Do Seat Belts and Air Bags Reduce Mortality and Injury Severity After Car Accidents?

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Abstract

We studied National Trauma Data Bank data to determine the effectiveness of car safety devices in reducing mortality and injury severity in 184,992 patients between 1988 and 2004. Safety device variables were seat belt used plus air bag deployed; only seat belt used; only air bag deployed; and, as explicitly coded, no device used. Overall mortality was 4.17%. Compared with the no-device group, the seat-belt-plus-air-bag group had a 67% reduction in mortality (adjusted odds ratio [AOR], 0.33; 99% confidence interval [CI], 0.28-0.39), the seat-belt-only group had a 51% mortality reduction (AOR, 0.49; 99% CI, 0.45-0.52), and the air-bag-only group had a 32% mortality reduction (AOR, 0.68, 99% CI, 0.57-0.80). Injury Severity Scores showed a similar pattern.

Mortality from motor vehicle collisions (MVCs) has declined steadily over the past 30 years, and in 2003 reached an all-time low of 1.48 deaths per 100 million miles of vehicle travel.[1] Seat belts have been identified as a significant contributor to this trend, but opinion regarding the benefits of frontal air bags is in a state of flux.[2] Mortality reduction in frontal collisions with air bag deployment has been estimated to be as high as 25% to 30%,[3-6] though recent studies have also shown a reduction in mortality of less than 10%.[7,8] The investigators in most of these studies have assumed deployment of air bags in cars equipped with them. In their evaluation of head-on collisions, Crandall and colleagues[9] used air bag deployment as the measure of safety restraint device use to more accurately portray the true benefit of air bags in decreasing mortality, but the benefits of safety restraint device use in all types of MVCs have been difficult to analyze.

To our knowledge, no population-based studies have been performed to evaluate the absolute risk for mortality and injury severity in MVCs that resulted in occupants' being transported to a hospital for evaluation. Thus, we conducted a cohort study to evaluate the mortality rate and injury severity of patients transported to trauma centers for all types of MVCs on the basis of type of safety restraint systems used or deployed. We hypothesized that the combination of seat belts and air bags would have the largest effect on decreasing mortality and injury severity.

Methods

Data Source

The data for this study were obtained from the National Trauma Data Bank (NTDB) version 4.0. Reporting of data to the NTDB is voluntary. The NTDB, managed through the American College of Surgeons, gathers data from 55% of level I trauma centers, 35% of level II trauma centers, and from as many US level III and IV trauma centers as possible. NTDB version 4.0 includes more than 1.12 million trauma cases (377 institutions) gathered from 1988 through 2004.

Target Population

The cohort of patients for this study was identified by reported mechanism of injury (e-codes), which identified the patient as being involved in an MVC. Single and multiple-car accidents were included in the cohort, which includes both collisions and rollover accidents. Crashes involving vehicles other than passenger cars and light trucks were excluded, as were those involving pedestrian collisions.

Restraint use was measured with the safety device variables of seat belt use, air bag deployment, and no devices used. Occupants coded for other safety devices (eg, helmets, protective clothing, eye protection) were excluded from the analysis, as they may represent special MVC cases, such as a race car crash. Infant seats were also excluded from the analysis. Patients not coded for a safety device were excluded from the analysis because it was unclear whether no devices were used or because the code for another safety device had not been entered.

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Am J Orthop. 2011;40(3):E26-E29.

Analysis Plan

Additional information about occupants was analyzed, including age, sex, race, seat position (driver, passenger), Injury Severity Score (ISS), and mortality. Vehicle information, other than safety restraint device use, was not available from the database. ISS categories were constructed to represent 2 groups—those with mild to moderate injury severity (ISS, 0-15) and those with severe to very severe injuries (ISS, >15).

SAS statistical software version 9.1 (SAS Institute, Cary, North Carolina) was used to perform multiple logistic regressions using mortality and ISS category as the dependent variable. Age, sex, race, seat position, and safety devices functioned as the predictor variables. In all analyses, a 1%, 2-tailed, type I error rate was used because the large number of observations within the database could result in a statistically significant difference between variables without a true clinically relevant difference being present.

Results

Of the 1.12 million patients with NTDB data, more than 225,000 were involved in a MVC. After applying all inclusion and exclusion criteria, we identified 184,992 patients as being involved in MVCs and having complete safety device use information (Tables I, II). Of these patients, the majority used at least 1 safety restraint device (seat belt only, 46.4%; air bag only, 3.8%; seat belt plus air bag, 8.9%). Compared with patients aged 16 to 64 years, patients older than age 65 were more likely to use seat belts (57.1% vs 44.7%) and seat belts plus air bags (13.0% vs 8.7%). More than half (56.1%) of the patients were men, and men were less likely than women to use seat belts or seat belts plus air bags. Safety restraint use was similar for the racial groups. Most patients (68.6%) were drivers, and drivers were more likely than passengers to have air bags, either alone, or in combination with seat belts.

Overall mortality was 4.17%. Comparison of crash outcomes revealed significant differences in mortality and ISS among the various safety restraint device groups (Table II). Patients who used seat belts plus air bags were less likely to die compared with patients who did not use any restraint devices (2.35% vs 5.68%). Significant decreases in mortality, compared with no restraint users, were also found in the seat-belt-only group (3.16% vs 5.68%) and the air-bag-only group (4.41% vs 5.68%). We found a similar result for ISSs, with the seat-belt-plus-air-bag group less likely to sustain severe or very severe injuries (14.47% vs 30.74%, respectively) than the no-device group. Seat belts and air bags each alone provided a significant protective effect, though to a lesser degree.

Logistic regression, controlling for age, sex, race, and seat position, revealed that seat belts in combination with air bags provided the largest reduction in mortality risk (Table III) compared with no-device use (adjusted odds ratio [AOR], 0.33; 99% confidence interval [CI], 0.28-0.39). Use of a seat belt alone (AOR, 0.49) or an air bag alone (AOR, 0.68) also provided a significant protective effect to all vehicle occupants (Table III). Risk for a severe or very severe ISS had a similar pattern, with significant protective effects found in all safety device groups (seat belt plus air bag AOR, 0.37; seat belt only AOR, 0.51; air bag only AOR, 0.66).

Vehicle occupants older than age 65 were more likely to die compared with occupants in all other age groups (Table III). Women were significantly less likely than men to die (AOR, 0.88) and were at significantly less risk for sustaining severe or very severe injuries (AOR, 0.91). No difference was found between drivers and passengers. Similar risks for mortality and ISS higher than 16 were found among the racial groups, with the exception of the vehicle occupants classified as white (Table III). All other racial groups (black, Hispanic, other) had a significantly lower risk for mortality (AOR, 0.75) and for severe or very severe injuries (AOR, 0.66) compared with the white group. This difference persisted with adjustment for age, sex, seat position, and differences in safety restraint device use rates.

Table I. Distribution of Safety Device Use Across Age, Sex, and Race

Patient Demographic		Safety Device Used in Motor Vehicle Accident: Air Bag + Seat Belt No.	(%)	Seat Belt Only No.	(%)	Air Bag Only No.	(%)	None No.	(%)	Total No. of patients No.	(%)
Demo	All	15,934	(8.9)	82,144	(46.0)	6836	(3.8)	73,840	(41.3)	178,754	(100)
Age, y	0-9	919	(8.7)	5485	(52.1)	266	(2.5)	3859	(36.7)	10,529	(100)
	10-15	234	(3.1)	3131	(41.4)	120	(1.6)	4071	(53.9)	7556	(100)
	16-64	12,276	(8.7)	62,641	(44.3)	5683	(4.0)	60,931	(43.1)	141,531	(100)
	65+	2505	(13.1)	10,887	(56.9)	767	(4.0)	4979	(26.0)	19,138	(100)
Sex	Female	8602	(11.0)	40,042	(51.2)	2935	(3.8)	26,569	(34.0)	78,148	(100)
	Male	7332	(7.3)	42,102	(41.8)	3901	(3.9)	47,271	(47.0)	100,606	(100)
Race	White	10,918	(9.1)	53,987	(45.0)	4708	(3.9)	50,240	(41.9)	119,853	(100)
	Black	1766	(7.5)	10,902	(46.3)	996	(4.2)	9905	(42.0)	23,569	(100)
	Hispanic	1219	(7.1)	8402	(48.8)	428	(2.5)	7177	(41.7)	17,226	(100)
	Other	1218	(12.0)	5179	(50.8)	329	(3.2)	3463	(34.0)	10,189	(100)
	Not indicated	813	(10.3)	3674	(46.4)	375	(4.7)	3055	(38.6)	7917	(100)

Table II. Distribution of Safety Device Use Across Other Categorical Predictors and Outcomes

		Safety Device Used in Motor Vehicle Accident									
		Air Bag + Seat Belt		Seat Belt Only		Air Bag Only		None		All	
Category		No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	%
Driver	No	2810	(17.6)	24,436	(29.7)	1181	(17.3)	27,760	(37.6)	56,187	(31.4)
	Yes	13,124	(82.4)	57,708	(70.3)	5655	(82.7)	46,080	(62.4)	122,567	(68.6)
Died	No	15,561	(97.7)	79,540	(96.8)	6543	(95.7)	69,738	(94.4)	171,382	(95.9)
	Yes	373	(2.3)	2604	(3.2)	293	(4.3)	4102	(5.6)	7372	(4.1)
ISS, >15	No	13,548	(85.0)	66,350	(80.8)	5213	(76.3)	50,563	(68.5)	135,674	(75.9)
	Yes	2386	(15.0)	15,794	(19.2)	1623	(23.7)	23,277	(31.5)	43,080	(24.1)

Abbreviation: ISS, Injury Severity Score.

Table III. Mortality and Serious Injury Severity Rates With Adjusted Odds Ratios (AORs)

	Mortality			Injury Severity Score, >15		
Predictor	Rate, %	AOR[a]	99% CI	Rate, %	AOR[a]	99% CI
Safety Device						
None (reference)[b]	5.55	1.00	—	31.52	1.00	—
Seat belt only	3.17	0.485	0. 45-0.52	19.23	0.509	0.49-0.53
Air bag only	4.27	0.677	0.57-0.80	23.74	0.656	0.60-0.71
Seat belt + air bag	2.34	0.332	0.28-0.39	14.97	0.367	0.34-0.40
Any safety device	3.11	0.480	0.44-0.53	18.88	0.498	0.47-0.52
Passenger Ref to Driver[c]	4.24/ 3.86	0.877	0.81-0.95	23.08/ 24.14	0.981	0.94-1.02
Female Ref to Male[c]	3.80/ 4.38	0.879	0.82-0.95	22.45/ 25.38	0.908	0.88-0.94
Age, y						
65+	10.40	1.00	—	30.08	1.00	—
16-64	3.37	0.262	0.24-0.29	23.65	0.654	0.62-0.69
9-15	3.60	0.285	0.23-0.34	24.38	0.643	0.59-0.70
<9	3.21	0.293	0.24-0.35	19.08	0.561	0.51-0.61
Race						
White	4.61	1.00	—	26.66	1.00	—
Black	3.22	0 773	0.69-0.86	19.62	0.685	0.65-0.72
Hispanic	3.04	0.784	0.69-0.89	18.33	0.638	0.60-0.68
Other	2.71	0.702	0.59-0.83	18.05	0.665	0.61-0.72
Not coded	3.55	—	—	19.08	—	—
BHO ref to white	3.06	0.752	0.69-0.82	18.87	0.663	0.63-0.69

Abbreviations: CI, confidence interval; BHO, black, Hispanic, other.

[a]Odds ratios adjusted to all other predictors. [b]All odds ratios reflect each individual level of predictor relative to reference. [c]A vs B reflects odds of A referenced to B.

Discussion

In this study, we found a substantial reduction in risk for both mortality and injury severity attributable to use of either seat belts or air bags in a variety of types of MVCs, including single-vehicle crashes. The combination of seat belts and air bags provided a 67% reduction in mortality and a significant reduction in severe injuries. Use of only a seat belt reduced mortality risk by more than 50%, and use of an air bag alone reduced mortality by more than 32%. These findings demonstrate a significant reduction in risk for mortality and severe injury from more than just head-on collisions in which seat belts are used and air bags are deployed. Furthermore, we found a much higher mortality rate for the older-than-age-65 group despite its members' being more likely to use safety restraints. Therefore, controlling for age (as was done in this study) is critical for evaluating such data.

Several investigators have attempted to quantify the protective effects of seat belts and air bags in MVCs. Initial studies generated risk reduction estimates for the vehicle rather than the patient by comparing cars with and without air bags.[3,5,9-13] Most studies have had case–control designs in which the samples were limited to car accidents in which a fatality occurred, which makes it impossible to estimate the absolute risk for mortality for vehicle occupants involved in a collision. In contrast, our study was limited to patients in a car accident that resulted in treatment at a hospital. Thus,

comparing mortality rates with survival rates for these patients in car accidents in which various safety devices were or were not used allows relative risk for mortality to be estimated. We defined our population as patients who required evaluation in a hospital emergency department in order to help eliminate minor accidents in which seat belts or air bags may not have been needed to prevent injury, which may artificially increase the apparent effectiveness of safety restraint devices. By analyzing a large cohort, we were able to show a similar protective effect from use of seat belts alone and from use of air bags when a variety of crash types was considered. In addition, from our data, we estimated an absolute mortality risk, which provides perspective on just how much protection is being provided by safety restraint devices. The mortality rate was reduced from almost 6% without use of restraint devices to just more than 2% with use of seat belts and air bags.

These results also demonstrated decreased risk for mortality in women—an effect opposite that found by Crandall and colleagues,[9,10] who hypothesized that differences in physical size may explain the difference in mortality. Our result is difficult to interpret completely because of the limited specific crash data available in the NTDB, but this difference could potentially be related to more aggressive driving patterns in men, which could increase the force of collisions in which they were involved.

Along with sex differences in mortality, a significant difference was found among mortality rates across racial groups. Despite similar rates of use of safety devices, the white group had a 33% increased risk for mortality compared with all other racial groups. This difference persisted when sex, seat position, safety device use, and age were controlled for in the logistic regression model. Few data have demonstrated a difference in mortality rates among racial groups. This difference may represent a difference in the types of vehicles driven, or a difference in the driving patterns of whites and the other racial groups. Another possibility is that the difference is an artifact of the NTDB sample, which is a sample of convenience from hospitals that may not be reporting all MVCs. Such a large difference certainly warrants further study to confirm a true difference, which may help identify a particular group to target with public health messages aimed at improving driver safety.

Limitations of this study include lack of specific crash data, such as speed, direction of impact, and size of vehicles involved in collisions. In prior studies, these parameters were shown to influence mortality rates. Despite lacking these data, our study demonstrated protective effects from seat belts and air bags that are similar to the effects found in prior studies. Although we attempted to analyze all types of crashes, our use of air bag deployment as a parameter may have resulted in selecting for head-on collisions, as air bags are designed to deploy in this type of collision. Thus, our finding a protective effect for air bags may have partially resulted from comparing head-on collisions with other types of crashes. In addition, our data may not be truly representative of the US population as a whole, as many of the hospitals that report to the NTDB are level I trauma centers—a situation that may select for more severe crashes, which may result in an underestimation of the true protective benefit of safety restraint devices. Finally, the patients in this study were not subject to randomization. There may be differences in physical and behavioral characteristics between people who do and do not use seat belts or between people who drive vehicles with and without air bags.

In summary, the results of this study demonstrated a substantial decrease in mortality for all types of motor vehicle accidents with use of seat belts and air bags. There may still be concerns that air bags inflict injury in low-speed crashes, but air bags provide a clear reduction in mortality in a large cohort. Further study regarding differences in mortality among racial groups is warranted, and public safety programs may be able to be targeted to specific groups to improve safety restraint use.

Authors' Disclosure Statement

The authors report no actual or potential conflict of interest in relation to this article.

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This paper will be judged for the Resident Writer's Award.