Injury Surveillance: The Role of Data Linkage

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Introduction

Injury surveillance efforts have frequently been hampered by the lack of readily available information on injury cause/mechanism. Unfortunately, those sources of information with the most injury detail are usually lacking with regard to data about the mechanism of injury. Hospital discharge records, for example, frequently do not have complete E–code data. Conversely, sources of information with detail about the cause of the injury, such as police crash reports, frequently do not include much detail concerning the injuries themselves. In recent years detailed injury information has become increasingly available with the widespread use of trauma registries (1). While trauma registries are biased in that they include only those patients with the most serious injuries, (2) they do provide a comprehensive source of surveillance data, with detailed information concerning the nature and severity of the injuries (3,4). Thus, linkage of data from several sources provides information not otherwise available, allowing valuable insights into injury causation.

Injury surveillance is important in order to identify patterns and types of injuries in the population (5–7). Based on such surveillance, more in–depth epidemiologic studies of risk can be conducted. Since risk factors and patterns for fatal and non–fatal injuries frequently differ (8), both mortality and morbidity data should be included in any injury surveillance effort. By combining data from multiple sources, it is possible to examine various degrees of injury severity, and to optimize the utility of the available information. As pointed out in Injury in America, "the U.S. requires effective injury surveillance systems for gathering and integrating information from a variety of sources on which to base the planning and evaluation of control efforts. This would include...the collection of more refined data on specific types and causes of injuries and exposures to injurious environments" (9).

Maryland provides an interesting "laboratory" for injury surveillance, as there is a wealth of data systems already in place which can be used to address questions related to injury. It is one of the few states with a centralized EMS system (10) consisting of a network of trauma hospitals, with coordinated transportation and communication services (11). There is a centralized repository for ambulance/helicopter reports, a statewide trauma registry, state hospital discharge records, and a coordinated system of medical examiners, with a central location for autopsy records.

Despite the availability of these various data sources, however, there is no uniform identifier which can serve to link all the records. Each of the data sources addresses different aspects of the injury–related incident. Traffic records, for example, are routinely utilized by law enforcement agencies, highway planners, managers in departments of transportation, and researchers. They are also used by emergency medical services agencies (EMS), and injury prevention planners. However, the crash report is usually prepared by the police officer who was at the scene of the crash, from data obtained at the scene. The crash report form does not include descriptions of the injuries, rather only a crude overall injury severity code (no injury, possible injury, non–incapacitating, incapacitating, or fatal injury). Details of the injury must be obtained from hospital records, either outpatient or inpatient.

The police report does not show the history of previous infractions of the drivers involved; thus, the driver record must be obtained separately. The police report also does not give details of damage to the vehicle beyond the damage severity codes of "disabling, functional, other vehicle damage, no damage, unknown." Nor does the form indicate the response times and treatments rendered by the emergency medical system; for this the ambulance runsheet is required. Also, records of rehabilitation services provided after discharge from the hospital are not documented; hospital discharge records do, however, indicate whether the patient was discharged to an inpatient rehabilitation facility or to home.

For victims that die, death certificates are available from the Division of Vital Records of the Department of Health and Mental Hygiene; autopsy records must be obtained from the Chief Medical Examiner of the State of Maryland. Cost information is maintained by hospital billing departments, the Maryland Health Services Cost Review Commission (HSCRC) and individual insurance companies.

Thus, for an individual crash event, relevant information must be obtained from separate data sources and, if necessary, manually linked. Each of the agencies involved may have a computer database of all or parts of their data, but these are typically "sanitized" by removal of identifiers such as names and addresses, before the computer file is made available, even to another state agency. Therefore, in order to understand the pre–crash, crash, and post–crash circumstances and the consequences and costs of injuries incurred, methods to link already available computerized data, and methods of obtaining non–computerized data, must be explored.

Sources of Injury Information

The available sources of data are briefly described below:

- Police crash reports. Police crash reports document details of all injury–causing crashes occurring throughout the state. While the exact nature of the injuries is not documented, each report includes a code (the KABCO code), which is a five–point scale based on whether there was no injury, minor injury, non–incapacitating injury, incapacitating injury, or a fatal injury. There is no indication, however, of whether or not the injured person was admitted to a hospital, or the final disposition of the injury.

- Maryland Ambulance Information System. For each person transported by ground or air ambulance throughout the state, an ambulance runsheet is completed. The runsheet documents the time elapsed between the injury and field response, as well as the mechanism of the injury, and the patient's vital signs. Runsheets are optically scanned and stored centrally at the Maryland Institute for Emergency Medical Services Systems (MIEMSS).

- Trauma Registries. Information on patients treated in trauma centers is entered into the Maryland Trauma Registry. There are currently nine trauma centers located throughout the state. The trauma registry includes basic information about pre–hospital care, status of the patient on admission, diagnoses, treatment and ultimate outcome. The registry is not population–based, and therefore, unto itself does not provide adequate data to quantitate the effectiveness of various preventive measures such as seatbelt and helmet use. However, despite this limitation, in combination with other databases, the registry can provide valuable information on patients with serious injuries. Other, more detailed registries are also frequently maintained by specific trauma specialty groups, such as orthopaedics.

- Hospital Discharge Records (HSCRC). For all patients discharged from acute care hospitals throughout the state, a discharge record is generated. This record includes information on the diagnoses, acute care charges, payor type and outcome dispositions for each patient. E–codes, which document the cause or mechanism of the injury, are currently available only for approximately half of all injury discharge records.

- Medical Examiner's Records. In Maryland there is a statewide medical examiner's system, with centralized records on all deaths throughout the state. Information on the causes of the injuries is kept in a computerized registry; however, data on the injuries themselves are not currently computerized.

- Death Certificates. All death certificates for deaths occurring to Maryland residents are maintained by the State Health Department, Division of Vital Records.

- Driver's Records. Driver histories may be obtained from the Maryland Department of Motor Vehicles.

Data Linkage Methodology

From the point of view of ongoing, electronic linkage of already available data, the ideal would be to have an identified state agency authorized to receive the full confidential files from each data owner, with names and other private information, within approximately three months of the injury–causing event. The data could then be linked and the individual identifier information removed before public release and after analysis by the different agencies for their own system evaluation and/or prevention activities. It may be that state legislation would be necessary in order to require all of the groups involved to augment their present computer information systems to include the necessary additional confidential information and to submit it to the designated central state agency.

Nevertheless, given current concerns about the confidentiality of data included in these various data sources, other means are currently required to accomplish these linkages. The two main strategies for data linkage are summarized below, followed by examples of studies using each method:

(1) A **sequential linkage method** requires identification of cases from a central source, and subsequent linkage of that information with other databases. For example, as discussed below in the Motorcycle Study, all injured motorcyclists were identified using police crash reports. Then, based on information from the crash report, it was possible to obtain enough information to link with ambulance runsheet, hospital discharge, and other databases. If this linkage process were successful, it would be possible to relate every police report to a list of injuries, if any, which resulted from the crash. This level of detail would allow for sensitive, and long–awaited, measures of system effectiveness and provide a basis for the monitoring of injury prevention efforts.

(2) A **probabilistic linkage** is based on collections of various variables, not unique, which in combination provide the best linkage between two different databases. Such a linkage does not require the use of confidential data. The success of such a linkage, however, is highly dependent upon the quality and completeness of this select set of variables.

In many instances, electronic linkage of data from multiple sources can be accomplished using several key indicators. Some key indicators include: date of the injury, date of birth of the injured, gender, and place of injury occurrence. Usually, the name of the victim is not accessible using available data sources. With the increasing availability of geographic information systems, another key variable in the future may be the longitude/latitude of the injury–related incident.

Table 1 shows the key variables of the various databases, with the most useful linkage variables highlighted.

Examples of Surveillance Studies Using Data Linkage

Several examples of injury surveillance studies which have resulted from linkage of two or more already existing databases are described below. The first, the Motorcycle Study (12) is an example of the sequential data linkage type.

<u>The Motorcycle Study</u>

Although there are many opportunities for such data linkages, these efforts are frequently manpower intensive, as there is no single identifier which can be used in an automatic linkage. In a surveillance study of motorcyclists conducted in Maryland, data from the following sources were linked: police crash reports, ambulance runsheets, EDs, trauma registries, hospital discharge records, driving records, and autopsy reports. In order to carry out this study, injured motorcyclists were identified from police crash reports. From the crash report, it was possible to ascertain the hospital, if any, to which the injured cyclist was taken. A data collection form was then sent to each hospital, requesting information on the diagnoses for each individual and whether the cyclist had been treated and released, admitted, or died in the emergency room. For those admitted to hospitals, the hospital record number was used to access the hospital discharge database. From this database, information on discharge diagnoses and hospital costs (charges) was obtained. If the motorcyclist died, autopsy reports were identified and abstracted at the Medical Examiner's Office. Driver histories were also requested for each of the motorcyclists included in the study.

Figure 1 illustrates the final, linked database, with the diagram of the motorcycle representing the police crash report, which was the starting point for case identification. The linkage success rate is illustrated in Table 2. During the one–year study period, there were 1882 police–reported motorcycle crashes, involving 1900 motorcycle drivers, 362 motorcycle passengers, and 40 pedestrians struck by motorcycles. Of the 1900 drivers, 1360 (72 percent) were transported to hospitals. Of this group, outcome data were available for 911 motorcyclists; 39 percent were either admitted or transferred, 54 percent were treated and released, and 5 percent died. The remaining 2 percent left the emergency department against medical advice.

Based on the findings from this study, several recommendations were made regarding data linkage. First, it was recommended that the police crash form be modified so that it would be possible, in the event of multiple persons injured, to determine which person was transported to which hospital.

Secondly, the recommendation was made that the ambulance runsheet have a "tearsheet" at the bottom, stamped with the same number, which would be filled out by the hospital ED staff. The tearsheet would indicate the disposition of the patient (treated and released, transferred, admitted, or died). It would then be returned to a central data repository where the data would be entered. With these two modifications, then, it would be possible, at least for vehicular injuries, to effect a linkage between police reports, ambulance records, and hospital discharge records. After a one–year trial of the tearsheet, however, it is apparent that compliance is not good, primarily because of the manpower required to complete the paperwork in the ED (13). Meanwhile, the Health Services Cost Review Commission (HSCRC) has agreed to add the ambulance runsheet number to its computerized records. While this assumes that the runsheet is legible, and that it will be put into the medical record, this development means that, at least for hospitalized cases, there can be an ongoing linkage between the crash, ambulance, and hospital records.

The following studies are examples of studies conducted using probabilistic data linkage:

<u>Linkage of Trauma Registry and Hospital Discharge Records</u>

To address the question of what proportion of injured patients admitted to hospitals are treated by trauma teams, a linkage between HSCRC and trauma registry data was attempted for those hospital discharges occurring in calendar year 1988. Using the HSCRC tape, all patients with a discharge diagnosis which included an ICD–9 code between 800.00 and 959.99 were selected (N=38,692). Of this group, 16,368 (42.3 percent) were admitted to trauma hospitals, with the remainder admitted to community hospitals. Included in the registry were 7,534 of these patients. For this subgroup admitted to trauma hospitals, an electronic linkage between trauma registry and HSCRC data was achieved for 74.3 percent. Of those unmatched, a large proportion were found to have been hospitalized for 24 hours or less or to have had an ISS of less than 13. Data from this linkage have been used in a study of the costs of intentional injury in Maryland (14). Using the trauma registry, patients admitted as a result of gunshot wounds, stabbings, or beatings were identified; cost information was then obtained through a linkage with the hospital discharge tapes.

<u>Linkage of Trauma Registry and Police Crash Report Databases</u>

– Study of the Pattern of Injuries in Lateral vs. Frontal Collisions

In this study, clinical data on the nature and severity of injuries was linked with data from police crash reports for 3675 car/truck drivers admitted to trauma centers (15). From the computerized vehicle diagram on the police crash report, it was possible to distinguish between crashes with primarily frontal vs. left lateral impacts. Different patterns of injuries were noted for drivers in these two types of collisions (see Table 3). Injuries to the face and lower extremities were significantly greater in frontal collisions; thorax, abdominal and pelvic injuries were significantly greater in lateral collisions.

In addition, drivers in lateral collisions were found to have significantly more multiple injuries to the abdomen and thorax. This information has potential use for clinical decision making, since drivers admitted to trauma centers following left lateral collisions have a higher incidence of occult abdominal and thoracic injuries.

<u>Linkage of Trauma Registry, Police Report, and Toxicology Databases</u>

- Study of Alcohol Use Among Injured Sets of Drivers and Passengers

  Crash report and blood alcohol concentration (BAC) data were linked for 109 injured driver/passenger pairs admitted to a Level I trauma center and identified using the trauma registry (16). Among those occupants, 47 drivers (43 percent) (mean BAC, 147 mg/dl) and 45 passengers (41 percent) (mean BAC, 127 mg/dl) were BAC+. No occupant was BAC+ in 57 crashes (52 percent); both were BAC+ in 40 (37 percent); and only one was BAC+ in 12 (11 percent). When both occupants were BAC+, the driver had the higher BAC in 68 percent of cases, and when one was BAC+, it was the driver 58 percent of the time. In six additional alcohol–related crashes with one driver and two passengers, the "wrong" occupant was driving on five occasions. Hence, in the 58 crashes involving BAC+ occupants, the least appropriate occupant was driving 67 percent of the time.

  From this data it is not appropriate to conclude that "designated driver" initiatives are ineffective. This study is based on a select group of individuals admitted to a trauma center, i.e., "numerator" data. However, the findings from this study seem to indicate a need for educational efforts that are directed not only toward encouraging drivers not to drink, but also toward discouraging passengers from traveling with drinking drivers. To fully assess the need for such educational endeavors, studies of driver/passenger BAC+ status among the non–injured motoring population are needed.

Summary

Linkage of already available sources of data provides an effective way of conducting injury surveillance. Although most of these injury sources are not population–based, they provide data which allow for generation of hypotheses for further epidemiologic study. Even without unique identifiers, an acceptable data linkage success rate can be attained using probablistic linkage techniques. Meanwhile, new techniques should be explored to find ways to effect an ongoing linkage of injury data sources.

In–depth studies may require even more detail concerning the mechanism of injury. In such instances, already available data may be augmented for the purposes of the study. For example, in an ongoing study of lower extremity injuries to motor vehicle occupants, crash reconstruction data are being obtained for the crashes which resulted in these injuries (17). By correlating the detailed findings about the crash with information about the specific nature and severity of the injury, it is possible to postulate the actual mechanism (e.g., dorsiflexion, inversion, eversion, axial load) which caused the injury. Such information, when combined with observations from the less detailed surveillance data, and with experimental research, can provide specific suggestions for injury mitigation.

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Table 1 – Available Sources of Injury Data

	Maryland Automated Accident Reports	Maryland Ambulance Information System	Syscom (Air Trans)	Maryland State Trauma Registry	Health Services Cost Review	Vital Statistics Death Certificate	Medical Examiners Data
Crash Characteristics	X						
Crash Date/Time	X	X	X	X			
Crash Location	X	X	X	X			
Crash Severity	?						
Safety Equipment	X		X	X			
VIN # and/or Vehicle Characteristics	X	X	X	X			
Seating Position	X			X			
Pre-existing Health Conditions				X	X		
Injury Type, Body Area, Severity, and Length of Stay		X	X	X	X		
EMS Response		X	X	X			
Treatment and Disposition by ED				X			
Alcohol/Drug Use	X			X			X
Admission Date/Time				X	X		
Name	X (hard copy)			X		X	X
Subject Sex	X	X	X	X	X	X	X
Subject Age/DOB	X/X	X/–	X/X	X/X	X/X	X/X	X
Hospital Discharge Diagnoses				X	X		
Outpt, Inpt, Rehab and Long Term Care Treatment/Disp.				X	X		
Total Charges/Reimbursement for Medical Care				X	X		
Primary/Secondary Payors				X	X		
Mortality	X			X	X	X	X

Table 2 – Results of Sequential Record Linkage

File	Drivers %	Passengers %	Pedestrians %
Past driving history of motorcycle drivers licensed in Maryland	83	–	–
Pre–hospital care of those transported by Maryland ambulances or helicopters (two counties were not reporting)	71	64	29
Emergency Department reports of treat– ments of crash victims transported to identified Maryland hospitals (five civilian hospitals plus clinics and federal hospitals did not take part in this study)	79	72	82
Emergency Department reports of treat– ments of crash victims transported to the 45 cooperating hospitals	92	92	92
Hospital discharge reports of crash victims identified as admitted to the participating Maryland hospitals	91	83	100
Trauma centers trauma registry data of crash victims identified as trans– ported to Maryland trauma centers	77	72	29
Autopsy records of those identified as motorcyclists or struck pedestrians killed in motorcycle crashes in Maryland	98	100	100

Table 3 – Incidence of Specific Organ/Skeletal Injuries by Direction of Impact

Injury	Number (%) in Frontal Crashes (n=2804)	Number (%) in Left Lateral Crashes (n=376)	p Value
Head/neck	1531 (54.6)	187 (49.7)	0.08
Brain	488 (17.4)	68 (18.1)	NS
AIS 4+	149 (5.3)	25 (6.7)	NS
Skull	420 (15.0)	35 (9.3)	<0.003
Face	1268 (45.2)	102 (27.1)	<0.0001
Thorax	680 (24.3)	137 (36.4)	<0.0001
Chest Wall	354 (12.6)	101 (26.9)	<0.0001
Lung	131 (4.7)	27 (7.2)	0.036
Diaphragm	7 (0.3)	10 (2.7)	<0.0001
Abdomen	693 (21.2)	138 (28.7)	<0.001
Liver	77 (2.8)	16 (4.3)	NS
Spleen	72 (2.6)	30 (8.0)	<0.0001
Kidney	50 (1.8)	10 (2.7)	NS
Intestine	44 (1.6)	3 (0.8)	NS
Bladder	5 (0.2)	13 (3.5)	<0.0001
Pelvis	154 (5.5)	75 (20.0)	<0.0001
Lower Ext.	508 (18.1)	26 (6.9)	<0.0001
Femur	208 (7.4)	17 (4.5)	0.04
Patella	84 (3.0)	1 (0.3)	<0.002
Tibia/fib.	127 (4.5)	4 (1.1)	<0.001
Ankle/foot	138 (4.9)	4 (1.1)	<0.001
Tarsal	113 (4.0)	1 (0.3)	<0.0001

Figure 1 - Motorcycle Study Linked Database