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Relationship Between Socioeconomic Factors and Severe Childhood Injuries

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ABSTRACT *The objective was to examine the relationship between injury rates and socioeconomic factors for children in Hamilton County, Ohio, using small-area analysis. The subjects were county residents less than 15 years old who were hospitalized or died of injuries between January 1, 1993, and December 31, 1995; they were identified through a population-based trauma registry. The census tract was the unit of analysis; the rate of injury per 100,000 population was the dependent variable. Risk factors included median income, level of education, percentage below the poverty level, percentage unemployment, percentage non-Caucasian, and percentage families headed by females. There were 2,437 children meeting the case definition; injuries per census tract ranged from 0 to 2,020.2 per 100,000 per year. Census tracts with higher injury rates had lower median incomes, more people with less than a high school education, more unemployment, more families headed by females, more people living below the poverty level, and more non-Caucasians than those with lower rates. In a regression model, percentage of people living below the poverty level, percentage of those who did not graduate from high school, and percentage unemployment were significant risk factors for injuries,* $P < .001$. *Since small-area analysis examines associations on an ecological level rather than an individual level, these studies should always be interpreted with caution because an association found at the level of the census tract may not apply at the individual level. Interventions to reduce injuries should target socioeconomically disadvantaged children living below the poverty level and those in areas with fewer high school graduates and more unemployment.*

KEYWORDS *Epidemiology, Injury, Injury Surveillance, Small-Area Analysis, Socioeconomic Factors.*

INTRODUCTION

Injury is the leading cause of death in the United States for people aged 1 to 44 years.[1] Injuries are the cause of 45% of deaths in children 1 to 4 years old and 56% of deaths in children 5 to 14 years old.[1] Injuries represent approximately one-third of the 80,000 emergency department visits per year to Children's Hospital Medical Center in Cincinnati, Ohio. In addition, there are over 1,300 admissions for injuries annually, accounting for about 8%–10% of all hospital admissions. Few population-based studies of risk factors for fatal and nonfatal injuries in chil-

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dren exist, especially for the midwestern United States. Regional studies are needed to determine whether geographic, environmental, age-related, or socioeconomic differences among children affect injury patterns. Recognition of factors contributing to childhood injuries at the community level will facilitate planning of focused prevention strategies.

Our preliminary studies and those of others have examined, in children less than 15 years old, the rates and causes for all injuries severe enough to result in hospitalization or death in Hamilton County, Ohio, from 1993 to 1995.[2] The crude annual injury rate for this time period was 424.5/100,000 children per year for the county. Injury rates were highest for those less than 1 year of age (556.8/100,000 per year). Males had higher annual injury rates than females (499.1/100,000 per year vs. 347.7/100,000 per year); African Americans had higher rates than Caucasians (620.9/100,000 per year vs. 346.9/100,000 per year).[2] Better characterization of risk factors for injuries at the community level is necessary to target specific high-risk groups and to plan geographically targeted interventions.

The purpose of this study was to define, for children 0–14 years old in Hamilton County, Ohio, the rates of severe injuries (those resulting in hospitalization or death) using small-area analysis by census tract and to identify specific socioeconomic ecologic risk factors for census tract populations with high injury rates.

METHODS

Setting and Sample

All of the study population were residents of Hamilton County, Ohio, less than 15 years of age; there was a total of 191,380 individuals.[3] The demographic and socioeconomic characteristics of the study population are detailed in Table 1. Injuries included all blunt and penetrating trauma, poisonings, burns, aspirations, inhalations, immersions, ingestions, bites, and suffocations resulting from intentional, unintentional, self-inflicted, and undetermined causes (ICD-9 [International Classification of Diseases, 9th edition] E codes 800.00 to 995.09) that resulted in hospitalization or death.[4] Sample size considerations precluded analysis of individual types of injuries separately; therefore, all injuries were analyzed together.

A patient's case was included in the study if it involved any resident of Hamilton County, Ohio, less than 15 years of age who was hospitalized or died of an injury between January 1, 1993, and December 31, 1995. Cases were identified retrospectively from two sources, the Children's Hospital Medical Center Trauma Registry and the Hamilton County Coroner's Office death records. Children's Hospital Medical Center, the only Level 1 trauma hospital for children in the region, admits more than 95% of patients in Hamilton County less than 15 years of age who are hospitalized with injuries (per conversations with Lea Carrier, Injury Coordinator, Hamilton County Injury Surveillance System, February 1998, and Margie Brunn, Children's Hospital Medical Center Trauma Services, February 1998). In the case of patients with repeat hospitalizations for a single injury event, only the initial hospitalization was included. Patients with an injury as a result of a medical or surgical complication were excluded (ICD-9 E codes 870–879.9); late effects of injuries were also excluded (ICD-9 E codes 905–909).[4]

Children's Hospital Medical Center Trauma Registry is an ongoing database established in 1991 and maintained by the Trauma Services Department; it contains information about all patients sustaining injuries. Information for the Children's

TABLE 1. Demographic and socioeconomic characteristics of Hamilton County, Ohio

Total population	866,228
Children less than 15 years of age	191,380
Male gender for children less than 15 years of age (%)	98,108 (51.3)
Race for children less than 15 years of age	
Caucasian	137,129 (71.6)
African American	51,273 (26.8)
Other*	2,978 (1.6)
Age distribution (%)	
<1 year	11,793 (6.2)
1–4 years	55,817 (29.2)
5–9 years	66,350 (34.7)
10–14 years	57,420 (30.0)
Median household income	$29,498
Socioeconomic indicators (% in the county)	
In tract with <high school diploma	24.4
Living below poverty level	13.0
Unemployed	5.5
Female-headed households	21.0

Source: From ref. 3.

*Other includes Asian/Pacific Islander (1.0%), American Indian (0.1%), and others (0.5%).

Hospital Medical Center Trauma Registry is obtained by abstracting medical charts of all patients admitted to the hospital or dying in the emergency department as a result of injury (ICD-9 E codes 800.00–995.09).[4] Checks are performed monthly by the Trauma Information Coordinator on a random sample of 10% of the charts in the trauma registry to ensure internal consistency and reliability within the database.

Children dying outside the hospital were identified by searching the records of the County Coroner's Office. Children less than 15 years of age who died as a result of trauma were identified, and data were abstracted from the death certificates. Death certificates from the County Coroner's Office were cross-checked with hospital fatalities to eliminate any duplicates.

Patients who were not admitted to the hospital, who died of an undetermined cause, or who were county residents who sustained an injury but were hospitalized or died outside Hamilton County were not included in the study.

Demographic and Injury Data and Analysis

Demographic information collected included the patient's age, gender, race, and home address. To maintain confidentiality, each patient was assigned an anonymous identification code before data analysis, and names were not used. Using the patient's home address, the census tract of residence was determined through a street address matching procedure, known as geocoding, using ArcView® (ArcView GIS version 3.0, 1996) and information obtained from the Cincinnati Area Geographic Information System (CAGIS). CAGIS is an organization in Hamilton County dedicated to geographic mapping of many different parameters of the county, such as census tract divisions, individual residences, streets, civil boundaries, properties, topology, and utilities. CAGIS provided the background maps to which each individual patient's address was mapped. Places of residence for all

injured patients were plotted on a map of Hamilton County. Information on the exact geographic location where the injury occurred was not obtainable from the available data.

Information for each patient was obtained concerning intent of injury and outcome. Intent of injury, determined by ICD-9 E code, was placed into one of four categories: unintentional, assault/abuse, self-inflicted, or unknown. Race was designated as Caucasian, African American, and other; other was a heterogeneous group consisting of Asian/Pacific Islanders (1.0%), American Indians (0.1%), and people of other races (0.5%). Age groups were assigned as less than 1 year, 1–4 years, 5–9 years, and 10–14 years.

Rates of injuries, with 95% confidence intervals, were calculated for each subgroup of age, race, and gender. Overall relative risks then were calculated for age group, gender, and race using the subgroup with the lowest injury rate as the reference group.

Rates of injuries resulting in hospitalization or death, with 95% confidence intervals, were calculated for each of the 217 census tracts in Hamilton County, Ohio, using injured residents as the numerator and 1990 US census statistics as the denominator.[3] Census data from 1990 were used because data from the US Census Bureau's annual county population estimates showed the change in the population of Hamilton County between 1990 and 1993 through 1995 was 1% or less in each of the three study years.[5] Because there were less than 100 injuries in all census tracts, confidence intervals were calculated assuming a Poisson distribution. Nine census tracts had less than 100 children younger than 15 years of age. These census tracts were excluded from the small-area analyses to avoid instability of rates due to small denominators. All rates were reported as number of injuries per 100,000 children per year. Rates of injuries by census tract were plotted on maps of Hamilton County to define areas visually by injury rates.

Socioeconomic/Demographic Variables

The relationship between injury rates and socioeconomic and demographic variables was examined according to census tract characteristic. For each census tract, the following variables were studied: (1) median household income, (2) non–high school graduates (percentage of the population greater than 17 years of age with less than a high school diploma), (3) unemployment (percentage of the active labor force that was unemployed), (4) non-Caucasian (percentage of the population that was non-Caucasian), (5) households headed by females (percentage of the population consisting of families headed by females and with children less than 18 years of age), and (6) poverty (percentage of the population living below the poverty level). Poverty level was determined by the US Census Bureau and was defined based on family size and income level. The average national poverty threshold for a family of four persons was $12,674 in 1989.[3] Socioeconomic and demographic information was obtained from the US Census Division for each of the census tracts in Hamilton County, Ohio.[3]

For each individual variable studied, census tracts were placed in ascending order from lowest to highest value for that variable. The census tracts then were divided into tertiles for each variable, and then injury rates were computed for each tertile. Relative risks for injuries, with 95% confidence intervals calculated by the Taylor series method, were computed for each socioeconomic variable (Epi Info 6, version 6.04b, 1997).[6] The stratum with the lowest incidence rate for each variable was used as the reference group to calculate relative risks for injuries. Small sample

size precluded any further analysis of socioeconomic or demographic variables by race, gender, or age.

Multivariate Analysis

A multiple linear regression model for injury was developed to explain, by census tracts, differences in injury rates based on each of the different variables studied. Overall injury rate (number of injuries per population per year) by census tract was the dependent variable; socioeconomic and demographic risk factors from the census tracts were the independent variables. Linear regression was performed with stepwise backward elimination. All covariates were entered into the model as continuous variables and retained if $P < .05$. The data were analyzed using the Statistical Package for the Social Sciences (SPSS, Inc., Release 10.0, 1999).

RESULTS

During the study period, 2,437 children sustained injuries resulting in hospitalization or death, translating to a rate of 424.5 injuries per 100,000 children per year. There were 52 children who died, for an annual mortality rate of 9.1 per 100,000 children. The majority of the injuries (87.3%) were unintentional, with 6.2% considered self-inflicted and 5.0% from assault or abuse; for the remaining injuries, the intent was unknown.

Demographic subgroup analysis is summarized in Table 2; relative risks for injuries are also shown. Risk for injuries was highest in children less than 1 year of age and lowest in children 5 to 9 years of age. Males had a higher risk for injury than females; African Americans had a higher risk than Caucasians.

The Figure depicts the rates of injuries by census tract. After excluding the nine census tracts with populations of less than 100 children younger than 15 years of

TABLE 2. Demographic characteristics of children 0 to 14 years of age sustaining injuries in Hamilton County, Ohio, from 1993 to 1995

Characteristic	Number of children injured (%)	Incidence rates* (95% CI)	Relative risk† (95% CI)
Children	2437	424.5	—
Age group			
<1 year	197 (8.1)	556.8 (479.1, 634.6)	1.6 (1.4, 1.9)
1–4 years	811 (33.3)	484.3 (451.0, 517.7)	1.4 (1.3, 1.5)
5–9 years	700 (28.7)	351.7 (325.6, 377.7)	1.0
10–14 years	729 (29.9)	423.2 (392.5, 453.9)	1.2 (1.1, 1.3)
Gender			
Males	1,464 (60.1)	497.4 (471.9, 522.9)	1.4 (1.3, 1.6)
Females	973 (39.9)	347.7 (325.9, 369.6)	1.0
Race			
Caucasian	1,422 (58.4)	346.1 (328.2, 364.1)	1.0
African American	955 (39.2)	620.9 (581.5, 660.2)	1.8 (1.7, 2.0)
Other	60 (2.5)	671.6 (512.5, 864.5)	1.9 (1.5, 2.5)

CI, confidence interval.
*Injured children per 100,000 per year.
†Reference group = 1.0.

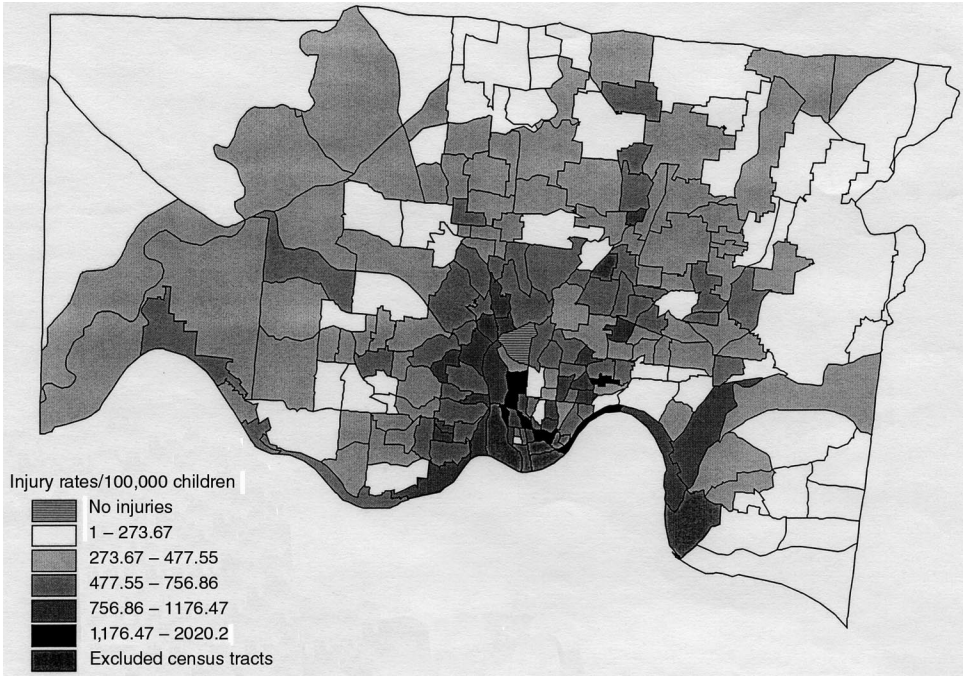

FIGURE. Annual rates of injuries by census tract for children sustaining severe injuries in Hamilton County, Ohio, from 1993 to 1995.

age, rates of injuries in the census tracts ranged from 0 to 2,020.2 per 100,000 children per year. There were higher injury rates along the southern part of the county, which is along the Ohio River, as well as in the more urban areas around downtown, in the center of the map.

Socioeconomic and demographic variables associated with an increased risk for injury are detailed in Table 3. Higher relative risks were associated with lower median income, lower level of education, more people living below the poverty level, higher percentage of unemployment, higher percentage of non-Caucasians, and higher percentage of households headed by females.

Multiple linear regression revealed that the percentage of people living below the poverty level, percentage of people with less than a high school education, and percentage of unemployment were all significant risk factors for injuries, $P < .001$. Results were not affected by the order in which the variables were entered into or removed from the model. The regression equation for the final model was as follows: Injury rate = 382.5 + (12.6 × Poverty) + (9.2 × Non–High School Graduates) – (23.7 × Unemployment), $R^2 = 0.46$, adjusted $R^2 = 0.46$, $P < .001$.

DISCUSSION

Epidemiological analyses of injuries have shown that they are not random occurrences. Factors that increase an individual's risk for injury have been identified. In

TABLE 3. Rates of injuries per 100,000 children per year and relative risks by tertiles of risk factors

Socioeconomic/demographic variable	Incidence rate*	Relative risk†	95% CI
Median income			
$0–$22,000	720.8	2.6	(2.4, 2.9)
$22,001–$32,850	376.6	1.4	(1.3, 1.6)
$32,851–$109,242	274.5	1.0	—
In tract with <high school diploma			
0–18.9	279.7	1.0	—
19.0–31.9	362.2	1.3	(1.2, 1.4)
32.0–78.0	682.4	2.4	(2.1, 2.6)
Living below poverty, %			
0–5.5	275.2	1.0	—
5.6–16.9	385.1	1.3	(1.2, 1.5)
17.0–85.1	714.0	2.5	(2.3, 2.8)
Unemployment, %			
0–3.4	296.8	1.0	—
3.5–7.2	343.1	1.2	(1.1, 1.3)
7.3–48.1	676.7	2.2	(2.0, 2.5)
Non-Caucasian, %			
0–3.8	337.3	1.0	—
3.9–26.9	384.7	1.1	(1.0, 1.2)
27.0–99.2	574.3	1.7	(1.5, 1.9)
Female-headed families with children <18 years of age			
0–13.9	275.9	1.0	—
14.0–30.8	391.0	1.4	(1.3, 1.6)
30.9–93.4	677.2	2.4	(2.2, 2.7)

CI, confidence interval.
*Per 100,000 children per year.
†Reference group = 1.0.

this study, younger children had a higher risk for injuries than older children, males had a higher risk for injuries than females, and African Americans had a higher risk for injuries than Caucasians. In addition, the percentage of people living below poverty, percentage of the population older than 17 years of age with less than a high school diploma, and percentage of unemployment in individual census tracts were significant risk factors for injuries. In concordance with this study, low socioeconomic status has been a well-documented risk factor for injury fatality.[7–15] This study is consistent with other studies that documented important risk factors for injuries, including young age, male gender, and non-Caucasian race.[7,9–14,16–22]

It is interesting to note that, although race is a significant risk factor for injury in the univariate analysis, in the multivariate analysis, race is not significant; it is confounded by other factors. Factors correlated with race, such as poverty, education, and unemployment, rather than race itself, resulted in higher injury rates in Hamilton County. Therefore, interventions to combat injuries in this county should focus on areas of low socioeconomic status and not on race.

Small-area analysis examines associations on an ecological level rather than an individual level. Ecologic studies should always be interpreted with caution because

an association found at the level of the census tract may not apply at the individual level. These associations are important when planning interventions designed to reach specific target populations.

Geographically, higher injury rates were found at the southern end of the county, along the Ohio River, and in the downtown Cincinnati area. These areas correspond to areas of populations with lower socioeconomic status. Areas with high concentrations of injuries, as seen in the geocoded maps, need particular study to find ways to reduce injuries. The maps provide an easy way to visualize problem areas for targeted intervention.

The overall Hamilton County childhood injury rate is lower than rates reported in other US studies.[7,16–20,23,24] Injury rates may be lower for several reasons. First, this study examined data from 1993 to 1995, while the other studies were from earlier years. The differences may be a result of changes in hospitalization trends or different demographic characteristics among the various studies. In addition, populations studied differ in definition of injuries; therefore, results of each study must be interpreted with these differences in mind.

This study found an annual death rate due to injury of 9.1 per 100,000 children in Hamilton County. This annual mortality rate is also lower than that seen in other areas of the US.[7,15,17–19,23,25,26] Mortality rates given in other published studies have ranged between 13.8 and 33.3 per 100,000 children per year.[7,15,17–19,23,25,26]

This study showed that rates of injuries varied widely among the different census tracts. Annual injury rates ranged from 0 to 2,020 per 100,000 children. Results must be interpreted with caution, however, because some areas have small numbers of injuries and wide confidence intervals.

It is important to note that, even with the multivariable analysis, only 46% of the variability in injury rates among census tracts was explained. Therefore, other factors that affect a multifactorial characteristic like injury rates should be sought.

Study Limitations

Some study limitations must be noted. First, only injuries severe enough to result in hospitalization or death were included. These injuries tend to differ from the less-severe injuries, but they are an important area in which to target intervention. In addition, patients hospitalized at places other than Children's Hospital Medical Center were not included. Based on a telephone survey of selected area hospitals, this represented less than 5% of all injuries to children 0 to 14 years old in the county.

It is possible that some of the injuries or deaths were missed if patients were hospitalized or died outside Hamilton County; the number of such children is not known. Therefore, the rates of injuries may be an underestimation of the true rate. Of note, however, is that the Hamilton County coroner performs autopsies on Hamilton County residents who die outside the county. Therefore, since county death records were obtained for this study, most, if not all, of the children who were country residents and died as a result of trauma were included. In addition, since Children's Hospital Medical Center is a regional referral center, many children that present to hospitals outside the county ultimately are transferred to our hospital for admission.

Another limitation is that only patients entered into the injury surveillance database were included. Some children might have been omitted unintentionally. However, admission logs were checked daily, and discharge logs were checked monthly to ensure inclusion of all patients in the injury surveillance system.

Whether a patient was hospitalized for an injury depended on the perceived severity of injury according to individual physicians and their threshold for admission. Also, some patients were admitted purely for social reasons, which may be related to the risk factors being analyzed. Younger patients may have been admitted more frequently for observation because of the difficulty in obtaining a reliable physical examination. All of these things may have affected the results.

Another potential limitation was that classification and categorization of injuries might have varied between individuals entering data into the database. However, all abstractors and coders of data have been trained specially to standardize this information. The abstracting quality from logs and from individual charts was examined. Abstractors were blinded to the fact that these patients were involved in this study, thereby enhancing validity.

Finally, it must be noted that there are limitations to conducting regression analysis using ecologic data. Associations found on the ecologic level may be different from those found on the individual level; community-level correlates do not imply causation on the individual level. Further research is needed on individual injuries to determine specific causes of injuries on an individual level. In addition, as recent studies have determined, characteristics of the communities themselves are important determinants of injury rates; therefore, community determinants of injuries must be sought.[27,28] Programs, legislation, and policies for injury prevention should target areas of lower socioeconomic status.

Ecologic studies such as this are helpful in understanding environmental factors that contribute to injuries, such as substandard infrastructure or lack of community organization and resources. Studies specific to injury mechanism or age could use this methodology and be invaluable in planning community-based, geographically targeted approaches to injury prevention, such as with Oklahoma City's successful burn prevention program.[29] Last, visual representations of the data by means of maps are particularly effective in motivating community members and in assisting policymakers as prevention strategies are planned.

CONCLUSIONS

Injury is the leading cause of morbidity and mortality in childhood. Although injury rates in Hamilton County are lower than in many other areas of the country, they are still a significant problem, especially among young children, males, and those of lower socioeconomic status. Specific risk factors for injuries have been identified. Also, specific areas in Hamilton County have been identified where injury rates are particularly high. This information will be used for targeted intervention to reduce injuries. Future studies will include characterization of particular types of injuries and their risk factors in specific geographic locations to develop solutions to decrease morbidity and mortality.

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