

# How to Use CIREN Data

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## What is the CIREN database?

- Original intent of CIREN to do in-depth investigation of severe injuries in crashes, particularly adding medical and biomechanical detail to what is available in NASS-CDS
- CIREN now contains approximately 2000 completed cases
- About 330 new cases per year



## Sampling Criteria

Adult Inclusion Criteria from CIREN

Crash Type	Crash Direction	Vehicle Model Year	Restraint	Occupant Position	Injury
Frontal	10 to 2 o'clock	Case Year – 8	Bag/Bag+belt	Row 1	AIS 3+ or *
			3-pt belt	Row 2	
Side	8-10 o'clock 2-4 o'clock	Case Year – 8 & FMVSS 214 compliant (MY 1997+)	Any & all	Any	AIS 3+ or *
Rollover	All	Case Year – 8 & FMVSS 214 compliant (MY 1997+)	Any & all except 100% ejection	Any	AIS 3+ or *
Fire	Any	CY – 8	Any & all	Any	AIS 3+ or *

\* AIS of 2 in 2 or more body regions OR AIS 2 in lower extremity with significant articular injury (pilon/talus/calcaneus/Lisfranc/Choparts)



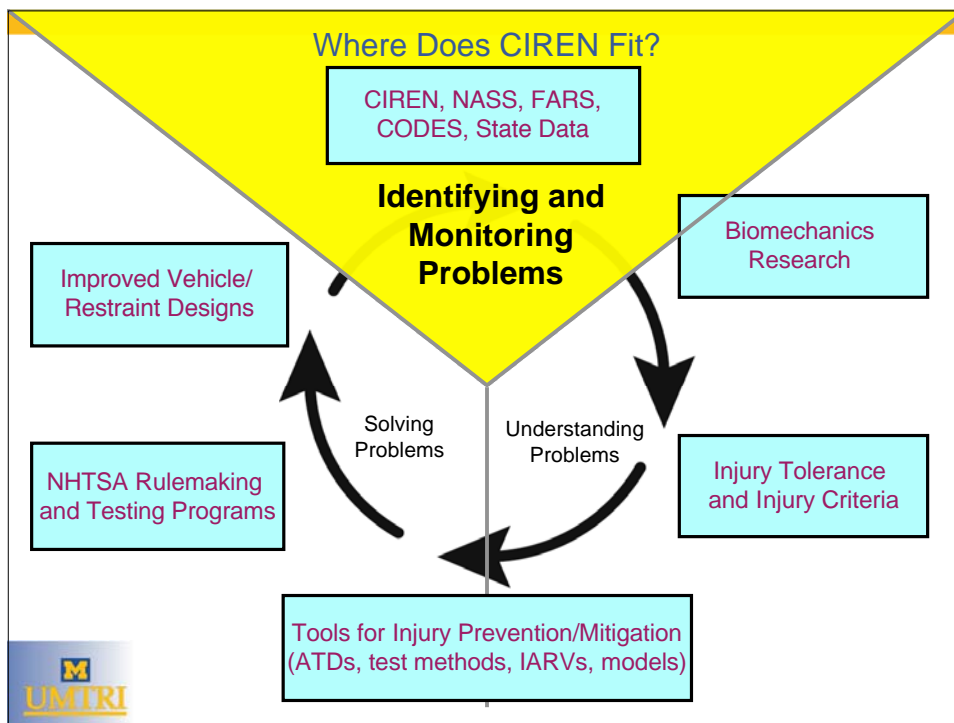
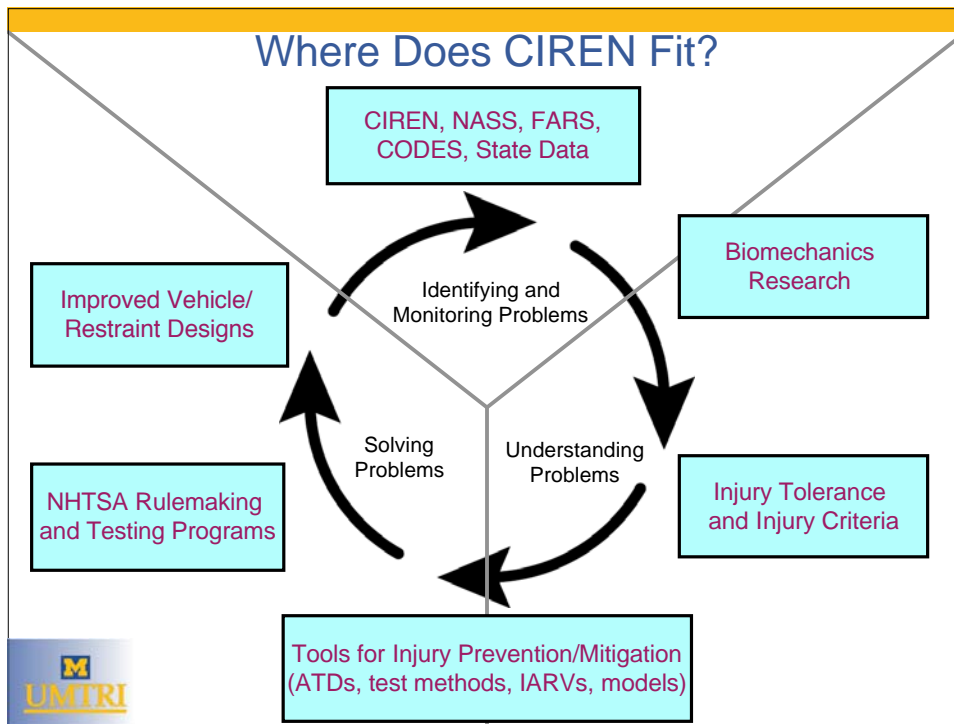
## Sampling Criteria

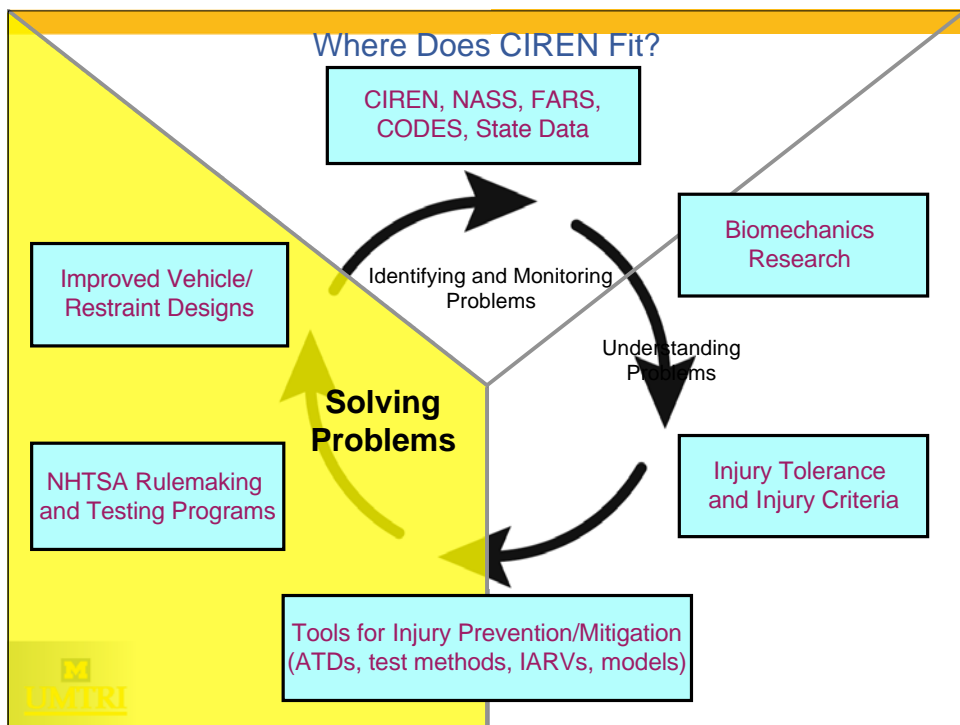
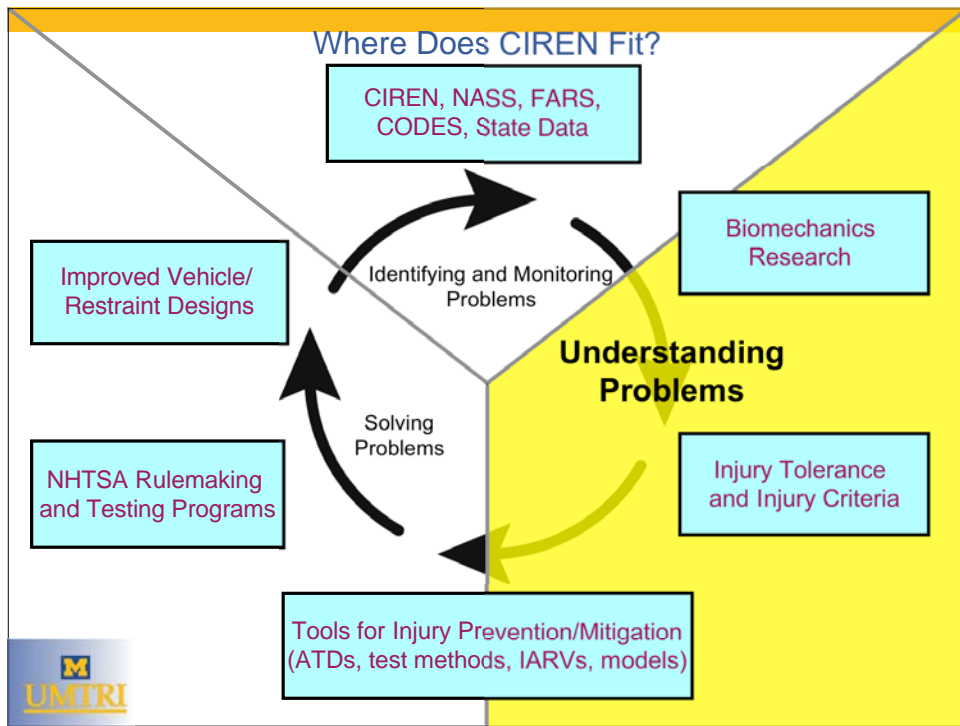
Adult Inclusion Criteria from CIREN

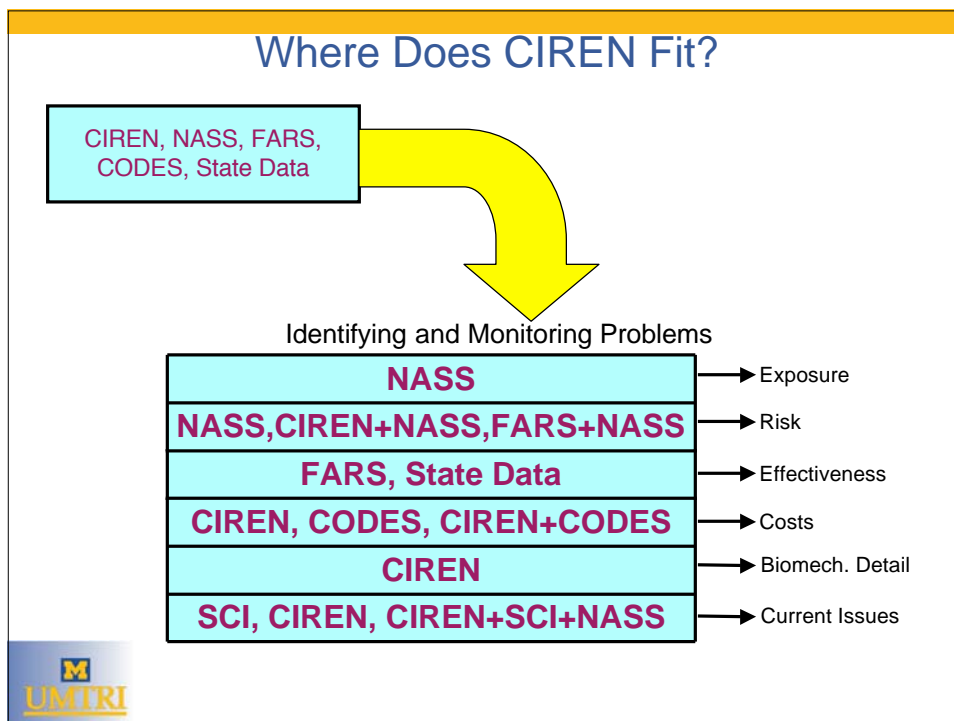
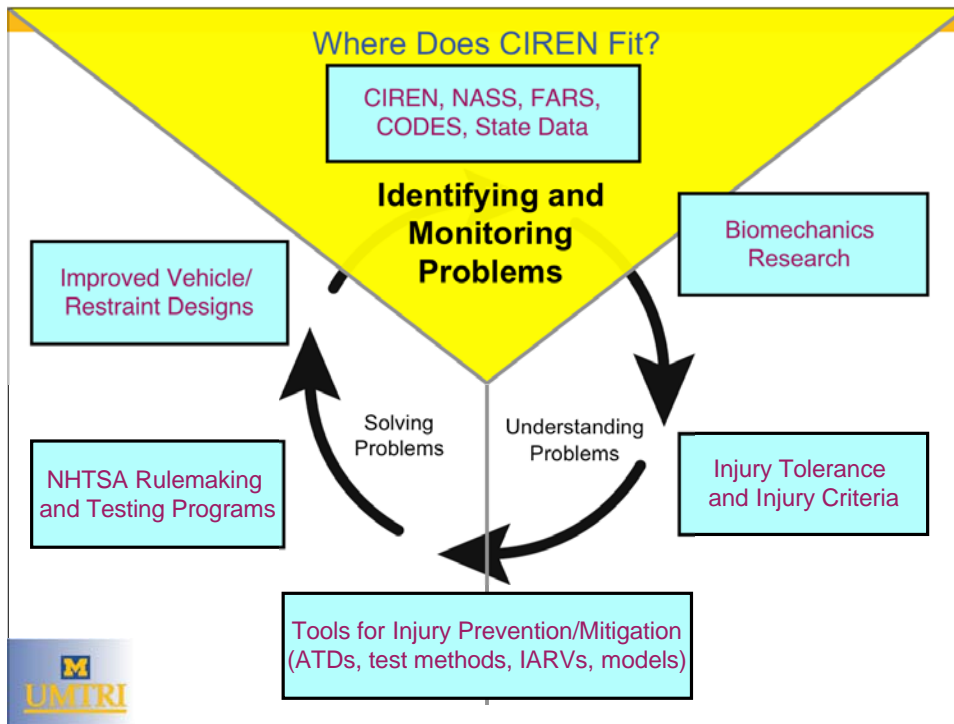
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## Data Analysis

Three general approaches:

- 1) CIREN primary
- 2) CIREN secondary
- 3) CIREN combined



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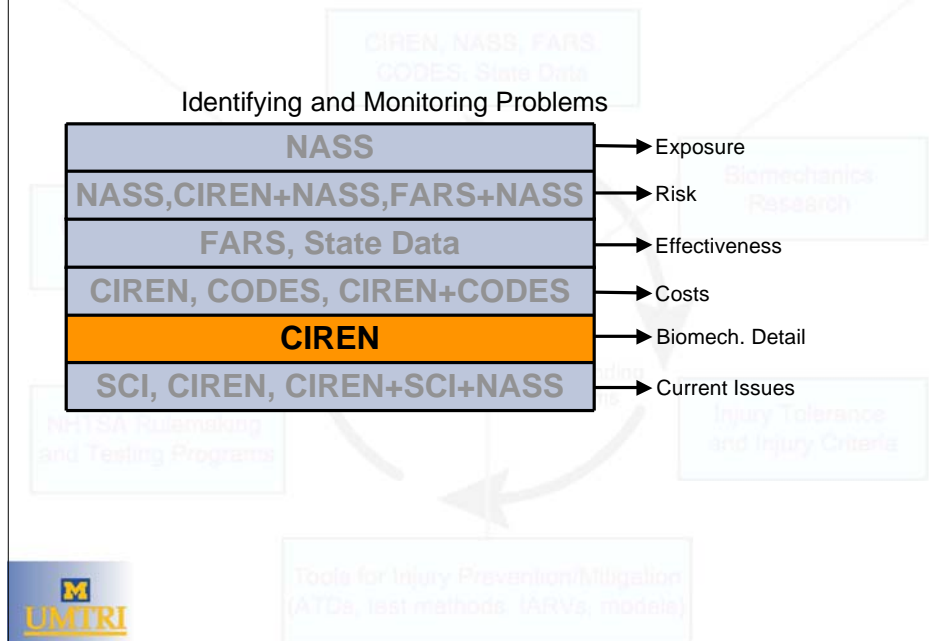
## Data Analysis: CIREN Primary

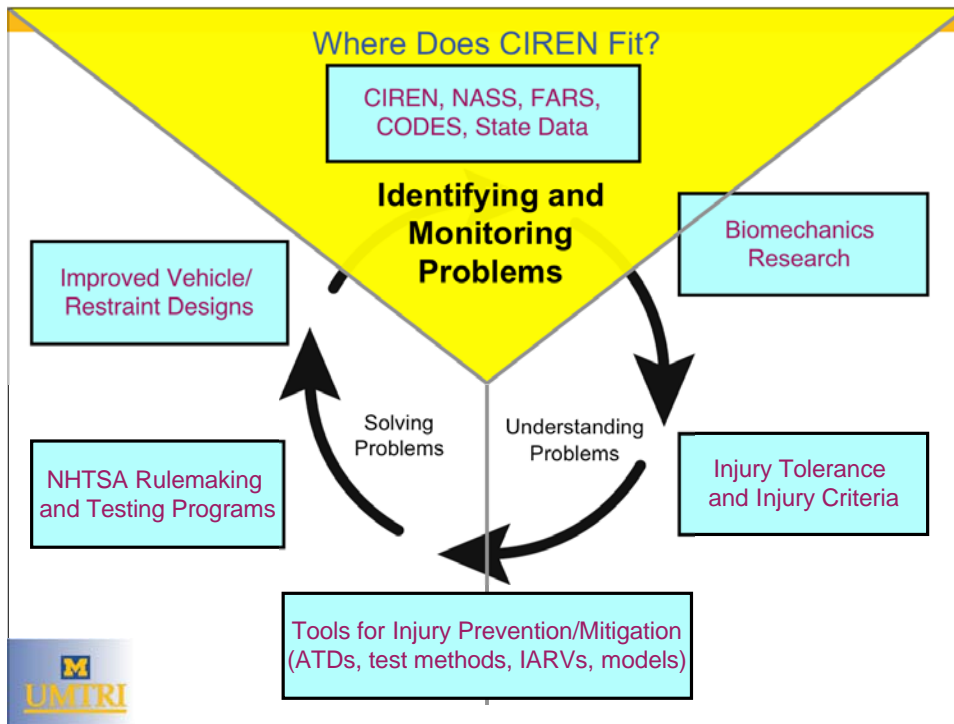
### CIREN Primary

- CIREN-Primary analysis is one in which CIREN serves as the key dataset from which information is being gathered
- Typically aimed at developing injury criteria through a series of steps that will include other data sources as well
- CIREN provides data on the biomechanical scenarios for a large number of cases with the injury(ies) of interest
- CIREN serves the critical function of providing “real-world” cases for validating subsequent modeling and cadaver testing



## Where Does CIREN Fit?





## Data Analysis: CIREN Primary KTH Example

### Sentinel Dataset

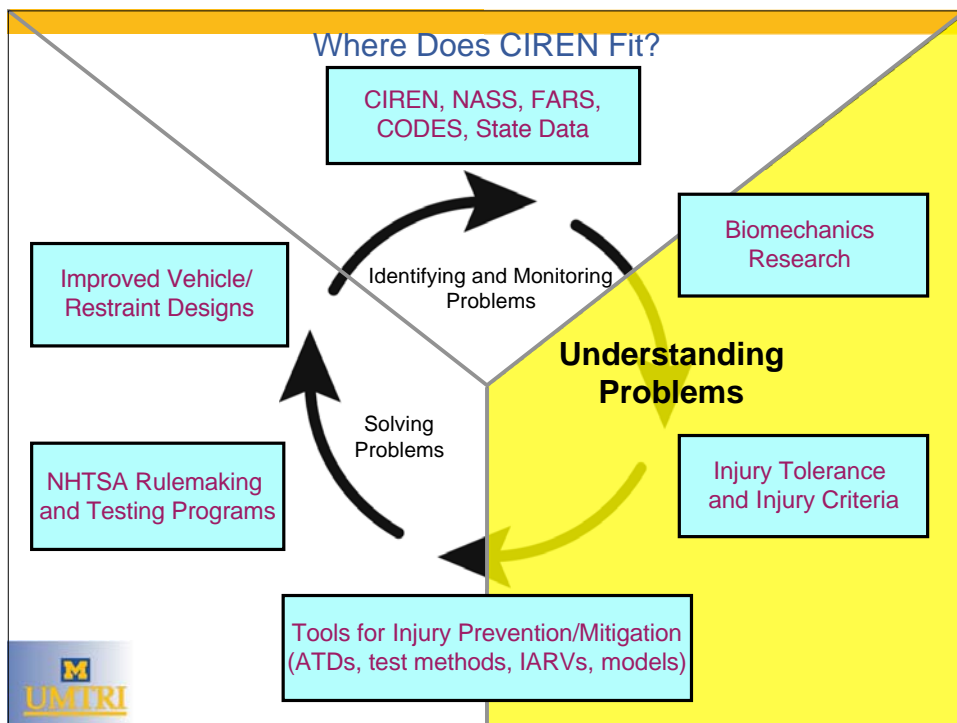
- Because CIREN contains a large set of the most serious injuries being seen in MVC's, injuries that increase in frequency because of some general change in crash conditions will increase in frequency in CIREN
- Changes can result from any of a number of sources: e.g., safety systems becoming more prevalent in the fleet, changes in crash patterns, and injury-relevant changes in demographics



## Data Analysis: CIREN Primary KTH Example

### Sentinel Dataset

- Unexpectedly large number of hip injuries in frontal crashes in early CIREN cases
- Occupants of newer model vehicles were experiencing more hip injuries and less knee and less knee and thigh injuries



## Data Analysis: CIREN Primary KTH Example

### Biomechanical Analysis

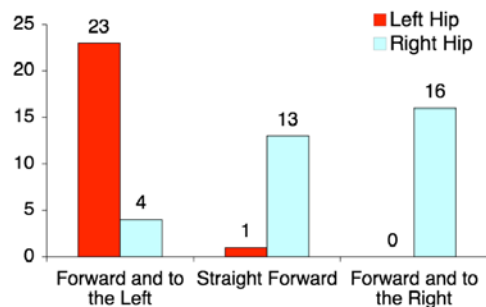
- The critical first step for virtually all analysis of CIREN is to select a crash type and an injury definition, and limit data analysis to those cases that meet these criteria
- In the KTH case, crash type was frontal and injuries were to knee, thigh, or hip



## Data Analysis: CIREN Primary KTH Example

### Biomechanical Analysis

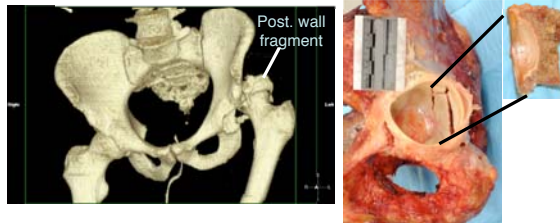
- The next step is to look at aspects of the injuries and their causation across the relevant crashes



## Data Analysis: CIREN Primary KTH Example

### Biomechanical Analysis

- Finally, cases in CIREN can be modeled using FEM or their conditions replicated in cadaver testing
- The key element of this step is that matching the outcome of CIREN cases represent the goal of any modeling or cadaver-testing; CIREN provides “real-world” validation



## Data Analysis

Three general approaches:

- 1) CIREN primary
- 2) CIREN secondary
- 3) CIREN combined



## Data Analysis: CIREN Secondary

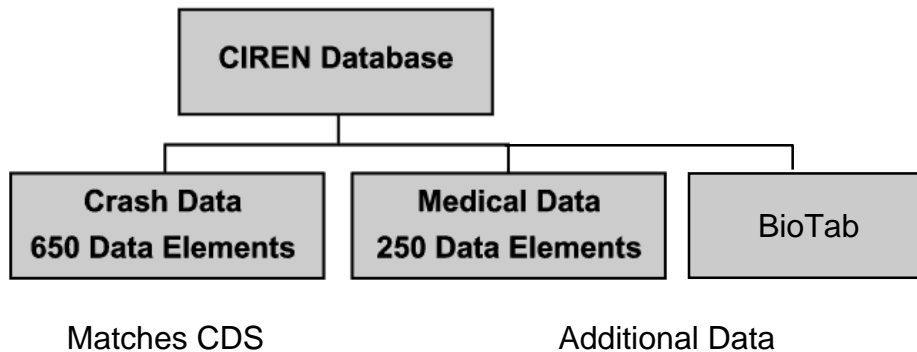
### CIREN Secondary

- CIREN contains more detail about medical condition than other databases, such as NASS-CDS
- Can be used to enhance results of NASS-CDS analysis with detail



## Data Analysis: CIREN Secondary

### CIREN Database Structure



Source: CIREN Program Report, 2002, NHTSA website

## Data Analysis: CIREN Secondary

### Example:

Detailing frequency of pelvis injury types

Use relative percent of pelvis injury types among CIREN pelvis-injured occupants, possibly changing w/ age

For example, from CIREN, we learn that acetabular fractures make up about 67% of injuries to the pelvis



## Data Analysis: CIREN Secondary

### Example:

Use CDS for overall frequency (or risk) of pelvis injury & then multiply by relative percent from above

If there are ~8.9k pelvis injuries per year from CDS, then acetabular fractures should be about 2/3 of that number, or ~6k.



## Data Analysis: What About Risk?

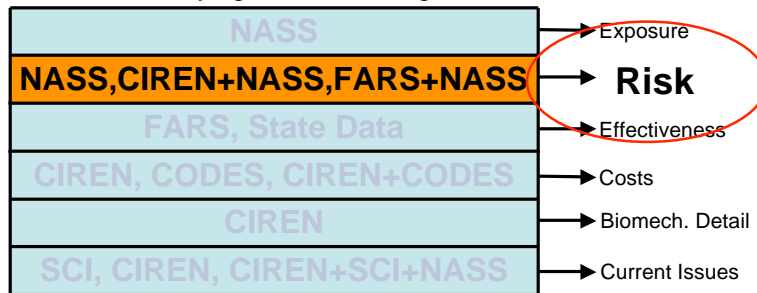
Three general approaches:

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## Where Does CIREN Fit?

Identifying and Monitoring Problems



## Data Analysis: CIREN Combined

- The key to understanding how CIREN might be used to estimate risk or at least relative risk is in the inclusion criteria
- The key inclusion criterion is the injury criterion; this makes CIREN an outcome-based sample, rather than a cohort (a random sample without regard to outcome)



## Data Analysis: CIREN Combined

- The first inclination is to select an injury (e.g., head) and possibly a crash type within CIREN, designate those occupants as “head-injured” and then use the remaining CIREN cases with the same crash type as “not head-injured”
- With these groups, it is computationally possible to perform logistic regression and compute risk statistics

$$\text{risk} = \frac{\# \text{injured}}{\# \text{exposed}} = \frac{\# \text{injured}}{(\# \text{injured} + \# \text{uninjured})}$$



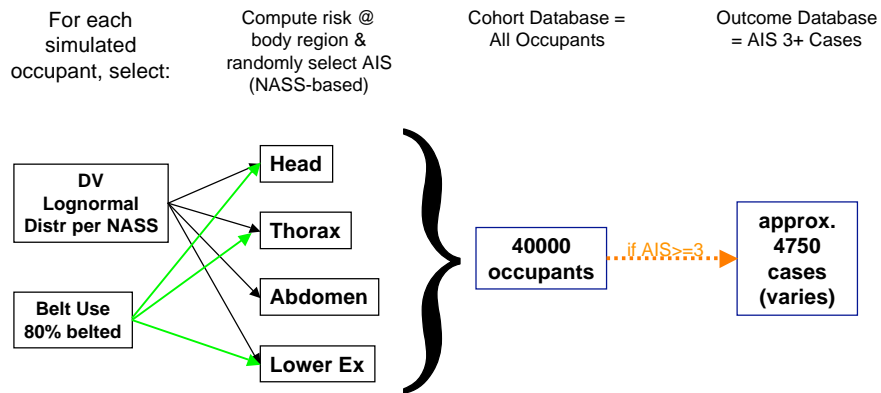
## Data Analysis: CIREN Combined

- However, strange things happen
  - Often, there is no significant effect of delta-V or belt use
- So we decided to look into it by running a simulation



## Data Analysis: CIREN Combined

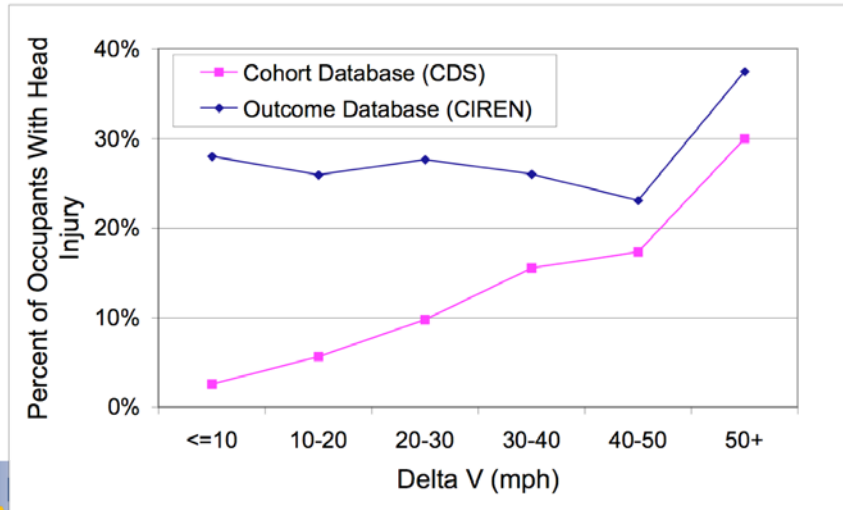
### Simulation





## Data Analysis: CIREN Combined

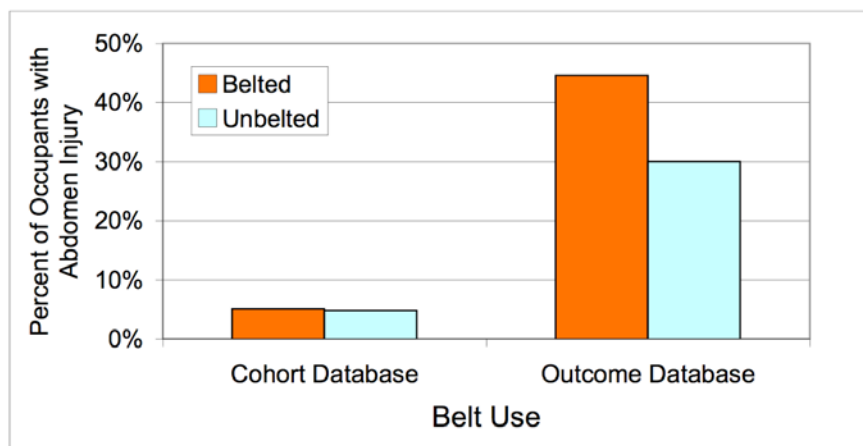
### Simulation



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## Data Analysis: CIREN Combined

### Simulation



UMTRI

## Data Analysis: CIREN Combined

### Simulation

What is going on?

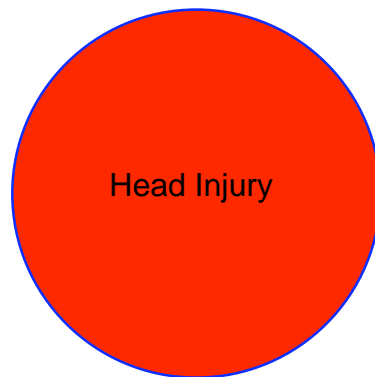
- The case-database results are influenced by the nature of the occupants who represent the “uninjured” group
- These occupants are injured, and their crash and restraint conditions reflect that

$$risk = \frac{\#injured}{\#exposed} = \frac{\#injured}{(\#injured + \#uninjured)}$$



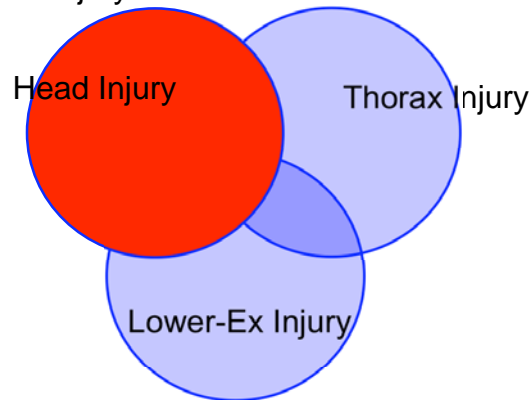
## Data Analysis: CIREN Combined

- If CIREN contained only one type of injury, e.g., head injury, it would be obvious that more information is necessary to estimate risk because there would be no uninjured cases



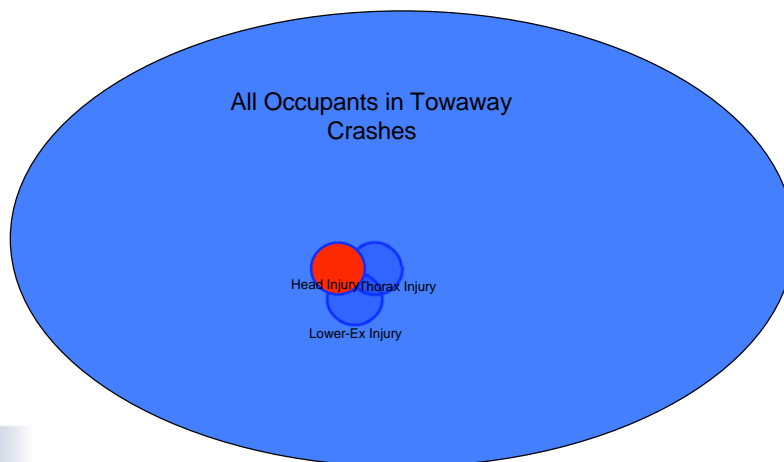
## Data Analysis: CIREN Combined

- However, with many occupants having different kinds of injuries, CIREN appears to have a group that could be labeled “uninjured” relative to a particular injury



## Data Analysis: CIREN Combined

- The appropriate “uninjured” group is the larger group of all occupants not available in CIREN



## Data Analysis: CIREN Combined

How Can CIREN Be Used to Estimate Risk??

An outcome-based sample cannot be used to estimate risk or relative risk without some kind of additional information



## Data Analysis: CIREN Combined

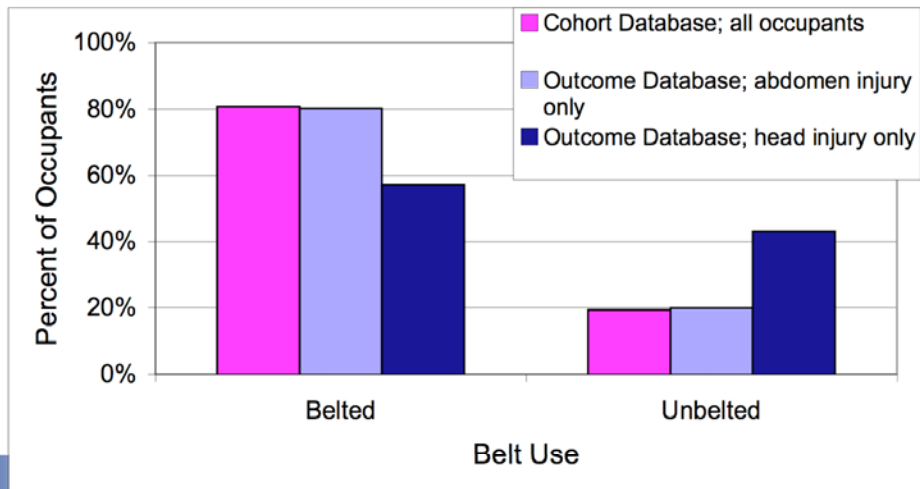
What Additional Information?

- 1) Exposure estimates
  - 2) Data on uninjured occupants
- => CIREN Combined



## Data Analysis: CIREN Combined

### Exposure estimates



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## Data Analysis: CIREN Combined

### Using Exposure

$$RR = \frac{RR_{obs}}{RR_{exp}}$$

Allows estimation of underlying risk ratio (e.g., unbelted/belted) from observed risk ratio in outcome database plus exposure

UMTRI

## Data Analysis: CIREN Combined

### Case-Control Methodology

- Epidemiology literature
- Breslow (1996)--Great lit review of case-control methods



## Data Analysis: CIREN Combined

### Classic Case-Control Methodology

- Basic concept of case-control is to select injured occupants (“cases”) from CIREN and select uninjured occupants (“controls”) from NASS-CDS
- In classic case-control, both cases and controls would be subject to the same crash-type restrictions, but other variables would be free to vary
- Any variables left free to vary would be viable candidates for predictors in estimating relative risk



## Data Analysis: CIREN Combined

### Classic Case-Control Methodology

- Logistic regression can be used with this combined dataset
- Odds ratios (e.g., estimated effects of delta-V, restraint use and other predictors) are unbiased
- Intercept is biased, so absolute risk is overestimated as well



## Data Analysis: CIREN Combined

### Classic Case-Control Methodology

- For low-probability events, such as severe injury, odds ratios are a reasonable estimate of relative risk
- If an outside estimate of overall risk is available, the intercept can be corrected

$$\beta' = \beta_0 - \ln\left(\frac{1-\tau}{\tau} \frac{p}{1-p}\right)$$

Where  $\beta'$  is the corrected intercept,  
 $\beta_0$  is the estimated intercept,  
 $\tau$  is the population proportion of cases, and  
 $p$  is the sample proportion of cases



## Data Analysis: CIREN Combined

Sounds too good to be true...

- Caveat #1: Logistic regression is sensitive to misspecification of the model; so, the parameters are unbiased using a case-control sample, but the model has to be carefully specified and checked against other data sources wherever possible



## Data Analysis: CIREN Combined

Sounds too good to be true...

- Caveat #2: The cases & controls must be random samples from the same basic population, aside from their different outcomes

Which led to...





## Data Analysis: CIREN Combined

An investigation of the potential to combine CIREN cases and NASS-CDS cases

- Caveat #2 simply means that if occupants from the case dataset are limited or biased in some way, selection of occupants from the control dataset need to be comparable
- For example, adult CIREN inclusion criteria generally restrict crash types to frontal, side, and rollover; this restriction needs to extend to selection of controls from CDS



## Data Analysis: CIREN Combined

An investigation of the potential to combine CIREN cases and NASS-CDS cases

- If the injured occupants that appear on the doorsteps of CIREN centers are a completely random sample of all injured occupants, and if the inclusion criteria are applied perfectly in practice, then the inclusion criteria are all we need to know
- However, allowing for the possibility of an imperfect world, we compared CIREN to CDS to see how the sets of cases in each compare



## Data Analysis: CIREN Combined

An investigation of the potential to combine CIREN cases and NASS-CDS cases

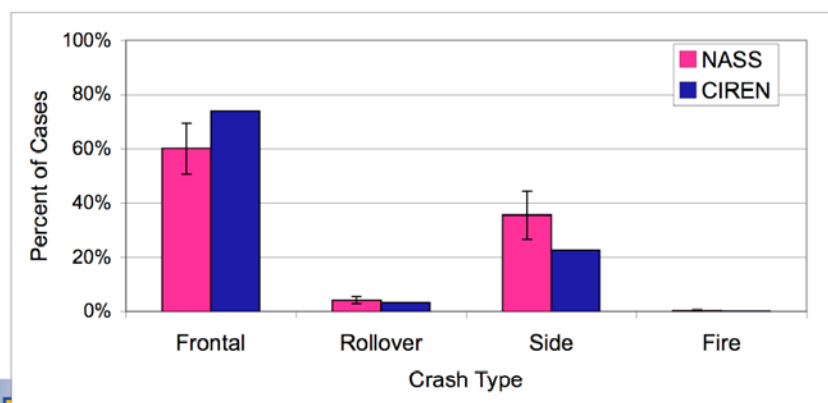
- The important comparison is between cases in CDS & CIREN, so the CIREN sampling criteria for adults were applied to CDS to generate a comparable database
- The simple distributions of many variables were compared
- The goal was to identify areas where the databases differ in order to refine the use of case-control methodology to account for these differences



## Data Analysis: CIREN Combined

An investigation of the potential to combine CIREN cases and NASS-CDS cases

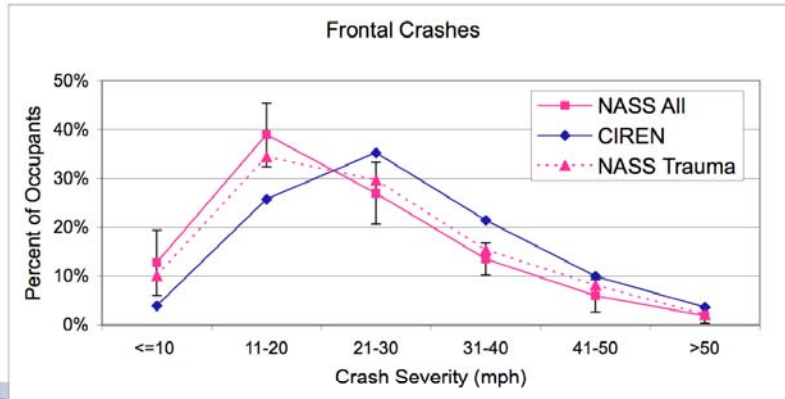
### Crash Type Distribution



## Data Analysis: CIREN Combined

An investigation of the potential to combine CIREN cases and NASS-CDS cases

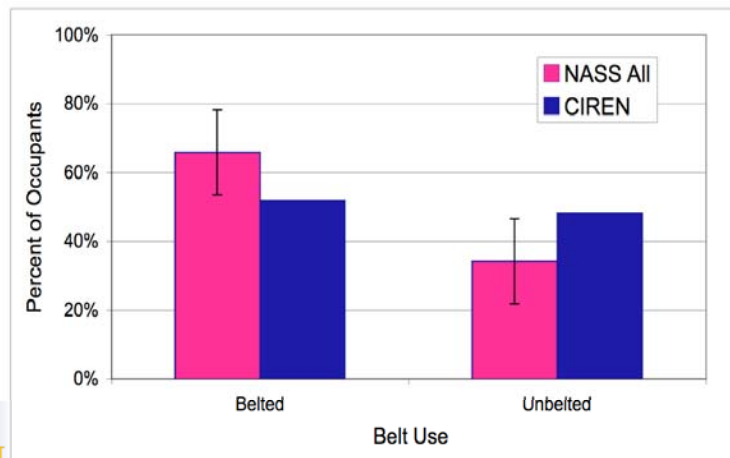
### Crash-Severity Distribution



## Data Analysis: CIREN Combined

An investigation of the potential to combine CIREN cases and NASS-CDS cases

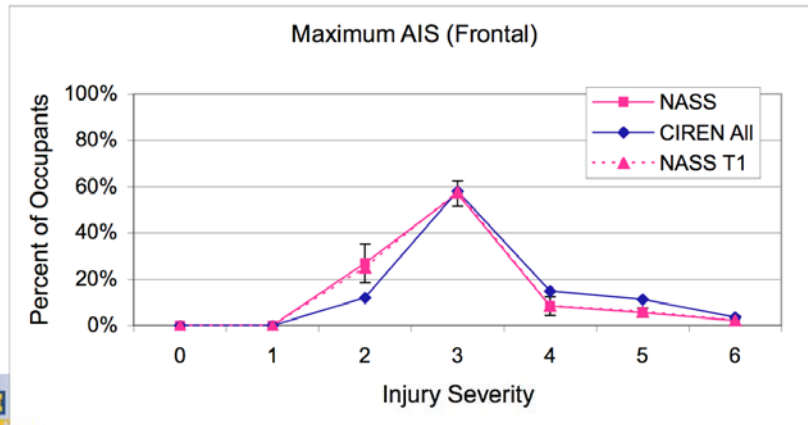
### Belt Use Distribution



## Data Analysis: CIREN Combined

An investigation of the potential to combine CIREN cases and NASS-CDS cases

### Injury-Severity Distribution



## Data Analysis: CIREN Combined

An investigation of the potential to combine CIREN cases and NASS-CDS cases

- To summarize, most variables in the two datasets had similar distributions with the exception of crash severity, belt use, and injury level
- These three variables are potentially internally consistent--in other words, higher crash severity and lower belt use both lead to greater injury levels



## Data Analysis: CIREN Combined

An investigation of the potential to combine CIREN cases and NASS-CDS cases

- However, to check that these differences really are consistent, we used case-control methodology to investigate further



## Data Analysis: CIREN Combined

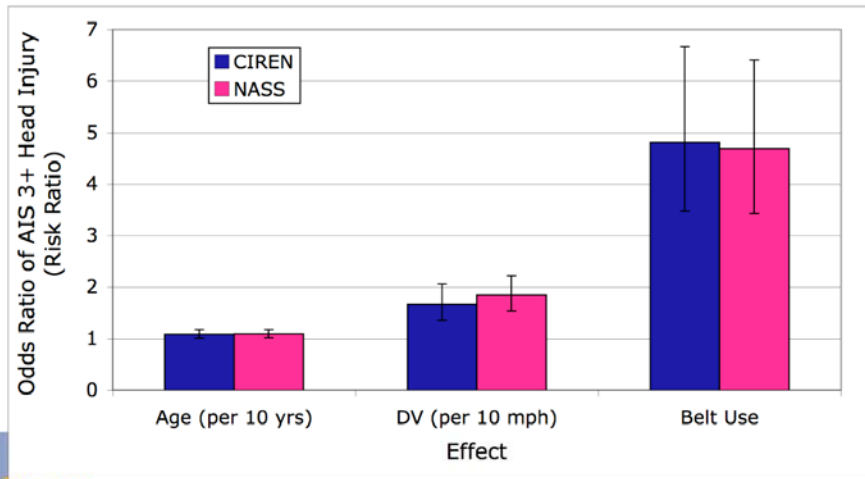
An investigation of the similarity between CIREN cases and NASS-CDS cases

- 1) We selected a control sample of occupants in frontal crashes with no head injury from NASS-CDS; CIREN sampling applied (MY, restraint, etc.)
- 2) We selected two case samples of head-injured occupants in frontal crashes, one from CIREN, and one from NASS-CDS
- 3) Using cumulative logistic regression, we estimated the odds ratios for delta-V and belt use and compared the two results



## Data Analysis: CIREN Combined

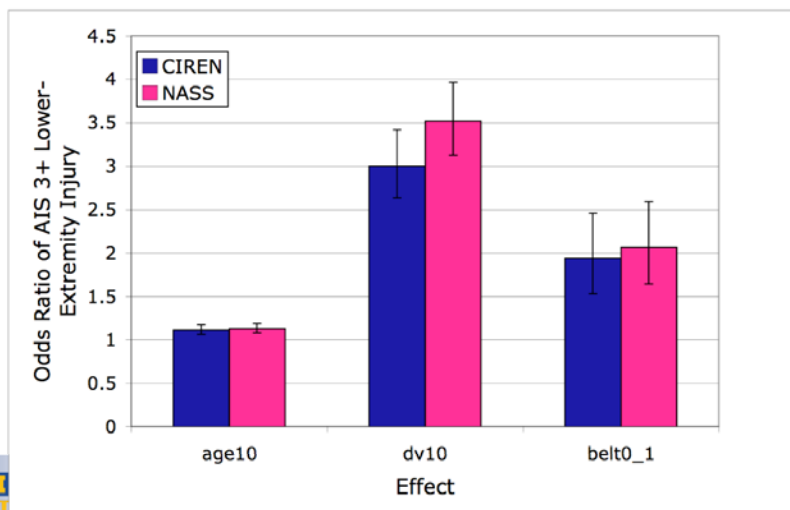
An investigation of case-control methods



UMLRI

## Data Analysis: CIREN Combined

An investigation of case-control methods



UMLRI

## Data Analysis: CIREN Combined

### Matched Case-Control

- For variables that may selectively differ between CIREN and CDS (e.g., delta-V) or for greater control of the comparison between cases & controls, it is possible to use the matched case-control
- In matched case-control, the controls are selected so that they match each case (there can be many controls for each case) on one or more variables (e.g., dV)
- The disadvantage of matching is that the effect of the matching variable cannot be estimated, although interactions with the matching variable(s) can



## Data Analysis: CIREN Combined

- Another approach to this problem was presented at the Sept. 2006 public meeting by Wake Forest
- Their approach involves using Mahalanobis' D as a metric for measuring how similar a CIREN case is to the world of CDS cases (selected using CIREN inclusion criteria)
- Our simple analysis was designed to identify variables that need to be matched or limited in the use of case-control methods
- Mahalanobis' D can potentially be used to select CIREN cases to avoid the need for matching



## Summary

Three general approaches:

- 1) CIREN primary
- 2) CIREN secondary
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## Summary

CIREN combined summary

An outcome-based sample  
cannot be used to estimate risk  
or relative risk without some kind  
of additional information





## Summary

### CIREN combined summary

- Case-control methods open up the possibility of estimating risk using CIREN data, combined with outside information
- This approach requires care in setting up models and interpreting results



## Summary

### CIREN combined summary

- Further investigation is needed (& underway) to understand the nature of differences between CIREN injured and the general population of injured occupants
- Methods such as Mahalanobis D and matching offer the possibility of controlling for these differences



## Summary

### CIREN combined summary

- The ability to use CIREN cases in case-control analyses makes it possible to analyze risk of less-common injuries where CDS has too few cases to generate reasonable models
- Such risk estimates, combined with the extensive biomechanical detail makes CIREN a powerful tool for improving crashworthiness



## Thank You

### NHTSA

Refaat Hanna  
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