Measuring socio-economic inequalities in the presentation of injuries to a paediatric A&E department: the importance of an epidemiological approach

C.E. Brown, P. Chishti, D.H. Stone*

Department of Child Health, Paediatric Epidemiology and Community Health (PEACH) Unit, University of Glasgow, Yorkhill Hospital, Glasgow G3 8SJ, UK

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Summary
Objectives. To contrast the socio-economic pattern of childhood injuries presenting to a paediatric accident and emergency (A&E) department revealed by using both a numerator-based and a denominator-based approach to the analysis of injury surveillance data.

Methods. Injury surveillance data collected during 1997–1998 at a Glasgow children's hospital A&E department were analysed. Socio-economic status was measured using Carstairs' deprivation index. Data from West Glasgow postcode sectors only were analysed in order to optimize epidemiological validity. Socio-economic patterning of injury was investigated in two ways—numerator-based and denominator-based.

Results. A total of 12,762 children (0–14 years) living in West Glasgow attended the A&E department of the Royal Hospital for Sick Children over the study period. Both analytical approaches showed a clear and statistically significant excess of injury presentations in children from more deprived postcode sectors, but the variation appeared much greater in the numerator-based rather than the denominator-based approach. In regression analysis, however, only the denominator-derived rates showed a statistically significant linear trend across deprivation categories.

Conclusion. The most appropriate and accurate means of measuring the extent of socio-economic (and other) inequalities in injury risk is to adopt a population-based rather than numerator-based perspective on the data collected by injury surveillance systems.

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Injury is a leading cause of death and disability in children and young people. Socio-economic factors play a strong role in contributing to inequalities in
the risk of injury in children. Since reducing health inequalities is a strategic objective of the UK government, the accurate measurement of social inequalities in injury incidence is essential.

Hospital-based injury surveillance systems are frequently used to capture data on the nature and socio-economic characteristics of victims of injury. These data are sometimes analysed as frequencies rather than rates as denominators are often unavailable. Caution is required, however, in drawing conclusions about the risk of injury based on clinical presentations that are not explicitly related to a population denominator. This paper aims to demonstrate the way in which the apparent social patterning of risk of childhood injury can vary, depending on whether numerator-based or denominator-based analytical approaches are employed.

Methods

An injury surveillance system known as CHIRPP (Canadian Hospitals Injury Reporting and Prevention Programme) has been running for several years at the Royal Hospital for Sick Children (RHSC), Yorkhill, Glasgow. A CHIRPP form is completed routinely on all children (0–14 years) presenting with an injury to the accident and emergency (A&E) department. The data are then coded, entered and stored on a computer.

We examined the CHIRPP data for a period of two complete calendar years (1997–1998). Socio-economic status was measured using Carstairs’ deprivation index based on the characteristics of Scottish postcode sectors at the time of the 1991 census. This involves allocating subjects, based on the home address, along a continuous scale ranging from 1 (most affluent) to 7 (most deprived). As the hospital was located to the west of Glasgow city centre, data from West Glasgow postcode sectors were analysed in order to optimize epidemiological validity.

To investigate the socio-economic patterning of injury, we analysed the data in two different ways—numerator-based and denominator-based. For the numerator-based approach, the percentage of children presenting to the A&E department was calculated as a frequency distribution within three age bands (0-4, 5-9 and 10-14 years) across the deprivation categories. For the denominator-based approach, the population at risk was regarded as children aged 0-14 years registered with a general practitioner located in a West Glasgow postcode sector on 31 December 1997. Although individual general practices tended not to reflect geographically discrete areas, the composite database derived from the age-sex practice registers in West Glasgow was, in effect, a geographically defined denominator population. Rates of presentation (per 1000 population) to the A&E department were calculated within the three age bands across the seven deprivation categories. For both analytical approaches, 95% confidence intervals were calculated. Linear regression analysis was performed to test for the presence of a linear trend of injury risk with deprivation.

Results

A total of 12,762 children aged 0-14 years, living in West Glasgow postcode sectors, attended the RHSC A&E department over the study period. Total numbers presenting in each age group were: 3979 for 0-4 years, 3977 for 5-9 years and 4806 for 10-14 years. Over the study period, the number of 0-14 year olds presenting from deprivation categories 1-2 was 2029, with 6857 presenting from deprivation categories 6-7 (a ratio of 3.4:1).

Table 1 and Fig. 1 show the results of the numerator-based analysis, and Table 2 and Fig. 2 show the results of the denominator-based analysis. Both show a clear and statistically significant social patterning of injury, but the variation appears much greater in the numerator-based rather than the denominator-based approach. This is confirmed by comparing the frequencies of injuries in children from the more deprived and the more affluent deprivation categories: the ratios of categories 7:1 and especially 6:1 are larger in the numerator- than in the denominator-based analyses. Nevertheless, both methods succeed in highlighting the increased injury risk in the more deprived compared with the more affluent children. However, when examining the nature of the trend across the deprivation categories, linear regression analysis revealed that only the denominator-derived rates displayed a statistically significant linear trend of increasing injury risk with deprivation.

Discussion

Injury is the leading cause of death in childhood throughout the industrialized world. Fatalities represent only the tip of the iceberg and
the vast majority of injuries to children result in short- or long-term disability rather than death. Many injuries to children present to A&E departments, where injury surveillance systems such as CHIRPP are increasingly deployed. The interpretation of the demographic and social patterning of such attendance data is, however, problematic for two major reasons. First, not all incident cases of (non-fatal) injury will attend an A&E department; some will be treated in the community while others will be admitted directly to hospital wards. Second, population denominators are seldom readily available and analyses based on numerators alone may be performed. This study focuses attention on the potentially misleading consequences of adopting a numerator-based approach to investigating patterns of injury risk.

The quality of CHIRPP data has been evaluated thoroughly in Canada and found to be generally high in terms of its sensitivity, positive predictive value and representativeness. The utility of the data for preventive and planning purposes is, however, dependent not only on its quality but also on its epidemiological validity, i.e. the extent to which observed frequencies and patterns truly reflect those occurring in the population. To investigate epidemiological validity, it is necessary to relate data derived from an injury surveillance system to a defined denominator. This may be difficult in

<table>
<thead>
<tr>
<th>Deprivation category</th>
<th>0-4 years</th>
<th>5-9 years</th>
<th>10-14 years</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>% (95% CI)</td>
<td>n</td>
</tr>
<tr>
<td>1</td>
<td>313</td>
<td>7.9 (7.0–8.7)</td>
<td>363</td>
</tr>
<tr>
<td>2</td>
<td>302</td>
<td>7.6 (6.8–8.5)</td>
<td>299</td>
</tr>
<tr>
<td>3</td>
<td>211</td>
<td>5.3 (4.6–6.0)</td>
<td>233</td>
</tr>
<tr>
<td>4</td>
<td>599</td>
<td>15.1 (14.0–16.2)</td>
<td>619</td>
</tr>
<tr>
<td>5</td>
<td>368</td>
<td>9.2 (8.4–10.2)</td>
<td>377</td>
</tr>
<tr>
<td>6</td>
<td>1437</td>
<td>36.1 (34.6–37.6)</td>
<td>1356</td>
</tr>
<tr>
<td>7</td>
<td>749</td>
<td>18.8 (17.6–20.1)</td>
<td>770</td>
</tr>
</tbody>
</table>

Test for linear trend
Ratio 7:1 2.4 2.1 2.1
Ratio 6:1 5.1 3.7 3.5

Figure 1  Numerator-based analysis: percentage of patients (from West Glasgow postcode sectors) presenting to A&E department by age and deprivation category, 1997-1998.
a complex urban setting where injured patients do not necessarily attend local hospitals according to strictly determined catchment areas.

For the purposes of the present study, we delineated the boundaries of a putative geographical catchment area of a children's hospital in West Glasgow. Local studies had established that the vast majority of children residing in that area utilized the RHSC at Yorkhill rather than any other A&E department (Yorkhill NHS Trust, personal communication). This knowledge enabled us to study the frequency and pattern of injuries attending the A&E department by adopting two contrasting analytical approaches—numerator-based and denominator-based. As social inequalities in health are currently the subject of much scientific and political interest, we decided to examine socio-economic patterns of injury in particular to test the null hypothesis that numerator- and denominator-based analyses would yield similar patterns.

Although both analyses indicated that injury presentation to an A&E department varies by deprivation category at all ages, the numerator-based analysis suggested much wider socio-economic inequalities in injuries than the denominator-based one. In the numerator-based approach, the extent of health inequalities was exaggerated, since results reflected, in part, the socio-economic structure of the population at risk. By relating the number of presentations to the population, this confounding influence of the population distribution was removed and the magnitude of socio-economic patterning was much reduced. The apparently higher risk of injury in

<table>
<thead>
<tr>
<th>Deprivation category</th>
<th>0-4 years, rate/1000 population (95% CI)</th>
<th>5-9 years, rate/1000 population (95% CI)</th>
<th>10-14 years, rate/1000 population (95% CI)</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>107.3 (96.3–119.1)</td>
<td>104.0 (94.0–114.6)</td>
<td>118.3 (108.3–128.9)</td>
</tr>
<tr>
<td>2</td>
<td>134.6 (120.7–149.4)</td>
<td>115.0 (102.1–128.9)</td>
<td>150.5 (135.9–166.1)</td>
</tr>
<tr>
<td>3</td>
<td>119.3 (104.6–135.4)</td>
<td>106.9 (94.3–120.7)</td>
<td>142.7 (128.1–158.2)</td>
</tr>
<tr>
<td>4</td>
<td>135.3 (125.4–145.8)</td>
<td>136.9 (127.0–147.2)</td>
<td>162.0 (151.0–173.5)</td>
</tr>
<tr>
<td>5</td>
<td>162.5 (147.6–178.4)</td>
<td>150.7 (136.9–165.3)</td>
<td>196.3 (180.8–212.5)</td>
</tr>
<tr>
<td>6</td>
<td>162.2 (154.6–170.1)</td>
<td>156.9 (149.3–164.8)</td>
<td>164.6 (157.2–172.1)</td>
</tr>
<tr>
<td>7</td>
<td>185.0 (173.2–197.3)</td>
<td>166.2 (155.6–177.3)</td>
<td>187.7 (177.0–198.8)</td>
</tr>
</tbody>
</table>

Test for linear trend: P = 0.002  P = 0.001  P = 0.02
Ratio 7:1: 1.7  1.6  1.6
Ratio 6:1: 1.5  1.5  1.4

Figure 2  Denominator-based analysis: rates of presentation to A&E department (per 1000 population living in West Glasgow) by age and deprivation category, 1997-1998.
the numerator-based analysis in Deprivation Category 6, for example, disappeared when rates were calculated. On the other hand, regression analysis revealed a statistically significant linear trend of increasing injury risk with deprivation only when the rates were considered. In other words, the numerator-based analysis was doubly misleading. First, it created the impression that the deprivation-related patterning of injury risk was greater than it actually was. Second, it produced a Type 2 epidemiological error—the apparent absence of a significant linear association between deprivation and injury risk when in reality one existed.

Due to the limited scope of our study, we were unable to take account of the possible confounding effect on injury frequency of geographical proximity of home address to the hospital. Previous research from Wales has demonstrated that, once adjustment for this geographical factor has been made, the relationship between child injury risk and deprivation is relatively weak.7

Few would disagree with the principle that a strictly population-based epidemiological approach is the ideal research method for the identification of high-risk and priority groups, and for the planning and targeting of healthcare services. On occasions, however, hospital-based researchers may be tempted or obliged to rely on numerators in the absence of easily accessible denominators for the purpose of risk analysis. Our study strongly cautions against such an approach and reinforces the view that the most appropriate and accurate means of measuring the extent of socio-economic (and other) inequalities in injury risk is to adopt a population-based rather than a numerator-based perspective on the data collected by injury surveillance systems.

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