Submitted: 20 November, 2023 Accepted: 16 January, 2024 Published: 08 June, 2024 DOI:10.22514/sv.2024.072

Open Access

Signa Vitae

ORIGINAL RESEARCH

Effect of seat belt use and airbags deployment on mortality in patients with road traffic injury

Jong Hee Kim[1], Gwan Jin Park[1,*], Young Min Kim[1], Hyun Seok Chai[1], Sang Chul Kim[1], Hoon Kim[1], Suk Woo Lee[1]

[1]Department of Emergency Medicine, Chungbuk National University Hospital, 28646 Cheongju, Republic of Korea

***Correspondence**
pkj83531@naver.com
(Gwan Jin Park)

Abstract

Seatbelts and airbags are safety devices designed to prevent road traffic injuries (RTI). They reduce fatal outcomes in patients with RTI; however, studies comparing the preventive effectiveness of these devices are limited. This study aimed to compare the effectiveness of these devices in reducing mortality of patients with RTI. This retrospective cohort study was conducted using the Emergency Department-based Injury In-depth Surveillance (EDIIS) registry between January 2011 and December 2020. All patients who sustained RTI in vehicles with <10 seats were eligible. The target population was categorized into four groups: seat belt use and airbag deployment, seatbelt use-only, airbag deployment-only and non-use. The primary and secondary outcomes were in-hospital mortality and intracranial injury. The adjusted odds ratios (AORs) (95% confidence intervals (CIs)) of safety device use for related outcomes were calculated using multivariate logistic regression analysis. Among the 82,262 patients, 13,929 (16.9%) were classified into the seat belt use and airbag deployment group; 47,123 (57.4%), seat belt use-only; 1820 (2.2%), airbag deployment-only; and, 19,300 (23.5%), non-use group. Compared to the seat belt use-only group, the AORs (95% CIs) for in-hospital mortality and intracranial injury were 1.70 (1.31–2.19) and 1.29 (1.13–1.47) in the seat belt use and airbags deployment group and 10.24 (7.49–13.99) and 3.00 (2.42–3.72) in the airbags deployment-only group, respectively. Seat belt use had significant preventive effects on in-hospital mortality and intracranial injury. Airbag deployment individually had no additional protective effect on clinical outcomes.

Keywords

Accidents; Traffic; Seat belts; Air bags; Treatment outcome; Mortality; Brain injuries

1. Introduction

Deaths from road traffic injury (RTI) reached 1.19 million annually in 2021, and passenger deaths in 4-wheel vehicle accounted for 30% of RTI fatalities [1]. It is the leading cause of death especially in children and people aged 5–29 years, and low- and middle-income countries bear the greatest burden of road traffic fatalities and injuries [1, 2]. In Korea, although the annual RTI incidence rate has increased slightly, the overall trend of deaths from RTI has been decreasing since 2013. The number of deaths in 2022 reached 2735 and the death rate of 4-wheeler passengers accounted for 49.1% of all RTI fatalities [3]. Most patients who survive RTI have severe disabilities and suffer high economic costs, resulting in a public health burden [4]. Several strategies have been implemented to reduce RTI, including road safety campaigns such as seat belt use; reducing alcohol-impaired driving; use of various safety technologies such as seat belts, airbags, child safety seats, and electronic stability control; and strong law enforcement [5–7].

Seat belt use is considered the most effective modality for saving lives in RTI events [5, 6]. Unbelted vehicle occupants were 10 times more likely to die, and proper use of seat belts can reduce the risk of death by 45% [8, 9]. However, seat belt use rates vary widely across countries. It increased to 90.4% in 2021 in the United States; however, it remained low in developing countries at <60% [9–11]. According to the 2021 Report on the Transport Culture Index of Korea, seat belt use rates increased from 73% in 2011 to 87% in 2017, but remained constant at 84% in 2021 [12].

Airbags have been introduced to provide further protection against RTI during severe collisions [13, 14]. Frontal airbags have saved 50,457 lives from 1987 to 2017 in the United States and reduced fatalities by 14% when seat belts were not used [9]. Most airbags are designed to deploy in moderate-to-severe RTI, but are affected by other variables such as speed and direction of impact [9, 14]. And regarding airbag-related injuries, unrestrained drivers in frontal collisions were more likely to sustain more severe injuries [14–16].

Both seat belts and airbags are well known to reduce fatal outcomes in patients with RTI and have been implemented with a safety device designed to prevent injuries. However, studies comparing the preventive effects of seat belts and airbags on clinical outcomes are limited. This study aimed to compare the effectiveness of these safety devices in reducing mortality of patients with RTI.

2. Materials and methods

2.1 Study design and setting, data source

This was a retrospective cohort study using Korea's Emergency Department-based Injury In-depth Surveillance (EDIIS) database. The EDIIS database is a nationwide prospective database of injured patients visiting the ED, supported by the Korea Centers for Disease Control and Prevention (CDC). It was established in five hospitals in 2006; and currently, 23 EDs gather injury-related information for injury prevention. The EDIIS database was constructed based on the core dataset of the World Health Organization's International Classification of External Causes of Injuries. It comprised 58 items, including patient demographics, injury-related information, emergency medical service (EMS) records, clinical findings, diagnosis, medical treatment in the ED, and clinical outcomes. General physicians in each ED collected primary surveillance data, whereas emergency physicians and trained research coordinators regularly supervised data recording and revised the data. All research coordinators were required to undergo training before participating and uploading the surveillance data into the web-based database system of the KOREA CDC. The data were reviewed monthly by a quality management committee for quality assurance [17].

2.2 Study population

The study population included all patients who sustained RTI in a vehicle and visited the ED between January 2011 and December 2020. We excluded cases resulting from out-of-vehicle RTI, who died before reaching the hospital from in-vehicle RTI, and those involving vehicles with $\geq$10 passenger (variables related to driver or passenger injuries were collected in three categories: $<$10 passenger vehicles; 11–19 passenger vehicles and pickup trucks; and, $>$20 passenger vehicles, buses, trucks, and large vehicles. The analysis is limited because of the low seat belt use rate in large vehicles and because most airbags are installed in the front seat, making it difficult to analyze airbag deployment in large vehicles). Additionally, we excluded children aged $<$6 years (they are obliged to use safety car seats as per Korean law) and those with missing data of seat belt use, airbag deployment and clinical outcomes. The flowchart of this study is illustrated in Fig. 1.

2.3 Main outcomes

The primary outcome was in-hospital mortality, which was defined as death in the ED or during admission for injury care determined at discharge from the ED or the hospital. The secondary outcome was intracranial injury, which was defined as Intenational Classification of Disease, Tenth Revision (ICD-10) diagnoses codes from S06.1 to S06.9. The diagnosis code was recorded in the discharge summary after ED or hospital admission.

2.4 Variables and measurement

The main exposure variables were seat belt use and airbag deployment as indicated by the EDIIS registry. The study population was categorized into four groups: seat belt use and airbag deployment, seatbelt use-only, airbag deployment-only and non-use. We collected information on demographic variables (age, sex and past medical history), day of injury (weekend and weekday), time of injury (day (06:00–18:00)), alcohol use, EMS use, injury-related variables (driving status, type of road (expressway, national way, alleyway and others), collision direction (frontal, lateral, rear, rollover, complex and others), anatomical location of injury), excess mortality ratio-based injury severity score (EMR-ISS), and hospital-related variables (time interval from injury to ED arrival, initial mental status and vital signs at the ED, length of ED stay, ED outcome and in-hospital mortality).

2.5 Statistical analysis

Counts and proportions were used for categorical variables, and medians and interquartile ranges (IQR) were used for continuous variables. We used the Kruskal-Wallis test for continuous variables and Pearson χ^2 test for categorical variables. Adjusted odds ratios (AORs) (95% confidence intervals (CIs)) of seat belt use and airbag deployment for related outcomes were calculated using multivariable logistic regression analysis. The model was adjusted for potential confounders including age, sex, day of injury, time of injury, driving status, type of road, collision direction, alcohol consumption, and EMS use. We conducted a sensitivity analysis based on injury severity. AORs (95% CIs) were calculated for patients with RTI with an EMR-ISS score $\geq$9 and $\geq$16. A two-sided p value < 0.05 was defined as significant. All statistical analyses were performed using SAS software (version 9.4; SAS Institute Inc., Cary, NC, USA).

3. Results

Of the 2,627,450 injured patients, 429,501 visited the ED due to RTIs. A total of 82,262 patients were included in the analysis, excluding those with out-of-vehicle injuries (n = 88,576), in-vehicle injuries involving vehicles with $>$10 seats (n = 161,041), children aged $<$6 years (n = 8209), unknown outcomes (n = 41), seat belt use (n = 22,742), and airbag deployment (Fig. 1).

Table 1 shows the demographic characteristics of the study population that used safety devices. Among the 82,262 eligible patients, 13,929 (16.9%) were in the seat belt use and airbag deployment group; 47,213 (57.4%), seat belt use-only group; 1820 (2.2%), airbag deployment-only group; and, 19,300 (23.5%), non-use group. The airbag deployment-only group was more likely to be younger (median age, 34 years), injured at night (18:00–06:00), consume more alcohol (20.8%), use more EMS (64.0%), and have poor mental status at the ED visit (all $p < 0.001$).

The highest proportion of patients was in the non-use group

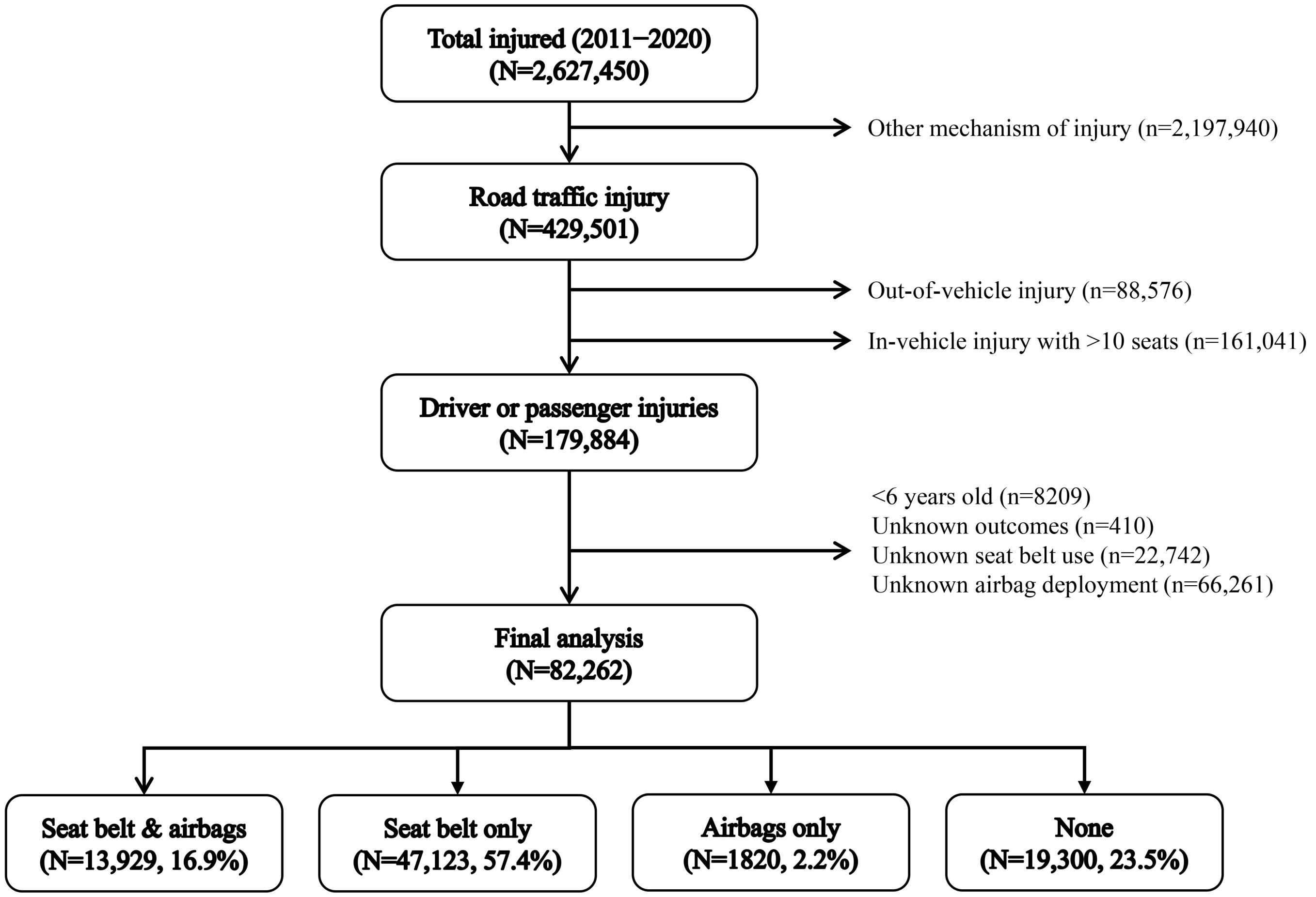

FIGURE 1. Study population.

(70.1%). Frontal collision was the most common in the seat belt use and airbag deployment, and airbag deployment-only groups (19.8% and 24.8%, respectively). Regarding the anatomical classification of injuries, the proportion of head and face injuries was higher in the airbag deployment-only and non-use groups (57.0% and 50.6%, respectively). However, neck injury was the most common in the seatbelt use-alone group (42.6%). The airbag deployment-only group had a higher injury severity score (median score, 13) and higher proportion of in-hospital mortality and intracranial injury (3.6% and 5.9%, respectively) (all $p < 0.001$; Table 2).

Fig. 2 shows the trends in the number of safety devices used by year. The proportion of non-users decreased from 29.3% in 2011 to 15.1% in 2020. The seat belt use rate reached approximately 82% by 2020. Compared to the seat belt use-only group, the seat belt use and airbags deployment group had higher in-hospital mortality and intracranial injury (AORs (95% CIs) were 1.70 (1.31–2.19) and 1.29 (1.13–1.47), respectively). The airbag deployment-only group was 10 times more likely to die (10.24 (7.49–13.99)) and 3 times more likely to suffer from intracranial injury (3.00 (2.42–3.72)) (Table 3).

For patients with RTI with an EMR-ISS $\geq$9, the AORs (95% CIs) for in-hospital mortality were similar to those in the main analysis. The AORs (95% CIs) for in-hospital mortality and intracranial injury were 1.65 (1.27–2.15) and 1.18 (1.03–1.35), respectively, in the seat belt use and airbags deployment group. For patients with RTI with EMR-ISS $\geq$16, there were no statistically significant differences in the proportions of in-hospital mortality and intracranial injury between the seat belt use and airbag deployment group and the seat belt use-only group. Regardless of the severity of the injury, the in-hospital mortality rate was 5–8 times higher and that of intracranial injury was 1.5–2.5 times higher in the airbag deployment-only group (Table 4).

4. Discussion

Based on the EDIIS data, we found that seat belt use had significant preventive effects against clinical outcomes. The proportions of both in-hospital mortality and intracranial injury were higher in the seat belt use and airbags deployment group than those in the seat belt use-only group, but there was no difference in severe RTI between the two groups. Airbag deployment itself did not reduce RTI-related in-hospital mortality and intracranial injury, rather, it showed a 10 times higher mortality rate and 3 times higher intracranial injury rate.

Seat belt use was the most effective modality for reducing RTI fatalities. Among the numerous efforts to increase the rate of seat belt use, mandatory seatbelt legislation is highly effective in promoting the wearing of seatbelts and is a cost-effective measure to reduce the severity and sequelae of traumatic RTI-related brain injuries [18, 19]. In fact, 69% of the countries worldwide have adopted the best practice of mandating the use of seat belts by front and rear seat occupants

TABLE 1. Demographic findings of the study population by safety devices.

	Total		Seat belt & airbags		Seat belt only		Airbags only		None		
	N	%	N	%	N	%	N	%	N	%	*p*-value
Total	82,262	100.0	13,929	16.9	47,213	57.4	1820	2.2	19,300	23.5	
Age											
>65 yr	7835	9.5	1403	10.1	4251	9.0	131	7.2	2050	10.6	<0.001
Median (IQR), yr	40 (29–54)		42 (31–55)		41 (31–53)		34 (25–49)		36 (25–53)		<0.001
Sex, male	42,053	51.1	8129	58.4	23,897	50.6	1107	60.8	8920	46.2	<0.001
Day of injury, weekend	29,264	35.6	4911	35.3	16,533	35.0	605	33.2	7215	37.4	<0.001
Time of injury											
06:00–18:00	50,431	61.3	7955	57.1	30,742	65.1	845	46.4	10,889	56.4	<0.001
18:00–06:00	31,831	38.7	5974	42.9	16,471	34.9	975	53.6	8411	43.6	
Alcohol consumption	4325	5.3	820	5.9	1229	2.6	378	20.8	1898	9.8	<0.001
EMS use	32,579	39.6	7408	53.2	15,586	33.0	1164	64.0	8421	43.6	<0.001
Mental status at the ED											
Alert	79,074	96.1	13,355	95.9	45,908	97.2	1600	87.9	18,211	94.4	<0.001
Verbal	873	1.1	191	1.4	264	0.6	77	4.2	341	1.8	
Painful stimuli	453	0.6	103	0.7	103	0.2	44	2.4	203	1.1	
Unresponsive	454	0.6	82	0.6	97	0.2	63	3.5	212	1.1	
Unknown	1408	1.7	198	1.4	841	1.8	36	2.0	333	1.7	
Vital signs											
SBP, Median (IQR)	133 (120–150)		136 (120–151)		135 (120–150)		130 (114–147)		130 (118–146)		<0.001
HR, Median (IQR)	82 (74–91)		83 (75–93)		81 (74–90)		86 (76–97)		82 (75–93)		<0.001
RR, Median (IQR)	20 (18–20)		20 (18–20)		20 (18–20)		20 (18–20)		20 (18–20)		<0.001

IQR, interquartile range; EMS, emergency medical services; ED, emergency department; SBP, systolic blood pressure; HR, heart rate; RR, respiratory rate.

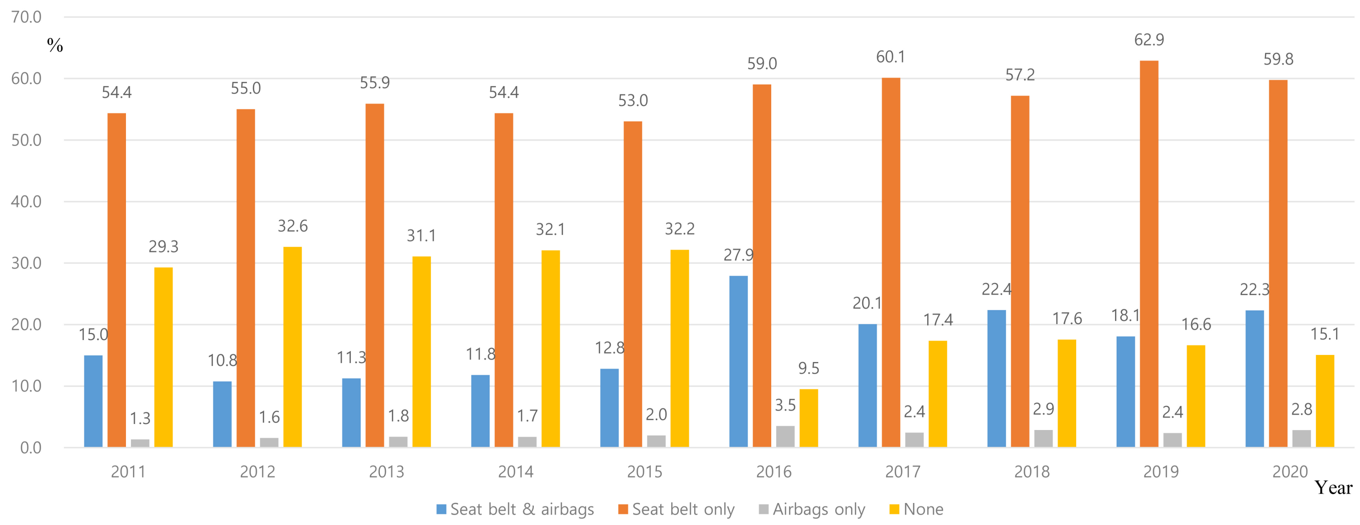

FIGURE 2. Trends in the applied safety devices by year.

TABLE 2. Injury-related characteristics by safety devices.

	Total		Seat belt & Airbags		Seat belt only		Airbags only		None		
	N	%	N	%	N	%	N	%	N	%	*p*-value
Total	82,262	100.0	13,929	16.9	47,213	57.4	1820	2.2	19,300	23.5	
Driving status											
Driver	49,759	60.5	10,804	77.6	32,115	68.0	1073	59.0	5767	29.9	<0.001
Passenger	32,503	39.5	3125	22.4	15,098	32.0	747	41.0	13,533	70.1	
Type of road											
Expressway	14,143	17.2	2991	21.5	8228	17.4	264	14.5	2660	13.8	<0.001
Nationalway	64,073	77.9	10,363	74.4	37,131	78.6	1430	78.6	15,149	78.5	
Alleyway	1381	1.7	205	1.5	681	1.4	42	2.3	453	2.3	
Others	2665	3.2	370	2.7	1173	2.5	84	4.6	1038	5.4	
Collision direction											
Frontal	10,712	13.0	2760	19.8	4603	9.7	451	24.8	2898	15.0	<0.001
Side lateral	7431	9.0	1021	7.3	4163	8.8	132	7.3	2115	11.0	
Rear	13,121	16.0	433	3.1	9432	20.0	44	2.4	3212	16.6	
Roll over	1262	1.5	206	1.5	580	1.2	28	1.5	448	2.3	
Complex	2658	3.2	422	3.0	1630	3.5	47	2.6	559	2.9	
Others	47,078	57.2	9087	65.2	26,805	56.8	1118	61.4	10,068	52.2	
Anatomical classification of injury											
Head & face	33,676	40.9	5311	38.1	17,556	37.2	1037	57.0	9772	50.6	<0.001
Neck	29,767	36.2	3509	25.2	20,122	42.6	351	19.3	5785	30.0	<0.001
Chest	14,729	17.9	4134	29.7	7197	15.2	476	26.2	2922	15.1	<0.001
Abdomen	19,887	24.2	3146	22.6	12,523	26.5	364	20.0	3854	20.0	<0.001
Upper extremity	14,720	17.9	3150	22.6	7741	16.4	421	23.1	3408	17.7	<0.001
Lower extremity	13,110	15.9	2866	20.6	6226	13.2	499	27.4	3519	18.2	<0.001
Injury severity											
EMR ISS ≥9	49,035	59.6	9030	64.8	25,772	54.6	1409	77.4	12,824	66.4	<0.001
EMR ISS ≥16	18,403	22.4	4194	30.1	8007	17.0	856	47.0	5346	27.7	<0.001
Median (IQR)	9 (4–14)		9 (4–17)		9 (4–12)		13 (9–25)		9 (4–17)		<0.001
Clinical outcomes											
In-hospital mortality	566	0.7	108	0.8	137	0.3	65	3.6	256	1.3	<0.001
Intracranial injury	1902	2.3	334	2.4	731	1.5	107	5.9	730	3.8	<0.001

EMR ISS, excess mortality ratio-based injury severity score; IQR, interquartile range.

[1]. However, seatbelt use rates did not increase further from the high 80% in developed countries and were found to be <60% in developing countries [9, 11]. Beyond legislation, various efforts have been made to increase the seat belt use rate, including public campaigns and the development of new technologies such as belt reminders or interlocks [1, 20, 21].

Airbags, in combination with seat belts, are regarded as supplemental safety measures that reduce the risk of injury from RTI. Despite using seatbelts, car occupants are injured when they hit the vehicle's interior parts such as the steering wheel or dashboard, and airbags reduce the level of contact [9]. Fatalities in frontal collisions, specifically in vehicles with airbag deployment, have been reduced by 22% among belted drivers [22]. The United States has implemented the mandatory installation of airbags; however, in Korea, no such obligation exists. However, vehicle manufacturers have voluntarily installed airbags; the installation rate of airbags in manufactured vehicles in Korea was 88.3% in 2003 [23].

Despite the reduced risk of injury from airbags, airbag deployment had no further protective effect on outcomes even in patients with severe RTI (with EMR-ISS greater than 16) in vehicles that used seatbelts. This finding is inconsistent with the findings of previous studies. Our results differ from those of most previous studies probably because the previous studies evaluated only the effect of frontal airbags in frontal collisions [6, 14, 22]. Stewart *et al*. [13] reported that airbag deployment reduced the severity of head injuries, but their study population was small (n = 1937) and confined to severely injured drivers

TABLE 3. Multivariable logistic regression analysis on study outcomes by safety devices.

	Total	Positive outcomes		Unadjusted	Adjusted*
	N	N	%	OR (95% CI)	OR (95% CI)
Primary outcome: In-hospital mortality					
Total	82,262	566	0.7		
Seat belt only	47,213	137	0.3	1.00	1.00
Seat belt & Airbags	13,929	108	0.8	2.69 (2.09–3.46)	1.70 (1.31–2.19)
None	19,300	256	1.3	4.62 (3.75–5.69)	5.94 (4.76–7.42)
Airbags only	1820	65	3.6	12.73 (9.44–17.16)	10.24 (7.49–13.99)
Secondary outcome: Intracranial injury					
Total	82,262	1902	2.3		
Seat belt only	47,213	731	1.5	1.00	1.00
Seat belt & Airbags	13,929	334	2.4	1.56 (1.37–1.78)	1.29 (1.13–1.47)
None	19,300	730	3.8	2.50 (2.25–2.77)	2.36 (2.12–2.63)
Airbags only	1820	107	5.9	3.97 (3.22–4.89)	3.00 (2.42–3.72)

Hosmer-Lemeshow goodness-of-fit for in-hospital mortality (χ^2 = 4.3826, p-value = 0.8211) and intracranial injury (χ^2 = 14.2958, p-value = 0.0744).
**Adjusted for age, sex, day of injury, time of injury, driving status, type of road, collision direction, alcohol consumption, and EMS use.*
OR, odds ratio; CI, confidence interval.

(Injury Severity Score (ISS) >12). A meta-analysis reported that frontal airbags reduced accident fatalities among belted drivers in frontal collisions. However, the size of the overall effect was too heterogeneous to draw conclusions [22].

Moreover, the deployment-only group had worse outcomes: a higher proportion of poor mentality in the ED and higher injury severity scores were observed. The proportions of in-hospital mortality and intracranial injuries were higher. Airbag deployment alone did not reduce the severity of injury, rather, it increased the risk of lower extremity injury when the seatbelt was not used [24, 25]. Airbags are generally designed to inflate in moderate-to-severe car crashes according to the direction and severity of their impact [9]. Unrestrained occupants are more likely to be positioned along the deployment path of an airbag during a collision, leading to higher lethality from the airbags [14, 16]. These results imply that evidence for the effectiveness of airbags is still lacking with respect to all crashes, and additional research is needed to consider various conditions such as the type of airbag embedded in the vehicle, collision direction, and severity of injury.

There is an overall reduction in the number of fatalities in frontal collisions, mainly owing to the reduced risk of serious head and neck injuries [16, 26]. However, most studies have included only car occupants wearing seatbelts in airbag-equipped vehicles. In this study, the head and face injury rate was 57% in the airbag deployment-only group, but those in the seat belt use and airbag deployment group and seatbelt use-only group were significantly lower (38.1% and 37.2%, respectively). These results reiterate that airbags are complementary safety devices rather than alternatives to seat belts. Considering that they are designed to be deployed during serious RTIs, we ensured that all occupants were properly seated and wore seatbelts to reduce the risk of injury.

Regarding the characteristics of the airbag deployment-only group, the airbag deployment-only group was more likely to be younger, injured at night, consume more alcohol, and use EMS at a greater rate. A higher risk of injury is associated with occupant physique or specific positions of occupant seating, specifically those who are unrestrained or improperly restrained [14, 27]. Our results showed that unrestrained occupants were younger, had more passengers, consumed more alcohol, and had poorer clinical outcomes (**Supplementary Table 1**). Unrestrained drivers are more likely to use cell phones while driving, drive at excessive speed limits, attempt to pass other vehicles, have alcohol-impaired driving, and not follow traffic rules [28]. Drivers have the greatest influence on passenger seat belt use, and driver restraint use is a significant predictor of restraint use, specifically among child passengers in the RTI [29]. Therefore, public efforts are required to prevent fatal RTIs by increasing traffic safety awareness and implementing a desirable driving culture for car occupants.

This study has several limitations. First, this was a retrospective cohort study and due to the large number of participants, there were noticeable differences between characteristics of the four groups, which may lead to treatment selection bias. And unmeasured potential confounders may have influenced the exposure and outcomes. Injury-related data, which can influence outcomes, such as speed at the time of collision, counterparts of the RTI, and passengers' seating positions, were not available in the EDIIS registry. Second, seatbelt use and airbag deployment, the main exposure variables, were ascertained only through face-to-face interviews with patients and guardians. Therefore, we excluded >80,000 patients from the analysis. Compared to the target population, missing values for mental status at the ED and injury-related data (especially the type of road and collision direction) accounted

TABLE 4. Sensitivity analysis according to the severity of injury.

		Total	Positive outcomes		Adjusted*
		N	N	%	OR (95% CI)
EMR ISS $\geq$9					
Primary outcome: In-hospital mortality	Total	49,035	539	1.1	
	Seat belt only	25,772	129	0.5	1.00
	Seat belt & Airbags	9030	104	1.2	1.65 (1.27–2.15)
	None	12,824	242	1.9	5.08 (4.04–6.38)
	Airbags only	1409	64	4.5	8.49 (6.18–11.67)
Secondary outcome: Intracranial injury	Total	49,035	1891	3.9	
	Seat belt only	25,772	725	2.8	1.00
	Seat belt & Airbags	9030	333	3.7	1.18 (1.03–1.35)
	None	12,824	726	5.7	2.06 (1.85–2.30)
	Airbags only	1409	107	7.6	2.45 (1.97–3.03)
EMR ISS $\geq$16					
Primary outcome: In-hospital mortality	Total	18,403	490	2.7	
	Seat belt only	8007	117	1.5	1.00
	Seat belt & Airbags	4194	92	2.2	1.31 (0.99–1.74)
	None	5346	221	4.1	3.92 (3.08–4.98)
	Airbags only	856	60	7.0	5.73 (4.11–7.98)
Secondary outcome: Intracranial injury	Total	18,403	1891	10.3	
	Seat belt only	8007	725	9.1	1.00
	Seat belt & Airbags	4194	333	7.9	0.87 (0.76–1.00)
	None	5346	726	13.6	1.66 (1.48–1.85)
	Airbags only	856	107	12.5	1.53 (1.22–1.90)

EMR-ISS $\geq$9 group: Hosmer-Lemeshow Goodness-of-fit for in-hospital mortality (χ^2 = 5.6502, p-value = 0.6863) and intracranial injury (χ^2 = 5.5763, p-value = 0.6946).
EMR-ISS $\geq$16 group: Hosmer-Lemeshow Goodness-of-fit for in-hospital mortality (χ^2 = 2.3181, p-value = 0.9697) and intracranial injury (χ^2 = 10.3805, p-value = 0.2393).
**Adjusted for age, sex, day of injury, time of injury, driving status, type of road, collision direction, alcohol consumption and EMS use.*
EMR-ISS, excess mortality ratio-adjusted injury severity score; OR, odds ratio; CI, confidence interval.

for a large proportion in the missing group. In addition, the missing data group had higher proportions of in-hospital mortality and intracranial injuries (**Supplementary Table 2**). This might have been subject to over- and under-estimation, which could have resulted in bias. Furthermore, we only had information on whether the airbags were deployed. Airbag-related data, such as the type, number, and location of airbags embedded in the vehicle, were limited and could not be used for the analysis.

5. Conclusions

Seat belt use showed preventive effects against in-hospital mortality and intracranial injury due to RTI. Airbag deployment with and without seat belt use had no additional preventive effects on the clinical outcomes. These results suggest that airbags are not a substitute for seatbelts, but act as a supplementary device to reduce RTI. Public health efforts are needed to increase the proper use of safety devices and implement a good driving culture for car occupants, which can help reduce the health burden of RTI.

AVAILABILITY OF DATA AND MATERIALS

The data presented in this study are available upon reasonable request from the corresponding authors.

AUTHOR CONTRIBUTIONS

JHK and GJP—designed this study. GJP and SCK—analyzed the results. JHK—drafted the manuscript. YMK, HSC, SCK, HK and SWL—reviewed and edited the manuscript. All the authors have read and approved the final version of the manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study was approved by the Institutional Review Board (IRB) of Chungbuk National University Hospital (IRB No. 2022-10-013). The requirement for informed consent was waived, and patient information was anonymized prior to analysis.

ACKNOWLEDGMENT

Thanks to all the members of participating institutions for helping collect data.

FUNDING

This research received no external funding.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

SUPPLEMENTARY MATERIAL

Supplementary material associated with this article can be found, in the online version, at https://oss.signavitae.com/mre-signavitae/article/1798889647069118464/attachment/Supplementary%20material.docx.

REFERENCES

[1] Geneva: World Health Organization. Global status report on road safety 2023. 2023. Available at: https://www.who.int/publications/i/item/9789240086517 (Accessed: 27 December 2023).

[2] Ou Z, Wu K, Ruan Y, Zhang Y, Zhu S, Cui J, *et al*. Global burden and trends of three common road injuries from 1990 to 2019 and the implications for prevention and intervention. Accident Analysis & Prevention. 2023; 193: 107266.

[3] Korea ROAD traffic authority. Traffic accident analysis system. Traffic accident statistics. 2023. Available at: http://taas.koroad.or.kr/web/bdm/srs/selectStaticalReportsList.do?menuId=WEB_KMP_IDA_SRS_TAA (Accessed: 27 December 2023).

[4] GBD 2019 diseases and injuries collaborators. Global burden of 369 diseases and injuries in 204 countries and territories, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. The Lancet. 2020; 396: 1204–1222.

[5] Fisa R, Musukuma M, Sampa M, Musonda P, Young T. Effects of interventions for preventing road traffic crashes: an overview of systematic reviews. BMC Public Health. 2022; 22: 513.

[6] Kahane, Charles J. Lives saved by vehicle safety technologies and associated federal motor vehicle safety standards, 1960 to 2012—passenger cars and LTVs—with reviews of 26 FMVSS and the effectiveness of their associated safety technologies in reducing fatalities, injuries, and crashes. 2015. Available at: https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812069 (Accessed: 05 October 2023).

[7] Namatovu S, Balugaba BE, Muni K, Ningwa A, Nsabagwa L, Oporia F, *et al*. Interventions to reduce pedestrian road traffic injuries: A systematic review of randomized controlled trials, cluster randomized controlled trials, interrupted time-series, and controlled before-after studies. PLOS ONE. 2022; 17: e0262681.

[8] Kwak BH, Ro YS, Shin SD, Song KJ, Kim YJ, Jang DB. Preventive effects of seat belt on clinical outcomes for road traffic injuries. Journal of Korean Medical Science. 2015; 30: 1881–1888.

[9] National Center for Statistics and Analysis. Occupant protection in passenger vehicles: 2021 data (Traffic Safety Facts). 2023. Available at: https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/813449.pdf (Accessed: 20 December 2023).

[10] Kargar S, Ansari-Moghaddam A, Ansari H. The prevalence of seat belt use among drivers and passengers: a systematic review and meta-analysis. The Journal of the Egyptian Public Health Association. 2023; 98: 14.

[11] Ojo TK. Seat belt and child restraint use in a developing country metropolitan city. Accident Analysis & Prevention. 2018; 113: 325–329.

[12] The Korea Transportation Safety Authority. Report on transport culture index of Korea. 2017. Available at: https://www.kotsa.or.kr/portal/bbs/transafe_view.do?bbscCode=transafe&cateCode=&bbscSeqn=5402&pageNumb=1&sechCdtn=0&sechKywd=%EA%B5%90%ED%86%B5%EB%AC%B8%ED%99%94%EC%A7%80%EC%88%98+%EC%8B%A4%ED%83%9C%EC%A1%B0%EC%82%AC&menuCode=05070000 (Accessed: 18 October 2023).

[13] Stewart TC, Girotti MJ, Nikore V, Williamson J. Effect of airbag deployment on head injuries in severe passenger motor vehicle crashes in Ontario, Canada. The Journal of Trauma. 2003; 54: 266–272.

[14] The Royal Society for the Prevention of Accidents. Road safety factsheet. 2017. Available at: https://www.rospa.com/rospaweb/docs/advice-services/road-safety/vehicles/airbags-factsheet.pdf (Accessed: 13 October 2023).

[15] Hanna K, Okumura K, Shnaydman I. Improving blunt cerebrovascular injury screening in motor vehicle collision patients: does airbag deployment matter? The American Journal of Surgery. 2022; 224: 1393–1397.

[16] Wallis LA, Greaves I. Injuries associated with airbag deployment. Emergency Medicine Journal. 2002; 19: 490–493.

[17] Jeon YK, Jeong J, Shin SD, Song KJ, Kim YJ, Hong KJ, *et al*. The effect of age on in-hospital mortality among elderly people who sustained fall-related traumatic brain injuries at home: a retrospective study of a multicenter emergency department-based injury surveillance database. Injury. 2022; 53: 3276–3281.

[18] WHO team. Occupant restraints: a road safety manual for decision-makers and practitioners, second edition. 2022. Available at: https://www.who.int/publications/m/item/occupant-restraints--a-road-safety-manual-for-decision-makers-and-practitioners (Accessed: 15 October 2023).

[19] Pan Y, Neuroth L, Chomitz I, Davila V, Liu K, McKenzie LB, *et al*. Seat belt laws and prevalence of use among high school students in the United States. Annals of Epidemiology. 2023; 79: 71–74.

[20] Kidd DG, Singer J. The effects of persistent audible seat belt reminders and a speed-limiting interlock on the seat belt use of drivers who do not always use a seat belt. Journal of Safety Research. 2019; 71: 13–24.

[21] Kidd DG, O'Malley S. Increasing seat belt use in the United States by promoting and requiring more effective seat belt reminder systems. Traffic Injury Prevention. 2023; 24: S80–S87.

[22] Høye A. Are airbags a dangerous safety measure? A meta-analysis of the effects of frontal airbags on driver fatalities. Accident Analysis & Prevention. 2010; 42: 2030–2040.

[23] Korea Consumer Agency. Passenger vehicle airbags safety survey. 2003. Available at: https://www.kca.go.kr/smartconsumer/sub.do?

menukey=7301&mode=view&no=1000338532 (Accessed: 05 October 2023).

[24] McGwin G Jr, Metzger J, Alonso JE, Rue LW 3rd. The association between occupant restraint systems and risk of injury in frontal motor vehicle collisions. The Journal of Trauma. 2003; 54: 1182–1187.

[25] Tekyol D, Çolak Ş, Tayfur İ, Hökenek NM, Algın A. Evaluation of the effects of airbag and seat belt use on the severity of the injury in traffic accidents. Haydarpaşa Numune Medical Journal. 2020; 60: 400.

[26] Barnes J, Morris A, Fildes B, Newstead S. Airbag effectiveness in real world crashes. 2013. Available at: https://repository.lboro.ac.uk/articles/conference_contribution/Airbag_effectiveness_in_real_world_crashes/9340655 (Accessed: 03 October 2023).

[27] O'Donovan S, van den Heuvel C, Baldock M, Byard RW. Injuries, death and vehicle airbag deployment. Medicine, Science and the Law. 2020; 60: 147–149.

[28] Yagoub U, Saiyed NS, Rahim BEA, Musawa N, Al Zahrani AM. Road traffic injuries and related safety measures: a multicentre analysis at Military Hospitals in Tabuk, Saudi Arabia. Emergency Medicine International. 2021; 2021: 6617381.

[29] Myers RK, Lombardi LR, Pfeiffer MR, Curry AE. Restraint use characteristics among crash-involved child passengers: identifying opportunities to enhance optimal restraint use. Traffic Injury Prevention. 2022; 23: S213–S217.

How to cite this article: Jong Hee Kim, Gwan Jin Park, Young Min Kim, Hyun Seok Chai, Sang Chul Kim, Hoon Kim, *et al*. Effect of seat belt use and airbags deployment on mortality in patients with road traffic injury. Signa Vitae. 2024; 20(6): 58-66. doi: 10.22514/sv.2024.072.