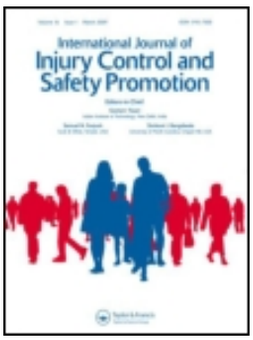

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Using an electronic medical record system to describe injury epidemiology and health care utilization at an inner-city hospital in Indiana

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Abstract

Injuries are a major public health problem worldwide. In the USA, injuries cause 146, 400 deaths annually, with 31 million non-fatal injury visits to emergency departments (EDs). EDs thus represent an important source of injury data. The primary objective of the current study was to describe the epidemiology of injury-related ED visits and assess injury-related utilization of health care resources in an inner-city hospital in Indiana, using data stored in a computerized medical record system. It involved a retrospective review of the records for injury visits to EDs and injury admissions over a 3-year period. The variables extracted and analysed included patients' demographics, external cause of injury, diagnosis, length of stay, ED and hospital charges. A total of 60,470 injury-related ED visits were made, the majority of patients were male (61.6%), uninsured (63.1%), treated in ED and discharged (98.4%). The leading causes of injury were falls (18.8%), motor vehicle crashes (18.4%), assaults (17.6%), being struck (11.2%) and overexertion (10.6). Firearms caused most injury deaths (32.4%; n = 314); motor vehicle crashes were the leading cause of hospitalization (26.6%; n = 642) and also the most expensive to treat as inpatients (mean charge $19,190). The mean charge per patient treated and discharged was $150 compared to $11,116 for patients admitted. These findings demonstrate the value of computerized medical records in capturing and storing E-coded injury data. The system generates data that can be used for epidemiological surveillance and injury prevention at the local level, and for assessment of impact of specific injuries on health care resources.

Keywords: Injuries; emergency department; medical record system; health care utilization.

Introduction

Injuries are a major public health problem worldwide and affect people of all ages, from all regions and economic groups. In 1998, injuries caused 16% of the global burden of disease, including 5.8 million deaths and a much higher number of non-fatal injuries.[1,2] Among people aged 15–44 years worldwide, the leading causes of fatal injuries are motor vehicle crashes, interpersonal violence, self-inflicted harm, wars and fire.[1] In the USA, injuries are implicated in 146,400 deaths annually, and are the leading cause of death in persons aged 1 to 34 years.[3] However, non-fatal injuries are far more common; it has been estimated that for every person killed by injury, 45 are hospitalized and 1300 are treated in emergency rooms and released.[4]

The National Electronic Injury Surveillance System (NEISS), which was developed to identify emerging consumer product safety problems in the USA, uses data from 101 emergency departments (EDs) to produce national estimates of injury incidence.[5] In 2000, 31 million non-fatal injuries were treated in the US EDs, an annual rate of 11,188 injuries per 100,000 people.[6] The effects of injury in terms of loss of productivity as a result of death, morbidity and long-term disability present an enormous economic loss. The annual economic cost of injury in the USA is sub-

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stantial and was estimated at $158 billion in 1989.[7] Direct health care costs represent a significant proportion of these costs.

ED and inpatient discharge data represent potentially important but largely unused sources of information for monitoring injury incidence, identifying risk factors and planning interventions.[8–11] These data can also characterize injuries by causes, demographical parameters of persons affected, consequences and outcomes of care. NEISS is one step towards improved characterization of the epidemiology of non-fatal injuries. However, it is not structured to provide estimates at the state or local level that is required to implement local preventive measures. In Indiana, for instance, the number and outcomes of patients with injuries treated in EDs is unknown.

The primary aim of this study was to demonstrate how hospital data routinely collected by a state-of-the-art electronic medical record system could be used to describe the epidemiology of injuries in an inner-city hospital of a metropolitan area in Indiana. The secondary aim was to estimate the impact of injuries on hospital charges and length of stay.

Materials and methods

Setting of the study

We conducted the study in a 250-bed university affiliated public hospital in Indiana. It serves a population of approximately 750,000 people with a racial distribution of 83.1% white, 14.5% black or African-American, 1.6% Asian/Pacific, 2.7% Hispanic and 1.6% others.[12] The computerized Regenstrief Medical Record System (RMRS), established in 1972, is the primary method for collecting, processing and monitoring patient encounter data.[13] It is a modular system composed of Registration and Scheduling, Laboratory, Pharmacy, and Database Modules that store clinical data, diagnoses, charges and insurance status information for all of the ED, outpatient and inpatient encounters. Detailed technical information about its data model, file structure and architecture, and how the data are captured and presented to clinicians, has been described elsewhere.[13,14] The RMRS has expanded over the last 30 years to include three other hospitals affiliated with Indiana University, as well as over 30 hospitals, clinics, and other health care facilities in the city. It currently contains more than a billion separate observations captured during the past 30 years for more than 1.5 million distinct patients across the network health institutions.

Subjects and data

The Institutional Review Board approved this retrospective cohort study and waived the requirement for informed consent. We conducted a retrospective review of computerized medical records of all ED visits to a single hospital over a 3-year period. Patients were selected if they visited the ED between 31 January 1997 and 31 December 1999, and had any injury as the primary reason for the visit.

An injury was defined by cause according to the Ninth Revision of the International Classification of Diseases, Clinical Modification (ICD-9-CM) and included E-codes 800–999 describing all traumatic injuries, burns and poisonings.[15] The E-codes were assigned by trained technicians based on patient's history, supplemented by the diagnosis and other information in the ED record written by the treating physician.

The following four categories of patient information were extracted from the RMRS: 1) demographic data (age, gender, race, insurance status); 2) injury codes (both external cause (E-codes)) and nature of injury or clinical manifestation of injury (N-codes); 3) hospital charges; and 4) utilization data (date of visit, ED disposition – whether treated and discharged, admitted or died; and if admitted, length of stay). Death information was obtained from both the ED and hospital discharge records.

As an estimate of the hospital's costs of care, actual charges for ED visits and inpatient care were obtained for each service that a patient received. For patients treated in the ED, the charge centres were hospital facility, attending physicians' fee, diagnostic tests, medical procedures and drugs; while for inpatients, additional charges for intensive care unit and rehabilitation services were included.

Statistical analysis

We performed separate analyses for patients treated solely in the ED and those admitted to hospital. We used proportions to describe the frequency distribution of patient visits by gender, age (grouped into six brackets: 0–14, 15–19, 20–24, 25–44, 45–64, 65+ years), race (African-American/black, white, Hispanic, Asian/Pacific, other), insurance status (Medicare, Medicaid, Wishard Advantage (a state-funded managed care programme for indigent patients), Commercial, uninsured), E-code (causes of injury), N-code (injury diagnoses), hospital utilization (ED, inpatient, length of stay), and charges. For purposes of analysis, we combined the E-codes into 14 categories (Appendix 1) and N-codes into 11 groups (Appendix 2). In cases of multiple injuries, all N-codes were recorded, but only the primary N-code diagnosis (considered as the most severe injury) was used in descriptive analysis.

We used analysis of variance to compare the mean length of stay (LOS) and the mean charge per visit between the various E-code and N-code diagnosis groups as well as health insurance schemes. We used multiple linear regression techniques to identify which variables, recorded at the time of presentation to the ED, were independently significant predictors of length of stay and hospital costs. Because of the skewed distribution of LOS and hospital charges, we carried out log transformation of these outcome variables. We also created a set of dummy independent variables for inclusion

into the predictive model: five markers for E-code diagnoses (motor vehicle crashes, firearms, falls, burns, assaults and all other causes (as reference category)); eight markers for N-code diagnoses (intracranial injury, limb fractures, dislocation, superficial soft tissue injury, injury to internal organs, burns, complications of injuries and open wounds (reference category)); and four markers for health insurance status (Medicare, Medicaid, Wishard Advantage, Commercial, and uninsured (reference category)). The analyses were performed using SAS for windows software version 8.02 (SAS Institute, Cary, NC, USA).

Results

A total of 60,470 injury visits (12.9% of all ED visits (n = 468,760) were made by 45,668 patients for all types of injuries during 1997 through 1999, an average of 1.3 visits per patient. The proportion of ED visits due to injuries declined slightly from 14.9% in 1997 to 12% in 1999, whereas the proportion of injury patients hospitalized doubled from 0.6% to 1.3% during the same period.

The demographical characteristics and injury profile of the patients are shown in Table 1. Age ranged from 0 to 105 years, with a mean of 31 (SD 15) years and median 30 years. Except among elderly patients aged 65 years and older, the majority of injured patients were male. The race distribution of injury patients' visits was fairly similar to that of the total patient population visiting the hospital during the study of review, with almost equal proportions of African-Americans and Caucasians, and shows overrepresentation of African-Americans when compared to their proportion in the general population of Indianapolis (45.5% vs. 14.5%).

Almost two-thirds of the study patients did not have any form of health insurance. A greater proportion of Hispanics had no insurance than all other races (74% vs. 62%). Of the 16% of injury patients covered by public health insurance programmes, slightly more than half were women. Men were twice as likely to be covered by commercial health insurance as women. Three-quarters of patients with injuries from firearms and two-thirds of those assaulted were uninsured.

Distribution of injuries

As shown in Table 1, the top five leading causes of injuries, accounting for 77% of the total, were falls, motor vehicle crashes, assaults and getting struck by or against an object, and overexertion. Of those patients involved in motor vehicle crashes, a vast majority (85.8%) were vehicle occupants; pedestrians comprised less than 10%. Men were the most affected by motor vehicle injuries, especially as motorcyclists or bicyclists.

Table 2 illustrates variations of injury incidence by external cause across the six age groups. The two most frequent causes of injuries in each age group are highlighted. Children aged less than 15 years, older adults of between 45–64 years and elderly people (aged 65 years and above) experienced the highest incidence of falls. Teenagers (15–19 years) and young adults (20–24 years) had the highest incidence of motor vehicle crashes, while young and middle-aged adults (20–44 years) were mostly affected by interpersonal violence (assaults). Motor vehicle crashes were either the first or second leading cause of injury in nearly each age group.

Motor vehicle collisions, falls and assaults were consistently the top three leading causes of trauma across all racial groups, accounting for over 50% of all injury incidents in each race. The frequency distribution of the causes of injury, however, varied slightly by race: among African-Americans,

Table 1. Characteristics of injury emergency department visits to Wishard Memorial Hospital, Indianapolis, 1997–1999.

Variable	No. (%)	% Male
Total	60,470 (100)	61.6
Age group (years)		
0–14	7,399 (12.2)	59.8
15–19	7,170 (11.9)	64.5
20–24	8,386 (13.9)	65.0
25–44	28,606 (47.3)	62.6
45–64	7,187 (11.9)	55.9
≥65	1,722 (2.9)	41.0
Ethnicity		
African American	27,493 (45.5)	61.7
White	30,295 (50.1)	60.6
Hispanic	1,555 (2.6)	76.8
Asian/Pacific	288 (0.5)	70.0
Other	281 (0.5)	64.8
Unknown	558 (0.9)	58.6
Health Insurance		
Medicare	2,152 (3.6)	49.0
Medicaid	4,934 (8.2)	44.5
Wishard Advantage	2,706 (4.5)	41.6
Commercial insurance	12,539 (20.7)	68.8
Self-pay (no insurance)	38,139 (63.1)	63.5
Ten Leading Causes of Injury		
1. Fall	11,357 (18.8)	51.1
2. Motor vehicle crashes	11,128 (18.4)	54.5
3. Assaults	10,622 (17.6)	69.8
4. Struck by/against object	6,762 (11.2)	64.6
5. Overexertion	6,422 (10.6)	62.5
6. Machine/Instrument	4,053 (6.7)	64.9
7. Dog bite	1,583 (2.6)	69.7
8. Foreign body in orifice	1,206 (2.0)	66.3
9. Burn	1,158 (1.9)	59.2
10. Firearm	1,000 (1.7)	87.0
Type of road user (in MVCs)*		
Driver	5887 (52.9)	52.9
Passenger	3667 (32.9)	50.6
Motorcyclist	282 (2.5)	85.5
Pedestrian	748 (6.7)	64.2
Pedal cyclist	142 (1.3)	84.5
Unknown	402 (3.6)	63.7

* MVC = motor vehicle crashes.

Table 2. ED injury visits by cause and age group of patients (in years).

	% of total visits (n) per age group						
External Cause	0–14 (7399)	15–19 (7170)	20–24 (8386)	25–44 (28,606)	45–64 (7187)	≥65 (1722)	All ages (60,470)
Fall	**25.9***	11.7	12.6	**16.6**	**28.3**	**48.1**	18.8
Motor vehicle crash	**23.1**	**22.3**	**19.7**	16.0	**18.5**	**17.6**	18.4
Assault	5.9	**20.6**	**20.3**	**21.1**	12.8	4.2	17.6
Struck by/against	17.8	11.4	10.5	10.4	9.1	7.6	11.2
Overexertion	4.8	9.3	11.6	12.2	11.6	5.6	10.6
Instrument/Machine	8.7	6.9	7.7	6.5	4.8	4.3	6.7
Dog bite	3.4	3.8	2.9	2.2	2.3	1.9	2.6
Foreign body	2.1	1.7	1.8	2.1	2.0	1.6	2.0
Burn	3.4	1.7	1.6	1.7	1.8	2.0	1.9
Firearm	0.4	2.8	3.1	1.6	0.7	0.4	1.7
Poisoning	0.3	2.0	1.6	1.5	0.5	0.1	1.3
Other	4.2	5.8	6.7	8.1	7.7	6.6	7.2

* The figures in bold refer to percent distribution of the two leading causes of injury in each age group.

Table 3. Causes of injury by patient disposition.

	Treated and released in the ED n* = 59,408 (98.4%)		Admitted to hospital n = 642 (1.1)		Died in ED n = 314 (0.5)	
External Cause	No. (%)	Rank	No. (%)	Rank	No. (%).	Rank
Fall	11,234 (18.9)	1	96 (15.0)	3	27 (8.6)	4
Motor vehicle crash	10,870 (18.3)	2	170 (26.6)	1	88 (28.0)	2
Assault	10,488 (17.7)	3	98 (15.3)	2	36 (11.5)	3
Struck by/against	6,711 (11.3)	4	37 (5.8)	6	14 (4.5)	5
Overexertion	6,398 (10.8)	5	13 (2.0)	9	11 (3.5)	7
Instrument/Machine	4,036 (6.8)	6	15 (2.3)	8	2 (0.6)	9
Dog bite	1,554 (2.6)	7	29 (4.5)	7	0	–
Foreign body	1,201 (2.0)	8	4 (0.6)	–	1 (0.3)	–
Burn	1,094 (1.8)	9	59 (9.2)	4	5 (1.6)	8
Firearm	835 (1.4)	10	63 (9.8)	5	102 (32.5)	1
Poisoning	746 (1.3)		2 (0.3)		2 (0.6)	9
Suicide	475 (0.8)		13 (2.0)	9	13 (4.1)	6
Drowning/Suffocation	23 (0.04)		1 (0.2)		2 (0.6)	10
Other	3,726 (6.3)		42 (6.5)		11 (3.5)	

ED = emergency department.
* excludes 106 patients who were transferred to other hospitals.

assaults were the most frequent (19%) followed by motor vehicle crashes (18%) and falls (17%); among the whites, falls were more common (20%), followed by motor vehicle crashes (18%) and assaults (16%). Patients of Hispanic or Asian/Pacific origins were mostly affected by motor vehicle crashes (22%), falls (19%) and assaults (12%).

Almost all of the injured patients in this cohort were treated and released from the ED; only 642 (1%) were hospitalized (Table 3). Of a total of 332 patients who died as a result of their injuries, 314 (95%) died in the ED. The importance of different injury mechanisms varied by patient disposition; falls and motor vehicle crashes were the leading causes of ED visits, whereas motor vehicle crashes were the single leading cause of hospitalization. In contrast, gunshot injuries, though relatively infrequent among injury patients treated in the ED and discharged, were the most life-threatening and caused one-third of all injury deaths.

The frequency distribution of clinical diagnoses by N-code revealed the relative importance of each external cause. More than half (51.5%) of all injury diagnoses were open

Table 4. Mean LOS (in days) and bed-days of hospitalized patients by cause of injury and N-code count (number of injury diagnoses).

Cause of injury	Number of discharges	Mean LOS	Total inpatient-days No. (%)
Motor vehicle crash	170	6.9	1173 (33.3)
Burn	59	7.8	460 (13.1)
Fall	96	4.3	413 (11.7)
Assault	98	4.0	392 (11.1)
Firearm	63	4.3	271 (7.7)
Dog bite	29	4.8	139 (3.9)
Struck by/against object	37	2.5	93 (2.6)
Suicide – attempted	13	4.7	61 (1.7)
Instrument/Machine	15	3.7	56 (1.6)
Overexertion	13	2.4	31 (0.9)
Poisoning	2	9.5	19 (0.5)
Foreign body	4	1.0	4 (0.1)
Drowning/Suffocation	1	2.0	2 (0.06)
Other	42	9.8	412 (11.7)
All causes	642	5.5	3531 (100)

LOS = length of stay.

wounds and contusions or abrasions, mainly caused by assaults and instruments. Less frequent but more serious trauma such as intracranial injury (5%), fractures (12.2%), dislocation or sprain of joints (20.4%) and injury to internal organs (0.06%) resulted mostly from firearms, assaults, falls and motor vehicle crashes.

Length of inpatient stay

The length of stay for hospitalized patients ranged from 1 to 67 days, and was not normally distributed. Overall, the mean LOS was 5.5 (SD 7.5) days with a median value of 3.0 days (Table 4). Of the major causes of injuries resulting in hospitalization of at least ten patients, burns, on average, resulted in significantly greater LOS (7.8 days) in comparison to all other external causes. For the total inpatient days, which take into account both the mean LOS and the frequency of hospitalization, motor vehicle-related injuries accounted for the largest proportion (33.3%).

To investigate factors contributing to the duration of hospitalization of trauma patients, we conducted multiple linear regression analysis of the log of LOS. Of the 21 potential predictor variables entered into the regression model, only five were significantly correlated with prolonged hospital stay (Table 5). Multiple injuries and burns explained the majority of the variation in LOS (Partial R-square = 0.06 and 0.04, respectively). Among the external causes of injury, motor vehicle crashes were the single most important predictor of length of stay.

Hospital charges

The distribution of individual patient charges varied considerably and was highly skewed, ranging from just $18 to $132,567. Table 6 shows how the charges were distributed by treatment setting and cause of injury. Although only 1% of the patients were admitted, they accounted for almost half of the overall costs among all injured patients. Overall, the mean charge per patient visit was $293, but varied by ED disposition: $159 for patients treated in ED and discharged; and $11,116 for patients admitted to the hospital. Mean inpatient charges per cause of injury ranged from $790 for poisonings to $19,191 for motor vehicle crashes. Motor-vehicle crashes accounted for the greatest proportion (40.3%) of the total charges.

The average charge per ICD-9 N-code diagnosis varied by treatment setting (Appendix 2): for ED visits without hospital admissions, it ranged from $92 for foreign body removal to $2,546 for internal injuries; while for patients admitted to the hospital, it ranged from $1,505 for poisonings to $51,143 for injuries to the spinal cord.

Charges information was available for 50,109 injury visits (82.9%). More than half (56.5%) of the total hospital charges were billed to uninsured patients, with a mean of $298 per visit. Private insurance companies covered nearly a third (29.1%) of injury patients and on average had a greater mean charge ($341) per visit. All of the government-sponsored health insurance programmes combined (Medicare, Medicaid and the state/county sponsored programme for indigent patients) made up less than 15% of the total injury-related charges that accrued over the 3-year period. Surprisingly, the mean charge per injury visit for patients covered by the Medicaid insurance programme ($407) was significantly higher than for those covered by commercial insurance companies and other government insurance schemes (Medicaid $178; Advantage $138).

We next examined how the charges for trauma care were distributed by each of the hospital's cost centres. As illus-

Table 5. Multiple linear regression of log of LOS and log of hospital charges.

Variable	Log of LOS			Log of Hospital Charges		
	Parameter Estimate	Standard Error	Partial R^2	Parameter Estimate	Standard Error	Partial R^2
Diagnosis:						
Multiple injuries†	0.36	0.10 (p < 0.001)	0.06	1.33	0.15 (p < 0.0001)	0.23
Burns	0.92	0.26 (p < 0.001)	0.04	1.17	0.39	
Injury to internal organs	0.67	0.27 (p = 0.01)	0.02	0.75	0.41	
Intracranial injury	0.20	0.20		0.43	0.29	
Fracture of limbs, trunk	–0.09	0.14		0.25	0.21	
Dislocation	0.26	0.28		0.52	0.45	
Soft tissue injuries	0.15	0.20		–0.43	0.30 (p = 0.007)	0.01
Complications of injuries	0.13	0.19		0.46	0.28	
Other‡						
Cause:						
Motor vehicle crashes	0.31	0.15 (p = 0.04)	0.01	0.98	0.22	
Firearms	0.18	0.20		1.20	0.29	
Fall	0.05	0.17		0.09	0.26	
Assault	–0.17	0.16		0.19	0.25	
Burn, scalds	–0.35	0.26		–0.42	0.28 (p = 0.0002)	0.02
Other causes‡						
Race:						
White	0.21	0.10 (p = 0.04)	0.014	0.18	0.16	
Black‡						
Gender:						
Female	0.05	0.11		0.32	0.16 (p = 0.04)	
Male‡						
Age – (continuous variable)	0.003	0.003		0.01	0.00 (p = 0.02)	
Medical Insurance:						
Medi-care/-aid	0.08	0.16		0.28	0.24	
Advantage	–0.12	0.28		–1.12	0.39 (p = 0.004)	
Private	0.03	0.11		0.08	0.16	
Self-pay‡						
	R^2 for complete model = 0.168			R^2 for complete model = 0.338		

LOS = length of stay.
† More than one ICD9-N-code diagnosis.
‡ Reference category.

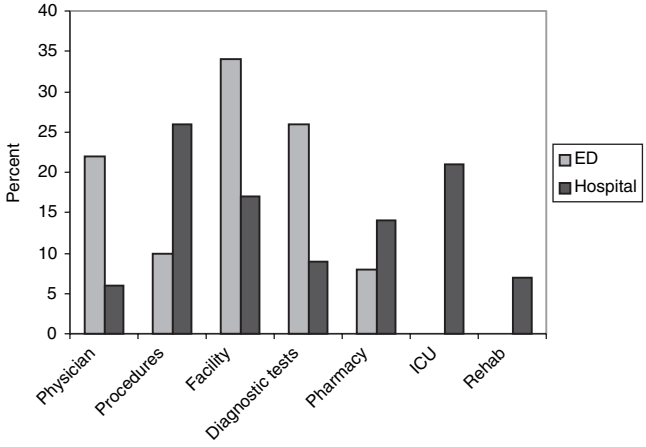

Figure 1. Percent distribution of charges by treatment setting and cost center.

trated in Figure 1, two cost centres – diagnostic tests and facility charges – accounted for 60% of the total ED charges. For patients admitted to hospital, medical procedures, ICU and facility charges represented nearly two-thirds of the total charge. Physicians' fees accounted for only 6% of total inpatient charges. The mean charge per cost centre was however fairly consistent across all external causes of injury, with the exception of motor vehicle-related injuries, where surgical procedures accrued higher charges.

Predictors of inpatient costs

Multiple linear regression analysis of the log-transformed total inpatient charges showed that six of the 19 variables included in the model were the most important predictors of hospital charges (Table 5). Multiple injuries explained the

Table 6. Hospital charges in US dollars by cause of injury and treatment setting.

	ED visits		Admissions to hospital		Total	
Injury Mechanism	Mean $	Total $	Mean $	Total $	Mean $	Total $ (%)
Motor vehicle	278	2,684,269	19,191	3,243,413	603	5,927,682 (40.3)
Fall	135	1,241,172	6,433	591,838	197	1,833,010 (12.5)
Assault	156	1,306,127	5,198	467,876	209	1,774,003 (12.1)
Firearm	573	441,879	10,378	643,460	1,302	1,085,339 (7.4)
Burn	133	125,835	12,562	716,052	844	841,887 (5.7)
Struck by/against object	113	640,444	3,328	113,159	132	753,603 (5.1)
Overexertion	86	451,813	3,650	43,811	94	495,624 (3.4)
Instrument/Machine	104	365,361	3,744	56,162	119	421,523 (2.9)
Dog bite	108	139,936	4,243	118,830	196	258,766 (1.8)
Suicide	198	75,875	5,546	66,562	360	142,437 (1.0)
Foreign body	63	62,683	1,316	5,264	67	67,947 (0.5)
Poisoning	53	34,545	790	790	54	35,335 (0.2)
Drowning/Suffocation	357	8,575	2,751	2,751	453	11,326 (0.07)
Other	108	308,106	17,984	755,345	282	1,063,451 (7.2)
All causes	159	7,886,620 (53.6%)	11,116	6,825,313 (46.4%)	293	14,711,933 (100)

ED = emergency department.

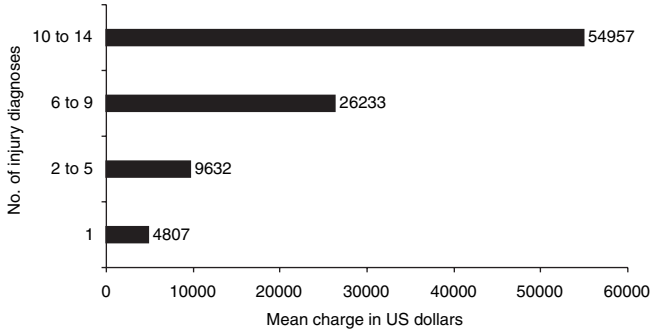

Figure 2. Variation in mean inpatient charges by the number of N-code injury diagnoses.

majority of the variation in charges (partial $R^2 = 0.23$): the greater the number of injuries the higher the mean hospital charge (Figure 2). Only two external causes of injury – motor vehicle crashes and firearms – were highly correlated with the increase in inpatient charges. On the other hand, the state/county insurance programme for indigent patients, as a primary payer of medical care bills, was significantly correlated with lower charges.

Discussion and conclusions

Most published reports quantifying the burden of injury as a basis for establishing intervention programmes rely on fatal or hospitalized cases as the primary sources of data, which may lead to choosing inappropriate priorities for prevention. Information on non-fatal injuries not requiring hospitalization is rarely used for such purposes, yet they represent over 90% of injured patients who seek medical care.[4,16] The use of non-fatal ED injury data, in conjunction with mortality and inpatient data, can provide a better understanding of injury burden and help in making appropriate decisions and priorities for intervention.[17] This, however, is limited by the general lack of a local source of data on ED visits for injuries, though the NEISS[11] functions to fill this gap at the national level. Our study illustrates the potential of using a comprehensive electronic medical record system containing clinical and health service information of all ED visits and hospitalizations, to identify the patterns and characteristics of injuries in the entire injury patients' population.

Consistent with a previous report,[18] our data show that most of the injured patients (98.4%) were treated in the ED and released. Over 75% of injury visits were due to five major external causes: falls; motor vehicle crashes; assaults; struck by or against object; and overexertion. This distribution slightly differs from the national estimates derived from the NEISS data, in which the top five leading causes are falls, struck by or against, cuts/piercing, motor vehicle crashes and overexertion.[11] Analyses of local data such as ours, therefore, could result in different decision-making concerning ED and city-wide resource allocations and treatment/prevention strategies than if national NEISS data were used.

We identified specific demographical groups at high-risk for specific injuries. Motor vehicle crashes are the leading cause of injury among adolescents and young adults aged 15–24 years, while fall injury incidence is greatest among children and elderly persons. There is also a difference in

injury incidence by race; assaults and firearm-related injuries were disproportionately more frequent among African-Americans than whites. This difference by race is consistent with previous research,[18,19] and may reflect underlying socio-economic differences within the study population. Other studies using state-wide hospital discharge data have also documented the relationship between low-income status and a greater risk of injury.[20,21] These differences by demographical characteristics indicate the need for injury prevention programmes to focus on particular subpopulations when targeting prevention programmes for selected injuries. However, a more comprehensive study that includes injury data from all hospitals within the metropolitan area may be needed to describe injury epidemiology and provide data that can be used to develop specific community-wide interventions. An emerging city-wide expansion of the RMRS database may make this possible when populated with sufficient numbers of patients and descriptive data from all hospitals in the city.[22]

This study also demonstrates the impact of different causes of injury on public health and health care utilization: falls are the leading cause of non-fatal injury; motor vehicle crashes are the leading cause of hospitalization; while firearms are the single largest cause of injury deaths, followed by motor vehicle crashes. These findings underscore the value of using both ED and inpatient injury data in the assessment of public health importance of different external causes of injury.

The second purpose of this study was to estimate the length of stay and injury-related charges for both ED and inpatient care. On average, patients with burns, firearm and motor vehicle injuries had longer hospital stay, more multiple injuries and accounted for more than half of the total inpatient days. These findings are comparable with those reported in other level I and level II trauma centres.[23,24] In the absence of Trauma and Injury Severity Score,[25] our results suggest that LOS can be used as a surrogate in epidemiological studies to identify and characterize patients with severe injuries, and also as a measure of hospital utilization. The RMRS, thus, provides valuable data for this purpose. However, information on injury severity needs to be captured in the electronic medical record system to allow for a more objective assessment of associations between severity of illness and health care utilization. The effects of complications of injuries and co-morbidity on hospital stay also need further evaluation.

The economic cost of injury and factors associated with resource utilization for injury patients has been investigated in several studies.[7,26–28] Our data show that the mean charge for injury admissions was $11,116 per patient, and the most expensive injuries were from motor vehicle crashes, burns and firearms. These findings are comparable with those reported in other trauma centres' studies.[26–29] However, the data further illustrate the economic burden of specific injuries to this particular hospital, nearly 80% of the total injury-related charges were attributed to five major causes: motor vehicle crashes; falls; assaults; firearms; and burns. By far, motor vehicle crash victims were the most expensive to treat even after controlling for other factors. Because the hospital is supported by county tax dollars, the costs of publicly funded efforts to enhance highway traffic safety could be justified by their resulting in subsequent cost savings for the county.

Our data further show that almost two-thirds of injury patients were uninsured, more than double the proportion reported in other level I trauma centres;[30] and only 16.2% had publicly funded health insurance, a much lower proportion than the national average of 28%.[6] This disparity between our data and national statistics in health insurance coverage suggests that trauma contributes significantly to the financial instability of this inner-city public hospital. The potential financial loss due to inadequate cost recovery can adversely affect the quality of care for all patients, injured and otherwise, and even closure of trauma care centres elsewhere in the USA.[31,32] Publicly funded hospitals are particular likely to be affected by large deficits in revenue. The fact that the RMRS stores both clinical and financial information for the ED and inpatient services implies that it can provide policy-makers, hospital administrators and insurance companies with the data needed to make strategic plans for both public prevention and treatment efforts, and to assess their financial implications.

We conclude that injuries are an important cause of patient visits to this inner-city public hospital, with the leading causes being falls, motor vehicle crashes and assaults. Injury patients treated at the hospital are often from the socially and economically disadvantaged population, and their medical care is poorly funded from public and private health insurance schemes. The RMRS represents a useful database for injury surveillance that can improve our understanding of injury epidemiology in the patient population being served by a specific hospital, their patterns of care and the impact on health care resources. Such information can be a powerful resource for strategic hospital and city-wide decision-making. There is, however, a need for a more comprehensive study using injury data from all hospitals serving the entire population of the city. Given the high cost of medical care for injuries and their social and economic consequences, more resources should be allocated to safety promotion and injury prevention.

Limitations

There are certain limitations to this study. First, the study was conducted at a single hospital; information on injured patients who seek treatment in other hospitals within the metropolitan area was not included. The injured population treated at this single hospital may not be typical of the entire population of the metropolitan area and represents an unknown proportion of all injured patients in the area. The findings are therefore not generalizable to the entire metro-

politan population. It would also not be appropriate to calculate the ratio of injury deaths to hospitalizations, and to the numbers treated and released in this inner city population. However, being specific to this public hospital, the findings are useful for internal planning purposes. Second, we had no direct information on the severity of injuries, such as the Trauma and Injury Severity Score.[24] Therefore, we had to use proxies such as charges and LOS. Third, there were missing data on certain variables; for example, charge information was incomplete in some ED visits. Finally, for diagnoses we relied on administrative data that have been shown to be specific but not sensitive for selected diagnoses.[33]

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Appendix 1. ICD-9-CM E-code grouping.

Injury Mechanism	ICD-9-CM E-Code
1. Motor vehicle crashes	E812–E829.9, E846–E848
2. Firearms	E922–E922.9, E955–E955.9, E965–E965.4, E970, E985–E985.4
3. Poisoning	E850–E869.9, E980–E982.9
4. Fall	E880–E888, E987–E987.9
5. Fire/Hot substance	E890–E899, E924–E924.9, E921–E921.9
6. Struck by or against object	E916–E918
7. Machine or instrument	E919–E920.9, E986
8. Suicide	E950–E954, E956–E958.9, E959
9. Assault	E960–E964, E966, E968–E968.9, E969 E967–E967.9
10. Dog/animal bite, snake bite	E906–E906.9, E905–E905.9
11. Foreign body in orifice	E914–E915
12. Overexertion	E927
13. Drowning/Suffocation	E910–E910.9, E911–E913.9, E983–984
14. Other[†]	
Accidents – unspecified	E928–E928.9
Late effects of accidents	E929–E929.9, E988–E988.9, E989
Adverse effects of medical care	E930–E949.9, E870–E879.9
Legal intervention	E971–E978
Other transport – railway/aircraft/boat	E800–E811.9, E840–E845.9, E830–E838.9
Miscellaneous	E849–E849.9, E900–E904.9, E907–E909.9, E923–E923.9, E985.5, E925–E925.9, E926–E926.9, E990–E999

[†] Includes the external causes listed.

Appendix 2. ICD-9-CM N-code grouping, and mean charge by treatment setting.

Nature of Injury (Diagnosis)	ICD-9-CM N-Code	Mean Charge in $	
		ED	Inpatient
1. Intracranial injury with/without skull fracture; dislocation/fracture of jaws	800.0–804.9, 850.0–854.9, 830–830.9	260	12,690
2. Nerve and spinal cord injuries;vertebrae fractures/ dislocation	805–806.9, 839–839.9, 950–957.9	188	51,143
3. Fracture of upper/lower limbs, ribs, sternum and pelvis.	807.0–809.9, 810.0–819.9, 820.0–829.9	197	13,624
4. Dislocation, sprains and strains of joints/muscles	831.0–838.9, 839.6–839.9, 840.0–848.9	108	6,338
5. Internal injury of the thorax, abdomen and pelvis; Injury to blood vessels	860.0–869.9, 900.0–904.9	2,546	29,604
6. Open wounds – head, neck, trunk, limbs	870.0–879.9, 880.0–887.9, 890.0–97.9	156	10,584
7. Superficial injury and contusions/crushing	910.0–924.9, 925.9–929.9	149	5,054
8. Burns	940.0–949.9	148	14,279
9. Poisonings and toxic effects non-medical substances	960.0–979.9, 980.0–989.9	166	1,515
10. Foreign body entering through orifice	930.0–939.9	92	4,638
11. Other[†]	958.0–959.9, 990.0–995.9, 905.0–909.9, 996.0–999.9	182	8,287

ED = emergency department.
[†] Includes complications of injuries, late effects, unspecified injuries and complications of surgical and medical care.

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