APPLICATIONS OF THE CRASH INJURY RESEARCH AND ENGINEERING NETWORK (CIREN) DATABASE

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ABSTRACT

The Crash Injury Research and Engineering Network (CIREN) is a multi-center collaborative research program that focuses on in-depth studies of serious motor vehicle crashes. Researchers collect and analyze data in order to improve vehicle design, and the treatment and rehabilitation of crash victims resulting in a reduction of injuries, deaths, disabilities, and human and economic costs. This paper will examine the data that are available in CIREN and show how the enhanced level of injury information can be used to complement the data currently found in other data collection systems that are used to identify injury trends in certain types of crashes.

CIREN is also the name of a research tool being developed, updated, enhanced, and maintained by The Volpe National Transportation Systems Center (Volpe) in Cambridge, Massachusetts, to help researchers collect and review injury data. Variables for CIREN crash reconstruction data are an extension of the National Automotive Sampling System (NASS) Oracle data model. Variables for the medical injury data are based on a variety of sources, including the National Trauma Registry, the Orthopedic Trauma Association, and the Uniform Pre-Hospital EMS Data Elements.

CIREN has established a number of outreach and education information dissemination programs at their respective centers. This paper will also show how this information is used to train and educate first responders to be more aware of crash circumstances that can be relayed to emergency room personnel to assist them in identifying and treating injuries that may not be apparent.

INTRODUCTION

The Crash Injury Research and Engineering Network (CIREN) is a multi-center research program involving a collaboration of clinicians and engineers in academia, industry, and government pursuing in-depth studies of crashes, injuries, and treatments to improve processes and outcomes. Its mission is to improve the prevention, treatment, and rehabilitation of motor vehicle crash injuries to reduce deaths, disabilities, and human and economic costs.

CIREN is also a computer database and wide area network for data sharing and analysis among ten Level 1 trauma centers. The computer database extends the National Highway Traffic Safety Administration's (NHTSA) National Automotive Sampling System (NASS) with medical and trauma related variables in a relational/object database system. The medical data includes injury location details, injury sub- classification systems and medical images for better biomechanical injury evaluation.
Under CIREN, a network of participants has been established, (See Figure 1), each member of which is a regional Level 1 trauma center. All are medical teaching institutions associated with a major university. Surgeons, research clinicians, crash investigators, and data coordinators staff each center.

CIREN's computer and research network allows researchers and industry sponsors to review data and share expertise. Finally, in addition to in-depth crash and injury research, each center trains hospital, law enforcement, and emergency response personnel.

BACKGROUND

NHTSA has funded hospital-related studies since the 1980's. In 1991, NHTSA's Office of Crashworthiness Research initiated the Highway Traffic Injury Studies. Over the next several years, research projects to collect detailed injury information on motor vehicle occupants were funded at four Level 1 trauma centers, including the National Study Center for Trauma and EMS/R Adams Cowley Shock Trauma Center in Baltimore, Maryland; the University of Medicine & Dentistry/New Jersey Medical School in Newark, New Jersey; the Children's National Medical Center in Washington, D.C.; and the William Lehman Injury Research Center/University of Miami School of Medicine/Ryder Trauma Center in Miami, Florida.

In the summer of 1996, General Motors, as part of a settlement agreement with the Department of Transportation, funded three additional Level 1 trauma centers, including the University of Michigan Medical Program for Injury Research and Education Center in Ann Arbor, Michigan; Harborview Injury Prevention and Research Center in Seattle,

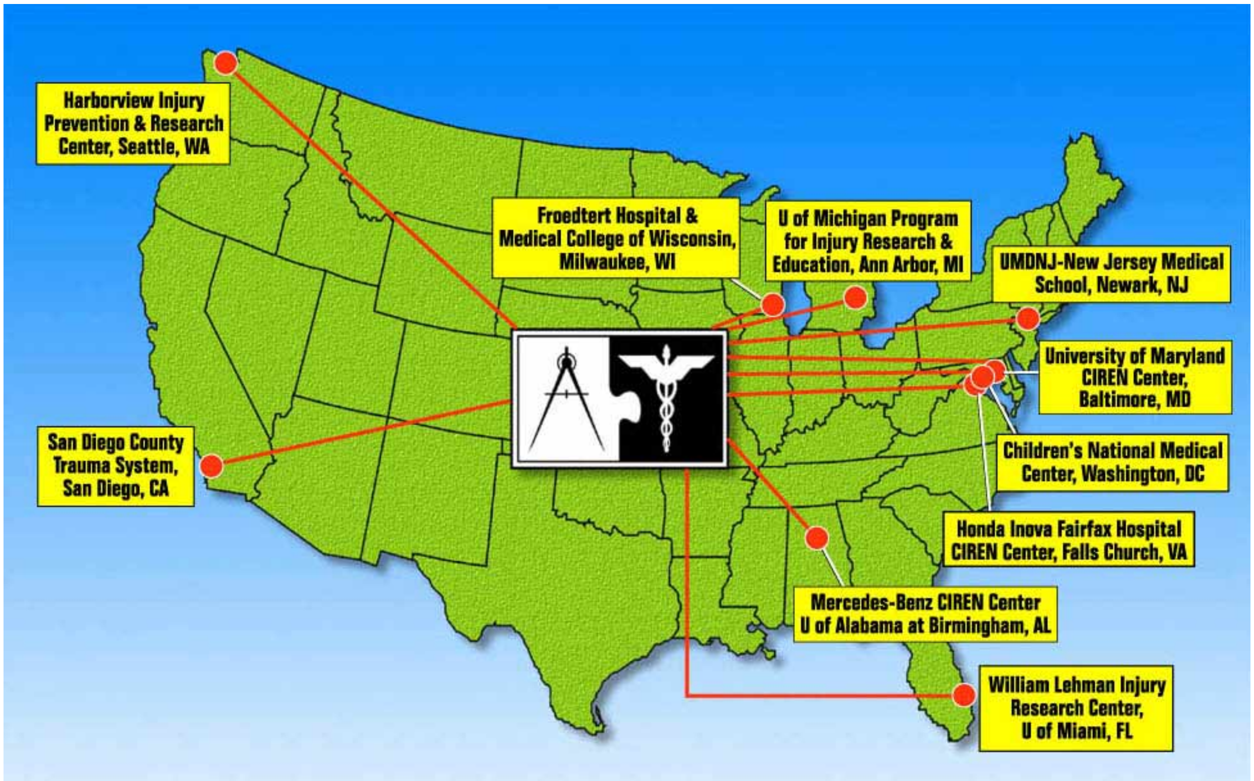

Figure 1. CIREN Center Locations

Washington, and San Diego County Trauma System in San Diego, California.

The first privately funded center was announced in April 1999. Mercedes-Benz announced the funding of an eighth trauma center-based research project at the University of Alabama at Birmingham. Ford announced the funding of the ninth CIREN Center at Inova Healthcare Services/Inova Fairfax Hospital in Falls Church, Virginia in May 2000. In October 2001, Froedtert Hospital and the Medical College of Wisconsin self-funded a CIREN Center at their hospitals in Milwaukee, Wisconsin.

In the spring of 2002, Ford did not exercise their option to renew the third year and subsequent years funding of the CIREN Center at Inova Healthcare Services/Inova Fairfax Hospital in Falls Church, Virginia. Honda R&D Co. Ltd., assumed funding of that facility in January 2003 and the name was changed to the Honda Inova Fairfax CIREN Center.

DATABASE DEVELOPMENT AND COMPOSITION

The CIREN was established in 1996 pursuant to an agreement between General Motors and the U.S. Department of Transportation. A Wide Area Network (WAN) consisting of a frame-relay private TCP/IP network running on fractional T1 lines was created. The CIREN centers were added to the NASS WAN. The WAN permits the individual trauma centers to communicate and provides a backbone for the automatic migration of data from the centers to the central repository at VOLPE.

Crash and medical data are collected by participating CIREN centers for nearly 50 cases per center per year. Each CIREN case includes approximately 650 crash related elements and 250 medical related elements.

Variables for the crash reconstruction set are an extension of the current NASS Oracle data model. The NASS data set contains variables which describe the overall crash environment (i.e., vehicle information, crash type, weather, deformation, intrusion). NASS-trained crash investigators employed at each CIREN center collect crash data.

The CIREN data set contains medical and injury data elements (i.e., vital signs, injury location, EMS data). Variables for the medical injury data were derived from a variety of sources including the NASS

Abbreviated Injury Scale (AIS) Coding Manual, the National Trauma Registry, the Uniform Emergency Medical System (EMS) Data Element Dictionary, and the Journal of Orthopedic Trauma.

CIREN combines detailed medical data (x-rays, ct-scans, etc.) with detailed crash data. Each CIREN case is one injured occupant in a motor vehicle crash. Multiple CIREN cases can be linked to one NASS case, that is, to a single crash.

There are 1,895 cases in the CIREN database (medical side) linked to 1,452 NASS cases (crash side). Of these, there are 753 males and 748 females in the database (See Table 1). The ages of these occupants have been grouped and are shown in Table 2.

Table 1.
Distribution of CIREN Cases by Sex

SEX	COUNT	PERCENTAGE (%)
Female - not reported pregnant	731	38.58%
Female - pregnant-1st trimester (1st-3rd month)	7	0.37%
Female -pregnant-2nd trimester (4th-6th month)	1	0.05%
Female - pregnant-3rd trimester (7th-9th month)	9	0.47%
Male	753	39.74%
Unknown	1	0.05%
Not coded (Sex not yet entered)	393	20.74%
Total	1,895	100%

There were 14,096 total injuries sustained by the 1,895 CIREN case occupants. Table 3 reflects all the injuries by body region sustained by the case occupants. This reflects multiple injuries for each case occupant. The 11 unspecified body regions are those injuries in cases not yet coded.

Table 2.
Distribution of CIREN Cases by Age Group

AGE	COUNT	PERCENTAGE
< 5	118	6.23%
6 - 11	96	5.07%
12 - 17	113	5.96%
18 - 23	290	15.30%
24 - 29	200	10.55%
30 - 35	159	8.39%
36 - 41	169	8.92%
42 - 47	138	7.28%
48 - 53	130	6.86%
54 - 59	107	5.65%
60 - 65	76	4.01%
>65	251	13.25%
Not coded	48	2.53%
Total	1895	100%

A crash is the total set of events (one or more) that results from an unstabilized situation such that at least one harmful event occurs not directly resulting from a cataclysm. An impact is defined as any vehicle-to-vehicle or vehicle to object (fixed, non-fixed, stationary or non-stationary) contact which may or may not result in vehicle damage. Noncollion events include events such as fire/explosion, emersion, or rollover.

Table 3.
Injury Count by Body Region

BODY REGION	INJURY COUNT	PERCENTAGE (%)
Head	1,608	11.43%
Face	1,911	13.58%
Neck	193	1.37%
Thorax	1,907	13.55%
Abdomen	1,411	10.03%
Spine	601	4.27%
Upper Extremity	2,325	16.53%
Lower Extremity	4,102	29.16%
Unspecified	11	0.08%
TOTAL	**14,069**	**100%**

Table 4.
Single Impact Vs Multiple Impacts

IMPACT TYPE	FIRST IMPACT ONLY	IST EVENT IMPACT (%)	MULTIPLE IMPACTS	MULTIPLE EVENT IMPACT (%)
Noncollision	1	0.05%	32	1.3%
Frontal	937	49.45%	1114	45.3%
Right Side	212	11.19%	359	14.6%
Left Side	261	13.77%	409	16.63%
Back	17	0.9%	79	3.21%
Top	7	0.37%	65	2.64%
Undercarriage	5	0.26%	28	1.14%
Unknown	3	0.16%	9	0.37%
Not Coded	452	23.85%	364	14.8%

CIREN crashes, like those in NASS, often involve more than one impact or event. Table 4 shows a count of those crashes where there is only one impact versus those situations where there are multiple impacts or events in the 1,895 CIREN cases.

OUTREACH

The benefit of the partnership between these centers is continuing to grow. Outreach is an important and expanding part of the research that is being conducted by the participating CIREN centers. CIREN served as a building block for many research projects assessing vehicle crashworthiness. It has also become an instrument in the development of training and outreach programs. Outreach activities seek to educate their audiences in the injury mechanisms and crash kinematics of motor vehicle crashes by conducting programs that:

- Emphasize injury mechanisms in real world crashes
- Show the relationship between man and machine
- Emphasize the consequences of misuse (and non-use) of restraint systems

CIREN outreach efforts to date include presentations to train emergency medical technicians, fire, police, and other first providers to look for injury mechanisms that may not be readily apparent (such as a deformed steering wheel under a deployed air bag or marks on a knee bolster). Often the first exposure that first responders have to new technologies (depowered air bags, side air bags, knee bolsters, etc.) is through an outreach activity conducted by one of the CIREN centers. First responders are instructed on how to assess injuries based on simple clues presented by crash type, damage patterns and intrusions. Information that is critical, especially if evidence is not readily apparent can be passed on to emergency room personnel to speed triage. Training also includes clues to help recognize injury mechanisms that may be caused by misuse of restraint systems.

CIREN data are being used to train physicians, surgeons, and emergency room staff to recognize possible occult injuries by looking beyond obvious injury pattern evidence and to ask detailed questions about the crash, not just where the victim was seated. In some cases, knowing specifics about the car can make a difference in treatment and outcome.

We have learned that if only the shoulder strap part of some older seat belt systems is worn, there is a significant risk of a life threatening liver injury. This information was part of some outreach training to law enforcement personnel and other first responders at one of our Centers. An alert police officer responding to a low speed crash is credited with saving a woman's life when he insisted she be transported to the local trauma center when he noticed she only had the shoulder portion of her safety belt fastened. He made the emergency room personnel aware of the circumstances of the crash and relayed what he had learned about the injury mechanism and the possibility of a life-threatening liver injury.

In some cases, knowing specifics about the car can make a difference in treatment and outcome. The car can tell a story. Injury patterns are usually predictable based on crash configuration, crash severity, occupant characteristics and restraint usage.

Figure 2 Side Impact Damage

For example, we know from analyzing side impact crashes in CIREN, if there is intrusion to the lower door panel, we can expect thorax injuries. If the intrusion is to the upper door panel, we can expect head injuries. If the intrusion is to both upper and lower door panels (See Figure 2), we should look for both thorax and pelvic injuries. (See Figure 3) The elderly are much more vulnerable in these types of crashes. Injuries sustained may include posterior rib fractures, pelvic fractures, diaphragm, and aortic injuries, and visceral injuries (lung, liver, spleen, kidney), if seated on the struck panels, we should look for both thorax and pelvic injuries. There are preliminary indications that the elderly are much more vulnerable in these types of crashes. Injuries usually sustained include posterior rib fractures, pelvic fractures (see below), diaphragm, aortic injuries, and visceral injuries (lung, liver, spleen, kidney), if seated on the struck side.

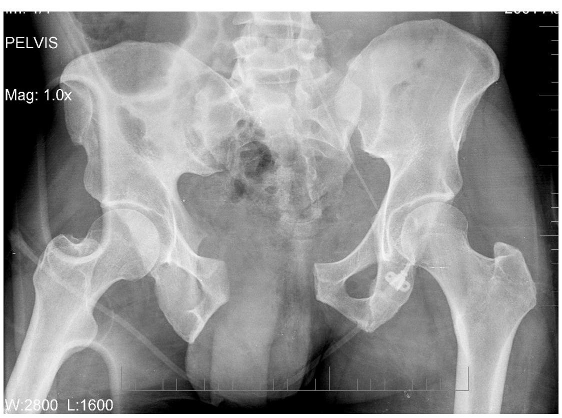

Figure 3 Pelvic Injury

Data from side impact crashes before and after the side impact protection standard (Federal Motor Vehicle Safety Standard No. 214) went into effect are used to illustrate the shift in injury patterns including a reduction in pelvic injuries. We have learned that there is a potential for aortic injuries in side impacts, even without the chest being crushed. According to one of the trauma doctors, "the shape of the chest changes and puts stress on the aorta, " even if there is a frontal air bag."

Figure 4 Frontal Impact Damage

Frontal crashes take on a different scenario. In full frontal crashes, the energy is more evenly distributed and the resulting injury patterns will change. Damage patterns and crush depth can be minor, moderate, or severe (see Figure 4). There is intrusion of the instrument panel and/or toe pan, steering column deformation and A-pillar movement. Injuries associated with full frontal crashes include lateral rib fractures; intestinal injuries attributed to the seatbelt, pelvic injuries and lower extremity injuries. In cases where the driver is unrestrained, there is increased risk of head and chest injuries.

There is also a risk of injuries to the abdomen (liver, spleen, and intestinal injuries from the seat belt loading or steering wheel rim contact), lower extremity injuries (femur/acetabular fractures with the knee loading the instrument panel; and foot, ankle and lower leg fractures (see Figure 5) from the toe pan) in adults, and seat belt injuries to children inappropriately restrained.

Figure 5 Ankle Fracture

In offset frontal crashes, (see Figure 6) since a smaller portion of the car absorbs the energy, there is a greater likelihood of injury with intrusion to the passenger car compartment.

The potential of injury increases with the amount of intrusion into the passenger compartment. This

Figure 6 Offset Frontal Crash

energy can be transferred to the A-pillar (see figukre 7) and the passenger compartment and there is a potential for vehicle rotation. Under these circumstances, there is an increased risk of head injury as well as rib fractures and injury to the thorax.

Children represent another part of the vulnerable population when it comes to motor vehicle crashes. We have learned that in lateral crashes, there is evidence of head, neck, and cervical spine injuries in young children. These injuries are often missed because they are hard to see on films. Also, because of the age of the child, they are often unable to “tell you where it hurts”. Awareness of crash type in motor vehicle crashes helps to make the emergency room staff aware of the possibility of these “occult” injuries and to locate them before they become troublesome. CIREN centers are continuing to analyze injury patterns associated with lateral and other crash types.

Child safety seats and the new tether hook and anchors are being analyzed using the Abbreviated

Injury Scaling (AIS) to assess the injury severity of head and thorax injuries and the sources and mechanisms that result in trauma to these regions.

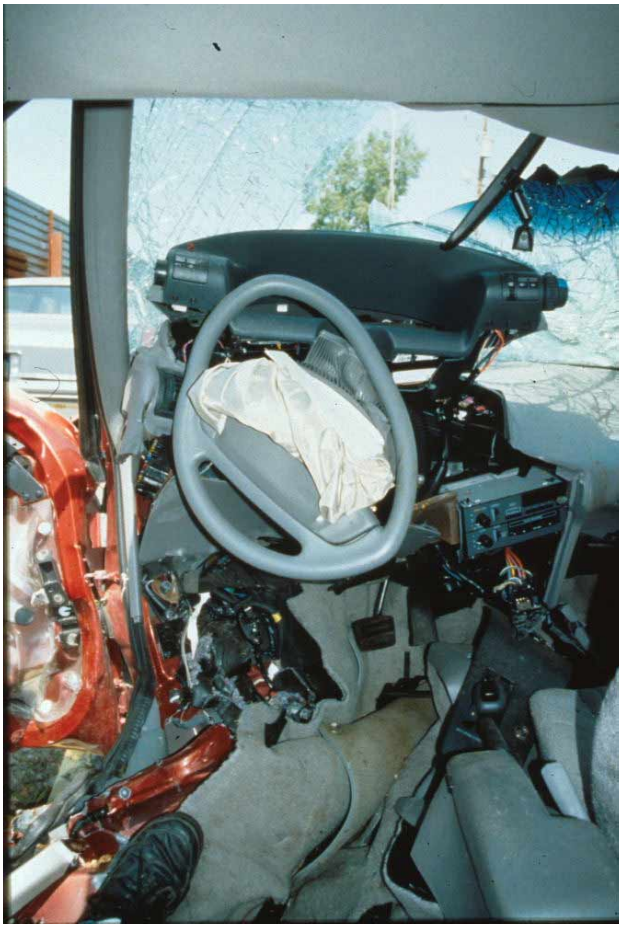

Figure 7 Offset Frontal Intrusion

The combination of crash and injury data available in CIREN is being used to demonstrate to automobile manufacturers and automotive parts designers the effects of equipment on injury prevention or injury causation (if misused). Automobile design has evolved a lot over the last 20 years. Rigid metal gave way to crushable front ends; steering wheels are collapsible; dashboards are padded, and door handles are recessed. More recently, knee bolsters, front and side airbags and seatbelt pretensioners were designed to help dissipate energy or the forces in a crash. However, if these devices do not perform in the real world the way they were anticipated, the detailed injury data collected from CIREN can provide valuable insight.

Outreach efforts have also taken on a "preventative approach." High school students are being taught about the "physics of car crashes." Presentations are aimed at those students that have not yet begun to drive. The content emphasizes the forces involved in a crash and emphasizes the physics of a crash, stressing the importance of belt use. CIREN data are used to illustrate real world injuries sustained in restrained and unrestrained vehicle occupants. As an added reinforcement to always wear safety belts, students are given a plastic car with a smooth clay cylinder and have to use material to restrain and protect the cylinder in different scenarios. It is hoped that these students will have a better understanding of the man/machine interface and drive defensively.

CONCLUSIONS

The engineers and clinicans involved in this research, through their outreach programs, have shown that CIREN data can be used to:

- Anticipate specific injuries associated with specific crashes
- Facilitate triage and transport
- Decrease time to diagnose injuries resulting in faster definitive treatment and better outcomes.

REFERENCES

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