University of Alberta

Child Injuries: Does Neighborhood Matter?

By

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I would like to dedicate this work to my dear parents Chandran and Nirmala, my brother Haran, and to all my friends who supported me over the last two years.

Abstract

This population-based study primarily explored the relationship between neighborhood contextual factors related to socioeconomic status (SES) and risk of injury among children under 17 years of age. The provincial health administrative databases and the Population Census were the data sources. Census tracts (CT) defined the neighborhood boundaries. In addition to hierarchical linear modeling, the relationships between injury and SES were assessed using traditional contextual and ecological analysis. At the individual- and CT-levels, Fractures, and Dislocations, Sprains and Strains were related to higher SES while Burns, Poisonings and Injury Hospitalizations were related to lower SES. Except for poisonings, all other outcomes examined had CT-level variation of significantly less than 5%. The final model for this outcome showed that in addition to low family SES, a high proportion of lone parent families in CTs increased likelihood of poisonings. The discrepancy in results between the multilevel and traditional contextual model was minimal.

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List of Abbreviations

AHCIP	Alberta Health Care Insurance Plan
EA	Enumeration Area
CCSD	Canadian Council of Social Development
CDC	Centers for Disease Control and Prevention
CI	Confidence Interval
CICH	Canadian Institute of Child Health
CSA	Canadian Standards Association
CT	Census Tract
HLM	Hierarchical Linear Modeling
ICC	Intraclass Correlation
ICD-9-CM	International Classification of Disease (Ninth Revision) Clinical Modification
MCMC	Monte Carlo Markov Chain
MVC	Motor Vehicle Collision
OR	Odds Ratio
PCCF	Postal Code Conversion File
RIGLS	Restrictive Iterative Generalized Least Squares
SES	Socioeconomic Status

CHAPTER 1
Introduction

1.1 Introduction

Afflicting one in four children every year (Centers for Disease Control and Prevention, 1999), child injuries are a major public health concern. They are the leading cause of death for children and adolescents over the age of one, and are responsible for more deaths than cancer, heart disease, respiratory disorders, diabetes and Acquired Immune Deficiency Syndrome (AIDS) combined (Avard et al., 1989). Furthermore, the economic cost of injury treatment is the third largest contributor to the cost of illness among all age groups (Health Canada, 1997a). However, by far the most profound consequence of child injuries is the physical and emotional suffering endured by the young victims and their families.

Children of lower socioeconomic classes bear a disproportionately larger amount of the burden of injuries (MacKay et al., 2000). The increase in the child poverty rate – from 19.5 in 1994 to 21 percent in 1996 – and the growing importance of injuries as a major public health problem (Canadian Council on Social Development, 1998), make the link between low socioeconomic status and child injuries a pressing issue.

Fundamental to the reduction of injury risk among low socioeconomic status children is the identification of the root causes for SES difference in risk. Family or individual psychosocial and behavioral factors related to low SES have been frequently studied. However, part of this difference may also be attributed to unsafe conditions more commonly found in deprived neighborhoods and these have been less well studied. Risk factors stemming from the built or social environment, such as unsafe road conditions (Guyer, Talbot & Pless, 1985), or social norms that demote the use of protective devices (Sellstrom & Bremberg, 1996), increase injury risk for all children in a given neighborhood, regardless of their individual or family status. Identifying such hazards and implementing preventive measures which include social and structural modifications of the environment that do not rely on cognitive abilities, would seem an appropriate approach to reducing injuries among children. This is because children's ability to assimilate the presence of hazards and to carry out appropriate avoidance behavior is not fully developed (Mueller, 1990) and thus most efforts at behavior modification are only minimally successful, if at all (Rivara & Barber, 1985).

This study explores primarily the association between neighborhood contextual factors and risk of injury among children. More specifically, it assesses whether likelihood of child injury varies by neighborhood of residence and determines the magnitude of any relationship between neighborhood socioeconomic conditions and injury risk. Risks for any injury in general, for specific injury types, and for injury hospitalizations are examined among children 0 to 17 years of age and residing in Edmonton, Alberta, Canada and surrounding areas during the study period of April 1, 1995 to March 31, 1996. Socioeconomic indicators derived from the Population Census, such as median family income, serve as proxy measures for the neighborhood socioeconomic environment.

1.2 Child Injury Prevalence

In Canada, injuries are the leading cause of death and the second leading cause of hospitalization for children, accounting in 1997 for about 1300 deaths and 50,000 hospitalizations in individuals under 19 years of age (Health Canada, 1997b, 1999). In 1996, injuries were responsible for 3% of all deaths for children under one year of age, 32% for children one to four years, 41% for children five to nine, 52% for children 10 to 14 and 72% for youth 15 to 19 (Health Canada, 1999). The proportion of injuries as a cause of hospitalization also increased with age for children and youth in Canada. Injuries were responsible for 2% of all hospitalizations for children under one year of age, 9% for 1 to 4 years of age, 17% for 5 to 9 years of age, 25% for 10 to 14 years of age and 30% for 15 to 19 years of age (Health Canada, 1999).

In the Province of Alberta, there were 182 injury fatalities among children and adolescents in 1997. Among these, motor vehicle collisions (MVCs) and suicide were the first and second leading causes, respectively, accounting for more than 60% of these. Of the 5,361 injury hospitalizations of children and adolescents during this period, falls, MVCs and self-inflicted injuries were the most common causes (Alberta Center for Injury Control and Research, 2000).

At the local level, in 1996, in the Capital Health Region there were 31 injury related child deaths, 667 injury related child inpatient hospitalizations, and 22,665 injury related visits to emergency rooms. The percentage of deaths attributed to injury among 0 to 4 year olds was 5%, for 5-14 year olds it was 36 % and for 15-19 year olds it was 70% (Capital Health, 1997). These figures reflect national level figures. Clearly, injuries among children and adolescents remain a major public health priority in the Capital Health Region.

Despite the bias in the literature towards severe outcomes such as death and hospitalization, the milder injuries are also important. Since they are more common, most of the economic burden of injury is caused by less severe injuries. Unfortunately, such injuries are also more difficult to count accurately as many minor injuries are treated at home or in doctors' offices.

However, in the United States the Centers for Disease Control and Prevention estimates that each year 20 - 25% of all children sustain an injury sufficiently severe to require medical attention, absence from school, and/or bed rest (Centers for Disease Control and Prevention, 1999).

1.3 Public Health and Injury Control

The most recent development in injury control has been to direct attention away from individuals and towards the environment within which the injury occurs. This shift of focus may be conceptualized using the Haddon Matrix (Appendix 1). This provides a framework within which to facilitate identification of the role of determinants of injuries – classified as host, agent and environment (social and physical) – in the three chronological phases of an injury event (i.e. pre-event, event, and post event). In regards to primary prevention strategies, which focus on the pre-event phase of the injury, research demonstrating the ineffectiveness of educational interventions aimed at behavioral change has drawn attention from the host component of the Haddon Matrix to those of the agent and the environment (Susser, 1993). Even if such interventions at the individual level were effective, high risk factors at the individual level, such as children who are more active, emotionally reactive or temperamentally difficult, or inattentive or distractible or who pose management problems, are poor predictors of injuries. In other words, they make up a very small proportion of the total number of children injured and thus correction of problems stemming from individual level risk factors is likely to have little effect on the overall injury rate (Rivara, 1995). This new focus in injury control suggests that the surrounding environment rather than the child may be 'accident prone' (Saunderland, 1984).

Targeting high risk individuals is inadequate for common diseases or mass exposures (Rose, 1985), such as child injury and low SES respectively. High-risk individual based prevention strategies seek to protect the individuals from the hazard. These rely on parents to "watch" their children or on children to "protect themselves". On the other hand, population or group-level based strategies seek to remove underlying hazards by modifying the environment. This often tends to be a more permanent solution (Rose, 1985). For instance, focus on high risk individuals in the reduction of playground injuries in an area would require programs aimed at increasing parental supervision while a more permanent approach, which targets the community or neighborhood, would be to improve safety of playground equipment. Such modification of the environment represents a "passive approach" to injury reduction; it protects people irrespective of their behaviors and without requiring their active cooperation. Passive prevention strategies are commonly preferred as they are more efficacious than the alternative "active approach" strategies that require change in individual behavior (Susser, 1993). This is not to say that group level or population based approaches are superior to individual level approaches in all circumstances, rather, the largely unexplored benefits of group level approaches would complement "high risk individual" based approaches in the reduction of the burden of child injuries.

1.4 Area variation in child injuries

Geographic variations in injury rates may indicate the presence of factors which pose a common threat to a population in certain areas and not others. Marshall (1991) suggests that such spatial differentials in disease rates seen in urban areas are attributed primarily to socioeconomic deprivation. This is supported by findings of systematic variation in injury by neighborhoods among children and adolescents in Canada (Wilkins et al., 1989). Those residing in the lowest income quintile neighborhoods were at the greatest risk of dying from injuries, with a death rate of 22.2/100,000, while the death rate attributed to injury for the other four quintiles ranged from 15.5 to 17.5 per 100,000.

Often such differences are seen not merely because of the concentration of low-income children, with individual characteristics indicating a predisposition to injuries, in low income neighborhoods, but also due to *contextual effects*: effects which stem from hazardous physical and social conditions of the areas where people live. Often geographical variation in injury rates emerges as a result of effects stemming from both sets of factors – the over-representation of "high-risk individuals" in certain areas and contextual factors inherent to an area (Curtis & Jones, 1998). Public policy directed toward improving hazardous contextual conditions would likely be quite different from steps taken to reduce individual risks (Waitzman & Smith, 1998).

1.5 Contextual Effects

While contextual factors have been given only secondary importance in relation to individual level influences in most disease causal models (Diez-Roux, 1998), accumulating evidence on the direct influence of place effects on health is drawing attention to them. For instance Haan, Kaplan, and Camacho (1987), using data from the Alameda county study, found that mortality risk is strongly predicted by an individual's residence in a high poverty neighborhood. This connection between neighborhood SES and individual health persisted even after the introduction of controls for both individual- and family-level SES.

In common with other diseases, the influence of community contextual factors on child injuries has received little attention. Contextual factors that pose a threat to the safety of children in deprived neighborhoods increase risk of injury for all children residing in such neighborhoods, regardless of their individual family socioeconomic status. The causal pathway from neighborhood contextual factors to child injury is hypothesized to operate through one of two systems of influence: the built environment and the social environment.

1.5.1 Contextual factors: The Built Environment

The built environment refers to those environments that are created, or at least significantly modified, by people. These include buildings, parks, businesses, schools, road systems, and other infrastructures that children encounter in their daily lives. Deprived urban environments are likely to present a different pattern of physical hazards to more advantages areas.

Factors in the built environment affect both psychological and physical well-being (Health Canada, 1997c). Areas with low-income populations are infrequently equipped with playgrounds and parks. As a result the streets become the most accessible substitute (Durkin et al., 1994; Rivara & Barber, 1985) and exposure to motor vehicles and risk of collision are increased (Rivara & Barber, 1985). In supporting this view, several reports show strong associations between pedestrian injury rates and areas characterized by few parks along with other factors of the structural environment such as few bicycle paths, poorly designed intersections, and dense traffic (Guyer, Talbot & Pless, 1985; Deschamps, 1981). Mueller et al. (1990) found areas with curbside parking in front of the child's home elevated the risk of pedestrian injury, probably because of the risk of 'darting out' into traffic. Poor neighborhoods may also present hazards, such as broken playground equipment, broken glass, and housing in poor repair (Durkin et al., 1994). Substandard housing conditions, more commonly found in such neighborhoods, may bring risk of fire and other accidents (Marmot & Wilkinson, 1999; Williams et al., 1996).

To help correct this problem, in many regions taking into account child safety in urban planning is increasingly becoming a priority. In areas where measures aimed at separating traffic from bicyclists and pedestrians were implemented there appeared to be significantly fewer injuries (Organization for Economic Cooperation & Development, 1983). The Dutch "Woonerf" or "living street" plan, in which motor traffic in areas of high housing density is restricted and pedestrians and cyclists have priority over vehicles, have decreased child pedestrian injuries markedly (Royal Dutch Touring Club, 1980). Closer to home, the National Building Code of Canada also includes measures that seek to decrease hazards of the built environment. To achieve a reduction in number and severity of scald injuries, the Code requires the limitation of temperatures of water heaters and exposing piping. Other requirements of the code are intended to reduce the chances of fire spread and to increase the ability of occupants to escape burning buildings (Health Canada: Family and Child Health Unit, 1996). At a more local level, the Capital Health Authority over recent years has made efforts to improve safety of playground equipment with routine inspections and upgrades. Even still, in 1997 only 54% of playgrounds in this region met Canadian Standards Association (CSA) guidelines (Capital Health, 1997).

Much effort is still needed in modifying the built environment to make it safe for all children. Having well designed homes, streets, transportation systems and playgrounds will promote the safety and health of children and youth.

1.5.2 Contextual factors: The Social Environment

The community social environment is a second system of influence. Through its effects on injury prevention practices and risk behavior, the social environment contributes to the geographic differences in injury rates. Therefore, in the individual assessment of injury risk, the social context in which an individual lives should be considered.

Norms perceived by parents pertaining to injury preventive practices of family, neighbors and friends directly influence parental injury preventive behavior (Sellstrom & Bremberg, 1996). In fact, these behavior norms were found to be stronger predictors of preventive behavior by parents, than what parents perceived were the norms of local child health professionals. While the literature on injuries is minimal, the influence of social norms on behaviors leading to other health outcomes is well documented. For instance, high school students are more likely to engage in risky sexual behavior if their friends are sexually active or if they believe that a majority of their peers have had intercourse (Walter et al., 1992). Adolescents' beliefs about the prevalence and acceptance of alcohol and drug use by peers are risk factors for alcohol and drug use (Bailey & Hubard, 1990). It seems reasonable to assume that injury preventive actions may likewise be influenced by the perceived social norm.

The extent of – or the lack of – social networks is also likely to influence injury preventive behavior. Lower levels of community attachment may result in greater reluctance to invest in such health-promoting human capital (Kaplan et al., 1996). This is likely to be a problem particularly for those of lower SES. Turner and Marino (1994), in a study of 1394 adults in metropolitan Toronto, found that higher levels of perceived social support were related to higher SES. Current psychological and sociobiological views suggest that the sense of relatedness with another organism may foster a sense of meaning or coherence that may have relatively direct motivational effects that facilitate health promoting behavior (House, Landis

& Umberson, 1988). For example, young and single pregnant women show higher levels of prenatal care in neighborhoods with strong social networks, perhaps because these networks put pressure on them to avoid compromising the health of their fetus and also provide them with more information about what constitutes effective prenatal care (Taylor, Repetti & Seeman, 1997). Other health habits such as injury prevention behavior may be similarly affected.

In addition to passive social pressures exerted by the perceived behavior and attitudes of peers, social contact with certain individuals may increase the availability of hazardous substances (Dolcini & Adler, 1994). This may particularly be a problem in poor neighborhoods where drug activity and substance abuse are suggested to be more prevalent (Durkin et al., 1994; Spencer, 1996) thus increasing the risk of poisonings resulting from drug overdose or alcohol intoxication for children living in such neighborhoods.

These studies indicate that, in order to be effective, injury prevention programs should be complemented with a strategy to alter social norms. The benefits of such approaches have been acknowledged repeatedly in community based injury prevention centers and have been applied in community interventions over the last decade (Schelp, 1988). "Acknowledging that health promotion rests on the shoulders not only of individuals but also of their communities means that we must commit resources over the next decade to designing, testing, and implementing interventions in this area" (Berkman, 1995).

1.6 Methodological Considerations in Identifying Contextual Factors

The methodological difficulty in quantifying the influence of contextual factors in the past has been a major obstacle in mitigating hazardous neighborhood contextual factors. For instance, ecological analysis produces a mixture of effects that consists of the aggregation of individual level effects, more appropriately termed compositional effects, and contextual effects. The compositional effects emerge in ecological analysis when high-risk individuals are found more commonly in particular neighborhoods (assuming neighborhoods are the ecological unit of analysis) (Duncan, Jones & Moon, 1998). Although ecological correlations may indicate the presence of contextual effects, they cannot be verified using ecological analysis nor is it possible to isolate contextual effects using this technique.

Many researchers have also resorted to traditional contextual regression analysis to try to identify effects on individuals that are consequences of contextual factors of areas. Traditional contextual regression analysis measures associations between area level and individual level risk factors and individual level outcomes. It treats group level measures as individual level observations. In doing so it bases the analysis on the false assumption that there are as many independent observations of group level measures as the number of individuals. This results in less conservative estimates of precision (i.e. narrower confidence intervals) for the influence of contextual factors. Therefore, by failing to recognize the hierarchical structure of the observations, studies employing traditional contextual analysis are also unable to produce precise measures of contextual effects.

At present, the statistical tool producing the most accurate estimates of the contextual effects is multilevel regression analysis or hierarchical linear modeling (HLM). This technique provides a means of isolating individual-level, compositional and contextual effects and also provides a way of showing when contextual effects matter. For instance, HLM is able to identify if the risk of child injury for individuals with low SES is a greater risk factor for those from neighborhoods with high unemployment rates than those from areas with low unemployment rates.

There are three key advantages to using HLM over traditional contextual regression analysis. These are:

1. HLM accounts for the hierarchical structure of the data and thus can produce more accurate estimates of standard error (SE);

2. HLM adjusts for auto-correlation or intra-class correlation. This arises from people within neighborhoods being more similar to each other compared to people across different neighborhoods, which will make the observations less independent. In single level regression techniques, where auto-correlation is not accounted for, this would increase the alpha level error;

3. Finally, HLM allows for 'random effects'. This is the variation in individual level associations by areas due to effect modification by contextual factors.

To my knowledge, only one study has employed this method to adequately tease out the 'true' contextual effects of neighborhood socioeconomic status on child injuries. Reading et al. measured the contextual effects of socioeconomic status on injuries for children from 0 to 4 years of age who were identified through an accident and emergency department in the United Kingdom (Reading et al., 1999). More specifically, they used multilevel logistic regression analysis to show that the Townsend index (a socioeconomic index based on unemployment rate, proportion of crowded accommodations, proportion owning cars and proportion of households owning accommodations) of the neighborhood of residence was a predictor of injuries among children 0 to 4 years of age, independently of their individual level characteristics.

In a similar manner, the current study identifies the relationship between deprivation related contextual factors of neighborhoods and likelihood of injury for children 0 to 17 years of age in an urban setting. Compared to the study by Reading et al. (1999), this study is more comprehensive in the study population examined and the types of injuries assessed. Not only will the effects be estimated for all injuries and severe injuries, but for different injury types as well, and by various age groups for children under 17 years of age. While the principal analysis will be done using a HLM software package, MLwiN, additional analyses involving simple regression techniques will be performed to compare and contrast the results to those generated from HLM.

1.7 Study Objectives

The study objectives are:

1. To describe injury patterns by age group and gender for any injury. various injury types and injuries requiring hospitalization for children 0 to 17 years of age.

2. To determine the association at the individual level between socioeconomic status, and likelihood of injury.

3. To determine the relationship between rate of child injury and neighborhood deprivation at the census tract (CT) level.

4. To identify the association between neighborhood socioeconomic environment and child injury.

    i. This relationship will be assessed using single level regression analysis or traditional contextual analysis.

    ii. The relationship will be assessed using hierarchical linear modeling (HLM).

    iii. The discrepancy in the magnitude and accuracy of associations elucidated using the two different methodologies will be determined.

    iv. Potential cross-level interactions will be explored to assess whether associations with contextual factors are different for children belonging to different socioeconomic groups. In other words, to determine whether the magnitude of contextual effects differs for varying levels of individual level socioeconomic status.

In addition to providing descriptive patterns of injuries in an urban setting, objectives one to three show the relationship between child injury and deprivation at the individual level and at the ecological level, respectively. Different patterns of relationships between risk factors and outcomes emerge at different levels of analysis. Therefore, in order to attain a holistic understanding of disease causation, associations at different levels of analysis must be examined. This dynamic nature of disease causality has been for the most part neglected in epidemiological research and studies on child injuries and socioeconomic status are no exception.

In addition to showing ecological correlation and contextual influences, objectives three and four provide methodological insight into statistical techniques used to determine contextual factors. Commonly mistaken for influences stemming from neighborhood factors are associations determined using ecological analysis and traditional contextual analysis, but it is HLM that produces the most correct estimate of such contextual influences. The ecological analysis performed in objective three provides area level correlations between child injury rates and neighborhood deprivation that represent the combination of compositional and contextual factors of a neighborhood. The contextual effects determined using traditional contextual analysis in objective four provides inaccurate estimates of neighborhood contextual influences on risk of child injury and this is exhibited by comparing the results to those determined using multilevel regression analysis in the second part of objective four.

This thesis is written in a paper-based format. Chapter 2 will provide a review of the literature on child injuries and SES. Chapters 3 and 4 are for the most part stand-alone papers. Chapter 3 will address objectives one to three and chapter 4 will address objective four. Chapter 5 will synthesize the findings across the two papers and provide a brief discussion and conclusion.

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CHAPTER 2

Background on Child injury and Socioeconomic Status

2.1 Definition: Injury

An injury is any specific and identifiable bodily impairment or damage resulting from acute exposure to thermal, mechanical, electrical, or chemical energy, or from the absence of essentials such as heat or oxygen (Gibson, 1961). Rarely do studies use such comprehensive criteria to define injuries. As injury events are treated at many different sites (e.g. home, emergency rooms), it is impossible to capture all events using one source, document or database. As a result, investigators often restrict definitions of injury events to those documented at a single site (e.g. emergency departments). Consequently, these studies are biased by factors that predispose cases to present to a specific site, such as severity of injury and accessibility. Surveys based on questionnaires also serve as common sources to identify injury events, but these are subject to recall bias by survey respondents. This study uses an administrative database to define injury events among children. This database captured injuries treated at physician's offices, emergency rooms, plus those that required hospital admissions; as such it comprises a large portion of the injury events.

2.2 Definition: Socioeconomic Status

Socioeconomic status is a multidimensional and nebulous term. While it often appears alongside terms such as poverty, deprivation and low income, all of these terms, while interrelated, refer to different conditions or experiences. *Socioeconomic status* is defined as a "descriptive term for a person's position in society, which may be expressed on an ordinal scale using such criteria as income, educational level attained, occupation, value of dwelling place, etc" (Last, 1995). While both the social and economic dimensions tend to coexist, resulting in synergistic effects, among some groups, either the social or economic dimension may play a role independent of the other. For instance, among ethnic minority groups, low SES is created or exacerbated by discrimination and marginalization, (Spencer, 1996) regardless of their income or economic situation.

'Poverty' and 'deprivation' refer to the lack of resources and conditions experienced by individuals belonging to the lower socioeconomic (social and/or economic) group. In developed nations poverty in most circumstances refers to 'relative poverty' in that people have insufficient resources to enable them to participate fully in the life of the society to which they belong. This relative limitation of resources imposes limits on housing, nutrition and leisure choices. 'Absolute poverty' is usually of little concern in Canada as current living standards virtually preclude the situation where people have insufficient basic resources such as food to sustain life (Spencer, 1996). The concept of 'deprivation' refers to the conditions, either social (e.g. marginalization) or material (e.g. not owning a car) in nature, experienced by people who are poor, whereas the concept of poverty relates to the lack of income and other resources which create these conditions and which make these conditions difficult to break away from (Townsend, 1987). Deprivation is a more a commonly used measure of low SES in studies originating from the United Kingdom, than from North America. Income is not captured in their Population Census enumerated in the United Kingdom and as such indices, such as the Townsend index, which measure the lack of resources (e.g. not owning a car) are used as a substitute. In North America, income is often available and as such it is possible to measure more components of poverty.

Psychosocially mediated effects of low SES are often shown by lack of self-esteem and feelings of powerlessness. There is evidence linking these feelings with relative poverty and adverse health outcomes for children as well as evidence for improvements in self-esteem and child rearing practices with improvements in SES (Garrett, Ng'andu & Ferron, 1994). Environmental influences of low socioeconomic status are manifested by higher rates of crime, unemployment, drug and substance abuse, and educational underachievement , all factors that create an unhealthy and threatening environment for child rearing. Furthermore, in such environments, there are few leisure facilities and services tend to be inadequate or of poor quality with limited public transport. These factors limit the ability of the poor to access the social and cultural life enjoyed by their fellow citizens, resulting in social exclusion (Spencer, 1996).

While terms like poverty, deprivation and low income tend to focus on groups at or near the lower limits of the social and/or economic spectrum, the relationship between socioeconomic status and health operates as a gradient and therefore functions across the spectrum (Ecob & Smith, 1999; Marmot et al., 1991; Rose, 1992). In a similar manner, this study examines the linear relationship between child injury and neighborhood socioeconomic status across the socioeconomic spectrum. Consequently, 'socioeconomic status' is the most suitable term for this investigation.

The lack of a gold standard measure for socioeconomic status makes the process of choosing the most appropriate SES indicator difficult (Liberatos, Link & Kelsey, 1988). It is often assumed that different indicators measure different components of SES. Consequently, generalizations on SES influences drawn from the relationships between the study SES indicators and the study outcomes are limited to the SES components measured by the indicators. Therefore it is crucial to distinguish the aspects of SES that the study indicators do and don't represent.

2.3 Study Socioeconomic Status Indicators

For this investigation, payment status of the Alberta provincial health insurance plan is used as the proxy for the individual level SES indicator and indicators from the 1996 Population Census are used to describe neighborhood SES.

While socioeconomic information on health administrative databases is rare, the database used by Alberta Health and Wellness contains information on whether residents are of low income, on social services or have Treaty Status. These individuals have their payments for the provincial health insurance plan subsidized by the Provincial or Federal (for Treaty Status) government while the remaining residents make payments of the full amount. Payment status is indicated for each individual in the Provincial health administrative database and, in this investigation, is used as the proxy for individual level SES. Although Treaty Status is a demographic classification and not a socioeconomic category, the Canadian Council on Social Development reported that 62% of Aboriginals residing in the City of Edmonton live in poverty (Lee, 2000). Nevertheless, care must be taken in generalizing these population-based statistics to every individual with Treaty Status; however, what does affect every individual with Treaty Status is the social consequences of being Treaty Status. This group is often discriminated against and marginalized. These are common consequences of social deprivation. In summary, while the Alberta health insurance payment status is not strictly a classification of SES, with careful consideration of the limitations of each category, it serves as a fair proxy for SES.

For this study, neighborhood SES is assessed using indicators from the Population Census pertaining to each census tract. Multiple 'raw' socioeconomic parameters rather than socioeconomic indices, such as the Townsend index, are used because the extent of health inequalities varies with different social indicators (Liberatos, 1988; Manor, Mathews & Power, 1997). Furthermore, the social workings of raw measures are more easily understood for hypothesis generation of the causal pathway.

Parameters measured at the CT level are group level variables, which can be either derived or integral in nature (Diez-Roux, 1998). Derived variables are measures, such as mean neighborhood income, that aggregate information from individual level units whereas integral variables do not have individual level analogues and therefore they can be measured only at the group level. In this study, except for the measure of income inequality of neighborhoods, the remaining CT level deprivation measures considered are derived. Derived ecological variables measure a different construct than their individual level equivalent, therefore, one would be interested in group-level variables that aggregate individual level information, even if the information is available for every individual (Schwartz, 1994). For instance, family income at the individual level measures economic status of the family, while mean neighborhood family income may be an indicator of playground quality, road conditions and other aspects of the neighborhood that affects all children in the neighborhood regardless of their individual level family incomes. This information cannot be captured by the individual level variable.

2.4 Literature Review on Child Injury and Socioeconomic Status

A literature search was conducted using the Medline database for articles published in the years from 1966 to 2000. The following keywords were used to identify the articles: *socioeconomic, poverty, deprivation, injuries, child and adolescent*. Additional studies in this area that were cited in these articles were also considered for this review. A total of 45 pertinent studies were found that fit the inclusion criteria of examining the association between child injuries and at least one deprivation measure. In addition, one systematic review of child injury and socioeconomic status was also found.

Table 2.1 demonstrates the diversity in the focus of the studies. There was wide variety in the age groups studied, in injury types and outcomes, SES indicators, and study methodologies. Of the 45 studies, analysis was performed at the individual level in 27 papers and at the ecological level in 13 papers. Four studies used traditional contextual analysis, primarily because group level deprivation measures were substituted for the unavailability of individual level ones. Finally, Reading et al. (1999) applied multilevel regression analysis to determine deprivation related risk factors inherent to neighborhoods and associated it with child injury among 0 to 4 year olds.

Mackay et al. (2000) recently reviewed 57 studies pertaining to the relationship between child injury and socioeconomic status. They concluded that the majority of the studies were methodologically weak. As well, they found difficulty in synthesizing the results due to the variety of socioeconomic measures used and when similar SES measures were used, the different operational definitions encountered added to the difficulty in summarizing the results. Despite this, they suggested that "...there is enough evidence presented in these studies to compel continued study into this issue (of child injury and SES)...."

Similar to Mackay's findings, in the studies that we reviewed the choice of injury type, injury severity, and the SES indicator used had strong implications on the relationship that emerged between injury and SES. As a result, this review will provide summaries of this relationship by injury types, severity of injuries and by the SES indicators used. This will be followed by a brief review of the study methodologies with a focus on the level of analysis, a discussion of the key studies, and limitations of the literature.

Table 2.1: Child Injury and Socioeconomic Status: Summary of Literature

Citation	Study Type/ Level of analysis	Ecological Unit	Age group	Injury Type	Outcome	SES Indicators*	Methodology
Backett et al 1959	Individual level –case control	n/a	5-14	Pedestrian	Non-fatal pedestrian accidents presented to the hospital	Crowding: + Ratio of dependents per earner: +	Chi square test
Manheimer et al 1966	Individual level - cohort	n/a	0-16	All injuries	Injuries requiring medical attention	Occupation: +	Compared rates
Savage 1972	Individual level – case control	n/a	0-14	Burns	Hospital admission	Income: + Occupation: + Maternal employment: +	Compared percentage of risk factors occurring in cases with that of the Population Census
Murdock et al 1974	Individual level –case control	n/a	0-15	Home accidents	Cases presented to hospitals (outpatients and admissions)	Occupational status: o Lone parents: o	Chi square test
Shaw 1977	Individual level - case control	n/a	1-5	Poisoning	Presented to emergency department	Parental education: o Occupation: o Crowding: o	Chi square test
Dershewitz 1978	Individual level - cohort	n/a	0-4	All injuries**	Injuries requiring medical attention	Health insurance: -	Chi square test
Nixon et al 1978	Individual level – case control	n/a	0-15	Drowning	Hospitalization or mortality	Occupational class: - swimming pool + bathtub	Chi-square test
Joseph et al 1979	Individual level – case control	n/a	Child	Burn injuries	Hospital admission	Occupation: + Maternal unemployment: -	Compared percentage of risk factors occurring in cases with that of the Population Census

* Note: '+' indicates positive relationship between injuries and low SES; 'o' indicates no relationship between injuries and low SES; '-' indicates negative relationship between injuries and low SES. Low SES refer to conditions such as low income, lone parenthood, unemployed, low occupational status, low education levels, crowded dwellings, etc.
** Analysis was performed for injuries stratified by specific injury types (e.g. Falls) as well. Associations with SES are shown only for all injuries.

Table 2.1: Child Injury and Socioeconomic Status: Summary of Literature (continued)

Citation	Study Type/ Level of analysis	Ecological Unit	Age group	Injury Type	Outcome	SES Indicators*	Methodology
Learmonth 1979	Individual level – case control	n/a	Child	Burns	Cases presented to hospital	Occupation: + Crowding: o Lone female parent: +	Compared percentage of risk factors occurring in cases with that of the Population Census
Langley et al 1980	Individual level – cohort	n/a	0-5	All injuries	Injuries requiring medical attention	Parental education: o Paternal occupation: o	Used ANOVA to compare three groups: 1)No injury, 2)One injury, and 3) More than one injury in the first five years of life
McCormick et al 1980	Individual level – cohort	n/a	<1	All injuries	Injuries requiring medical attention	Income: o Education: o	Chi square test
Walker et al 1982	Individual level – cohort	n/a	0-12	All injuries	Cases receiving outpatient medical care	Income: + Lone parents: +	Chi square test
Langley et al 1983	Individual level – cohort	n/a	0-7	All injuries	Injuries requiring medical attention	Education: o Occupation: o Housing index: o	Chi square with tests for linear trends between number of injuries and SES gradient
Wadsworth et al 1983	Individual level – case control	n/a	0-5	All injuries**	Injuries requiring medical attention	Lone parents: o all injuries o hospital admission	Logistic regression

* Note: + indicates positive relationship between injuries and low SES; 'o' indicates no relationship between injuries and low SES; '-' indicates negative relationship between injuries and low SES.
Low SES refer to conditions such as low income, lone parenthood, unemployed, low occupational status, low education levels, crowded dwellings, etc.
** Analysis was performed for injuries stratified by specific injury types (e.g. Falls) as well. Associations with SES shown only for all injuries.

Table 2.1: Child Injury and Socioeconomic Status: Summary of Literature (continued)

Citation	Study Type/ Level of analysis	Ecological Unit	Age group	Injury Type	Outcome	SES Indicators*	Methodology
Sunderland 1984	Ecological level	Constitu-encies	0-15	Pedestrian	Mortality	SES index: + (based on crowding and availability of toilet facilities)	Comparison of ranking of seven constituencies by SES to ranking by pedestrian injury mortality rate
Nersesian et al 1985	Individual level - cohort	n/a	0-17	All injuries**	Mortality	Medicaid or Food stamps or Aid to Families with Dependent Children (AFDC): +	Chi square test
Rivara et al 1985	Ecological level	Census tract	0-14	Pedestrian injuries	Injuries reported to police	Income: + Lone parents: + Crowding: +	Regression analysis with injuries per acre (within CTs) as the outcome
Wise et al 1985	Ecological level	Census tract	0-19	All injuries**	Mortality	Income: +	Poisson regression to test for association between mortality rates and census tracts categorized into one of three income groups
Emerick et al 1986	Individual level –case control	n/a	<1	All injuries**	Mortality	Maternal education: + Lone female parent: +	Relative risks and chi square test

* Note: '+' indicates positive relationship between injuries and low SES; 'o' indicates no relationship between injuries and low SES; '-' indicates negative relationship between injuries and low SES. Low SES refer to conditions such as low income, lone parenthood, unemployed, low occupational status, low education levels, crowded dwellings, etc.
** Analysis was performed for injuries stratified by specific injury types (e.g. Falls) as well. Associations with SES shown only for all injuries.

Table 2.1: Child Injury and Socioeconomic Status: Summary of Literature (continued)

Citation	Study Type/ Level of analysis	Ecological Unit	Age group	Injury Type	Outcome	SES Indicators*	Methodology
Pless et al 1987	Ecological level	Census tract	0-14	Pedestrian /Bicycle injuries	Cases presented to hospital and had Maximum Abbreviated Injury Scale (MAIS) Scores >1	Child poverty index: +	Comparison of three groups of CTs categorized by SES as low, intermediate or high SES.
Alwash et al 1988	Individual level – case control	n/a	0-5	All injuries	Cases presented to accident department	Occupation: +	Chi square test to compare mild, moderate and severe injuries
Larson et al 1988	Individual level - cohort	n/a	0-3	All injuries	Injuries requiring medical attention	Maternal employment: + Female lone parents: + Education: +	Logistic regression
Pless et al 1989	Individual level – case control	n/a	0-14	Pedestrian / Bicycle Injuries	Maximum Abbreviated Injury Scale (MAIS) score of at least 2 out of 6	Maternal employment: o	Logistic regression analysis
Avery et al 1990	Ecological level	Health District	0-14	All injuries	Mortality	Jarman 8 indices: + (based on lone parents, the unskilled, crowding, unemployed, mobility and ethnic minority)	Pearson correlation coefficient between rates and SES index
Dougherty et al 1990	Ecological level	Census tract	0-14	Pedestrian /Bicycle injuries	Mortality and injuries requiring hospital care or police reports	Income: + morbidity o mortality	Test for linear trend of increasing median income

* Note: '+' indicates positive relationship between injuries and low SES; 'o' indicates no relationship between injuries and low SES; '-' indicates negative relationship between injuries and low SES. Low SES refer to conditions such as low income, lone parenthood, unemployed, low occupational status, low education levels, crowded dwellings, etc.

** Analysis was performed for injuries stratified by specific injury types (e.g. Falls) as well. Associations with SES shown only for all injuries.

Table 2.1: Child Injury and Socioeconomic Status: Summary of Literature (continued)

Citation and country	Study Type/ Level of analysis	Ecological Unit	Age group	Injury Type	Outcome	SES Indicators*	Methodology
Mueller et al 1990	Traditional contextual	Census tract	0-15	Pedestrian	Mortality or hospital admission	Individual level: condominium/ apartment: + Ecological level: income: +	Conditional logistic regression with age and sex matched control group
Braddock et al 1991	Ecological level	Census tract	0-14	Pedestrian	Morbidity determined from police reports	Income: + Lone parents: + Crowding: + Rent: o Density: +	Analysis of variance was used to compare three groups of CTs categorized by frequency of injuries
Roberts et al 1992	Ecological level	Census tract	0-15	All injuries	Hospital admission	Unemployment rate: +	Spearman rank correlation coefficients between standardized injury morbidity ratios and unemployment rate
Carey et al 1993	Ecological level	Census tract	0-14	All injuries**	Mortality	SES indicator: + (based on income, education, occupation, wealth, prestige)	Test for linear trend of increasing injury mortality with increasing SES
Jolly et al 1993	Ecological level	Postal Code	0-14	All injuries**	Hospital admission	Income: + Education: + Unemployment: + Lone parents: + (Australian Bureau of Statistics indicator)	Pearson correlation coefficients between injury rates and SES indicator followed by path analysis involving multiple regression techniques

* Note: '+' indicates positive relationship between injuries and low SES; 'o' indicates no relationship between injuries and low SES; '-' indicates negative relationship between injuries and low SES. Low SES refer to conditions such as low income, lone parenthood, unemployed, low occupational status, low education levels, crowded dwellings, etc.
** Analysis was performed for injuries stratified by specific injury types (e.g. Falls) as well. Associations with SES shown only for all injuries.

Table 2.1: Child Injury and Socioeconomic Status: Summary of Literature (continued)

Citation	Study Type/ Level of analysis	Ecological Unit	Age group	Injury Type	Outcome	SES Indicators*	Methodology
Anderson et al 1994	Ecological level	Township	12-16	All injuries	Injuries requiring medical attention	Income: o	Life table analysis comparing the proportion remaining injury free over 2 years for three towns
Cummings et al 1994	Traditional contextual	Census tract	<1	All injuries	Mortality	Individual level: Female lone parent: o Ecological level: Income: o	Logistic regression analysis
Durkin et al 1994	Ecological level	Census tract	0-17	All injuries**	Injuries resulting in hospitalization or deaths	Income: + Education: + Unemployment rate: + Lone parents: + Crowding: +	Multiple linear regression
Harris et al 1994	Individual level – case control	n/a	<1	Unintentional injuries	Injuries requiring medical attention	Parental education: o Employment: + Medicaid: o Lone parents: o Race White/Non-white: o	Logistic regression
Petridou et al 1994	Individual level – case control	n/a	5-14	School injuries	School injuries admitted to hospital	Paternal education: + Lone parents: +	Conditional logistic regression (Matched for age and gender)
Roberts 1994	Individual level – case control	n/a	Pre-school and school aged children	Pedestrian injuries	Hospitalization or mortality	Lone parents: + Elley Irving scale: +	Logistic regression analysis

* Note: '+' indicates positive relationship between injuries and low SES; 'o' indicates no relationship between injuries and low SES; '-' indicates negative relationship between injuries and low SES. Low SES refer to conditions such as low income, lone parenthood, unemployed, low occupational status, low education levels, crowded dwellings, etc.
** Analysis was performed for injuries stratified by specific injury types (e.g. Falls) as well. Associations with SES shown only for all injuries.

Table 2.1: Child Injury and Socioeconomic Status: Summary of Literature (continued)

Citation	Study Type/ Level of analysis	Ecological Unit	Age group	Injury Type	Outcome	SES Indicators*	Methodology
Roberts et al 1996	Individual level – case control	n/a	0-15	All injuries	Mortality	Occupation: +	Rates and Poisson regression modelling to test the decline in injury mortality rates across occupational status over time.
Williams et al 1996	Individual level – case control	n/a	11 13 15	All injuries**	Injuries requiring medical attention	Occupation: o Crowding: o Car ownership: o	Logistic regression
Overpeck et al 1997	Individual level – case control	n/a	0-17	All injuries	Medically attended non-fatal injuries	Income: o Maternal education: - Health coverage: - Lone parents: +	Linear regression to assess relationships with injury rates
Roberts 1997	Individual level – case control	n/a	0-15	All injuries**	Mortality	Registrar general's occupational class: +	Poisson regression used to test the linear trend in injury deaths across social classes
Scholer et al 1997	Traditional contextual	Census tract	0-4	All injuries	Mortality	Individual level: Maternal education: + Female lone parent: + Ecological level: Income: o	Poisson regression
Werneck et al 1997	Individual level – case control	n/a	0-11	Burns	Cases admitted to burn units	Maternal education: o Recent unemployment of mother: + Crowding: + Housing condition index: o	Unconditional logistic regression

* Note: '+' indicates positive relationship between injuries and low SES; 'o' indicates no relationship between injuries and low SES; '-' indicates negative relationship between injuries and low SES. Low SES refer to conditions such as low income, lone parenthood, unemployed, low occupational status, low education levels, crowded dwellings, etc.
** Analysis was performed for injuries stratified by specific injury types (e.g. Falls) as well. Associations with SES shown only for all injuries.

Table 2.1: Child Injury and Socioeconomic Status: Summary of Literature (continued)

Citation	Study Type/ Level of analysis	Ecological Unit	Age group	Injury Type	Outcome	SES Indicators*	Methodology
Calhoun et al 1998	Ecological level	Zip Code	0-15	Pedestrian injuries	Hospital admission	Income: + Female lone parent: + Housing value/rental value: + Families receiving public assistance: +	Comparison of areas with and without injuries using t-test.
Scholer et al 1998	Traditional contextual	Census tract	0-5	Burns	Mortality	Individual level: Maternal education: + Female lone parent: + Ecological level: Income: o	Poisson regression
Reading et al 1999	Multilevel analysis	Groups of adjacent enumeration areas with similar SES	0-4	All injuries	Cases presented to accident and emergency department	Individual level: Lone parent All injuries: o Hospital admissions: + Ecological level: Townsend material deprivation index: + all injuries + hospital admissions	Multilevel logistic regression analysis

* Note: '+' indicates positive relationship between injuries and low SES; 'o' indicates no relationship between injuries and low SES; '-' indicates negative relationship between injuries and low SES. Low SES refer to conditions such as low income, lone parenthood, unemployed, low occupational status, low education levels, crowded dwellings, etc.
** Analysis was performed for injuries stratified by specific injury types (e.g. Falls) as well. Associations with SES shown only for all injuries.

2.4.1 Injuries of Low Socioeconomic Groups

Most of the injury types that were found to vary by SES, were over represented in children from lower socioeconomic status families or deprived areas. This was the case for assault or intentional injuries (Durkin et al., 1994; Emerick, Foster & Campbell 1986; Roberts, 1997; Williams et al., 1997; Wise et al., 1985), burns and scalds (Durkin et al., 1994; Joseph & Douglas, 1979; Learmouth, 1979; Nersisian et al., 1985; Roberts, 1997; Savage, 1972; Scholer et al., 1998; Wadsworth et al., 1983; Werneck & Reichenheim, 1997; Wise et al., 1985). pedestrian and bicycle injuries (Backett & Johnson, 1959; Braddock et al., 1991; Calhoun et al., 1998; Carey, Vimpani & Taylor, 1993; Dougherty, Pless, & Wilkins, 1990; Mueller, Rivara & Lii, 1990; Pless et al., 1987; Pless, Verrault & Tenina, 1989; Rivara & Barber, 1985; Roberts, 1994; Roberts, 1997; Saunderland, 1984; Williams et al., 1997) and poisoning injuries (Roberts, 1997; Shaw, 1977; Wadsworth et al., 1983). Among these, some of the largest discrepancies in SES were noted for burn injuries among children. This type of injury repeatedly emerged with one of the largest magnitudes of association with low socioeconomic status relative to other injury types examined (Nersisian et al., 1985; Roberts, 1997; Wadsworth et al., 1983; Wise et al., 1985).

2.4.2 Injuries of High Socioeconomic Groups

A small number of studies found that injuries resulting from motor vehicle collisions [MVC], sports injuries and drowning injuries were over represented in children from affluent families or neighborhoods. Although several investigators identified MVCs as a greater hazard for children from deprived families (Durkin et al., 1994; Emerick, Foster & Campbell, 1986; Nersisian et al., 1985; Roberts, 1997), studies by Williams et al. (1997) and Wise et al. (1985)

found MVCs among children to be positively correlated with high socioeconomic status. Age is a possible explanation in that MVCs involving teenage drivers may have different SES patterns than those involving child passengers. Adolescents from more affluent families are perhaps more likely to own cars and may therefore be at a greater risk of MVCs due to the increased exposure to driving. This factor was not considered in any of the studies in this review.

Child injuries resulting from sports activities also tended to be more common in children from families of high SES or affluent areas. A case control study of adolescents in Scotland (Williams et al., 1996) found these injuries to be strongly positively associated ($P < 0.001$) with family affluence. In a similar manner, although Jolly, Moller & Volkmer (1993) found rates of sports injury to be positively correlated with unemployment rate in the area, the association was much weaker compared to that for all injury. Furthermore, while a higher percentage of lone parents and a low score on a socioeconomic status index (based on the Australian Bureau of Statistics) were found to increase total injury rates of areas, no such associations were found for sports related injury rates. Both studies by Williams et al. (1996) and Jolly, Moller & Volkmer (1993) attribute such findings to increased exposure to sporting activities for children of higher social classes.

Exposure to risk is also implicated in explaining associations found between high socioeconomic status and drowning. Mortality or hospital admissions resulting from child drowning occurred more frequently among children with fathers in high occupational status (Nixon & Pearn, 1978); however, when this was analyzed by site of immersion, there was a striking social class bias in domestic bath-tub accidents towards families of lower social class ($P<0.01$) and bias in swimming pool accidents towards families of high social class. Another study found children of lower SES to be at an increased risk. Nersisian et al. (1985) found mortality due to drowning to be significantly higher for children participating in social welfare programs when compared to all other children in a population-based analysis of all children in Maine, United States. However, site of immersion was not examined in this study.

In summary, sports related injuries are more prevalent in high SES groups. The evidence on socioeconomic bias in drownings is equivocal since the site of immersion was not always documented. Similarly, it is difficult to conclude any socioeconomic bias for MVCs since the driver/passenger status was not examined.

2.4.3 Severe Injuries

Several authors contrasted the effects of SES on severe injuries, commonly identified as those requiring hospital, to non-severe injuries. Not only do these types of injuries magnify the human suffering associated with typical injuries, but they also increase the economic cost for treatment and care.

Rates of severe injuries were consistently disproportionately high among children from lone parent homes while the same study populations did not show such a relationship for non-severe injuries (Wadsworth et al., 1983; Reading et al., 1999; Harris & Kotch, 1994). In contrast to the these findings at the individual level, Jolly, Moller & Volkmer (1993) found the correlation between injury rates and the percentage of single parents in an area (area being defined as the geographic area bounded by a single postal code) to be higher for non-severe injuries (outpatients) compared to those for injuries requiring hospital admission. However, this study is flawed in that the postal codes used reflected the location of the hospital rather than the residence of the children and not all of the children in the hospital catchment area would have presented to the 'expected hospital'. Therefore, based on the studies reviewed, sufficient evidence exists to indicate a positive relationship between lone parenthood and severe injuries at the individual level but no conclusive relationships can be drawn at the ecological level.

Only two investigations examined parental occupation with regards to its association with injury severity. Alwash & McCarthy (1988) found lower parental occupational class to be a bigger risk factor for severe injury than non-severe injury. Manheimer et al. (1966) found higher injury rates among professionals for all injuries but no such difference for severe injuries. Both studies suggest an inverse relationship between parental occupational status and injury severity among children.

Inconsistent results were found in the two studies that assessed the association between income and injury severity. Using multilevel regression analysis, Reading et al. (1999) found factors inherent to deprived neighborhoods – as indicated by the Townsend index of social deprivation – to be a better predictor for severe injury than non-severe injury among children 0 to 4 years of age. In contrast, Dougherty, Pless, & Wilkins (1990) found neighborhood median household income quintile to be negatively correlated with pedestrian injury morbidity rates but not for mortality rates, but the insufficient number of deaths in this investigation may have obstructed the detection of any statistically significant associations between mortality and SES quintiles. Therefore, the finding of a relationship between low income and injury severity by Reading et al. (1999) probably is more reliable.

Except for marital status, where the risk of severe injuries relative to non-severe injuries for children from lone parent households was repeatedly found to be greater, it is difficult to draw conclusions about the associations with specific indicators. This is due to the limited numbers of studies that examined similar SES indicators in association with injury severity, but on balance there appears to be a general trend towards a greater correlation between low SES and severe injuries among children.

2.4.4 Socioeconomic Indicators

The patterns of association between injury and SES varied depending on the SES indicators used. Different SES indicators measure different constructs that are each involved in unique causal pathways to injuries. These pathways are even more distinct at the different levels of analysis (i.e. individual level and ecological level). Consequently, the findings will be summarized by the different socioeconomic indicators used with a focus on the level of analysis.

SES Indicators: Income

Low family income repeatedly appeared to be a risk factor for child injuries. However, this was the case only for individual level analyses (Savage, 1972; Walker & Raines, 1982) and ecological analysis (Braddock et al., 1991; Wise et al., 1985; Calhoun et al., 1998; Dougherty, Pless & Wilkins, 1990; Jolly, Moller & Volkmer, 1993; Durkin et al., 1994). Most of the studies that assessed the relationship between individual level outcomes and income measured at the area level (i.e. traditional contextual analysis), did not find any significant associations (Cummings et al., 1994; Scholer, Mitchel & Ray, 1997; Scholer et al., 1998). Such differences in findings may be attributed to the different constructs measured in the different study types. In traditional contextual analysis, income is a proxy for the neighborhood environment, such as road conditions or socio-cultural attitudes toward injury preventive behavior. At the individual level, the same indicator reflects the socioeconomic status and the related psychosocial and behavioral factors of the child's family. The positive relationships found at the ecological level may just represent the aggregation of individual level associations (i.e. compositional effects), where the over-representation of low income individuals in certain areas are responsible for the observed high injury rates, instead of representing factors inherent to low income areas that contribute to the increased risk.

In summary, these studies suggest that factors inherent to low income census tracts do not influence significantly the likelihood of child injury while low income at the family level does increase the likelihood of child injury. However, care must be taken when using the studies in this review to draw conclusions on area level influences on child injury, primarily because the use of census tracts as the ecological unit in all of these studies may be unsuitable for detecting such associations. Census tracts are often heterogeneous with respect to SES and this may obscure the detection of influence of area level factors related to SES measured at the CT level (Cherkin, Grothaus & Wagner, 1992).

SES Indicators: Education

There were three studies that found a positive correlation between child injuries and low parental education at the individual level. However, they examined only injuries requiring hospital admissions (Petridou et al., 1994), those with a Maximum Abbreviated Injury Score (MAIS) of at least two (Pless, Verrault & Tenina, 1989), or those resulting in death (Emerick, Foster & Campbell, 1986). In contrast, four of the six studies that did not find an association between parental education and child injuries studied "injuries requiring medical attention" as the outcome (Langley, Silva & Williams, 1980, 1983; Harris & Kotch, 1994; McCormick, Shapiro & Starfield, 1981); most such injuries are minor (Overpeck et al., 1997). Shaw (1977) found no relationship with parental education when examining children who were *thought* to have ingested poisonous substances and presented to the emergency department. As well, neither the diagnoses nor the severity of the cases were reported and physician-seeking behavior may have biased the injury outcome. Werneck & Reichenheim (1997) also found no association between injuries and parental education when examining a severe outcome (i.e. hospital admissions), but the sample size was small and the final model contained numerous covariates that may have obscured the detection of such a relationship.

Overpeck et al. (1997) found maternal education of less than 12 years to be a protective factor of medically attended child injuries when access to care and health coverage were adjusted for in a study conducted in the United States. The authors suggest that this may reflect a bias toward sports injury in the injuries studied and the greater likelihood of children of higher SES to experience sports related injury.

Two studies assessed ecological level correlation between injuries and education. Both found that areas with low proportion of educated people had significantly higher area level child injury hospitalizations and mortality rates (Durkin et al., 1994; Jolly, Moller & Volkmer, 1993).

In summary, parental education appears to be a predictor of severe injuries at both the individual level and at the ecological level. Again the variation in injury definitions studied impeded the detection of unambiguous findings. For non-severe injuries, parental education does not appear to influence the likelihood of injuries at the individual level.

SES Indicators: Occupation

Parental occupational status has also been frequently studied as a possible predictor of child injuries. Due to the unfeasibility of aggregating occupational status of individuals to single group level measures, it was only assessed at the individual level. Except for findings by Manheimer et al. (1966), the investigations that found a positive correlation between injuries and low occupational status tended to focus on more severe outcomes such as mortality (Roberts & Power, 1996; Roberts, 1997), cases presenting to an accident department (Alwash

& McCarthy, 1988), cases presenting to a hospital (Learmouth, 1979) and injuries requiring hospital admission (Savage, 1972). Although Manheimer et al. (1966) claimed a positive relationship when examining a generally less severe outcome – injuries requiring medical attention – they did not use any statistical tools to check for the significance in difference in rates and thus it is hard to draw any firm conclusions.

Investigations that found no relationship between parental occupational status and injuries tended to focus on injuries requiring medical attention (Langley, Silva & Williams, 1980, 1983; Williams et al. 1996). Most such injuries are minor (Overpeck et al., 1997). While Murdock & Eva (1974) found no association between parental occupation and injuries presented to the hospital, their study was limited to injuries occurring only at home. The findings of no association between injury and parental occupational status by Shaw (1977) in their examination of poisoning among 0 to 5 year olds that presented to the emergency department may apply only to poisonings. Shaw's findings lack credibility in that they examined children *thought* to have ingested poisonous substances, and not just those that *were* poisoned. Therefore, as mentioned earlier, there is a strong possibility for bias in the outcome, especially for poisoning injuries.

The difference in exposure to swimming pools attributed to SES probably explains the finding by Nixon & Pearn (1978) that drowning injuries resulting in mortality or hospital admission were more prevalent in higher occupational status groups (i.e. professional).

Overall, severe child injuries tend to be more common among those with low occupational status parents, with significant variation by injury type. Child injuries resulting in non-severe outcomes do not appear to be correlated with parental occupational status in the studies reviewed.

SES Indicators: Unemployment

Investigators consistently detected a positive correlation of parental unemployment with child injury. At the individual level, maternal unemployment was the most commonly studied measure of parental employment. It was positively correlated with child injuries in most investigations (Harris & Kotch, 1994; Joseph & Douglas, 1979; Larson & Pless, 1988; Savage, 1972; Werneck & Reichenheim, 1997) except for one done by Pless, Verrault & Tenina (1989) in which no relationship was detected. This finding suggests that either pedestrian injuries are unrelated to maternal unemployment or that adjusting for socioeconomic area of residence obscures the relationship between maternal unemployment and pedestrian injuries. All three studies that examined the significance of unemployment rate at the ecological level found it to be positively associated with child injury rates (Durkin et al., 1994; Jolly, Moller & Volkmer, 1993; Roberts et al., 1992).

Among the SES indicators examined, parental employment status appears to be one of the more reliable predictors of child injuries at both the individual level and at the ecological level. However, at the ecological level unemployment rates were assessed for correlation with rates of severe outcomes (i.e. injury hospitalizations) only, thus this geographical correlation cannot be generalized to non-severe injuries.

SES Indicators: Lone Parenthood

Lone parenthood was the most commonly assessed SES risk factor for child injuries in this review, and the majority of the studies that investigated this SES indicator found it to be a risk factor for injury. These observations were documented at all four levels of analysis: individual level (Emerick, Foster & Campbell, 1986; Larson & Pless, 1988; Learmouth, 1979; Overpeck et al., 1997; Petridou et al., 1994; Roberts, 1994; Walker & Raines, 1982), ecological level (Braddock et al., 1991; Calhoun et al., 1998; Durkin et al., 1994; Jolly, Moller & Volkmer, 1993), traditional contextual (Cummings et al., 1994; Scholer, Mitchel & Ray, 1997; Scholer et al., 1998), and multilevel (Reading et al., 1999). Most investigators did not distinguish between the sex of the lone parent. Two studies reported lone parenthood to be correlated only with severe injury (i.e. hospital admissions) and not for non-severe injury in the same study populations. No such patterns of association between child injuries and lone parenthood by injury severity were noted in the remaining studies. A few studies found no relationship between child injury and lone parenthood (Cummings et al., 1994; Harris & Kotch, 1994; Murdock & Eva, 1974); no specific analytical method (e.g. individual level) nor injury severity predominated among these studies. A possible explanation for the findings of Harris & Kotch (1994) and Murdock & Eva (1974) is that the relationship between SES and injury does not exist for children less than one year of age, the age group assessed in these two studies. This is supported by the observation that, except for findings by Emerick (1986), investigators have repeatedly reported the lack of association between injuries and various SES indicators for this age group (Harris & Kotch, 1994; McCormick, 1980; Murdock & Eva, 1974).

Overall, while most of the studies in this review report lone parenthood to be a risk factor for child injuries above the age of one, certain investigations claim this to be the case only for injuries requiring hospital admissions and no such association for non severe injuries.

SES Indicators: Dwelling Conditions

Several measures of dwelling condition were considered as potential risk factors for child injuries. Among these, crowding was the predominant condition assessed. Children from crowded households were found to be at an increased risk of injury in only two studies (Backett & Johnson, 1959; Werneck & Reichenheim, 1997) and no such relationship was found for three other studies (Learmouth, 1979; Shaw, 1977; Williams et al., 1996) at the individual level. Because of the variety of age groups and outcomes examined, it is difficult to determine a probable cause for this discrepancy in findings, but studies using ecological analysis consistently showed that areas with higher proportion of crowded dwellings were more likely to have higher child injury rates (Braddock et al., 1991; Durkin et al., 1994; Rivara & Barber, 1985). Pedestrian injury was the focus of most of these studies. A possible explanation is that large numbers of crowded housing units in a neighborhood increases the number of children spending time outside the home and this would seem to permit increased exposure to traffic (Rivara & Barber, 1985). Another explanation is that crowding at the area level may serve as a proxy for a low-income neighborhood that may be characterized by insufficient playgrounds and parks, in which case the streets may become the substitute play area.

Other dwelling factors were generally found not to be associated with child injuries. At the individual level, type of accommodation (Shaw, 1977), housing index based on building material (Werneck & Reichenheim, 1997), and another housing index based on size of house, and state of repairs among other factors (Langley, Silva & Williams, 1983) were not found to increase the risk of child injury at the individual level.

Dwelling value was assessed by two studies at the ecological level that, although similar in many aspects of study design, found conflicting results. While Braddock et al. (1991) found no relation at the CT level between median rent and rates of child pedestrian injury among children up to 14 years of age, Calhoun et al. (1998) found median rent and median housing value of zip codes (larger geographical units that census tracts) to be positively correlated with higher rates of pedestrian injury among those up to 15 years of age. The key difference between these two studies was the outcome. Calhoun et al. (1998) used hospital admission resulting from pedestrian injury while Braddock et al. (1991) examined police reports where less severe cases were also included. Therefore, a possible explanation for the observed discrepancy is that the median rent of neighborhoods is correlated only with pedestrian injuries that are severe enough to require hospital admission.

SES Indicators: Health Insurance

A few American studies used health insurance coverage as an indicator of deprivation to examine differential patterns of medically treated child injuries by socioeconomic status. Health insurance coverage status in the United States includes those with incomes sufficiently low to qualify for Medicaid coverage, those who are enrolled in a prepaid Health Maintenance Organization (HMO) and those have no coverage either because they cannot afford insurance or because of wealth, the cost of health care is not a concern. Among the three groups, those with Medicaid coverage belong to the lowest class, and those enrolled with HMOs are considered to be of the highest class.

Overpeck et al. (1997) showed that children who had no health care coverage had fewer medically attended and non-fatal injuries than children who had coverage (i.e. Private health insurance or Medicaid). This relationship persisted after factors such as accessibility to place for injured care, maternal education, single adult in the home, race and poverty were adjusted for. Dershewitz (1978) found medically treated injuries among 1 to 4 year olds to be significantly higher among those enrolled in a prepaid HMO compared to children participating in a program primarily serving under-privileged children. At first glance these two studies seem to contradict previous studies by suggesting injuries are more common in children of higher SES groups, however, the results may not represent injury occurrence but rather reflect the effect of SES on treatment seeking patterns. The excess cost of treatment for those without adequate coverage in the United States may deter those belonging to low social classes from seeking treatment. In fact, Overpeck & Kotch (1995) estimated that for children without coverage, as many as 30% of total injuries and 40% of serious injuries may not have been attended. This is supported by findings by Nersisian et al. (1985) who found Medicaid or other social programs (e.g. Food Stamps) to be positively correlated with child injury fatalities, an outcome that cannot be altered by differential medical service utilization by socioeconomic status.

In addition to showing associations between child injuries and SES, studies examining health insurance coverage also reveal the potential for a critical bias resulting from differential physician utilization pattern by SES. This is particularly a concern when using non-severe medically treated injuries as an outcome in countries without universal health care.

2.4.5 Study Methodologies

Most of the papers reviewed focused on the individual level relationship between child injuries and deprivation (Table 2.1). Ecological analysis was used in 13 papers. Four papers used traditional contextual analysis to try to identify contextual effects or area level risk factors on the individual child. Only one study, Reading et al. (1999), applied multilevel regression analysis to determine deprivation related risk factors inherent to neighborhoods for child injuries among 1 to 4 year olds in the United Kingdom.

Of the 27 individual level analysis studies, 19 followed the case control study design where one or more socioeconomic indicators of injured children were compared to those not injured. The older case control studies often lacked scientific rigor. For instance, a few of these earlier investigations did not check for the significance in difference in rates between socioeconomic groups (Joseph & Douglas, 1979; Learmouth, 1979; Savage, 1972) and therefore the possibility that the findings may have been attributed to chance was not considered. On the other hand, more recent studies tended to use reliable statistical tools, and several also controlled for possible covariates in the examination of the association of injury and SES indicators by using multivariate analysis (Harris & Kotch, 1994; Overpeck et al., 1997; Petridou et al., 1994; Pless, Verrault & Tenina, 1989; Roberts, 1994; Wadsworth et al., 1983; Werneck & Reichenheim, 1997; Williams et al., 1996). However, as many of these were based on maternal interviews, the results were susceptible to recall bias. This was not an issue with the eight cohort studies done at the individual level in this review (Table 2.1). However, multivariate analysis was employed in only one of them (Larson & Pless, 1988).

Ecological analysis was done by thirteen investigators to explore the relationship between injury rates and socioeconomic measures at the neighborhood level. The type and quality of study methods varied considerably (Table 2.1). The older ecological studies compared the proportion deprived among the injured children to the proportion of deprived for the child population in the area as based on census figures or other population based surveys (Emerick, Foster & Campbell, 1986; Joseph & Douglas, 1979; Learmouth, 1979; Murdock & Eva, 1974; Nixon & Pearn, 1978; Savage, 1972). In some instances, these studies did not test for statistical significance of difference in proportions (Joseph & Douglas, 1979; Learmouth, 1979; Savage, 1972,). However, more recent studies used more acceptable methodologies such as Poisson regression analysis (Wise et al., 1985).

Despite the inaccurate estimates produced by traditional contextual analysis, four investigations in this review used this study design (Cummings et al., 1994; Mueller et al., 1990; Scholer, Mitchel & Ray, 1997; Scholer et al., 1998). This choice was usually justified by the inability to obtain individual level socioeconomic information and therefore aggregate socioeconomic information was used. All of these studies used measures of income that were aggregated to the census tract level as the area level deprivation measure. Most of these studies used multivariate analysis. Poisson regression techniques were used by Scholer, Mitchel & Ray (1997) and Scholer et al. (1998) while Cummings et al. (1994) used logistic regression analysis to determine associations between likelihood of child injury and neighborhood income.

The false assumption that there are as many observations of ecological level factors as the number of individuals in traditional contextual analysis produces estimates of contextual factors that underestimate the precision (confidence intervals) of the estimate. Multilevel analysis corrects for this by basing the analysis on the correct number of observations of individuals and ecological factors.

Only one study in this review used multilevel regression analysis to determine the inherent risk of deprived areas on the risk of child injuries (Reading et al., 1999). This technique provides the most statistically accurate estimates of contextual effects resulting from factors inherent to place; hence this was the only study that provided the most accurate estimate of contextual effects of neighborhood deprivation on child injuries in this study. Furthermore, this technique is also able to provide the proportion of variation in outcomes accounted for by area level factors.

The study by Reading et al. (1999) was the first study to show quantitatively that place of residence does matter for child injury, independently of individual level characteristics. They applied the multilevel technique to assess the contextual socioeconomic factors of neighborhood of residence associated with risk of injury for children 0 to 4 years of age in the County of Norfolk, England. The cases consisted of children who presented to an accident and emergency department between 1993 and 1995. The area level deprivation measure used was the Townsend Score measured at the neighborhood level. This is the sum of the standard scores for unemployment rate, the proportions of households in overcrowded accommodation, the proportion of households in accommodation not owned by the household, and the proportion of households not owning a car.

At the individual level, number of younger siblings, young maternal age, male gender and shorter distance from hospital (correlates with lower socioeconomic areas) were found to be risk factors. Area level factors accounted for 10% of the variation in the injury outcome. Multilevel logistic regression analysis showed that Townsend Score at the social area level (aggregation of adjacent enumeration districts with similar deprivation measures) was associated with injury with a resulting odds ratio of 1.03 (95% confidence interval: 1.01 1.05) for an increase in score of 1. This meant an odds ratio for likelihood of injury of 1.28 between the poorest (Townsend score of –3.0) and the most affluent (Townsend score of 5.3) social area. For severe injuries, there was only a slight increase in the odds ratio for Townsend Score at the social area level to 1.04 (95% confidence interval: 1.01 1.08), and lone parenthood also appeared to be an additional risk factor. This meant an increase in odds of severe injury of 1.49 from the most affluent to the poorest social area for if the individual characteristics of the child remain the same.

2.5 Limitations of the Literature

Despite the large body of literature on child injuries and SES, it is difficult to draw definitive inferences about this relationship because in the studies reviewed: i) there was wide discrepancy in the populations studied, ii) the SES indicators were not consistent iii) injury outcomes and definitions varied widely and iv) many of the study methodologies and analytical techniques were weak.

While many injury types and severities were assessed for relationships with various SES indicators among different age groups across the studies, there was systematic variation in associations by all of these factors. Therefore, it is important to consider the difference in influences of SES by these factors. However, no single study in this review had examined all of these factors simultaneously and therefore it is difficult to draw inferences about the relative importance of the relationships between injuries and SES that vary by these factors.

While many earlier studies used inadequate, if any, statistical techniques to assess associations between SES and injury, several recent ones were prone to recall bias resulting from parental recollection of injuries. Furthermore, few studies used a mutivariate approach to adjust for multicollinearity. Some studies had insufficient sample sizes thus compromising the power of the analyses to detect socioeconomic differences in injuries. There is also a major gap in our knowledge about what SES risks stem from factors inherent to the area of residence. Only one study (Reading et al. 1999), using multilevel regression analysis, accurately identified the association between neighborhood contextual factors and likelihood of injuries.

The present study will address many of these limitations. This is a population-based study that will examine childhood injury stratified by various age groups, injury types, and injury severity (i.e. hospital admission). It will determine the relationship between injuries and various indicators of SES using a multivariate approach at the individual level and at the ecological level. Furthermore, it will determine deprivation related contextual factors specific to neighborhoods that influence risk of injuries.

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CHAPTER 3

Relationship Between Child Injury and Socioeconomic Status at the Individual Level

3.1 Introduction

There is general consensus that the risk of injury poses a greater threat to children from economically deprived families, but there is no agreement as to the degree of risk. A recent review of studies on child injuries and socioeconomic status (SES) by Mackay et al. (2000) concluded that while the quality of studies was generally poor, there is enough evidence to show that injuries are common in children of lower SES, the variation in SES indicators and injury outcomes used across the studies makes it difficult to deduce conclusive relationships.

While interesting for purposes of comparison, due to differing social and health care systems the American and British studies which tend to dominate this subject area have limited applicability to the Canadian situation. As well, estimates of risk difference due to SES are hard to make because there are no comprehensive population-based studies that have examined differences in SES by injury type, injury severity, and age group. Often the effects of deprivation are shown for specific populations, such as those treated for injuries in emergency departments, or for all injury in general despite the variation in SES influences by injury type (Nersesian et al., 1985), injury severity (Alwash & McCarthy, 1988) and age group (Irwin et al., 1992).

The aims of this study are to describe patterns of injury by age group, gender, and injury type and to determine patterns of socioeconomic disparity in injuries for children living in Edmonton, Alberta, Canada, a City of about 800,000 people. The provincial health care premium subsidy group status of the child's family serves as the proxy for SES. The underlying assumption of linking deprivation to injuries is that SES can alter a child's exposure to hazards or alter a child's ability to avoid hazards (Horwitz et al., 1988).

3.2 Methods

A case control study design was used to identify family socioeconomic differences between children who sought treatment for injuries for the 1995/96 fiscal year (the cases) from those who did not (the controls), as determined from diagnoses provided to the Provincial health administrative database by the child's attending physician. Children, 0 to 17 years of age, living in Edmonton, Alberta, and stratified into different age groups, were examined for outcomes of All Injury, for injury type by diagnosis and for Injury Hospitalization. Information pertaining to the cases and controls was acquired through the Alberta Health Physician Fee-For-Service database.

In Alberta, the fee-for-service system is used to reimburse physicians for medically required services provided to residents registered with Alberta Health. All residents of Alberta and their dependents are eligible for coverage and it is estimated by Alberta Health that over 99% of Albertans are registered. Data on registrant demographics and Alberta Health Care Insurance Plan (AHCIP) eligibility are listed in a stakeholder registry. Claims submitted by physicians for services are documented in the physician fee-for-service database. Each claim is recorded with one to three diagnostic codes based on the *Ninth Revision of the International Classification of Diseases* (ICD-9).

The use of the physician claims database to identify the cases means that distinct injury incidents cannot be readily identified. In the database, an 'event' is marked by a physician claim corresponding to a patient visit for medical treatment. Physician visits made for treatment of injuries were distinguished from those made for other reasons by using only physician diagnoses with ICD-9 codes between 800.0 - 999.9 (Karaffa, 1992). The number of injury related physician visits made by a single patient during the study period is primarily a reflection of injury incidence and injury severity. In other words, a repeat physician visit by a single patient indicates that a new injury event has taken place or that an injury was severe enough to require more than one visit. Other factors potentially influencing repeat visits include physician-seeking behavior related to social and psychological factors but these are expected to have minimal influence on the total number of physician visits.

The data provided did not allow determination as to which of these factors is acting in any given event; therefore the number of visits was not examined. Rather, the study population was dichotomized into those who were "injured" and those who were "not injured".

The "injured" cases consisted of Alberta Health Registrants who had at least one physician claim with an ICD-9 diagnostic code of 800-999.9 during the fiscal year April 1, 1995 to March 31, 1996 and whose integer age as of March 31, 1996 was between 0 and 17 years. The "not injured" controls consisted of persons 0 to 17 years of age who were registered with Alberta Health and who were not treated for injuries during the same fiscal year regardless of whether they did or did not see a physician for any other illness during the study period. The area of residence of the study population was limited to that bounded by the City of Edmonton, Alberta, Canada and surrounding urban areas.

3.2.1 Indicators

Indicator: Age

Age as of March 31st, 1996 was derived from the Stakeholder registry. For ease of presentation and assurance of adequate sample size, four age groups were created (0-4, 5-9, 10-14 and 15-17 years of age). Injury patterns tend to be homogeneous within these intervals (Hanvey et al., 1994; United States National Pediatric Trauma Registry, 1993) with the exception of those under 1 year of age who experience different patterns of injuries compared to 2-4 year olds; however, sample sizes were too small to permit analysis based on such classifications (i.e. 0-1 and 2-4 years of age).

Indicator: Gender

The child's gender was obtained from the stakeholder registry.

Indicator: AHCIP premium payment levels

The health care premium payment levels served as the indicator for deprivation. The AHCIP premium payment levels for families are categorized into the following four groups.

1. Non-subsidized – Families making full premium payments. In logistic regression analysis this was the referent group.
2. Subsidized: Partially or fully – Low income families whose taxable income, minus non-refundable tax credits, is less than $12,620 and who apply for subsidy, have from 20 to 100 percent of their premium payments subsidized. These are referred to in the analysis as the Subsidized group.

3. Social Services – The premiums of families receiving Social Services support are paid for by the Provincial government.
4. Treaty Status – Aboriginal families meeting the criteria for Treaty Status have their premiums paid for by the Government of Canada. Not all families of Aboriginal descent are Treaty Status and these individuals are responsible for paying their own premiums using the criteria described in 1-3 above.

3.2.2 Outcomes

There were six outcome measures:

- All Injury together,
- Injury requiring hospitalization, documented as "Inpatient Services" (IPSR) on the physician-fee-for service database, and
- Four specific injury categories based on the ICD-9 code submitted by the physician (Karaffa, 1992). The four injury categories are:
    - Dislocations, sprains and strains (ICD-9 codes 830 – 848.9),
    - Fractures (ICD-9 codes 800 – 829.9),
    - Burns (ICD-9 codes 940 – 949.9), and
    - Poisonings (ICD-9 codes 960 – 989.9).

Children were enumerated as cases for the injury groups using the criteria below:

- Each child was counted only once for each of the four injury category, regardless of the number of physician claims made within each category.
- A child could appear in more than one injury category. If physician claims were made that fell under different injury categories, the child was counted in each injury category.

3.3 Analysis

Logistic regression analysis was used to assess the relationship between likelihood of injury and AHCIP payment group and gender. Cases were not matched to the controls since the number of controls was sufficient such that matching the two groups by any variable(s) such as gender would not have significantly increased the precision of analysis (Hennekens & Mayrent, 1987). Separate analyses, stratified by age groups, were performed for All Injury, each injury category and Injury Hospitalization. Performing separate analysis for each subgroup means that the regression models would not need to account for possible interactions between the stratifying factors. Explanatory factors appearing significant at an alpha level of 0.05 were included in the final model.

3.4 Results

3.4.1 Population Demographics

Data were available for 173,702 children of whom 51% were male. Seventy-six percent of the study population received no premium subsidy; these were considered to be the highest socioeconomic group (Table 3.1). Of the remainder, 12.6% were Subsidized, 7.4% were under Social Services and 3.8% had Treaty Status. With increasing age, the proportion of the Non-Subsidized group increased while the proportions of the other three groups decreased.

Table 3.1: Percentage of Children in the Study Population Belonging to Each AHCIP Premium Payment Group by Different Age Groups*

Payment Group	Age 0 – 4y (n=47,810)	Age 5 – 9y (n=49,933)	Age 10 – 14y (n=48,699)	Age 15 – 17y (n=27,260)	Age 0 – 17y (n=173,702)
No Subsidy	71.8	75.7	78.7	80.1	76.2
Subsidy	15.4	12.6	11.1	10.4	12.6
Treaty Status	4.4	4.0	3.3	3.0	3.8
Social Services	8.4	7.7	6.9	6.4	7.4

* Note: Gender variation within age groups ranged from 0.0% to 0.6%.

The likelihood of physician contact for different age groups adjusted by premium subsidy status and gender is presented in Table 3.2. In the study population, 13.3% of children had no physician contact, defined as any utilization of Alberta Health and Wellness physician services, during the 1995/96 fiscal year. Compared to children whose families were not receiving any premium subsidy, children receiving Subsidy, children whose families were on Social Services and especially Treaty Status children were less likely to have any physician contact during the year. Male infants and preschoolers were more likely to have physician contact, while 15-17 year old females were more likely to have physician contact.

Table 3.2: Odds Ratios (OR) and 95% Confidence Intervals (CI) for Likelihood of Physician Contact by AHCIP Subsidy Status and Gender

	Age group									
	0-4 years		5-9 years		10-14 years		15-17 years		0-17 years	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
No subsidy (ref)	1.00	-	1.00	-	1.00	-	1.00	-	1.00	-
Subsidy	1.00	0.90, 1.13	0.94	0.87, 1.02	0.88	0.83, 0.96	0.87	0.78, 0.96	1.00	0.96, 1.05
Treaty Status	0.62	0.53, 0.73	0.59	0.53, 0.66	0.64	0.57, 0.72	0.75	0.63, 0.89	0.70	0.65, 0.75
Social Services	0.73	0.64, 0.83	0.73	0.66, 0.80	0.85	0.78, 0.93	0.88	0.77, 0.99	0.85	0.80, 0.89
Male	1.22	1.13, 1.32	1.04	0.99, 1.10	0.97	0.92, 1.01	0.64	0.60, 0.69	0.94	0.91, 0.96

3.4.2 Epidemiology of Child Injuries

Twenty four percent (42,032 children) of the study population had at least one physician visit for the purpose of seeking treatment for an injury. This figure varied significantly by age group, gender and injury type. Males in the 15 to 17 years age group were at the greatest risk for All Injury in general (36.3%) while females 0 to 4 years of age were at the lowest risk (17.9%) (Table 3.3). Dislocations, Sprains and Strains were the most common category of injury with 83.6 of every 1,000 children in the study population seeking treatment for this type of injury. Poisoning was the least common injury category with 7.2 of every 1,000 children seeking medical treatment for it. Hospitalizations attributable to injury were even less common with a rate of 5.2 per 1,000 children.

Table 3.3: Rates* of Cases by Age Group and Gender

Injury Type	Age 0-4		Age 5-9		Age 10-14		Age 15-17		All Ages 0-17		
	F	M	F	M	F	M	F	M	F	M	Total
All Injury	178.7	209.8	181.3	216.1	261.9	312.2	277.8	363.1	218.1	264.7	242.0
Dislocations, Sprains, & Strains	24.8	24.2	43.9	41.6	134.2	130.3	162.5	187.2	82.2	84.9	83.6
Fractures	12.8	13.6	23.1	24.3	38.1	58.0	23.5	64.6	24.5	37.3	31.0
Burns	11.3	16.2	5.9	7.8	8.5	9.1	10.2	10.7	8.8	10.9	9.9
Poisoning	12.8	12.7	2.6	2.8	4.8	3.3	15.8	7.6	8.2	6.4	7.2
Hospitalizations	3.8	4.6	3.9	4.2	3.9	6.7	6.6	10.3	4.3	6.0	5.2

*Number injured / 1,000 persons during the 1995/96 fiscal year

3.4.3 Gender and Child Injuries

Gender was a significant predictor of injuries for most subgroups examined (Table 3.4). Males were at a greater risk for All Injury in general (OR=1.29, 95% CI 1.26 - 1.32). For Fractures and Dislocations, Sprains and Strains, males appear to experience more of these injuries at later age groups, with an odds ratio of 3.11 (95% CI 2.72 - 3.55) for Fractures among those aged 15 to 17 years. Males were at a greater risk for Burns in the younger age groups. In the older age groups, males were also at an increased risk for injuries requiring hospitalizations (OR=1.84, 95% CI 1.42 - 2.37 among 10-14 year olds and OR=1.77, 95% CI 1.36 - 2.32 among 15-17 year olds). Older males were less likely than females to have a diagnosis of poisoning (10-14 years: OR=0.73, 95% CI 0.55 – 0.97; 15-17 years: OR=0.55, 95% CI 0.43-0.69).

Table 3.4: Odds Ratios of AHCIP Payment Group and Gender for Likelihood of Injuries by Injury Type and Age Group

	Age group									
	0-4 years		5-9 years		10-14 years		15-17 years		0-17 years	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
All Injury										
Subsidy*	1.08	1.01, 1.15	1.05	0.98, 1.13	0.95	0.89, 1.01	0.82	0.75, 0.89	0.94	0.91, 0.97
Treaty Status*	1.21	1.09, 1.35	1.14	1.02, 1.28	1.03	0.92, 1.15	0.95	0.82, 1.11	1.04	0.98, 1.10
Social Services*	1.26	1.17, 1.37	1.28	1.18, 1.39	1.10	1.02, 1.19	1.12	1.01, 1.24	1.15	1.10, 1.19
Male	1.22	1.17, 1.28	1.24	1.18, 1.30	1.28	1.23, 1.33	1.48	1.41, 1.56	1.29	1.26. 1.32
Dislocations, Sprains & Strains										
Subsidy	-	-	-	-	0.91	0.83, 0.99	0.79	0.71, 0.89	0.81	0.77, 0.86
Treaty Status	-	-	-	-	0.95	0.81, 1.10	0.78	0.64, 0.96	0.77	0.70, 0.86
Social Services	-	-	-	-	1.07	0.96, 1.19	1.07	0.94, 1.21	0.95	0.89, 1.02
Male	-	-	-	-	-	-	1.30	1.22, 1.39	1.10	1.06, 1.14
Fractures										
Subsidy	-	-	-	-	-	-	0.69	0.56, 0.86	0.80	0.73, 0.88
Treaty Status	-	-	-	-	-	-	0.82	0.57, 1.19	0.97	0.84, 1.12
Social Services	-	-	-	-	-	-	1.17	0.93, 1.46	1.01	0.91, 1.12
Male	-	-	-	-	1.63	1.50, 1.78	3.11	2.72, 3.55	1.62	1.53, 1.71
Burns										
Subsidy	1.29	1.04, 1.58	1.23	0.90, 1.68	1.10	0.81, 1.48	-	-	1.25	1.09, 1.44
Treaty Status	1.45	1.03, 2.05	1.55	0.97, 2.48	1.37	0.85, 2.21	-	-	1.42	1.14, 1.78
Social Services	1.83	1.45, 2.32	1.51	1.06, 2.15	1.77	1.30, 2.41	-	-	1.66	1.42, 1.94
Male	1.49	1.27, 1.74	1.37	1.11, 1.70			-	-	1.31	1.19, 1.45
Poisoning										
Subsidy	1.36	1.10, 1.69	1.01	0.57, 1.78	1.26	0.82, 1.95	1.41	1.00, 1.99	1.40	1.19, 1.64
Treaty Status	1.50	1.06, 2.14	2.57	1.37, 4.83	2.90	1.72, 4.89	4.82	3.37, 6.89	2.53	2.05, 3.12
Social Services	2.01	1.58, 2.55	3.22	2.07, 5.01	2.12	1.37, 3.28	2.26	1.57, 3.25	2.26	1.91, 2.66
Male					0.73	0.55, 0.97	0.55	0.43, 0.69	0.83	0.74, 0.93
Injury Hospitalizations										
Subsidy	1.23	0.84, 1.81	0.99	0.65, 1.53	1.14	0.78, 1.66	0.60	0.35, 1.02	0.95	0.77, 1.17
Treaty Status	1.87	1.08, 3.26	1.21	0.62, 2.37	1.32	0.72, 2.43	2.02	1.17, 3.51	1.50	1.12, 2.02
Social Services	1.91	1.26, 2.90	1.71	1.11, 2.63	1.31	0.84, 2.05	1.49	0.95, 2.36	1.52	1.22, 1.89
Male					1.84	1.42, 2.37	1.77	1.36, 2.32	1.49	1.30, 1.70

* Reference Group for Subsidy, Treaty Status and Social Services is No-Subsidy status.

Note: Blanks represent variables not significant in the final regression models. However, non-significant dummy variables of a categorical variable with other dummy variables that are significant were included in the final models and listed in the table.

3.4.4 AHCIP Payment Status and Child Injuries

For All Injury in general, and considering all ages together, children from Subsidized families were less likely to be injured and those with Treaty Status and on Social Services were more likely to be injured in comparison to those from families who make full premium payments (highest socioeconomic index) (Table 3.4). However, patterns of associations with SES groups were more consistent within different injury types. Injuries resulting in a dislocation, strain or sprain were less common among children from Subsidized families (OR = 0.81, 95% CI 0.77-0.86) or Treaty status children (OR = 0.77, 95% CI 0.70-0.86) in comparison to children from families with Non-Subsidized premiums (Table 3.3). Treatment for fractures was less likely for Subsidized children (OR=0.80, 95% CI 0.73-0.88) than those from Non-Subsidized families. Risk of Burns was significantly greater in children of the three lower socioeconomic groups - Subsidized (OR=1.25, 95% CI 1.09-1.44), Treaty Status (OR=1.42, 95% CI 1.14-1.78) and Social Services (OR=1.66, 95% CI 1.42-1.94). Similarly, Poisoning was also a greater risk among children of Subsidized (OR=1.40, 95% CI 1.19-1.64) families, children with Treaty status (OR=2.53, 95% CI 2.05-3.12), and those under Social Services (OR=2.26, 95% CI 1.91-2.66). Lastly, children with Treaty Status (OR=1.50, 95% CI 1.12-2.02) and those on Social Services (OR=1.52, 95% CI 1.22-1.89) were at greater risk for hospitalization due to injury. Possible interactions between gender and subsidy level were tested for a few models and there appeared to be no significant interactions.

In summary, within diagnostic groups, any significant associations between injuries and SES were in the same direction, but there was variation in the magnitude of associations across the age groups.

3.5 Discussion

The strong and consistent nature of injury patterns seen within injury categories by subsidy levels, and thus by inference to SES, provides good evidence that children of different SES have different injury experiences. Burns, Poisoning, and Injury Hospitalizations tended to be more common among children of Subsidized, Treaty Status, or Social Services families while Fractures and Dislocations, Sprains, and Strains were less common.

Sports injuries account for a large portion of injuries resulting in fractures, and dislocations, sprains and strains in adolescents (Alberta Center for Injury Control and Research, 2000), and sports injuries have been reported to be more prevalent among adolescents from more affluent families (Williams et al., 1997). The greater odds of these injuries among adolescents in the Non-Subsidized group may well be due to greater exposure to sports and recreational activities for those from higher SES families. More affluent families may have resources that allow their children to be more easily involved in organized sports. Several authors have documented that children from higher SES families were more active or exercised more frequently than did those from lower SES families (Gottlieb & Chen, 1985; Sallis et al., 1992).

In agreement with previous findings (Roberts, 1997; Shaw, 1977; Wadsworth et al., 1983), this study suggests substantial SES differences in Poisoning injuries among children and adolescents. Unintentional poisoning is a major and frequent cause of injury in young children. Young children in lower SES homes may be more likely to come into contact with potentially toxic substances. In a study of safety practices and living conditions of low income urban families with young children, few homes had locked storage space, and most hazards, including cleaning supplies, medicines, insect poisons, were stored sub optimally (Santer & Stocking, 1991).

Among adolescents, suicidal intention and drug abuse also become common reasons for poisonings (Lovasik et al., 1994). The considerably high risk of Poisoning injuries for Treaty Status adolescents is most likely attributed to the high rates of substance abuse (Gfellner & Hundleby, 1995) and suicide attempts among Native Canadian youths, especially among females (Canadian Institute of Child Health, 1994), among whom a common method of suicide is poisoning (Lovasik et al., 1994). The underlying causes may be due to unfavorable social conditions prevalent in this group such as depression, and poverty (Tookenay, 1996).

Burn injuries are also more likely among children from low SES families. The difference in SES risks may be attributed to the lack of parental supervision among children from low-income families (Nersesian et al., 1985). This could potentially lead to scalding injuries from unsupervised bathing, or to flame burns caused by playing with matches or lighters without the presence of adult supervision. Inadequate storage of matches and lighters in low-income homes (Santer & Stocking, 1991) may also contribute to the higher rates. The lack of SES differences in Burn injury among older adolescents is likely to be attributed to the low sample size of Burn injury cases in this age group to allow the detection of SES differences.

The findings also suggest that deprived children have disproportionately high Injury Hospitalizations, supporting the findings of Alwash and McCarthy (1988) and Reading et al. (1999). This is most likely a reflection of higher injury severity experienced by children of lower socioeconomic groups.

Data Quality

In assessing the results of this study, it is necessary to consider the quality of the physician claims data used. Unfortunately, there has been no evaluation of the Alberta Health administrative databases for accuracy of information and generalizations can only be drawn from evaluations of similar databases elsewhere. On that note, the validity of demographic information can be generalized from a recent assessment of the Manitoba Health Service Commission (MHSC) registry file, which is largely comparable to the Alberta Health database. The reliability of the date of birth of registrants of the MHSC registry was found to be over 90% (Roos et al., 1979). Similarly, the reliability of the demographic information on the Alberta Health database is expected to be high.

A more important issue is whether the ICD-9 diagnostic code documented on the physician claims validly reflects the patient's clinical condition. Several studies have attempted to assess the accuracy of the diagnostic codes by comparing those on computer files to hospital medical record re-abstractions (Fisher et al., 1992; Benesch et al., 1997) or by intra- and inter-physician agreement of diagnosis (Roos et al., 1982). On average, a rate of agreement of about 80% was found. Benesch et al. (1997) indicate that the validity of ICD-9 codes depends on the ICD-9 code used. A high degree of accuracy is expected in ICD-9 codes that effectively describe the underlying pathophysiology of that injury (e.g. burns) (Benesch et al., 1997). Although there are no North American studies that evaluate the quality of injury specific ICD-9 codes, inferences may be drawn from an Australian study that examined the accuracy of injury diagnostic codes in a hospital database by comparing it to the hospital record contents. An error of 19% and 61% among injury codes listed under principal diagnosis and other diagnoses respectively were found. Of the erroneously recorded codes, 94% fell within the range of the injury diagnostic codes ICD-9 800.0 to 999.0 (Ackland and Chandraraj, 1997). In other words, an injury had been recorded in the database, but not necessarily the same injury as had been described in the hospital record.

Studies assessing the accuracy of the ICD-9 codes often base their analysis on the first three digits of the code. In this study, however, the codes are aggregated into the four injury categories in which the first two digits of ICD-9 codes do not overlap. Therefore, a more applicable assessment would consider the accuracy of ICD-9 codes truncated at the first two digits. Since no such study exists and since the studies assessing the first three digits of the ICD-9 codes resulted in conservative estimates of accuracy, a satisfactory degree of accuracy of the injury categories can be assumed for this study.

Limitations

This study has several limitations. Any influence of SES should vary by the external causes of injuries (e.g. falls) and not by the diagnosis, but there are no data available about the external causes of any of the injuries reported in this study. Although I chose diagnostic groups that tended to have common external causes, there was still sufficient heterogeneity in external causes within these groups to minimize potential SES associations. For instance, data from the Alberta Center for Injury Control and Research based on Emergency Department visits suggest that among children and adolescents, about 45% of dislocations, sprains & strains, and 40% of fractures tend to result from sports activities (Alberta Center for Injury Control and Research, 2000). Many different external causes may be responsible for the remaining portions of these diagnoses. Therefore, it is difficult to elucidate stronger relationships between these diagnoses and SES.

The shortcoming in the classification of the subsidy groups with regard to adequately describing socioeconomic groups is another limitation. The subsidy groups are only fair proxies of true SES and they may hide as much variation as they show. Over three-quarters of the study population was in the highest SES group as defined in this study. The SES gradient in this portion of the study population is unknown. Furthermore, Treaty Status is a demographic classification and not a socioeconomic category. However, a recent publication by the Canadian Council on Social Development reported that 62% of Aboriginals residing in the City of Edmonton live in poverty (Lee, 2000). Nevertheless, care must be taken in generalizing these population-based statistics to every individual with Treaty Status. However, what does affect every individual with Treaty Status is the social consequences of being Treaty Status. Treaty status individuals are often discriminated against and marginalized; these are common consequences of social deprivation. Similar consequences may be experienced by those on Social Services and those whose family incomes are low enough to be part of the Subsidy group. However, in contrast to the Treaty Status group, their experiences stem from predominantly an economic condition. In summary, while the Alberta health insurance payment status is not strictly a classification of SES, with careful consideration of the limitations of each category, it serves as a fair proxy for SES.

Also of concern is the differential utilization of physician services by SES. The variation in injuries by SES may simply relate to differential use of, or access to, health services rather than being a real difference in injury rates (Jolly, Moller & Volkmer, 1993; Reading et al., 1999). However, the initial analysis showed that children of lower SES in the study population were *less* likely to see a physician for treatment of any illness and yet overall they were *more* likely to see a physician for treatment of injury. Since the entire study area is urban, consisting of an adequate geographical distribution of health centers, differential physical accessibility to health care services by SES is probably not a major concern. Rather, differential utilization is more likely due to varying physician-seeking behavior (Spencer, 1996). These results should be viewed with caution as it has been suggested that findings of differential medical services utilization found in Canadian studies are in most instances an artifact of the research design and analytical techniques used than a valid reflection of the actual experience (Badgley, 1991). However, in our assessment of whether children utilized any health service (e.g. physician visit for treatment), we used multivariate logistic regression analyses. Furthermore, we stratified the analysis by age group intervals. A population based administrative database which contained information on virtually all children in the area for one year duration provided the data for this analysis.

Although it has been suggested that severe injuries would inevitably be hospitalized without bias of SES, (Jolly, Moller & Volkmer, 1993; Reading et al., 1999), the assumption that Injury Hospitalization captures all severe and only severe cases is dubious. Other possible predictors of hospital admission, such as informal judgments made by medical professionals about s parent's ability to bring their child for outpatient treatment, have been suggested (Williams et al., 1997). Further investigation into the criteria for hospitalization and non-hospitalization of severe injuries among children is required before using injury hospitalization as an outcome that is not biased by differential medical service utilization.

Many of these limitations discussed above can be attributed to the nature of the administrative data used in the study. As health administrative databases are used primarily for resource allocation decisions, detailed information such as or external causes of injuries are usually not captured. Therefore, analysis of associations based on such information can only serve as an exploratory tool to primarily generate hypothesis. Despite these drawbacks, such databases can provide a useful picture of the pattern of health conditions in populations.

These study findings provide some direction for targeting injury prevention programs to children and adolescents of different socioeconomic and cultural groups. For instance, educating parents of lower SES families through public health nurses as to the hazards of leaving matches, lighters, households cleaners and medications in areas that are accessible to their children are some strategies that may be more specific and cost effective in comparison to those that are implemented among all socioeconomic groups. In targeting Native Canadian children, special consideration must be taken with regard to the appropriateness of the prevention strategies in the cultural context (Committee on Native American Child Health and

Committee on Injury and Poison Prevention, 1999). Multi strategy injury prevention approaches that are specific to the social and cultural conditions of children would reduce the overall burden of child injuries.

3.6 Conclusion

This is a comprehensive study on patterns of child injuries in the City of Edmonton and surrounding areas by age group, gender and injury type. It identifies low income, Treaty Status and Social Services children to be at high risk for Burns, Poisonings and Injury Hospitalizations, and higher income adolescent children to be at a greater risk for injuries resulting in Fractures, Dislocations, Sprains and Strains. Application of this knowledge in the planning of injury control strategies will make prevention efforts more specific, effective and economical (Irwin et al., 1992).

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CHAPTER 4

Neighborhood Contextual Factors and Likelihood of Child Injury

4.1 Introduction

The likelihood of a child being injured depends partly on the social and physical environment of the area where he or she lives. Factors such as the quality of playgrounds, road conditions and local social norms pertaining to use of safety equipment may cause differences in risk of injury across neighborhoods. Such contextual factors cause people with similar individual attributes to have a different risk of injury in one neighborhood when compared to another (Curtis & Jones, 1998).

Currently, emerging evidence demonstrates systematic variation in child injury rates by community or neighborhood socioeconomic status (Wilkins et al., 1989). It is not known whether the high injury rates reported in deprived neighborhoods are due to contextual effects (i.e. factors inherent to the place) or to aggregated effects resulting from the localization of low-income families in deprived neighborhoods (Curtis & Jones, 1998). In other words, areas with high levels of child injuries may simply be composed of a high proportion of children with individual characteristics indicating a predisposition to injuries. Alternatively, regardless of their individual characteristics, all children in a given neighborhood may be affected by contextual factors or factors inherent to the neighborhood. Often both sets of factors are responsible for area variation in injury rates by SES. However, policy changes to alleviate high injury rates in an area are likely to be different for those stemming from individual level factors compared to factors inherent to neighborhoods (Waitzman & Smith, 1998).

Identifying and studying contextual factors is hard due to the difficulty in quantifying them using commonly known statistical methods. Ecological analysis confounds the contextual effects with the 'aggregation of individual effects' (compositional effects) at the area level. Traditional contextual analysis produces inaccurate estimates of contextual effects as it assumes there are as many observations of community-level variables as the number of individuals.

Multilevel modeling or hierarchical linear modeling (HLM) is the statistical method that produces the most statistically correct estimate of contextual effects. HLM is similar to traditional contextual analysis in that it measures the effects of individual level and ecological level variables on individual outcomes. It differs from traditional contextual analysis in that it is able to take the hierarchical nature of the data into account. This provides a way to isolate individual-level, compositional and contextual effects and it also provides a way to show for which types of people contextual effects matter most (i.e. cross-level interactions).

This study uses HLM to determine the relationship between neighborhood socioeconomic environment and likelihood of injury among children. These findings are compared to those determined using traditional contextual analysis and the discrepancy in the magnitude and accuracy of associations are examined. Additionally, geographic relationships between injury rates and SES at the neighborhood level are determined using ecological analysis and the predictor variables are compared to those from the contextual analyses.

4.2 Methods

Children aged 0 to 17 years and who lived in Edmonton, Alberta, and surrounding urban areas during the fiscal year April 1, 1995 to March 31, 1996 were examined. The physician claims database and stakeholder registry of Alberta Health and Wellness were used to identify the study population. The census tract (CT) defined the neighborhood of residence, as it was the smallest census geographic unit in which all parameters of interest for deprivation were reported. The mean population within a CT is about 4,000 individuals (range 2,500 – 8,000) (Statistics Canada, 1997). The subjects' demographic information and a proxy indicator for socioeconomic status at the family level were obtained from the Alberta Health administrative databases as described in Chapter 3. The 1996 Population Census provided information on neighborhood socioeconomic environments of the study population at the CT level (Statistics Canada, 1997).

4.2.1 Study Area

The residence of the study population was limited to the Capital Health Region, one of the 17 Health Regions in the Province of Alberta, Canada, which consists mainly of the City of Edmonton and the surrounding communities of St. Alberta and the County of Strathcona. The study population was further limited to those children and adolescents residing in urban CTs, thus eliminating the population living on the fringes of the health region. In urban settings, health differences resulting from deprivation are especially pronounced (Reijneveld, 1998) and parameters at the CT level do not adequately reflect the socioeconomic environment in areas with low population densities. For this study, CTs in urban areas were characterized according to the 1996 Population Census' definition of an urban CT: at least 400 persons per square kilometer with a population of 1,000 or more (Statistics Canada, 1997). Child injuries in a total of 151 CTs were investigated.

4.2.2 Census Tract Level Indicators

The following eight socioeconomic indicators were used to characterize the CT:

Income:

Median family income: Neighborhood income is expected to be indicator of social conditions and built environment related to deprivation in a neighborhood (Wise et al., 1985).

Unemployment rate

The unemployment rate is the unemployed labour force, expressed as a percentage of the total labour force, in the week prior to enumeration (Statistics Canada, 1997). Unemployment has consistently been found to be associated with health problems including injuries (Roberts et al., 1992). It is perceived that neighborhoods with high unemployment rates will foster stressful social environments.

Education

Reflecting the percentage of people over age 15 with a high school diploma (Statistics Canada, 1997), this measure is likely related to child health outcomes through its influence on parental attitudes, knowledge, behavior and practices of safety precautions (Scholer et al., 1997). Also, the social norms and attitudes of the neighborhood on issues such as the importance of preventive health behaviors are also likely to be determined by the education level of the residing population. It is also a relatively more stable measure of deprivation than income and unemployment (Liberatos, Link & Kelsey, 1988).

Repairs

This is defined as the proportion of dwellings requiring minor repairs such as repair of missing or loose floor tiles, bricks or shingles, defective steps, and railing or siding (Statistics Canada, 1997). This indicator serves as a proxy to the condition of the built environment (i.e. those environments that are created, or at least significantly modified, by people).

Crowding

Crowding is calculated as:

$$\text{Crowding} = \frac{\text{Average number of individuals per household - 1}}{\text{Average number of rooms per dwelling}}$$

Increased crowding is hypothesized to represent less structured areas for play (Rivara & Barber, 1985) and social stress in neighborhoods.

Income inequality

Gini indices, a measure of income inequality, were calculated using the POVCAL program developed by the World Bank (Chen, Datt & Ravallion, 2000). This is based on the Lorenz curve of cumulative income distribution where the Gini index is the difference in area between the expected and observed curves (Gastwirth, 1972). In neighborhoods of high income inequality, individuals are more likely to be aware of their relative standings of inferior and superior social positions and feel the psychological effects (Soobader & LeClere, 1999).

Proportion of lone parents

In addition to economic deprivation (Lee, 2000), stressful households and inadequate supervision (Reading et al., 1999), due to insufficient resources, are particular hazards for children from lone parent homes. A high proportion of families exhibiting these characteristics in a community is likely to contribute to local social norms that are more conducive to unsupervised playtime.

Mobility

Mobility is defined as the proportion of people who moved within census sub-divisions (non-migrant) in the previous year (Statistics Canada, 1997). This identifies areas with high proportions of transient populations and has also been found to be a predictor of injuries at the ecological level (Avery et al., 1990). It is hypothesized that transient populations are likely to have fewer social networks, and this has been reported to be a predictor of injuries (Harris & Kotch, 1994).

4.2.3 Outcomes

In each of the three analyses: 1) ecological analysis, 2) traditional contextual analysis and 3) hierarchical linear models (HLM), six outcome measures were assessed. The six outcome measures focussed on Any Injury, injury that required hospitalization (documented as "Inpatient Services" (IPSR) on the physician-fee-for service database), and each of four injury categories based on the International Classification of Diseases - Ninth Revision (ICD-9) code (Karaffa, 1992) submitted by the physician. The four injury categories were:

(i) Dislocations, sprains and strains (ICD-9 codes 830 – 848.9),

(ii) Fractures (ICD-9 codes 800 – 829.9),

(iii) Burns (ICD-9 codes 940 – 949.9) and,

(iv) Poisonings (ICD-9 codes 960 – 989.9).

All outcomes were broken down further by age groups (0-4, 5-9, 10-14 and 15-17 years of age). Performing separate analysis for each subgroup means that the analyses would not need to account for possible interactions between the stratifying factors.

For analyses involving traditional contextual models and HLM the outcomes were dichotomous; children who saw a physician for injury treatment during the study period were compared to those who did not see a physician for injury treatment regardless of whether they did or did not see a physician for any other illness during the study period. Children were enumerated as cases for the injury groups using the following criteria.

- Each child was counted only once for each injury category regardless of the number of physician claims made. Therefore, for each of the six outcomes, each individual in the study population was dichotomized into whether they received treatment for Any Injury, whether they received treatment for each of the four injury types or whether they were hospitalized for injury treatment at any time during the study period.
- A child could appear in more than one injury category. If physician claims were made that fell under different injury categories, the child was counted in each injury category.

For ecological analysis, rates of each of the six injury outcomes in each census tract (CT) were calculated. The postal codes listed in the administrative databases were linked to their respective census tracts using a Postal Code Conversion File (PCCF) provided by Statistics Canada. Numerator data for injury rates in each CT were calculated by summing the injury cases as described above (i.e. children who received at least one service for injury treatment during the study period) for each of the six injury outcome measures. The denominator consisted of all children identified through the Alberta Health stakeholder registry as residing in the study area. The numerator and denominator data were stratified by age groups (0-4, 5-9, 10-14 and 15-17 years of age) to calculate age specific rates only when sample sizes were sufficient to produce parametric rates.

4.3 Analysis

4.3.1 Ecological Analysis

Linear regression analysis was performed to determine the association between injury rates and deprivation measures at the CT level. Univariate linear regression models were constructed to assess correlations between each CT level deprivation parameter and each injury type by age group. Deprivation measures significant at $p < 0.10$ in the univariate analyses and at $p<0.05$ in the multivariate analyses were considered when constructing the final regression models for each outcome. Of the possible models meeting this criterion, the one that resulted in the highest R-square value was chosen as the final model. The Stata (StataCorp, 1997) program was used for this analysis.

4.3.2 Traditional Contextual Analysis

Single level logistic regression analysis was performed to determine the association between likelihood of injury – the dependent variable – and the Alberta Health Care Insurance Plan payment subsidy status (proxy for family level SES), gender and eight CT level deprivation measures – the independent variables. Univariate analyses were performed to assess the association between each CT level deprivation measure with each outcome. Univariate associations between injury and subsidy status and gender were calculated in Chapter 3. Indicators significant at $p < 0.10$ in the univariate models and significant at $p<0.05$ in multivariate models were considered for the final multivariate models. The choice of the most appropriate final models in each case was based on the -2 log likelihood deviance statistic. The Stata (StataCorp, 1997) program was used for this analysis.

4.3.3 Multilevel Analysis

Associations between likelihood of injury and subsidy status, gender and eight CT level deprivation measures were again assessed but using multilevel logistic regression techniques. The foremost concern in performing multilevel analysis is the adequacy of sample size. Unfortunately, there is no standard method for power calculation in multilevel analysis. Power calculations in HLM are complex as there are several different types of parameters (fixed and random) and effects (cross-level interactions) to consider, each of which have their own 'ideal' conditions for maximum power (Kreft & de Leeuw, 1998). Additionally, in power calculations for hierarchical data sets, it is important to account for intraclass correlation, that is the proportion of between group variance to total variance. The higher the intraclass correlation, the less independent are the observations within the groups, and thus the sample size needs to be larger to achieve sufficient power (Mok, 1995). Ideally, powers would be estimated for each dataset as in simple regression analysis, since each dataset is unique in its intraclass correlation, variance etc., but this is not feasible since this process is too complex and power can be estimated for detecting only a single type of effect or parameter at a time. Researchers using multilevel modeling techniques have resorted to a few studies that used, among other methods, the Monte Carlo Markov Chain (MCMC) simulation method to estimate power in hierarchical data sets (Bassiri, 1988; Kim, 1990; Mok, 1995). They generalized from these studies to estimate sample size and power for their own studies. Although generalizing like this is unacceptable in studies employing simple regression analysis, this approach is commonly used in multilevel analysis because no feasible alternative is available.

Bassiri (1988) used the MCMC method to attempt a sample size calculation. In a group of 150, 5 observations per group were found to suffice to obtain a power of 0.90 to detect cross-level interactions. Using fewer observations led to a rapid drop in power. In the current study, the sample size at the group level is 151 (number of CTs), therefore if an *average* of 5 observations per census tract is considered as the minimum sample size required for analysis then a minimum total number of about 750 (5 x 150) individuals, 375 cases and 375 controls, would be required for adequate power in multilevel regression analysis models.

Bryk and Raudenbush's (1992) recommendations for model building were followed to create the model for this study. Detailed description of the model building process for this study is provided in Appendix 2. Initially, a model with individual level variables that were *fixed* (i.e. variation across CTs was set to zero) and significant at $p < 0.05$ were constructed. The variables considered were gender and the premium subsidy group. In the next step, the individual level variables were allowed to vary one at a time by neighborhood of residence. If the variation in slopes across CTs was significant, the variable was set as *random*, if not, it was *fixed*. Finally, the random intercepts and the random slopes (if any) were regressed onto the CT level indicators that appeared significant at $p < 0.10$ in the traditional contextual univariate analyses. It was not necessary to repeat this univariate analyses using multilevel analysis because estimates of precision of coefficients for CT level variables are more conservative in single level or traditional contextual analysis than in multilevel analysis. Similar to the single level analysis, the choices of the most appropriate final models were based on the -2 log likelihood deviance statistic. The MLwiN software (Rabash, Healy, & Browne, 1998) was used for this analysis.

4.4 Results

4.4.1 Ecological Analysis

Except for Burns, Poisoning and Injury Hospitalization, rates of injury were normally distributed (Table 4.1). Rates for these injury categories had values of zero in several CTs. To satisfy the assumptions of linear regression analysis, the age groups were further aggregated to 0-9 and 10-17 years in order to obtain a more normal distribution of injury rates at the CT level in these categories. Even with this adjustment, the distributions for Poisoning among 10-17 years olds and Injury Hospitalizations among the 0-9 and 10-17 year age groups were not normally distributed, as there were still several CTs with injury rates of zero. We decided against aggregating the age groups any further as preference was given to identifying distinct patterns of associations between injury rates and neighborhood deprivation by these age groups.

Table 4.1: Summaries of Injury Rates* in Census Tracts

Injury Type	Age Group in years	n	Median	Mean	Standard Deviation	Minimum	Maximum	Percent Census tracts with Zero Rates
All Injury	0-4	151	19.26	19.17	3.22	11.53	28.25	0.00
	5-9	151	19.54	19.63	3.49	8.93	30.83	0.00
	10-14	151	28.91	28.54	4.01	15.74	38.72	0.00
	15-17	151	31.71	31.82	5.57	15.56	46.30	0.00
	All	151	23.81	23.84	2.94	15.61	31.52	0.00
Dislocations, Sprains, Strains	0-4	151	2.37	2.45	1.06	0.00	6.76	0.66
	5-9	151	4.40	4.17	1.58	0.00	8.76	1.32
	10-14	151	12.89	12.84	2.74	4.08	18.61	0.00
	15-17	151	16.89	17.15	4.12	6.45	28.89	0.00
	All	151	8.10	8.11	1.81	3.14	13.83	0.00
Fractures	0-4	151	1.38	1.37	0.70	0.00	3.85	5.96
	5-9	151	2.37	2.45	0.97	0.42	6.58	0.00
	10-14	151	4.71	4.81	1.58	0.00	10.43	0.66
	15-17	151	4.13	4.45	1.81	0.00	11.90	1.32
	All	151	3.05	3.11	0.66	1.67	5.41	0.00
Poisoning	0-9	151	0.70	0.76	0.4	0.00	2.24	2.65
	10-17	151	0.65	0.72	0.54	0.00	2.63	13.91
	All	151	0.69	0.74	0.34	0.00	1.97	1.32
Burns	0-9	151	0.93	1.01	0.55	0.00	2.98	2.65
	10-17	151	0.88	0.95	0.61	0.00	3.39	9.27
	All	151	0.92	0.98	0.44	0.00	2.47	0.66
Injury Hospitalization	0-9	151	0.34	0.41	0.37	0.00	3.60	12.58
	10-17	151	0.62	0.66	0.43	0.00	2.48	9.93
	All	151	0.20	0.23	0.17	0.00	0.91	8.61

* Number injured per 100 persons during the 1995/96 fiscal year

Tables 4.2 and 4.3 provide descriptive summaries of CT level deprivation indicators (Table 4.2), and their Pearson correlation coefficients (Table 4.3). Histograms and scatterplots of all deprivation measures indicated normal distributions with no outliers. The strongest correlation was -0.751 and this was between proportion of lone parent families and median family income at the CT level.

Table 4.2: Descriptive Statistics of CT level Deprivation Measures

Census tract Indicator	n	Median	Mean	Standard Deviation	Minimum	Maximum
Education[1]	151	0.69	0.68	0.10	0.41	0.92
Unemployment[2]	151	8.50	9.14	3.36	2.50	25.20
Repairs[3]	151	0.28	0.27	0.06	0.06	0.47
Lone parents[4]	151	0.17	0.17	0.06	0.05	0.32
Crowding[5]	151	0.58	0.58	0.11	0.29	0.90
Income[6]	151	$45,181	$46,556	$12,773	$20,220	$87,829
Income Inequality[7]	151	33.79	34.26	5.10	19.87	50.25
Mobility[8]	151	0.14	0.15	0.06	0.03	0.33

[1] Education: Proportion of people with high school diploma
[2] Unemployment: Percent unemployed of labor force
[3] Repairs: Proportion of dwellings requiring minor repairs
[4] Lone parents: Proportion of families that are lone parent families
[5] Crowding: Proportion of dwellings that are crowded
[6] Income: Median family income
[7] Income Inequality: Gini Index
[8] Mobility: Proportion of people who moved (within the Census Subdivision) in the previous year

Table 4.3: Pearson Correlations Among CT Level Deprivation Measures

	Education	Income	Unemployment	Mobility	Repair	Lone parent	Crowding	Income Inequality
	Positively correlated with SES		Negatively correlated with SES					
Education	1.000							
Income	0.671*	1.000						
Unemployment	-0.688*	-0.661*	1.000					
Mobility	-0.237*	-0.711*	0.519*	1.000				
Repair	-0.256*	-0.143	0.144	-0.165*	1.000			
Lone Parent	-0.573*	-0.751*	0.625*	0.644*	0.117	1.000		
Crowding	-0.197*	-0.016	0.088	-0.052	-0.122	0.196*	1.000	
Income Inequality	0.119	-0.201*	0.272*	0.493*	-0.307*	0.315*	-0.227*	1.000

* p-value < 0.05
Note: Indicators on the left side of the heavy vertical line are positively correlated with SES (e.g. as income increases SES increases) and those on the right side of the heavy vertical line are negatively correlated with SES (e.g. as unemployment rate increases SES decreases).

The standardized beta coefficients for univariate analysis of injury rates and deprivation measures for All Injury, different injury types and Injury Hospitalization by age groups are shown in Table 4.4. The standardized beta coefficients are coefficients obtained if all independent variables (i.e. deprivation measures) were standardized to a mean of zero and standard deviation of 1, thus giving them the same unit of measurement. The non-standardized coefficients and the 95% confidence intervals are provided in Appendix 3.

CT level education and income tend to be positively correlated with rates of Fractures, and Dislocations, Sprains and Strains and negatively correlated with rates of Poisoning, Burns and Injury Hospitalizations. In a similar manner, unemployment rate, proportion of mobility, proportion of lone parents and income inequality are always inversely related with rates of Fractures or Dislocations, Sprains and Strains, and positively correlated with rates for Burns, Poisoning and Injury Hospitalizations.

The proportion of dwellings requiring minor repairs is positively correlated with rates of Fractures among all age groups except among 5-9 year olds for which no significant relationship is found. The proportion of crowded dwellings is directly related to Burns among 0-9 and 0-17 year olds and Dislocations, Sprains and Strains among 5-9 and 0-17 year olds and inversely related to Fractures among 0-4 year olds and Injury Hospitalizations among 0-17 year olds.

Table 4.4: Beta Coefficients* of Univariate Linear Regression Models Between Injury Rates and SES Indicators at the CT Level From Ecological Analysis

Injury Type	Age Group in years	Education	Income	Unemployment	Mobility	Repair	Lone Parent	Crowding	Income Inequality
		Positively Correlated with SES		Negatively Correlated with SES					
All Injury	0-4	--			---	+++		+++	----
	5-9	--					++	+++	---
	10-14		++	---	---				---
	15-17		++	--	----	++		++	----
	All		++	--	----	++		++	----
Dislocations, Sprains & Strains	0-4		++	--	---		--		
	5-9		++	---	---		--	++	---
	10-14	++	++++	---	---		--		--
	15-17	++	+++	--	--				---
	All	+++	+++++	----	-----		---	++	---
Fractures	0-4					++		--	
	5-9								
	10-14		++		--	++	--		--
	15-17				--	++			
	All	++	+++	--	----	++	---		--
Poisoning	0-9	-	--						
	10-17		-		++		++		
	All	--	---		++	++	++		
Burns	0-9	---	--	++			++	++	
	10-17								
	All	--	---	++	++		+++	++	
Injury Hospitalizations	0-9								
	10-17								
	All		--		++			----	+

* + is equivalent to a value of 0.1 for a beta coefficient (e.g. +++ is equivalent to 0.3); - is equivalent to a value of -0.1 for a beta coefficient.
Note 1: Beta coefficients shown only for $p<0.05$
Note 2: Indicators on the left side of the heavy vertical line are positively correlated with SES and those on the right side are negatively correlated with SES

The R^2 values in the multivariate models (Table 4:5) ranged from 0.03 in the model predicting rates of Poisoning among 10-17 year olds to 0.34 in the model predicting Dislocations, Sprains and Strains among 0-17 year olds. Multivariate models were not constructed for rates of Fractures among 5-9 year olds, Poisoning among 0-9 year olds, Burns among 10-17 year olds, and Injury Hospitalizations among 0-9 and 10-17 year olds as none of the SES indicators were significantly associated with these outcomes.

In the final multivariate models (Table 4.5), rates for All Injury, Fractures and Dislocations, Sprains and Strains tended to increase with increasing SES while rates for Poisoning, Burns, and Injury Hospitalizations decreased with increasing SES. The only exceptions were proportion of dwellings requiring minor repairs, which was directly correlated with rates of All Injury among 0-4 year olds and 15-17 year olds and Fractures among 0-4 year olds and 15-17 year olds when other SES indicators were controlled for. Also, injury rates for All Injury and Dislocations, Sprains and Strains were positively correlated with the proportion of crowded dwellings after controlling for other SES indicators. Also, rates of Injury Hospitalizations decreased with increasing proportion of crowded dwellings in CTs.

Table 4.5: Multivariate Regression Model Coefficients and 95% Confidence Intervals for CT Level SES Indicators* From Ecological Analyses

Injury Type & Age Group (Years)	R^2	Education	Income	Unemployment	Mobility	Repair	Lone Parent	Crowding	Income Inequality
		Positively Correlated with SES		Negatively correlated with SES					
All Injury									
0-4	0.25	-	-	-	-1.09 (-1.81,-0.37)	1.58 (0.85, 2.31)	-	0.96 (0.53, 1.40)	-
5-9	0.16	-	-	-	-	-	-	0.95 (0.45, 1.5)	-1.51 (-2.56,-0.46)
10-14	0.13	-	-	-1.41 (-2.35,-0.47)	-	-	-	-	-1.67 (-2.92,-0.43)
15-17	0.08	-	-	-	-1.63 (-3.01,-0.25)	1.50 (0.11, 2.89)	-	-	-
All	0.24	-	-	-	-1.10 (-1.84, 0.35)	-	-	0.46 (0.05, 0.86)	-1.52 (-2.49,-0.55)
Dislocations, Sprains, & Strains									
0-4	0.07	-	-	-	-0.43 (-0.69,-0.17)	-	-	-	-
5-9	0.16	-	-	-0.53 (-0.89,-0.16)	-	-	-	0.31 (0.08, 0.54)	-0.57 (-1.07,-0.07)
10-14	0.14	-	-	-1.17 (-1.81,-0.54)	-	-	-	-	-0.87 (-1.71,-0.02)
15-17	0.10	0.81 (0.17, 1.44)	-	-	-	-	-	-	-2.26 (-3.51,-1.00)
All	0.34	0.42 (0.17, 0.67)	-	-	-1.24 (-1.62,-0.85)	-	-	0.41 (0.18, 0.65)	-
Fractures									
0-4	0.09	-	-	-	-	0.22 (0.05, 0.40)	-	-0.13 (-0.23,-0.02)	-
5-9	N/a	-	-	-	-	-	-	-	-
10-14	0.05	-	-	-	-0.57 (-0.96,-0.18)	-	-	-	-
15-17	0.03	-	-	-	-	0.46 (0.00, 0.91)	-	-	-
All	0.13	-	-	-	-0.37 (-0.53,-0.22)	-	-	-	-

* Unit changes in CT level indicators refer to: increase in 10% of population with high school diploma, increase in median income of $10,000, increase in unemployment rate by 5, increase in 10% of population who moved in the past year, increase in 10% of dwellings requiring minor repairs, increase in 10% of lone parent families, increase in 10% of crowded dwellings, increase in Gini index of 5 units.

Note: Indicators on the left side of the heavy vertical line are positively correlated with SES and those on the right side are negatively correlated with SES

Table 4.5 (continued): Multivariate Regression Model Coefficients and 95% Confidence Intervals for CT Level SES Indicators* From Ecological Analyses

Injury Type & Age group (yrs)	R^2	Education	Income	Unemployment	Mobility	Repair	Lone Parent	Crowding	Income Inequality
		Positively Correlated with SES		Negatively Correlated with SES					
Poisoning									
0-9	N/a	-	-	-	-	-	-	-	-
10-17	0.03	-	-	-	0.15 (0.02, 0.29)	-	-	-	-
All	0.10	-	-0.08 (-0.12, -0.04)	-	-	-	-	-	-
Burns									
0-9	0.07	-	-	0.16 (0.03, 0.29)	-	-	-	0.08 (0.00, 0.16)	-
10-17	N/a	-	-	-	-	-	-	-	-
All	0.11	-	-0.10 (-0.15, -0.04)	-	-	-	-	0.07 (0.01, 0.14)	-
Injury Hospitalization									
0-9	N/a	-	-	-	-	-	-	-	-
10-17	N/a	-	-	-	-	-	-	-	-
All	0.16	-	-0.02 (-0.04, -0.00)	-	-	-	-	-0.06 (-0.08, -0.03)	-

*Unit changes in CT level indicators refer to: increase in 10% of population with high school diploma, increase in median income of $10,000, increase in unemployment rate by 5, increase in 10% of population who moved in the past year, increase in 10% of dwellings requiring minor repairs, increase in 10% of lone parent families, increase in 10% of crowded dwellings, increase in Gini index of 5 units.

Note: Indicators on the left side of the heavy vertical line are positively correlated with SES and those on the right side are negatively correlated with SES

4.4.2 Traditional Contextual Analysis

In the final multivariate traditional contextual analysis models, risk of All Injury, and Dislocations, Sprains and Strains tend to be directly related to CT level income, proportion of crowded dwellings, proportion of dwellings requiring minor repair, and proportion of lone parent families and negatively related to unemployment rate, mobility, and income inequality (Table 4.6). Likelihood of Fractures appears to increase with increasing CT level education, income, and proportion of dwellings requiring minor repairs and it tends to decrease with increasing proportion of people who moved in the past year (mobility), proportion of crowded dwellings, and income inequality.

Increasing proportions of lone parents, dwellings requiring repairs, and crowded dwellings appear to be directly related to risk of Poisoning and Burn injuries in some of the final multivariate models. Additional CT level predictors for likelihood of Poisoning injuries in the final models are higher income and lower unemployment rates.

Table 4.6: Multivariate Logistic Regression Analysis Model Coefficients and 95% Confidence Intervals for Subsidy Status, Gender and CT level SES Indicators From Traditional Contextual Analyses

Injury type	AHCIP payment groups (Ref: No Subsidy)			Gender	CT level deprivation Indicators†							
	Partial subsidy	Treaty Status	Social Services	Male	Education	Income	Unemployment	Mobility	Repair	Lone parent	Crowd	Income Inequality
All Injury												
0-4	1.10 (1.03,1.17)	1.27 (1.14,1.42)	1.32 (1.21,1.43)	1.22 (1.16,1.28)				0.92 (0.88,0.96)	1.11 (1.06,1.15)		1.06 (1.03,1.08)	0.93 (0.88,0.99)
5-9	1.05 (0.98,1.12)	1.15 (1.03,1.29)	1.29 (1.19,1.40)	1.24 (1.19,1.30)						1.06 (1.02,1.10)	1.04 (1.02,1.06)	0.85 (0.81,0.90)
10-14	0.97 (0.91,1.04)	1.10 (0.99,1.23)	1.18 (1.09,1.27)	1.28 (1.23,1.33)			0.89 (0.85,0.93)	0.94 (0.89,0.99)	1.04 (1.01,1.08)	1.10 (1.04,1.17)		0.90 (0.86,0.95)
15-17	0.84 (0.77,0.92)	0.99 (0.85,1.16)	1.21 (1.08,1.34)	1.48 (1.41,1.56)		1.09 (1.04,1.14)			1.09 (1.04,1.14)	1.12 (1.04,0.92)		0.86 (0.81,0.92)
0-17	0.97 (0.93,1.00)	1.10 (1.04,1.17)	1.22 (1.17,1.27)	1.29 (1.26,1.32)		1.04 (1.03,1.06)	0.96 (0.94,0.99)	0.94 (0.91,0.97)	1.05 (1.02,1.07)	1.14 (1.10,1.18)	1.01 (1.00,1.03)	0.88 (0.85,0.91)
Dislocations, Sprains, & Strains												
0-4								0.87 (0.79,0.95)			1.07 (1.01,1.14)	
5-9								0.88 (0.81,0.95)			1.05 (1.00,1.10)	0.87 (0.78,0.97)
10-14	0.96 (0.87,1.04)	1.05 (0.90,1.23)	1.19 (1.07,1.32)			1.08 (1.04,1.12)	0.90 (0.84,0.96)			1.17 (1.08,1.27)		0.85 (0.79,0.90)
15-17	0.83 (0.74,0.93)	0.84 (0.68,1.03)	1.18 (1.03,1.34)	1.30 (1.22,1.39)		1.12 (1.08,1.17)				1.25 (1.13,1.37)	0.95 (0.92,0.99)	0.78 (0.72,0.84)
0-17	0.97 (0.82,0.92)	0.88 (0.79,0.97)	1.08 (1.01,1.15)	1.10 (1.06,1.14)		1.10 (1.07,1.13)	0.94 (0.90,0.98)	0.90 (0.86,0.95)		1.23 (1.16,1.29)		0.85 (0.81,0.89)
Fractures												
0-4									1.23 (1.09,1.40)			
5-9												
10-14	0.99 (0.86,1.14)	1.16 (0.92,0.15)	1.11 (0.94,1.32)	1.64 (1.50,1.78)				0.89 (0.82,0.96)			0.92 (0.88,0.96)	0.88 (0.79,0.98)
15-17	0.72 (0.58,0.90)	0.87 (0.60,1.26)	1.26 (1.00,1.59)	3.11 (2.72,3.54)		1.08 (1.03,1.13)			1.18 (1.07,1.30)			
0-17	0.83 (0.76,0.91)	1.05 (0.91,1.22)	1.09 (0.98,1.20)		1.04 (1.00,1.07)			0.88 (0.83,0.92)	1.10 (1.05,1.15)			

† Unit changes in CT level indicators refer to: increase in 10% of population with high school diploma, increase in median income of $10,000, increase in unemployment rate by 5, increase in 10% of population who moved in the past year, increase in 10% of dwellings requiring minor repairs, increase in 10% of lone parent families, increase in 10% of crowded dwellings, increase in Gini index of 5 units.

Table 4.6 (continued): Multivariate Logistic Regression Analysis Model Coefficients and 95% Confidence Intervals for Subsidy Status, Gender and CT level SES Indicators From Traditional Contextual Analyses

Injury type	AHCIP payment groups (Ref: No Subsidy)			Gender	CT level deprivation Indicators+							
	Partial Subsidy	Treaty Status	Social Services	Male	Education	Income	Unemploy-ment	Mobility	Repair	Lone parent	Crowd	Income Inequality
Poisoning												
0-9	1.39 (1.14,1.71)	1.72 (1.26,2.34)	2.26 (1.84,2.79)						1.26 (1.12,0.14)		1.12 (1.03,1.20)	
10-17	1.27 (0.97,1.67)	3.70 (2.73,5.01)	2.02 (1.51,2.69)	0.60 (0.50,0.72)		0.82 (0.68,0.99)				1.44 (1.17,1.76)		
0-17	1.38 (1.18,1.62)	2.47 (2.00,3.05)	2.22 (1.88,2.62)	0.83 (0.74,0.93)			1.19 (1.08,1.30)					
Burns												
0-9	1.24 (1.04,1.48)	1.38 (1.04,1.83)	1.63 (1.33,1.99)	1.44 (1.27,1.64)					1.13 (1.01,1.26)	1.18 (1.05,1.31)	1.10 (1.03,1.17)	
10-17	1.13 (0.90,1.42)	1.20 (0.82,1.77)	1.42 (1.09,1.85)							1.16 (1.02,1.31)		
0-17	1.20 (1.05,1.38)	1.32 (1.05,1.66)	1.55 (1.32,1.81)	1.31 (1.19,1.45)				1.13 (1.04,1.22)	1.16 (1.07,1.25)		1.09 (1.04,1.15)	
Injury Hospitalization												
0-9	1.12 (0.84,1.49)	1.54 (1.00,2.35)	1.81 (1.34,2.45)									
10-17	0.88 (0.65,1.19)	1.61 (1.07,2.43)	1.38 (1.00,1.89)	1.79 (1.49,2.15)								
0-17	0.95 (0.77,1.17)	1.50 (1.12,2.02)	1.52 (1.22,1.89)	1.49 (1.30,1.70)								

+ Unit changes in CT level indicators refer to: increase in 10% of population with high school diploma, increase in median income of $10,000, increase in unemployment rate by 5, increase in 10% of population who moved in the past year, increase in 10% of dwellings requiring minor repairs, increase in 10% of lone parent families, increase in 10% of crowded dwellings, increase in Gini index of 5 units.

4.4.3 Multilevel Regression Analysis

Table 4.7 presents the CT level variance and the proportion of variation in injuries accounted for by CTs. Except for Poisoning among 10-17 year olds, which had 5.02% of variation accounted for by CTs, the remaining groups had percentages of variance accounted for by CTs that were less than 5%. Therefore, a multilevel model was constructed for only this group.

In the final model for Poisoning injuries among 10-17 year olds, gender and subsidy status were significant individual level predictors while proportion of lone parents in CTs and unemployment rates in CTs were the only ecological level predictors that remained in the final model. The relationships between the individual level variables (subsidy status and gender) and the outcome (likelihood of injury) did not vary significantly by CT, hence there were no random effects.

The changes in coefficient estimates and the changes in the percent CT variance remaining unexplained are shown in Table 4.8. Model E was chosen as the final model over Model D, even if the percent variance remaining unexplained at the CT level was higher in model E. Firstly, according to the log deviance statistic, Model E was a better fit. Secondly, according to Snijders and Bosker (1999) this increase in the proportion of variance remaining unexplained can be attributed to either misspecification of the model or chance fluctuation. Since our diagnostics do not reveal any model misspecification and also since the increase in the percent variance remaining unexplained from model D to model E is small (0.05%), this increase is most likely attributed to a chance fluctuation. In the final model, 2.8% variation at the CT level remained unexplained.

Table 4.7: Census Tract Variance in the Multilevel Null Models and Percent of Variance at the CT Level For Different Injury Types and Age Groups

Injury Type	Age group	CT Variance (Standard Error)	Percent variation accounted for by CT
All injury	0-4	0.017 (0.004)	0.51
	5-9	0.017 (0.004)	0.51
	10-14	0.020 (0.004)	0.60
	15-17	0.028 (0.006)	0.84
	All Ages	0.020 (0.003)	0.60
Dislocations Sprains & Strains	0-4	0.017 (0.016)	N/A
	5-9	0.036 (0.013)	1.08
	10-14	0.028 (0.007)	0.84
	15-17	0.036 (0.009)	1.08
	All Ages	0.048 (0.007)	1.44
Fractures	0-4	0.000 (0.000)	N/A
	5-9	0.000 (0.000)	N/A
	10-14	0.027 (0.011)	0.81
	15-17	0.027 (0.017)	N/A
	All Ages	0.023 (0.006)	0.69
Burns	0-9	0.109 (0.031)	3.21
	10-17	0.061 (0.031)	0.92
	All Ages	0.092 (0.022)	2.70
Poisoning	0-9	0.028 (0.025)	N/A
	10-17	0.174 (0.057)	5.02
	All Ages	0.135 (0.056)	3.94
Injury Hospitalization	0-9	0.056 (0.047)	N/A
	10-17	0.012 (0.033)	N/A
	All Ages	0.036 (0.023)	N/A

Table 4.8: Odds Ratios and 95% Confidence Intervals for Multilevel Models for Poisonings Among 10 to 17 Year Olds

Parameter	Parameter Estimates and 95% Confidence Intervals				
	Model A (Null)	Model B	Model C	Model D	Model E (Final)
Partial*		1.33 (1.01, 1.74)	1.33 (1.01, 1.74)	1.32 (1.00, 1.75)	1.28 (0.97, 1.69)
Treaty*		3.78 (2.80, 5.12)	3.78 (2.80, 5.12)	3.78 (2.94, 5.15)	3.63 (2.67, 4.95)
Social Services*		2.01 (1.74, 2.32)	2.01 (1.50, 2.69)	2.00 (1.49, 2.70)	1.96 (1.46, 2.63)
Male**			0.60 (0.50, 0.72)	0.60 (0.50, 0.72)	0.60 (0.50, 0.72)
Census tract Unemployment rate				1.00 (0.85, 1.18)	0.80 (0.65, 1.00)
Census tract Lone Parents					1.46 (1.14, 1.86)
Percent Variance remaining unexplained at CT level	5.02	3.24	3.24	2.78	2.83
-2 log likelihood	-104756	-105593	-107256	-107345	-107496
(change in degrees of freedom)		(d.f. = 3)	(d.f. = 1)	(d.f. = 1)	(d.f. = 1)

* Reference is the non-subsidized group
** Reference is female

4.4.4 Comparison of Results Derived From Single Level Analysis and Multilevel Analysis

The explanatory variables in the final models for Poisoning among 10 to 17 year olds were the same as those derived through multilevel regression analysis and traditional contextual (single level) regression analysis (Table 4.9). Although the coefficient estimates are similar, the confidence intervals for CT level explanatory variables are slightly larger for those estimated using multilevel analysis.

Table 4.9: Coefficients and 95% Confidence Intervals Derived Using Multilevel Regression Analysis and Traditional Contextual Analysis

Explanatory Variables	Multilevel Analysis		Traditional Contextual Analysis	
	Coefficients	95% Conf Intervals	Coefficients	95% Conf Intervals
Partial	1.28	(0.97, 1.69)	1.27	(0.97, 1.67)
Treaty	3.63	(2.67, 4.95)	3.70	(2.73, 5.01)
Social Services	1.96	(1.46, 2.63)	2.02	(1.51, 2.69)
Male	0.60	(0.50, 0.72)	0.60	(0.50, 0.72)
Lone Parents (Census tract)	1.46	(1.14, 1.86)	1.44	(1.17, 1.76)
Unemployment (Census tract)	0.80	(0.65, 1.00)	0.82	(0.68, 0.99)

4.5 Discussion

The key finding in this study is the correlation between neighborhood contextual factors and risk of injury among children, independent of their individual level characteristics. However, except for Poisonings among the 10 to 17 year age group, the percentage variation explained by CT of residence for all other injury outcomes was minimal (0-3%). This means that the area variation seen in injury rates and its correlation with CT level deprivation measures (with R^2 values ranging from 0.03 to 0.34) is largely a reflection of differences in the composition of individual level SES by CTs. Also, contextual factors that appear to be correlated with injury risk in the traditional contextual analyses have little predictive power.

In hypothesizing a causal pathway to explain influences of neighborhood level factors one must consider that in the likelihood of contextual effects operating in relationships, CT level measures are not analogous to individual level ones (Robinson, 1950; Schwartz, 1994). On that note, CT level SES indicators are mere proxies for the 'true' or the most proximate etiologic agents operating at the CT level. In a similar manner, the variables that are the most important determinants may not have been included in the final models. The study may have only controlled for the effects of other important risk factors that are correlated with these variables (Morgenstern, 1982).

On that note, low-income areas usually mean fewer parks, more industry and unsafe road and building conditions (Durkin et al., 1994; Rivara & Barber, 1985). In addition to factors of the built environment, social conditions in low income areas, such as locally based attitudes that promote risky behavior (Sellstrom & Bremberg, 1996) or increased drug activity (Durkin et al., 1994; Carey, Vimpani & Taylor, 1993), are conditions that may increase injury risk among children residing in particular neighborhoods.

While such contextual factors are responsible for the relationships that appear in traditional contextual and multilevel analyses (where the latter is more statistically correct), effects resulting from the localization of individuals of similar SES may also be represented in relationships appearing in ecological analyses. There is an abundance of literature on the predisposition to injury for children belonging to low SES families due to differences in psychosocial, behavioral and parental characteristics operating at the individual level (Nersesian, 1985; Larson & Pless, 1988). This may be reflected in the neighborhood socioeconomic profile and injury rates of the population when such individuals behaving in a systematically similar fashion tend to have common neighborhoods of residence, all of which results in an observed compositional effect at the ecological level. Along with contextual effects, these effects may also be represented in ecological relationships.

Dislocations, Sprains and Strains, and Fractures tend to be more common in children from higher SES families and rates of these injuries are greater in neighborhoods of higher SES. These injury diagnoses tend to result from sports related activities (Alberta Center for Injury Control and Research, 2000) and, as has been suggested by others (Dershewitz, 1978; Jolly, Moller & Volkmer, 1993; Williams et al., 1997;), children from higher SES families are probably exposed to more sports activities and as such experience more injuries resulting from them. At the ecological level, more affluent neighborhoods may have more resources to spend on extracurricular or sports activities. For instance, in a comparison of a school situated in a low-income neighborhood to one situated in a high-income neighborhood, physical education classes involved more frequent and more vigorous exercises in the affluent school (Sallis et al., 1996). In assessing the differences in risk of these injuries by neighborhood of residence, the traditional contextual analysis provides a mixed picture where positive correlations with median income and lower unemployment rates suggest the risk of these injuries is greater in neighborhoods of higher SES while positive correlations with proportion of lone parents in CTs suggest greater risk in neighborhoods of lower SES. This may be attributed to the heterogeneity of the causes of injuries within these groups, as there are other injury causes (e.g. pedestrian injuries) resulting in fractures, and dislocations, sprains and strains for which deprived areas may be a risk. For instance, a strong correlation between low neighborhood income and risk of pedestrian injury, as have been previously reported (Mueller et al. 1995), may explain the correlation with low SES found in these diagnoses.

The likelihood of Burn injury appears to be greatest among children from low SES families and those living in deprived neighborhoods. Furthermore rates of Burn injuries are higher in deprived neighborhoods. While differences in SES risks are likely attributed to low parental supervision (Nersesian et al., 1985) and inadequate storage of sources of ignition (Santer, 1991) in low income homes, unfavorable conditions inherent to low income neighborhoods may also be partly responsible for the increased risk among some children. Substandard housing that is more susceptible to fire (Nersesian et al., 1985) or local social attitudes that attribute less value to safety practices, found more commonly in deprived neighborhoods, may increase the risk of Burn injury for a child in a low income neighborhood, regardless of his or her family SES. While such factors inherent to CTs were found to have very minimal, if any, influence on likelihood of Burn injury, they appear to play a more significant role in the risk of Poisoning.

This study shows contextual factors of CTs along with family subsidy status to be important predictors of Poisonings among children 10 to 17 years of age, but not for the other injuries and age groups examined. Even so, the CT level variation in rates of Poisoning in this age group appears to be more a result of the differences in composition of people rather than contextual factors of the CT as the largest reduction in variation remaining unexplained at the CT level occurred with the addition of family subsidy status in the final multilevel model. For every 10% increase in the percent of lone parents in a CT, the risk of Poisoning increased by almost one and a half times (OR=1.46) when subsidy status, gender, and unemployment rates in CTs were controlled. When the model's additive affects were considered, the risk increased drastically. For instance, when gender and unemployment rate of the CT is controlled, the risk of Poisoning injury for a Treaty status child living in a CT with the highest proportion of lone parents in the study area (32%) is estimated to be 6.4 times that of a non-subsidized child living in a CT with the lowest proportion of lone parents in the study area (17%).

The influence of social norms on injury preventive behavior such as inappropriate storage of medications, household cleaners and alcohol has been shown by Sellstrom and Bremberg (1996). They found perceived norms of friends and other parents to be significant determinants of parental injury preventive behavior, above that of low parental socioeconomic status. While proximity of residence was not considered in their study, Smith (1994) suggests that beliefs are more related to local cultures and less related to those that are separated by distance. Therefore a high proportion of families of low SES in a neighborhood, taking inadequate safety measures such as improper storage of toxic substances, is likely to increase risk of injuries for all children in the neighborhood by influencing parental perceptions of social norms related to preventive behavior.

While accidental poisonings are a major cause of poisonings in young children, suicide attempts become increasingly prevalent in the older adolescents (Lovasik et al., 1994). Areas with a high proportion of lone parent households were correlated with a high proportion of transient populations in the neighborhood. This may prevent the development of neighborhood social networks, and this in turn may lead to isolation – a precursor to parasuicide. Furthermore, the limited availability of extracurricular activities for adolescents in deprived communities (Sallis et al., 1996) may also lead to isolation and loneliness. Another factor that may perhaps fuel suicides in some neighborhoods and not others is the "suicide culture" that develops with a single case of suicide where committing suicide becomes more attractive with recent news of a peer in the community committing suicide. However, the results suggest that such contextual factors inherent to neighborhoods, while significant, explains very little variation in poisoning injuries.

The high risk of Poisoning injuries for Treaty Status adolescents is most likely attributed to high rates of substance abuse (Gfellner & Hundleby, 1995) and suicide attempts among Native Canadian youths, especially females (Canadian Institute of Child Health, 1994), among whom the common method of suicide is poisoning (Lovasik et al., 1994). The underlying causes maybe due to unfavorable social conditions that are more commonly found in this group such as depression and poverty (Tookenay, 1996).

In contrast to Reading et al's (1999) findings that contextual factors associated with neighborhood deprivation are more related to severe injuries than non severe injuries among children, the CT level factors considered in my study were not able to predict likelihood of Injury Hospitalizations, a proxy that is commonly used to identify severe injuries (Jolly, Moller & Volkmer, 1993; Reading et al., 1999). Although it has been suggested that severe injuries would inevitably be hospitalized without bias of SES, the assumption that Injury

Hospitalization captures all severe and only severe cases is dubious. Other possible predictors of hospital admission such as informal judgments made by medical professionals about the parents' ability to bring the child for outpatient treatment have been suggested (Williams et al., 1997). Further investigation into the criteria for hospitalization and non-hospitalization of severe injuries among children is required prior to using injury hospitalization as an outcome that is not biased by differential medical service utilization.

The amount of variation in likelihood of injury explained by CT of residence is consistent with the literature in that place-to-place variation in health outcomes between administrative areas falls into the 1.0 to 5.0 percent range (Boyle & Willms, 1997; Reijneveld, 1998). However, only Poisonings among 10-17 year olds had sufficient variation at the CT level (5%) to construct a multilevel model.

Comparison of Analytic Methods

The small discrepancy in the coefficient estimates obtained using HLM and traditional contextual regression may be attributed to the different iterative methods used and the different distributions of the ecological level variables involved with the two techniques. Also, multilevel techniques account for intra-class correlation, or the natural tendency for individuals to be more similar to each other within CTs in comparison to across CTs. This would tend to decrease the magnitude of individual level associations in multilevel models when compared to those obtained using single level analysis. Lastly, the precision (95% confidence intervals) of coefficients of CT level explanatory factors are slightly more conservative as the sample size of CT level factors is much lower and accurate in multilevel data sets. This has the potential to have major implications on whether CT level explanatory variables are included in the final multivariate model. For instance, unemployment rate at the CT level was barely significant at p=0.05 to be included in the final model in HLM while this was not a concern in the final model of the traditional contextual analysis. In summary, using HLM over traditional contextual analysis did not appear to be beneficial for this study as the predictors included in the final models were the same in both analyses and the estimates in their coefficients and precisions were quite similar as well. However, the results from both sets of analyses may well be quite different in other study contexts.

Limitations

In addition to other issues, this work has certain limitations associated with the inherent flaws of the multilevel techniques. Many of the major issues related to the study population are discussed in detail in Chapter 3. These include: lack of information of external cause of injuries, restrictions and validity concerns of the individual level deprivation indicators, differential physician service utilization by SES and the definition of the study cases.

In considering the appropriateness of CT as the operational definition of a neighborhood, the consequences are as important in contextual analysis as in ecological analysis. Census tracts are administrative boundaries and have no explicit theoretical justification in the outcome being studied (Duncan, Jones & Moon, 1998). True contextual relationships may be obscured by an analysis that uses an ecological unit such as a CT that has a relatively heterogeneous SES composition. The United States Census Bureau has shown that such heterogeneity exists. The census data at the block level (which is similar to Canada's enumeration area (EA)) revealed pockets of poverty that were obscured by analyses conducted at the census tract level (Cherkin, 1992). Morgenstern (1982) suggested that in order to minimize inferential problems in ecological studies, the groups be made as homogeneous as possible by using smaller units of analysis. To verify this, I performed a brief analysis to determine the variation in Poisoning injuries among 10 to 17 year olds explained by EA of residence. While the percentage of explained variance by CTs was 5.0%, variation at the enumeration area level was 7.8%.

However, for this study the CT is the smallest census geographic unit for which socioeconomic information is available. Much of this information is suppressed at the EA level to maintain confidentiality. An additional limitation to using such small units in ecological analyses is that estimates of injury rates become less stable due to the low number of observations within each unit.

Another limitation common to studies employing multilevel techniques is the lack of a standard method to calculate sample size and statistical power. As mentioned earlier, it is common practice to generalize sample size calculations from other studies, even though the data sets are different. Currently, no feasible alternative is available.

A further potential weakness in this study is that while the SES constructs were analyzed as linear and continuous parameters, other forms of the parameters may have revealed important associations. Teevan (1985) found considerable variation in associations with outcomes when measures of social class were each used as categorical and ordinal variables but with different cut points and number of categories. Although the direction of relationship between SES and the disease outcome would remain the same, this may have an effect on the magnitude of associations or whether an indicator is significant or not. For instance, data from some investigations suggest that children only in the lowest income quintiles are at an increased risk for injuries (Dougherty, Pless & Wilkins, 1990; Jolly, Moller & Volkmer, 1993). If income were used as a categorical variable in such cases, the actual relationship would be obscured in the analysis. For this study, examination of preliminary scatter plots and residual plots of the models did not suggest such relationships.

4.6 Conclusion

Despite the limitations discussed above, this study provides evidence to suggest difference in risk of child injury by socioeconomic factors inherent to place of residence and independent of individual level characteristics. However, the predictive powers of CT of residence for the majority of injury types assessed were negligible, with the exception of Poisoning among 10 to 17 year olds for which the predictive power of CT level factors was minimal. However, modification of the environment should remain a priority in injury reduction as strategies aimed at behavior modification have proven to be minimally, if at all, successful. Furthermore, this study findings does not preclude the possibility of contextual effects stemming from areas defined by other boundaries (e.g. enumeration areas). Localized injury reduction approaches that are specific to the social and economic needs of the residing population and which consider the neighborhood social and economic contexts in the planning, development and implementation phases will likely be more efficacious.

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CHAPTER 5

Conclusion

5.1 Synthesis and Discussion

The primary purpose of this research was to determine if deprivation related contextual factors of neighborhoods that children reside in influence the likelihood of injury. The principal finding is that contextual factors of census tract of residence are correlated with risk of injuries among children, independent of their individual level characteristics. However, except for Poisonings among the 10 to 17 year age group, the percentage variation explained by CT of residence for all types of injury outcomes was minimal (0-3%).

Study Limitations

This deficiency in explained variance by place of residence is likely an artifact of two key limitations: the lack of information on the external cause of an injury (e.g. falls, motor vehicle collisions), and the proper choice of the contextual unit of analysis. The lack of data about the external cause of injury may well obscure the associations with contextual factors due to the heterogeneity of external causes within each injury category studied.

Choosing the right contextual unit is a major issue in multilevel analysis (Balock, 1984). Cherkin, Grothaus and Wagner (1992) suggests enumeration areas are more suitable units of analysis. However, in deciding the size of the contextual unit, the unit needs to be small enough to detect place effects but large enough to have practical significance. The problem is that as smaller areas (e.g. enumeration areas (EAs)) are grouped together, the aggregated areas they form (e.g. census tracts) are more heterogeneous and thus less able to explain variation in outcomes (Roberts, 1997). Basically, with respect to defining neighborhood boundaries, the smaller the area studied the larger the place effect, but localized heterogeneity in injury patterns by geographic areas as small as EAs, while interesting academically, is unlikely to draw the attention of policy makers. Reading et al. (1999) devised an interesting alternative that combined some enumeration areas but still maintained homogeneity in the variables of interest. To investigate place effects on child injuries, they combined adjacent blocks – analogues to enumeration areas – with similar characteristics. This may explain the higher proportion of variation in child injuries accounted by place of residence in their study. While in the present study I could show that enumeration areas of residence could explain a higher proportion of variance in outcomes than census tracts, multilevel models for these outcomes could not be constructed due to the lack of information on SES at the EA level.

Multilevel Analysis

There are three key benefits to using multilevel analysis over traditional contextual analysis in this investigation. With multilevel level analysis I could determine the variation in outcomes explained by CT for each injury outcome and thus assess the predictive power of contextual factors. Second, this method demonstrated that associations between individual level SES and likelihood of injury did not vary by CT of residence – i.e. the effect of family SES on likelihood of injury is the same across different neighborhoods. Lastly, multilevel analysis provided more accurate estimates of associations between likelihood of injury and contextual factors. While the discrepancy in the estimates of coefficients were no more than 3% and the differences in the confidence intervals were relatively minor as well, the latter may have had serious consequences stemming from whether an explanatory variable is included in the final multivariate model. This is because most researchers use a stringent p-value cut off (a value of usually 0.05) as a criteria to include a variable in the final model, and since p-values of contextual factors tend to be larger in multilevel models than in traditional contextual models, a CT level variable that is included the final multivariate model in traditional contextual regression analysis may not be in that of the multilevel regression analysis.

Comparison of Results From Different Levels of Analysis

Another valuable finding in this study was that the patterns of association between SES and injury were for the most part similar in individual and ecological level analysis. The variation by age group and injury category was similar in both sets of analyses. Burns, Poisoning and Injury Hospitalizations were more likely to be associated with lower SES at the individual level and at the ecological level. Dislocation, Sprains and Strains, Fractures and All Injury tended to be associated with affluent socioeconomic status at both levels of analysis.

Burns, Poisonings and Injury Hospitalizations among certain age groups were associated with SES indicators at the individual level but not at the ecological level. These injury groups reflect more uncommon injuries, and thus the discrepancy may be caused in part by unstable rates of injuries at the CT level, thus obscuring the detection of geographic correlations. Another possible explanation is that the SES indicators assessed at the ecological level could not explain the geographic variation of these injury types.

Among certain age groups, injuries resulting in Fractures and Dislocations, Sprains and Strains were related to SES at the ecological level but not at the individual level. Based on the results produced in multilevel analysis, contextual effects were ruled out as a possible major contributor to the CT level variation in these groups. These findings indicate that compositional effects determined by socioeconomic groupings, other than partially subsidized, Treaty Status, and Social Services are responsible for such geographic differences. It should also be noted that the heterogeneity of the external causes (e.g. pedestrian injury) of injuries resulting in these diagnostic groups may obscure relationships that might be observed if the outcomes were examined by the external causes.

Poisonings among 10 to 17 year olds was the only injury category for which all four different types of regression models (i.e. individual level, ecological level, traditional contextual and multilevel) were constructed. The inverse correlation with SES was large at the individual level and moderate at the ecological level. For example, after accounting for gender, the odds of Poisoning injuries amongst Treaty Status children aged 10-14 years were about 3 times that of non-subsidized children and about five times higher for those aged 15-17 years. Analysis of geographical variation in rates did not, however, provide strong evidence in SES effect. Of the eight CT level deprivation indicators assessed, only mobility could predict rates of Poisoning injuries and this accounted for only about 3% of the variation in Poisoning rates. The distinct SES indicators used across the levels makes it difficult to compare meaningfully the findings from the two types of analysis. The results suggest there is an individual level SES component to explain Poisonings in this group but they provide little evidence to suggest a geographical component. Furthermore, the ecological variation may merely reflect the differential SES composition of people by CTs rather than factors inherent to a given CT.

The relationships between SES and injury assessed using the contextual analyses (i.e. traditional contextual analyses and multilevel analysis) differed from those determined using ecological analysis for poisonings among 10-17 year olds. While the same CT level predictors were assessed in both instances, the CT level predictors in the final multivariate models were different. In both contextual analyses the CT level variables that remained in the final model were proportion of lone parents and unemployment rates, in the ecological analysis, the proportion of people who moved in the previous year in a CT remained as the predictor variable in the final model. The discrepancy in the findings between these two types of analysis confirms the ecological fallacy. Characteristics of aggregate regional populations should not be used to generate assumptions about individuals in the population (Robinson, 1950). Also, results from ecological analyses should not be used to make assumptions about contextual effects. In summary, the results of this study suggest that in assessing the risk of Poisoning among 10 to 17 year olds, one must consider SES related characteristics of the individual or family and SES related factors inherent to the census tract they reside in.

5.2 Relevance and Future Directions

This study shows that the contextual factors inherent to neighborhoods are able to alter the risk of injury among children. Only one other study, less comprehensive than the present study, has provided evidence for risk of neighborhood contextual factors on child injury (Reading et al., 1999). In considering the methodological issues plus the inherent limitations of the data sources, the present study can only serve to generate hypotheses pertaining to place effects on child injuries. Further investigations using both qualitative and quantitative methods are required to identify the contextual factors that are the root cause of the increased risk in certain neighborhoods. It is recommended that the following issues be considered seriously in future studies:

- Injuries must be examined by external causes. This could be achieved in part by ensuring that E-codes are also used when coding diagnoses,
- Ecological unit boundaries used in health outcome studies should reflect naturally occurring social and/or physical contexts rather than arbitrary administrative boundaries, and,
- The contextual factors examined must be practically modifiable and have sufficient degree of causal proximity to the outcome (injury) as to facilitate identification of the "root cause" of these injuries.

The main difficulty in conducting such ideal investigations is the lack of good quality data that meet the criteria listed above. The cornerstone to injury control is surveillance. Timely and comprehensive data on injuries by external causes and potential correlates would provide the foundation for understanding the vast components of injury etiology, for predicting injury occurrences and for devising effective preventive approaches. Currently, it is difficult to find sources other than administrative databases that hold such a large amount of information, particularly with respect to the number of cases. This investigation had the advantage of using a large enough sample at both the individual level and at the ecological level to allow for hierarchical modeling. Such a sample size permitted analyses of not only All Injury in general but injuries by type and age group. These stratifications had serious implications on the results.

Identification of socioeconomic characteristics specific to communities must be made a priority. William Haddon, a pioneer in injury research said "Whatever the kind or nature of mass disease or injury, the part exerted by the socio-economic environment is probably the most neglected of any epidemiologic influence, and accidents are not different in this respect from any other causes of damage" (Haddon, 1964). Many have investigated the link between SES and injuries but this investigation is unique in extracting the components of the "black box" that links SES to injuries. More specifically I attempted to identify the neighborhood level components in the relationship between SES and child injury.

Essentially, place does matter for child injury, but it is not nearly as important as that of family level factors. The heterogeneity of census tracts with respect to SES probably obscured much of the detection of place effects stemming from neighborhoods in this study. Currently, the lack of adequate data at the individual and ecological level pertaining to injury and neighborhood factors makes teasing out the role of place effects particularly difficult.

5.3 References

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Appendix 1: Haddon's Matrix Applied to Motor Vehicle Collision

Phase	Determinants		
	Host	Vehicle	Environment
Pre-event	• Alcohol and drug abuse	• Antilock brakes	• Divided highways
Event	• Age	• Safety belts	• Impact-absorbing barriers
Post-event	• First-aid training	• Puncture-resistant gas tanks	• Trauma care systems

Source: Haddon, 1980; Tintinalli, 1996.

Tintinalli, J.E., Ruiz, E., Krome, R.L. (eds) (1996). *Emergency Medicine - A Comprehensive Study Guide*. McGraw-Hill: New York.

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Appendix 2: Constructing Multilevel Models

Multilevel logistic regression was performed using the Restricted Iterative Generalized Least Squares (RIGLS) algorithm. The first step in multilevel analysis theoretically involves fitting a separate regression model of individual level dependent and independent variables for each context unit (in the present case: census tract) (Bryk & Raudenbush, 1992; Kreft & de Leeuw, 1998). For this study, this can be represented by equation 1.

$$Y_{ij} = \beta_{0j} + \beta_{1j}Partial_{ij} + \beta_{2j}Treaty_{ij} + \beta_{3j}SocServ_{ij} + \beta_{4j}Gender_{ij} + \varepsilon_{ij} \qquad (1)$$

Where Y_{ij} — is the value of the dependent/response value for the *i*th case in the *j*th group (CT). Since the outcome is dichotomous (injured vs. not injured), Y_{ij} is replaced with a logit function

$$Y_{ij} = \ln\left[\frac{\pi_{ij}}{1-\pi_{ij}}\right]$$

where π_{ij} is the probability of an injury for individual *i* in CT *j*

β_{0j} — is the value of the intercept in the *j*th group

β_{1j} — is the regression coefficient for the explanatory variable 1 in the *j*th group

X_{ij} — is the value of the individual level explanatory variable for the *i*th case in the *j*th group (CT)

ε_{ij} — Are the residual error terms for the *i*th case in the *j*th group, which are assumed to be normally distributed $N(0, \sigma^2)$

This first step is similar to techniques such as Analysis of Covariance (ANCOVA) where patterns of slopes and intercepts may be obtained for each CT (Duncan, Jones & Moon, 1998). However, the difference arises because ANCOVA allows for variation in intercept but does *not* allow for variation in slopes (fixed) of individual level relationships across the different

CTs. ANCOVA assumes that the relationship between individual level predictors and outcomes for different neighborhoods is *fixed* or in other words the effects within each neighborhood is the same. In contrast, multilevel technique allows for variation in intercepts *and* in slopes between individual level factors across the different neighborhoods.

In the second theoretical step of constructing a multilevel model, common underlying relationships for the intercepts and each of the slopes (if they are *random*) are identified. This is based on the assumption that the differences between contexts (varying slopes and intercepts) are coming from higher-level distributions that relate to a larger underlying population. This can be represented by five equations:

$$\beta_{0j} = \gamma_{00} + \mu_{0j} \quad (2a)$$

$$\beta_{1j} = \gamma_{10} + \mu_{1j} \quad (2b)$$

$$\beta_{2j} = \gamma_{20} + \mu_{2j} \quad (2c)$$

$$\beta_{3j} = \gamma_{30} + \mu_{3j} \quad (2d)$$

$$\beta_{4j} = \gamma_{40} + \mu_{4j} \quad (2e)$$

γ_{00} are the grand mean of all the cases

$\gamma_{\_0}$ are the mean slopes across all CTs

$\mu_{\_j}$ are the residuals associated with the *j*th group, which are assumed to be normally distributed $N(0, \tau^2)$

If the slopes do not vary across the different neighborhoods or contexts, then that individual level predictor is said to be *fixed* and assigned a variation in slopes of zero ($\tau^2 = 0$, $\mu_{\_j} = 0$ and $\beta_{\_j} = \gamma_{10}$). For instance if the risk of injury for males is no different from one neighborhood to another, μ_{4j} is not significantly different from zero and therefore there is no need for equation 2e. Otherwise, gender is said to be a *random* variable.

Up to this point, none of the ecological variables have been considered. In the last step of constructing the model, the random intercept and the random slopes (if any) are regressed on the ecological level variables (X_j in equations 3 and 4). Regressing the random intercepts will determine if neighborhood factors influence the likelihood of injuries. Regressing the random slopes will determine if they can explain the variation in slopes of individual level associations across the different contexts (cross level interactions). This provides the final multilevel model.

$$\beta_{0j} = \gamma_{00} + \gamma_{01}X_j + \mu_{0j} \quad (3)$$

$$\beta_{1j} = \gamma_{10} + \gamma_{10}X_j + \mu_{1j} \quad (4)$$

In practice, prior to any model building, the intra-class correlation (ICC) is determined. This is the proportion of variance in outcome (likelihood of injury) accounted for by CT level factors over the total variance (sum of individual and area level variances). In health and context literature, at the CT level an average of 5% is common. Outcomes (for all injuries, different injury categories and injury hospitalization broken down by age groups) showing percentage of variance at CT level of significantly less than 5% were not considered for constructing multilevel models in this investigation. The variance components obtained from multilevel null models (i.e. model with intercept only) were used along with the formula provided by Snijders and Bosker (1999) (equation 5) to calculate the percentage of variation accounted for by CT level factors.

$$\text{Intraclass Correlation} = \frac{\tau^2}{\tau^2 + \frac{\pi^2}{3}} \quad (5)$$

Bryk, A., Raudenbush, S.W. (1992). *Hierarchical Linear Models*. Sage: London.

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Appendix 3: Univariate Linear Regression Model Coefficients and 95% Confident Intervals for CT Level SES Factors[*] For Traditional Contextual Analyses

Injury Type & Age group (years)	Education	Income	Unemployment	Mobility	Repair	Lone Parent	Crowding	Income Inequality
All Injuries								
0-4	-0.62 (-1.13, 0.11)	0.22 (-0.19, 0.63)	-0.36 (-1.13, 0.41)	-1.40 (-2.20, -0.65)	1.56 (0.78, 2.34)	0.16 (-0.74, 1.05)	0.88 (0.41, 1.35)	-2.35 (-3.31, -1.40)
5-9	-0.63 (-1.18, -0.08)	-0.14 (-0.59, 0.30)	-0.20 (-1.04, 0.64)	-0.67 (-1.50, 0.21)	0.28 (-0.61, 1.17)	0.88 (0.41, 1.35)	1.12 (0.62, 1.62)	-1.96 (-3.03, -0.89)
10-14	0.42 (-0.22, -1.07)	0.59 (0.09, 1.09)	-1.75 (-2.67, -0.83)	-1.60 (-2.60, -0.61)	0.73 (-0.28, 1.75)	-0.90 (-2.00, 0.21)	-0.14 (-0.75, 0.48)	-2.19 (-3.42, -0.96)
15-17	0.37 (-0.53, 1.27)	0.81 (0.12, 1.51)	-1.26 (-2.58, 0.06)	-1.90 (-3.20, -0.50)	1.78 (0.38, 3.17)	-0.64 (-2.18, 0.90)	-0.33 (-1.18, 0.52)	-2.96 (-4.67, -1.25)
All	-0.04 (-0.51, 0.44)	0.53 (0.17, 0.89)	-1.06 (-1.74, -0.37)	-1.70 (2.40, -1.04)	0.93 (0.20, 1.67)	-0.35 (-1.17, 0.46)	0.66 (0.22, 1.09)	-2.41 (-3.26, -1.56)
Dislocations, Sprains & Strains								
0-4	0.11 (-0.06, 0.28)	0.16 (0.03, 0.29)	-0.38 (-0.62, -0.13)	-0.43 (-0.69, -0.17)	0.02 (-0.25, 0.29)	-0.33 (-0.62, -0.04)	0.10 (-0.06, 0.26)	-0.27 (-0.61, 0.06)
5-9	0.17 (-0.08, 0.43)	0.30 (0.10, 0.49)	-0.60 (0.97, -0.23)	-0.79 (-1.20, -0.41)	-0.12 (-0.52, 0.28)	-0.41 (-0.84, 0.02)	0.34 (0.11, 0.58)	-0.91 (-1.39, -0.43)
10-14	0.63 (0.20, 1.06)	0.82 (0.50, 1.14)	-1.35 (-1.97, -0.73)	-1.40 (-2.05, -0.75)	-0.22 (-0.91, 0.48)	-1.00 (-1.73, -0.24)	0.33 (-0.09, 0.74)	-1.29 (-2.14, -0.44)
15-17	0.67 (0.01, 1.33)	0.88 (0.38, 1.38)	-1.29 (-2.25, -0.32)	-1.40 (-2.40, -0.41)	0.57 (-0.48, 1.62)	-0.71 (-1.85, 0.42)	-0.09 (-0.72, 0.54)	-2.07 (-3.34, 0.80)
All	0.52 (0.24, 0.80)	0.74 (0.55, 0.94)	-1.13 (-1.52, -0.73)	-1.40 (-1.8, -1.03)	-0.73 (-0.53, 0.39)	-0.95 (-1.43, -0.47)	0.37 (0.10, 0.64)	-1.20 (-1.75, -0.66)
Fractures								
0-4	0.03 (-0.09, 0.14)	0.03 (-0.06, 0.12)	-0.02 (-0.19, 0.15)	-0.05 (-0.23, 0.13)	0.25 (0.07, 0.42)	-0.04 (-0.24, 0.15)	-0.14 (-0.25, -.04)	0.09 (-0.14, 0.31)
5-9	0.01 (-0.15, 0.16)	-0.04 (-0.16, 0.08)	-0.09 (-0.33, 0.14)	-0.03 (-0.28, 0.21)	0.01 (-0.24, 0.25)	0.03 (-0.23, 0.30)	-0.01 (-0.16, 0.13)	-0.10 (-0.41, 0.21)
10-14	0.13 (-0.13, 0.38)	0.23 (0.04, 0.43)	-0.21 (-0.59, 0.17)	-0.57 (-0.96, -0.18)	0.38 (-0.02, 0.77)	-0.46 (-0.89, -0.03)	-0.17 (-0.41, 0.07)	-0.59 (-1.08, -0.09)
15-17	0.17 (-0.12, 0.46)	0.18 (-0.05, 0.41)	-0.32 (-0.75, 0.11)	-0.44 (-0.89, 0.01)	0.46 (0.00, 0.91)	-0.39 (-0.89, 0.11)	-0.13 (-0.41, 0.14)	-0.16 (-0.73, 0.42)
All	0.12 (0.01, 0.22)	0.16 (0.08, 0.23)	-0.21 (-0.37, -0.06)	-0.37 (-0.53, -0.22)	0.22 (0.06, 0.39)	-0.28 (-0.46, -0.10)	-0.07 (-0.17, 0.04)	-0.24 (-0.45, -0.03)

[*] Unit changes in CT level indicators refer to: increase in 10% of population with high school diploma, increase in median income of $10,000, increase in unemployment rate by 5, increase in 10% of population who moved in the past year, increase in 10% of dwellings requiring minor repairs, increase in 10% of lone parent families, increase in 10% of crowded dwellings, increase in gini index of 5 units.

Note: Indicators on the left side of the dotted line are positively correlated with SES and those on the right side are negatively correlated with SES

Appendix 3 (continued): Univariate Linear Regression Model Coefficients and 95% Confident Intervals for CT Level SES Factors* For Traditional Contextual Analyses

Injury Type & Age group (years)	Education	Income	Unemployment	Mobility	Repair	Lone Parent	Crowding	Income Inequality
Poisoning								
0-9	-0.06 (-0.12, 0.01)	-0.05 (-0.10, 0.00)	0.05 (-0.05, 0.14)	-0.00 (-0.10, 0.10)	0.06 (-0.04, 0.16)	0.058 (-0.05, 0.17)	0.03 (-0.03, 0.09)	-0.09 (-0.21, 0.04)
10-17	-0.02 (-0.10, 0.07)	-0.06 (-0.13, 0.01)	0.02 (-0.11, 0.15)	0.15 (0.02, 0.29)	-0.04 (-0.18, 0.10)	0.14 (-0.01, 0.28)	-0.28 (-0.11, 0.06)	0.12 (-0.05, 0.29)
All	-0.05 (-0.10, 0.00)	-0.08 (-0.12, 0.04)	0.06 (-0.02, 0.14)	0.11 (0.03, 0.19)	1.00 (0.01, 0.18)	1.33 (0.04, 0.23)	0.22 (-0.03, 0.07)	-0.02 (-0.13, 0.09)
Burns								
0-9	-0.14 (-0.22, -0.05)	-0.08 (-0.14, -0.01)	0.17 (0.04, 0.30)	0.07 (-0.07, 0.21)	0.05 (-0.09, 0.19)	0.14 (-0.01, 0.29)	0.09 (0.01, 0.17)	-0.14 (-0.31, 0.03)
10-17	-0.03 (-0.13, 0.07)	-0.04 (-0.12, 0.04)	0.00 (-0.14, 0.15)	0.05 (-0.11, 0.20)	-0.06 (-0.22, 0.09)	0.08 (-0.09, 0.25)	-0.08 (-0.10, 0.09)	0.06 (-0.14, 0.25)
All	-0.10 (-0.17, 0.03)	-0.10 (-0.15, 0.04)	0.15 (0.05, 0.25)	0.17 (0.06, 0.27)	0.05 (-0.06, 0.16)	0.22 (0.10, 0.33)	0.07 (0.01, 0.14)	0.04 (-0.10, 0.18)
Injury Hosp								
0-9	-0.02 (-0.08, 0.04)	-0.03 (-0.07, 0.02)	0.04 (-0.05, 0.13)	0.06 (-0.04, 0.15)	-0.06 (-0.16, 0.03)	0.01 (-0.09, 0.12)	-0.02 (-0.07, 0.04)	0.06 (-0.06, 0.18)
10-17	0.03 (-0.04, 0.10)	-0.00 (-0.06, 0.05)	-0.04 (-0.14, 0.07)	0.004 (-0.07, 0.15)	0.04 (-0.07, 0.15)	0.08 (-0.04, 0.20)	-0.02 (-0.09, 0.04)	-0.03 (-0.17, 0.11)
All	-0.00 (-0.03, 0.02)	-0.02 (-0.04, -0.00)	0.03 (-0.01, 0.07)	0.04 (-0.00, 0.08)	0.04 (-0.01, 0.08)	0.00 (-0.04, 0.05)	-0.06 (-0.08, -0.03)	0.05 (-0.01, 0.10)

*Unit changes in CT level indicators refer to: increase in 10% of population with high school diploma, increase in median income of $10,000, increase in unemployment rate by 5, increase in 10% of population who moved in the past year, increase in 10% of dwellings requiring minor repairs, increase in 10% of lone parent families, increase in 10% of crowded dwellings, increase in gini index of 5 units.

Note: Indicators on the left side of the dotted line are positively correlated with SES and those on the right side are negatively correlated with SES