI during the study period. Multilevel (hierarchical) logistic regression models were used to estimate odds ratios (ORs) and 95% confidence intervals (CIs). The analyses were performed using MLwiN version 2.27. First, a null model was calculated to determine the variance among neighbourhoods. Then, to determine the crude risk of childhood VI by level of neighbourhood deprivation, a neighbourhood model that included only neighbourhood-level deprivation was calculated. Next, a full model that included neighbourhood-level deprivation and sex, age and the twelve family and individual-level socio-demographic variables, added simultaneously to the model, was calculated (Aim 1). Finally, a full model tested for cross-level interactions between the family- and individual-level socio-demographic variables and neighbourhood-level deprivation to determine whether the effects of neighbourhood-level deprivation on childhood incidence differed across the socio-demographic variables (Aim 2).

Random effects: The between-neighbourhood variance was estimated both with and without a random intercept. It was regarded to be significant if it was more than 1.96 times the size of the standard error, in accordance with the precedent set in previous studies [22-24].

Ethical considerations

This study was approved by the Ethics Committee at Lund University.

Results

In the total study population (643,304 children), 20%, 62%, and 18% of children aged 2 to 11 years lived in low-, moderate- and high-deprivation neighbourhoods, respectively. During the follow-up period (January 1, 2000 to December 31, 2010), 1,056 children were diagnosed with childhood VI (Table 1). Childhood VI cumulative
Table 1: Distribution of population, number of childhood visual impairment events, and age-standardized cumulative rates of hospitalization (per 1000) by neighborhood-level deprivation.
hospitalisation rates increased from 1.5 per 1000 in neighbourhoods with low deprivation to 2.4 per 1000 in neighbourhoods with high deprivation. A similar pattern of higher hospitalisation rates with increasing neighbourhood deprivation was observed across all fourteen family- and individual-level socio-demographic categories.

The OR for hospitalisation for childhood VI for children living in a high- versus low-deprivation neighbourhoods in the crude neighborhood-level model was 1.49 (95% CI=1.20–1.86) (Table 2). Neighbourhood-level deprivation remained significantly associated with childhood VI risk after adjustment for age, sex, and the twelve family- and individual-level socio-demographic variables (OR=1.33, 95% CI=1.05–1.68, p=0.016) for high-deprivation versus low-deprivation neighbourhoods. Risk of childhood VI was higher in young, male childhood and children whose parents with low level

| Model 1 | Model 2 | Model 3 | Model 4 |
|---------|---------|---------|---------|
| OR      | 95% CI  | OR      | 95% CI  | OR      | 95% CI  | OR      | 95% CI  |
| Neighborhood-level variable (ref. Low) |         |         |         |         |         |         |         |
| Moderate | 0.93    | 0.77    | 1.12    | 0.94    | 0.78    | 1.13    | 0.92    | 0.76    | 1.11    | 0.92    | 0.76    | 1.11    | 0.368    |
| High     | 1.49    | 1.20    | 1.86    | 1.47    | 1.18    | 1.83    | 1.33    | 1.05    | 1.68    | 1.33    | 1.05    | 1.68    | 0.016    |
| Age      | 0.87    | 0.85    | 0.89    | 0.87    | 0.85    | 0.89    | 0.87    | 0.86    | 0.88    | <0.001  |         |         |         |
| Gender to boys (ref. girls) | 1.44    | 1.28    | 1.63    | 1.44    | 1.28    | 1.63    | 1.54    | 1.37    | 1.74    | <0.001  |         |         |         |
| Family income (ref. High income) |         |         |         |         |         |         |         |         |         |         |         |         |         |
| Middle-high income | 0.80    | 0.68    | 0.96    | 0.81    | 0.68    | 0.97    | 0.021    |
| Middle-low income | 0.85    | 0.71    | 1.01    | 0.87    | 0.73    | 1.03    | 0.110    |
| Low income | 0.73    | 0.60    | 0.88    | 0.76    | 0.62    | 0.91    | 0.004    |
| Marital status (ref. Married/co-habiting) |         |         |         |         |         |         |         |         |         |         |         |         |         |
| Never married, widowed, or divorced | 0.96    | 0.85    | 1.09    | 0.95    | 0.83    | 1.07    | 0.368    |
| Maternal immigrant status (ref. Born in Sweden) |         |         |         |         |         |         |         |         |         |         |         |         |         |
| European countries | 1.09    | 0.83    | 1.43    | 1.11    | 0.84    | 1.46    | 0.484    |
| Others | 1.14    | 0.85    | 1.54    | 1.14    | 0.85    | 1.53    | 0.368    |
| Paternal immigrant status (ref. Born in Sweden) |         |         |         |         |         |         |         |         |         |         |         |         |         |
| European countries | 1.03    | 0.79    | 1.35    | 1.05    | 0.80    | 1.37    | 0.764    |
| Others | 1.26    | 0.93    | 1.69    | 1.27    | 0.94    | 1.71    | 0.110    |
| Maternal education attainment (ref. > 12 years) |         |         |         |         |         |         |         |         |         |         |         |         |         |
| ≤ 9 years | 1.24    | 1.03    | 1.50    | 1.21    | 1.00    | 1.46    | 0.046    |
| 10–12 years | 1.13    | 0.98    | 1.30    | 1.12    | 0.97    | 1.29    | 0.134    |
| Paternal education attainment (ref. > 12 years) |         |         |         |         |         |         |         |         |         |         |         |         |         |
| ≤ 9 years | 1.23    | 1.02    | 1.47    | 1.22    | 1.02    | 1.46    | 0.036    |
| 10–12 years | 1.18    | 1.02    | 1.36    | 1.17    | 1.01    | 1.35    | 0.046    |
| Urban/rural status (ref. Large cities) |         |         |         |         |         |         |         |         |         |         |         |         |         |
| Middle-sized towns | 0.86    | 0.72    | 1.03    | 0.88    | 0.74    | 1.06    | 0.162    |
| Small towns/rural areas | 1.00    | 0.85    | 1.18    | 0.99    | 0.84    | 1.17    | 0.920    |
| Maternal age at child birth (ref. <30 years) |         |         |         |         |         |         |         |         |         |         |         |         |         |
| 30-39 | 0.95    | 0.82    | 1.10    | 0.93    | 0.80    | 1.08    | 0.317    |
| ≥ 40 | 0.91    | 0.60    | 1.39    | 0.83    | 0.55    | 1.27    | 0.368    |
| Paternal age at child birth (ref. <30 years) |         |         |         |         |         |         |         |         |         |         |         |         |         |
| 30-39 | 0.96    | 0.83    | 1.11    | 0.97    | 0.83    | 1.12    | 0.617    |
| ≥ 40 | 1.06    | 0.84    | 1.34    | 1.05    | 0.83    | 1.32    | 0.689    |
| Family history of visual impairment (ref. Without family history) |         |         |         |         |         |         |         |         |         |         |         |         |         |
| Certain conditions originating in the perinatal period | 2.52    | 1.21    | 5.25    | 2.34    | 1.12    | 4.88    | 0.021    |
| Congenital malformations | 4.34    | 3.58    | 5.26    | <0.001  |         |         |         |         |         |         |         |         |         |
| Variance (S.E.) | 1.160 (0.110) | 1.138 (0.109) | 1.075 (0.107) | 1.064 (0.107) |
| Explained variance (%) | 9 | 10 | 15 | 16 |

Table 2: Odds ratios (OR) and 95% confidence intervals (CI) for childhood visual impairment; Results of multi-level logistic regression models
education, those with comorbidities of certain conditions of originating in the perinatal period and congenital malformations, and those with a family history of VI.

A test for cross-level interactions between the individual-level socio-demographic variables and neighbourhood-level deprivation in the context of risk of childhood VI showed no meaningful cross-level interactions or effect modification.

The between-neighbourhood variance (i.e. the random intercept) was more than 1.96 times the size of the standard error in all models, indicating that there were significant differences in childhood VDI incidence between neighbourhoods after accounting for neighbourhood deprivation and the individual-level variables. Neighbourhood deprivation explained 9% of the between-neighbourhood variance in the null model (Table 2). After inclusion of the family- and individual-level variables, the explained variance was 16%.

Discussion

We found that living in a deprived neighbourhood increased the odds of hospitalisation for childhood VI by 49%. It is noteworthy that we found this effect in a country with a comparatively strong system of universal health care and social welfare. Our finding that family history and individual-level factors of comorbidities of perinatal conditions and congenital malformations effect on the odds of childhood VI is consistent with the previous findings [4,6,7].

Level of neighbourhood deprivation may influence risk of childhood VI through a number of general mechanisms, including unfavourable health-related behaviours of injury [25], women during pregnancy [26,27], neighbourhood social disintegration (i.e. criminality, high mobility or unemployment) [22], it has been suggested that crime lies in the pathway linking the neighborhood social environment to poor health [28,29]. High level deprivation neighborhoods is associated with an increased risk of childhood VI, it may support the explanations of the rates of VI higher in developing countries.

Like several countries, Sweden has a nationwide childhood vision screening program, to identify children with eye disease. However, living in deprived neighbourhoods can cause isolation from health-promoting milieus (e.g. safe places to exercise and decent housing) and services. In comparisons of wealthy nations, associations between neighborhood characteristics and different health outcomes were inconsistent [30]. This implies that neighborhood determinants of health are complex. Such determinants may include access to health care, education, and social services. Access to these services is uneven in the U.S., where the effects of income inequalities on health are more pronounced [31]. For example, children from low income countries are associated with high risk of VI [32]. However, in the present study, no important relationships with family income were observed. Children with parents with lower level education, with family history of VI, and with comorbidities of certain conditions of originating in the perinatal period and congenital malformations were associated with a high risk of VI.

The present study has several strengths, which include: 1) the ability to analyse data on a large national cohort of children aged 2 to 11 years; 2) the prospective design; 3) the completeness of the data (for example, only 1% of the data on maternal education level and family income were missing); 4) the use of small, well-defined neighbourhoods with an average of 1,000 residents; and 5) the ability to adjust for a set of family- and individual-level socio-demographic factors (age, sex, family income, maternal marital status, parental country of birth, parental education level, urban/rural status, parental age at child birth, comorbidities of perinatal conditions and congenital malformations, and family history of VI). Accounting for family income is particularly important as it is a major confounder that can affect an individual's choice of neighbourhood. Another strength is the possibility to generalise our results to other populations (external validity), particularly to populations in industrialised societies.

The present study has several limitations. These include the possibility that some selective factors operate in the process of hospitalisation to favour certain children being hospitalised or seeking health care. The number of diagnoses for autism may thus be underestimated since information only enters the system when the child comes into contact with inpatient or outpatient health care. However, this type of bias is less likely to constitute a problem in studies from Sweden. This is because affordability of healthcare should not be a selective factor, because of equal access to primary and hospital care [33]. Any selective factors should therefore most likely imply a non-differential bias, i.e., the selective factors, if any, are most likely operating in the same way across neighborhoods. The Swedish Hospital Discharge Register contains no information about diagnostic procedures, which is a limitation, but any bias this caused would be non-differential. However, with respect to VI, the overall diagnostic validity of the Hospital Discharge Register is close to 90% [34,35].

Conclusions

This prospective nationwide study showed that, after accounting for family- and individual-level socio-demographic factors (age, sex, family income, parental marital status, parental country of birth, parental education level, urban/rural status, parental age at childbirth, family history of VI, and comorbidities of certain conditions of originating in the perinatal period and congenital malformations), neighbourhood deprivation was associated with an increased risk of childhood VI. This finding represents valuable knowledge for health care professionals who work in neighbourhoods with varying levels of neighbourhood deprivation.

Acknowledgements

This work was supported by the ALF funding from Region Skåne awarded to Jan Sundquist and Kristina Sundquist, and a grant from the Swedish Research Council (awarded to Kristina Sundquist). The registers used in the present study are maintained by Statistics Sweden and the National Board of Health and Welfare.

Competing Interests

There are no competing interests.

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Citation: Li X, Sundquist J, Zöller B, Sundquist K (2015) Neighbourhood Deprivation and Risk of Childhood Visual Impairment: A Nationwide Study from Sweden. J Preg Child Health 2: 148. doi:10.4172/2376-127X.1000148

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