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## COMPARING SOURCES OF AIR BAG INFORMATION AND THEIR IMPLICATION IN REPORTING LOWER EXTREMITY INJURIES

Segui-Gomez M., MD, MPH and Lesochier, J., PhD

Harvard Injury Control Center  
Boston, Massachusetts

### ABSTRACT

Reports in the literature about injuries in airbag-equipped motor-vehicle crashes have used different sources of information to determine air bag status. Other than resource consuming crash investigations, these include: hospital records, accident reports, and structural vehicle information obtained from the VIN# or specialized journals.

The purpose of the present analysis is to assess the agreement regarding air bag status among these sources and compare the effect that different classifications might have on the characterization of injuries. We focus the analysis on the effect of source of air bag information on the distribution and nature of Lower Extremity Injuries (LEIs).

As a part of a larger pilot that linked trauma registry records with motor-vehicle crash reports, we analyzed 52 linked records of drivers in cars of model/year  $\geq$  1987. Air bag status for each case was obtained from trauma registry, crash report, and journals. Each source led to a different number of cases with air bag: four based on trauma registry data, three using crash reports, and seven with journals. Only for one case there was agreement among the three sources. In two other cases, two sources agreed. The seven remaining cases had air bag in only one data source.

Based on diagnoses reported by the trauma registry, 18 drivers had at least one LEI, with a total of 28 LEI diagnoses. The most commonly reported LEIs were fractures. The number of LEI diagnoses per driver varied by air bag status classification, being the lowest when crash information was used. The nature of LEI differed by the type of air bag source. Using crash information, air bag drivers sustained only superficial LEIs, whereas according to journal data such drivers presented only fractures and open wounds. The distribution of AIS severity scores for LEIs among drivers with air bag also differed by source; according to crash information all injuries were minor, but when using journals, all were moderate.

Although the sample for this investigation was small, it raises questions about the comparability of reports that use different sources of information regarding air bag status, and provides a framework for further research.

# Comparing Sources of Airbag Information And Their Implications For Reporting Pelvic And Lower Extremity Injuries

*Maria Segui-Gomez & Hana Lescohier  
Harvard Injury Control Center*

## ABSTRACT

Reports in the literature about injuries in airbag-equipped motor-vehicle crashes have used different sources of information to determine airbag status. Other than resource-consuming crash investigations, these include: medical records, crash reports, and structural vehicle information obtained from the Vehicle Identification Number or manufacturers' information.

The purpose of the present analysis is to assess the agreement regarding airbag status among sources and compare the effect of different classifications on the characterization of injuries, particularly Pelvic and Lower Extremity Injuries (PLEIs).

As part of a larger study that linked trauma-registry records with motor-vehicle crash reports, we analyzed 52 records of drivers in cars of model/year  $\geq$  1988. Airbag status for each case was obtained from medical records, crash reports, and manufacturers' information. Each source identified a different number of cases with airbag: four were detected in medical records, three using crash reports, and seven with the manufacturers' information. Only one case had agreement among all three sources. In two other cases, two sources agreed, and in seven cases, airbag presence was noted by only one data source.

Based on diagnoses reported by trauma registries, eighteen drivers had at least one PLEI, with a total of 28 PLEI diagnoses. The most commonly reported PLEIs were fractures. The number of PLEI diagnoses per driver varied by airbag status classification, being the lowest when crash information was used. The nature of PLEIs differed by source of airbag data. Using crash information, airbag-drivers sustained only superficial PLEIs, whereas according to

manufacturers' data such drivers presented only fractures and open wounds. The distribution of AIS severity scores for PLEIs among drivers with airbags also differed by source; according to crash information all injuries were minor, but when using manufacturers' classification, all were moderate.

Although the sample for this investigation was small, the findings raise questions about the comparability of reports that use different sources of information regarding airbag status, and provide a framework for further research.

## INTRODUCTION

Since the mid 1970's (when airbags were first installed in vehicles), researchers have been evaluating airbag effectiveness in reducing crash-associated mortality and morbidity by comparing crash outcomes for car occupants protected by airbags with crash outcomes for those who were not protected. A key element in such research is, therefore, the ability to accurately classify occupants in crashes according to airbag status.

In order to determine airbag status, different sources of information have been used. Some researchers have used car specific airbag equipment information encoded in the Vehicle Identification Number (VIN).<sup>1-5</sup> Another source used for ascertaining the presence of airbag equipment is the manufacturers' information pertaining to each model/year car.<sup>6</sup> However, research based on these sources has limitations because the presence of an airbag in the vehicle does not necessarily imply that the airbag actually deployed. One method used to address this problem is adding crash-severity criteria as controls in

approximating airbag deployment.<sup>7</sup> The majority of airbag evaluations that apply an analytical/statistical approach to crash data sets have relied on airbag-equipment data sources to determine airbag status.

A second approach for classifying occupants in crashes by airbag status uses actual deployment of the airbag as a sole criterion. Information on airbag deployment may be found in different sources: crash investigations conducted by research teams,<sup>8,9</sup> crash reports filed by police or drivers, medical records,<sup>10,11</sup> and airbag module replacement requests in insurance claim databases.<sup>12</sup> Some studies have relied on non-routine sources such as reports by auto mechanics.<sup>14</sup> Most of the case studies or case series reports of airbag-mediated injuries published in the medical literature use this second approach. Unfortunately, with the exception of the papers noted above, the specific source of airbag-deployment information is seldom noted.

Currently, little is known about the validity of each data source or the level of agreement among them. It is fair to assume that discrepancies among sources do exist as a result of the different approaches employed to determine airbag status (equipment vs. deployment) and the different manner in which data are collected and recorded. The implications for injury descriptions are also unknown.

Since frontal airbags are designed to protect primarily the head and upper torso - thus improving survival - it is expected that as the number of airbags increases, there will be a decline in the number and severity of injuries to these body regions, while PLEIs will rise. Although PLEIs are usually not life threatening, such injuries result in extensive disability and concomitant economic and personal costs<sup>15</sup> and warrant, therefore, warranting additional research.

The purpose of the present analysis is to identify the level of agreement regarding airbag status among three data sources, and assess the effect of different airbag-status classifications on the characterization of injuries. Since recent research indicates that airbags may not be effective in preventing Pelvic and Lower Extremity Injuries (PLEIs),<sup>16</sup> and further research is expected on this topic, we focus on the implications of source of airbag information for the distribution and nature of PLEIs.

## METHODS

In preparation for a project on airbag-associated injuries, we conducted a pilot study to assess linkage of

data sources and to evaluate data quality. We collected information from the six adult Level-I trauma centers in Massachusetts on 238 drivers injured in motor-vehicle crashes who were admitted to these hospitals during the two month period of May-June, 1993. Data submitted by each hospital-based trauma registry included patient identifiers and demographics, injury circumstances (e.g., location where the crash occurred, safety devices), and injury outcomes (e.g., ICD-9-CM diagnoses, length of stay, discharge disposition). Injury severity for each patient was assessed by admission Glasgow Coma Scale (GCS) scores provided by the hospitals, and by Abbreviated Injury Scores (AIS) and Injury Severity Scale (ISS) scores derived from submitted diagnoses through the computerized mapping algorithm ICDMAP.<sup>17</sup> Second, we used patients' identifiers to search databases at the Massachusetts Registry of Motor Vehicles and link the hospital data with information about the vehicle (i.e., make/model/year, type of plate/plate#, VIN) and the crash. Crash reports provided information about safety devices, direction of impact, object against which the vehicle collided, ejection from vehicle, and estimated cost of repair. Finally, data regarding airbag presence in the vehicle were also obtained from manufacturers' information published in the Market Data Book for each vehicle's make/model/year.<sup>18</sup>

Analysis for this paper was performed on 52 patients for whom: (1) data source linkage was successful, (2) both medical and crash report data were available, and (3) the vehicle involved in the crash was of model year 1988 or newer (since the proportion of cars equipped with driver-side airbags in model years prior to 1988 was less than 2%).<sup>19</sup> These 52 cases were classified by airbag status according to three different sources of information: medical records (obtained from hospital-based trauma registries), crash reports (obtained from the Massachusetts Registry of Motor Vehicles), and manufacturers' information (available in the journal Market Data Book). Vindicator<sup>20</sup> was not used to decode the airbag-equipment information since we were able to find the VIN for only 23 out of the 52 cases. Demographic, injury, and outcome variables were compared for drivers with and without airbags across the different sources of airbag information. Significance tests were not performed because of the small size of the sample and the descriptive nature of the analysis.

## RESULTS

**AIRBAG STATUS.** There was little agreement on airbag status among the three sources of information

examined. Each source reported a different number of airbag-involved cases. The medical records listed four patients where the airbags deployed, the crash reports identified three such cases, and according to the manufacturers' information, seven of the crashed vehicles were equipped with driver-side airbags. Overall, ten patients with an airbag were identified by the three sources combined. When the different sources were compared for each case, the disagreement was apparent. In seven of the cases an airbag was reported by a single source (one by medical records, one by crash reports, and five by manufacturers' model/year information); in two cases an airbag was reported by two data sources (for one case medical and crash reports agreed, and in another case medical and manufacturers' information agreed), in only one case there was an agreement by all three sources of information. These results are presented in Table 1.

Table 1. Agreement on Airbag Status Among Sources of Information (n = 52).

<i>Air bag Present</i>			
Medical record	Crash reports	Manufacturers'	Total
x	x	x	1
x	x		1
x		x	1
x			1
	x		1
		x	5
4	3	7	10
<i>Air bag Present</i>			
Medical record	Crash reports	Manufacturers'	Total
48	49	45	42

**DEMOGRAPHICS.** The male to female ratio was 1.4 for the sample as a whole. When airbag status was considered, the male/female ratio for patients injured in non-airbag crashes was similar to the overall ratio. This was true for all three groups classified by source of information. In airbag crashes, females outnumbered males according to all three sources of information although the proportions varied by source.

Mean age for patients in the sample was 41.6 years. About half of the patients (24 cases) were less than 35 years old. The age distribution for groups classified as non-airbag was similar to that of the total sample. Age distribution for patients with an airbag present differed by source of information. Among the groups identified with airbag by both medical records and manufacturers' information there was an even age distribution. But the crash-reports airbag group had a

skewed distribution with no patients older than 44 years of age.

**INJURY CHARACTERIZATION.** Injuries were described by number and type of diagnoses and severity measures.

**Diagnoses:** Trauma registries reported up to ten diagnoses per patient. Overall, two hundred and forty (240) diagnoses were reported for all 52 patients. Eighteen non-trauma diagnoses (ICD-9-CM other than 800-959) were excluded from further analysis. Thus, the average number of trauma diagnoses per patient was 4.2. The most commonly affected body region was external, followed by head & neck, thorax, upper extremities, and lower extremities. Contusions and lacerations were the most frequent diagnoses reported, followed by open wounds to the head, intracranial injuries, and fractures of the upper extremities. These distributions were consistent when compared by airbag status for the three sources of information.

Among the 222 trauma diagnoses reported, twenty eight (13%) were of Pelvic and Lower Extremity Injuries (PLEIs). These are discussed later in this section.

**Severity.** Two measures of injury severity were used. ISS were available for 44 patients. Mild injuries (ISS = 8) accounted for more than half of the sample (23 patients). There were 12 patients with moderate injuries (ISS = 9-15), and nine patients with severe injuries (ISS = 16). ISS distributions were similar when analyzed by airbag status across the different data sources.

GCS scores at arrival to the trauma centers were available for 47 patients. Thirty-nine of them were conscious (GCS2 ≥ 13), three patients had an altered level of consciousness (GCS = 5-12), and five patients were comatose (GCS ≤ 4). When the distribution of GCS scores by airbag status was considered, no differences were found by source.

**OUTCOMES.** Discharge disposition was used as a proxy for injury outcome. Out of the 52 cases, thirty-four were discharged home and three died in the hospital. The remaining 15 patients were discharged either to home with home help (four patients) or to other facilities (rehabilitation centers - eight patients, other hospitals - two patients, nursing homes - one patient). The discharge distribution for groups classified as non-airbag was similar to that of the total sample. Among the airbag groups, discharge disposition followed a similar pattern when medical records or crash reports were used as the classification criterion. According to these two sources, all three deaths occurred in non-airbag protected patients. But when patients were classified according the manufacturers' information, a different pattern was revealed, with patients discharged home more often, and one death occurring in this group (Table 2).

**Table 2. Discharge Disposition by Airbag Status and Source of Airbag Information (n = 52)**

Source of airbag information	Medical records		Crash report		Manufacturers		Total
	ob	no ob	ob	no ob	ob	no ob	
Air Bag status							
Discharge Disposition							
Home	2	32	2	32	6	28	34
Home with special help		4		4		4	4
Rehabilitation	1	7	1	7		8	8
Nursing Home	1			1		1	1
Morgue		3		3	1	2	3
Transfer to other hospital		2		2		2	2
<i>Total patients</i>	<b>4</b>	<b>48</b>	<b>3</b>	<b>49</b>	<b>7</b>	<b>45</b>	<b>52</b>

**PELVIC AND LOWER EXTREMITY INJURIES.** Of the 52 patients in the study, eighteen had PLEIs.

**Airbag status.** The classification of these 18 patients by airbag status varied by source of information used. The medical records identified three cases where airbags deployed, the crash reports identified one such case, and manufacturers' information listed two vehicles equipped with a driver-side airbag. Overall, there were four patients for whom at least one data source reported the presence of an airbag. When the different sources were compared for each patient, there was no case where the three data sources agreed. In two cases an airbag was reported by only one source, and for two other cases, two sources agreed.

**Diagnoses.** Of the 18 patients with PLEIs, six had multiple PLEI diagnoses, resulting in a total of 28

PLEI diagnoses. Most of the patients with more than one PLEI belonged to non-airbag categories.

PLEIs were grouped into categories by nature of injury. (See appendix.) In the sample as a whole, the most commonly reported category was fracture of the lower limb (ICD-9-CM: 820-829) followed by superficial injuries to the hip, thigh, leg, ankle, foot, and toes (ICD-9-CM: 916-917). When the distributions of PLEIs were compared by airbag status, all three non-airbag groups had distributions similar to the entire sample. But for the airbag groups, there were some differences. When crash reports were used to identify airbag status, only superficial injuries and contusions were observed. PLEIs were distributed over a greater number of categories in the other two airbag groups (Table 3).

**Table 3. Categories of Pelvic and Lower Extremity Injuries by Airbag Status and Airbag Information (n = 18)**

Source of airbag information	Medical record		Crash report		Manufacturers		Total
	ob	no ob	ob	no ob	ob	no ob	
Airbag Status							
PLEIs ICD-9-CM categories							
805.6-.7	1			1	1		1
808		2		2		2	2
820-829	1	8		9	2	7	9
835-838		1		1		1	1
890-897		4		4	1	3	4
916-917	1	5	1	5		6	6
924	2	2	2	2		4	4
959.6-.7		1		1		1	1
<i>Total PLEI diagnoses</i>	<b>5</b>	<b>23</b>	<b>3</b>	<b>25</b>	<b>4</b>	<b>24</b>	<b>28</b>
<i>Total PLEI patients</i>	<b>3</b>	<b>15</b>	<b>1</b>	<b>17</b>	<b>2</b>	<b>16</b>	<b>18</b>

Table 4. AIS Scores by Airbag and Source of Airbag Information (n=18)

Source of airbag information	Medical record		Crash report		Manufacturers		Total
	ob	no ob	ob	no ob	ob	no ob	
Airbag Status							
AIS							
Minor (1)	3	7	3	7		10	10
Moderate (2)	1	14		15	4	11	15
Serious (3)	1	1		2		2	2
Unknown (9)		1		1		1	1
Total PLEI diagnoses	5	23	3	25	4	24	28
Total PLEI patients	3	15	1	17	2	16	18

AIS scores. AIS scores ranged from minor (AIS 1) to serious (AIS 3). The most frequent AIS score was moderate (15 of the 28 diagnoses). The distribution of AIS scores for all three non-airbag groups was similar to the overall distribution. This was not the case for the airbag groups. Each airbag group showed a different distribution. All PLEIs diagnoses in the manufacturers' airbag group were of moderate severity as compared with PLEIs diagnoses in the crash-reports airbag group, which were of minor severity. In the medical-records airbag group, PLEIs diagnoses ranged from minor to serious severity (Table 4).

Maximum AIS scores for the lower extremities showed a similar pattern.

## CONCLUSIONS

Airbags for front seat occupants of motor vehicles will become standard equipment by the year 2000, although it will take many more years to replace the entire vehicle fleet with airbag equipped cars. In the years ahead, the nature of airbag evaluations is expected to shift from assessment of overall effectiveness in reducing mortality and morbidity, to a focus on specific injury patterns which (1) could be mediated through modifications in airbag design, or (2) are not amenable to protection by airbags. Pelvic and lower extremity injuries fall into the latter category and have been commanding greater attention.

In the present report we evaluated how the choice of data source to identify airbag presence may affect the characterization of injuries in general. PLEIs in particular, among drivers admitted to trauma centers following a crash. We found that the choice of source did make a difference in the case of PLEIs. Specifically, the nature and severity of PLEIs in airbag-associated crashes differed by source of information. These results suggest that findings which describe PLEIs by airbag status may not be comparable across studies that rely on different sources of data. The results also raise questions about the use of PLEIs as a measure of control for crash severity unless the validity of data sources is studied further.

It should be noted that the identification of airbag status by source of information is not a moot issue but one which presents a continuing challenge as

additional protective equipment (such as side airbags) is being installed in vehicles. Given the low level of agreement regarding airbag presence among the three data sources examined, the validity of each source should be further investigated. Many experts have noted that motor-vehicle crash reports are a poor source of information about restraints use, although we are not aware of published evaluations on this topic. Indeed, we found that crash reports did yield the lowest number of airbag cases among the three sources inspected. The comparison of medical and crash information with manufacturers' data is problematic because the former sources only record actual airbag deployment while the latter notes whether the equipment is present in the specific model. As expected, the manufacturers' data identified the largest number of airbag cases. Yet, the assumption that manufacturers' data would point to the presence of equipment in cases where airbag deployment was reported, was not borne by the findings. Among the five with deployed airbags noted in medical records and/or crash reports, only two had an airbag installed according to the manufacturers' data. The agreement between the sources that reported airbag deployment was also low.

This study was limited by a small sample size. Nevertheless, the results suggest the need for further research on the reliability and validity of sources that provide information on protective devices. The implications of using different data sources to classify patients for evaluation research and clinical studies, also require additional investigation.

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## APPENDIX

### Categories of ICD-9-CM diagnoses related to pelvic and lower extremities injuries

Codes	Description	Codes	Description
805.6, 805.7	Fracture of vertebral column without mention of spinal cord injury, sacrum and coccyx.	905.3, 905.4	Late effects of injuries, poisonings, toxic effects, and other external causes: fracture of neck of femur and lower extremities.
806.6, 906.7	Fracture of vertebral column with spinal cord injury: sacrum and coccyx	916-917	Superficial injury to hip, thigh, leg, ankle, foot, and toe(s).
808	Fracture of pelvis.	924	Contusion of lower limb and of other and unspecified sites.
820-829	Fracture of lower limb.	928	Crushing injury of lower limb.
835-838	Dislocation: hip, knee, ankle, foot.	945	Born of lower limb(s).
839.4/.5/.69	Dislocation other vertebra: sacrum and coccyx.	956	Injury to peripheral nerve(s) of pelvic girdle and lower limb(s).
843-846	Sprains and strains of joints and adjacent muscles.	959.6, 959.7	Injury, other and unspecified hip thigh, knee, leg, ankle, and foot
847.3, 847.4	Sprains and strains of other/unspecified.		
848.5	Other and ill-defined sprains and strains, pelvis.		
890-897	Open wound of lower limb.		
904	Injury to blood vessels of lower extremity sites.		