Heliyon 10 (2024) e25336

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon

Research article

Seat belt use and cardiac arrest immediately after motor vehicle collision: Nationwide observational study

Yeongho Choi [a,b,c], Jeong Ho Park [b,c,d,*], Young Sun Ro [b,c,d], Joo Jeong [a,b,c], Yu Jin Kim [a,b,c], Kyoung Jun Song [b,c,e], Sang Do Shin [b,c,d]

[a] Department of Emergency Medicine, Seoul National University College of Medicine, Seoul National University Bundang Hospital, Bundang, South Korea
[b] Laboratory of Emergency Medical Services, Seoul National University Hospital Biomedical Research Institute, Seoul, South Korea
[c] Disaster Medicine Research Center, Seoul National University Medical Research Center, Seoul, South Korea
[d] Department of Emergency Medicine, Seoul National University College of Medicine, Seoul National University Hospital, Seoul, South Korea
[e] Department of Emergency Medicine, Seoul National University Boramae Medical Center, Seoul, South Korea

A R T I C L E I N F O

Keywords:
Seat belts
Motor vehicles
Traffic collisions
Cardiac arrest

A B S T R A C T

Objective: Motor vehicle collisions (MVCs) are known to cause traumatic cardiac arrest; it is unclear whether seat belts prevent this. This study aimed to evaluate the association between seat belt use and immediate cardiac arrest in cases of MVCs.
Method: This cross-sectional observational study used data from a nationwide EMS-based severe trauma registry in South Korea. The sample comprised adult patients with EMS-assessed severe trauma due to MVCs between 2018 and 2019. The primary, secondary, and tertiary outcomes were immediate cardiac arrest, in-hospital mortality, and death or severe disability, respectively. We calculated the adjusted odds ratios (AORs) of immediate cardiac arrest with seat belt use after adjusting for potential confounders.
Results: Among the 8178 eligible patients, 6314 (77.2 %) and 1864 (29.5 %) were wearing and not wearing seat belts, respectively. Immediate cardiac arrest, mortality, and death/severe disability rates were higher in the "no seat belt use" group than in the "seat belt use" group (9.4 % vs. 4.0 %, 12.4 % vs. 6.2 %, 17.7 % vs. 9.9 %, respectively; $p < 0.001$). The former group was more likely to experience immediate cardiac arrest (AOR [95 %CI]: 3.29 [2.65–4.08]), in-hospital mortality (AOR [95 %CI]: 2.72 [2.26–3.27]), and death or severe disability (AOR [95 %CI]: 2.40 [2.05–2.80]).
Conclusion: There was an association between wearing seat belts during MVCs and a reduced risk of immediate cardiac arrest.

1. Introduction

Motor vehicle collisions (MVCs) are major causes of death and disability and pose a significant burden of disease worldwide [1,2]. MVCs are important causes of traumatic cardiac arrest, accounting for 50–60 % of all traumatic cardiac arrest cases [3,4]. The survival rate from traumatic cardiac arrest is known to be very poor [5,6], and many of those who survive are known to suffer severe disabilities

* Corresponding author. Department of Emergency Medicine, Seoul National University College of Medicine, Seoul National University Hospital, Seoul, South Korea

E-mail address: timthe@gmail.com (J.H. Park).

https://doi.org/10.1016/j.heliyon.2024.e25336
Received 19 March 2023; Received in revised form 25 December 2023; Accepted 24 January 2024
Available online 1 February 2024
2405-8440/© 2024 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

[7]. Primary prevention is of paramount importance because of the fatal outcomes of traumatic cardiac arrest.

Seat belt use is known to be a good measure for preventing and reducing mortality from MVCs [8]. Previous studies have reported that seat belts prevent fatal injuries such as spinal cord injury, traumatic brain injury, aortic injury, and face injury in those who experience MVCs [9–12]. Seat belt use may reduce the rate of immediate cardiac arrest by preventing fatal injuries. However, it is not clear whether seat belt use can prevent immediate cardiac arrest in MVCs.

The aim of this study was to evaluate the association between seat belt use and immediate cardiac arrest among those who experienced MVCs. We also evaluated whether the preventive effect of seat belts was different according to various characteristics, including age, sex, time of incidents, urbanisation level of incidents, and seating position in the car.

2. Methods

2.1. Study design and setting

This cross-sectional study used data from a retrospectively collected nationwide community-based trauma registry in Korea. The study complied with the Declaration of Helsinki, and its protocol was approved by the Institutional Review Board of the study hospital with a waiver of informed consent (IRB No. 30-2019-72).

South Korea has 51.3 million people living in 17 administrative provinces in an area of 100,210 km^2. South Korea introduced the mandatory wearing of seat belts by all vehicle passengers on expressways in 1985, on motorways in 2011, and on all roads in September 2018. The law applies only to vehicles fitted with seat belts.

In South Korea, the prehospital emergency medical service (EMS) is exclusively managed by the National Fire Agency (NFA). This EMS system is classified as intermediate, as personnel often administer intravenous fluids and engage in advanced airway management. In South Korea, the declaration of death is a prerogative reserved for physicians, hence patients with traumatic cardiac arrest are routinely transferred to emergency departments by EMS teams. EMS providers are legally mandated to complete ambulance run sheets for every EMS transport. As per the field triage decision scheme, these providers evaluate patients to ascertain if they meet the criteria for transportation to trauma centers [13]. While the EMS transport protocol suggests transporting eligible patients to the closest regional trauma center, this is a recommendation rather than a compulsory action. The Ministry of Health and Welfare has officially designated regional trauma centers in South Korea, with the number of such centers increasing from 11 in 2018 to 13 in 2019. The Ministry of Health and Welfare categorized the emergency medical centers (EMCs) into one of three categories based on resource availability and functional requisites: Level 1 ($n = 36$) and Level 2 ($n = 118$) EMCs have the resources and facilities for emergency care and must be staffed by emergency physicians around the clock, year-round, whereas Level 3 EMCs ($n = 248$) can be staffed by general physicians. All trauma centers were designated as EMCs.

2.2. Data source

Our study utilized We used data from the Korean Nationwide Severe Injury Registry, which collects all cases of EMS-assessed severe injuries across the country. This registry is a national observational database established in 2013, developed in partnership with the National Fire Agency (NFA) and the Korea Disease Control and Prevention Agency (KDCA). Its purpose is to track the occurrence and outcomes of severe injuries and mass-casualty incidents by identifying cases at the community level. The registry was constructed using three data sources: ambulance runsheets, EMS severe trauma in-depth registry, and hospital medical record review. The registry includes the following cases: Emergency Medical Services (EMS) evaluated cases involving severe trauma, which were defined as patients with injuries who met the criteria for transport to a trauma center according to the field triage decision scheme [13]. The National Fire Service employs the field triage decision scheme, developed in 2011 by the US CDC, as a nationwide protocol, translating it into Korean. The EMS severe trauma in-depth registry was used to ascertain if the cases met the field triage decision scheme criteria. For patients to fulfill the physiologic criteria of the field triage decision scheme, which include abnormal mental status (defined as non-alert response on the alert, verbal, pain, or unresponsive scale) or hypotension (systolic blood pressure $\leq$90 mm Hg), vital signs from the ambulance runsheets are included as well [10 or >29 respirations/min]. Medical record reviewers extracted the diagnoses, Abbreviated Injury Scale scores, hospital management, and clinical outcomes for all identified cases transported to EMCs from the KDCA. Nine medical record review experts were trained to conduct medical record reviews. Information about mortality and Glasgow Outcome Scale (GOS) at discharge were primarily collected from first-visit hospitals. If patients were transferred from the ED to the first hospital visit, mortality and GOS at discharge in the second visiting hospitals were also collected. The quality management committee comprised emergency physicians, epidemiologists, statistics experts, and medical record review experts, who reviewed the data each month while providing feedback to each medical record reviewer. A detailed description of the data acquisition of each registry, including the training and quality of the medical record reviewers, is provided in a previous study [14].

2.3. Study population

All EMS-assessed severely injured MVC patients aged $\geq$15 years old or older from January 2018 to December 2019 were included. Severe injury was defined as a case that meets the criteria of the field triage decision scheme. Patients with mechanisms of injury other than MVCs in which seat belts cannot be used (pedestrians, bicycles, motorcycles, special industrial vehicles, or rail vehicles) were excluded. Patients with unknown seat belt use in the car were also excluded.

2.4. Outcomes

The primary outcome was immediate arrest, including cardiac arrest at the scene or arrest during transport to the hospital. The secondary outcome was in-hospital mortality. The tertiary outcome was death or severe disability at the time of discharge. Death or severe disability was defined as a GOS $\geq$3 (severe disability, persistent vegetative status, or death). If patients were transferred from the first hospital, the in-hospital mortality and GOS information were collected from the second hospital by reviewing the medical records at that hospital.

2.5. Variables and measurements

The main exposure was seat belt use. Seat belt use data were collected by medical record review. We collected information on age, sex, and past medical history component according to the Elixhauser comorbidity index [15]. We calculated the Elixhauser comorbidity score according to the point system of Van Walraven et al. [16]. We also collected data regarding season, the time of incidents (night [0 a.m.–6 a.m.], morning [6 a.m. to 12 p.m.], afternoon [12 p.m.–6 p.m.], and evening [6 p.m. to 0 a.m.]; start time included and the end time excluded in each group), urbanisation level of incidents (metropolitan, urban, and rural) which was determined based on the classification of the accident occurrence location within municipal-level divisions in the administrative area, seating position (driver or passenger), and alcohol use (yes or no). Furthermore, we collected the injury severity scores. For patients with out-of-hospital cardiac arrest or death on arrival, the injury severity score was not calculated as there was not enough information for a thorough severity assessment for most of those patients. Ambulance response time interval (time from emergency call to arrival of the ambulance at the scene) and hospital managements (operation or embolization in the hospital) were also collected.

2.6. Sample size calculation

In previous studies, the seat belt usage rate in Korea was approximately 80 % [17], and in studies limited to Traumatic Brain Injury (TBI), the odds ratio for death when not wearing a seat belt was about 2 [10]. Therefore, applying a 15 % margin of error and assuming a 95 % confidence interval with an assumed 3 % incidence of immediate cardiac arrest [17], the required sample size was 5529 individuals.

2.7. Statistical analysis

Descriptive analyses were performed to examine the distribution of the study variables. Categorical variables were reported as numbers (percentage), and continuous variables were reported as median (interquartile range [IQR]) or mean (standard deviation [SD]). χ^2 test was used for categorical variables, and Kruskal–Wallis test, for continuous variables.

Unadjusted and adjusted odds ratios (ORs) with 95 % confidence intervals (CIs) of seat belt use for the study outcomes were calculated using logistic regression with seat belt use as the reference. The model was adjusted for age, sex, Elixhauser comorbidity score, season, time of incidents, urbanisation level of incidents, seating position, and alcohol use. To determine whether the preventive effect of seat belt use differed according to characteristics including age, sex, seating position, urbanisation level of incidents, and time of incidents, we conducted an interaction analysis. In this analysis, the time and urbanisation level of incidents were dichotomized

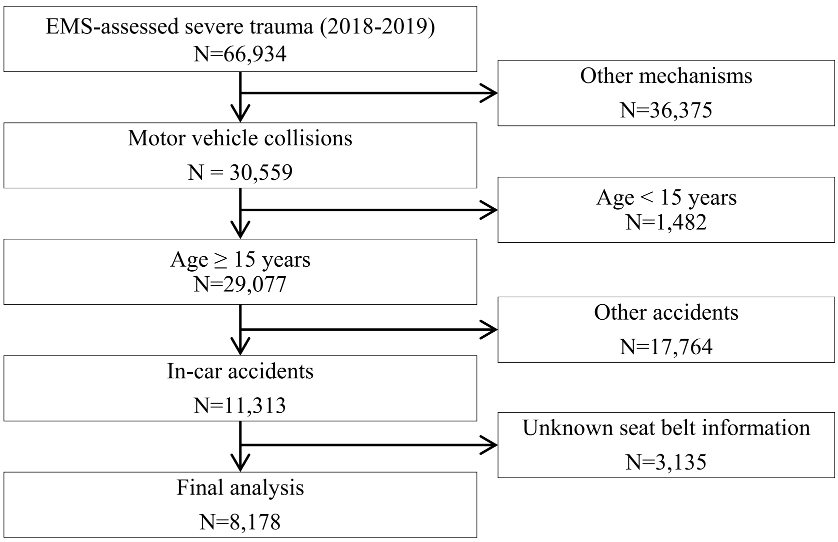

Fig. 1. Patient flow chart. EMS, emergency medical service.

(time of incidents: 6 a.m.–6 p.m. or 6 p.m.–6 a.m., urbanisation level of incidents: metropolitan/urban or rural). *P* values were based on a two-sided significance level of 0.05. SAS software, version 9.4, of the SAS system for Windows, was used for all analyses.

3. Results

3.1. Demographics

Among the 66,934 EMS-assessed severe trauma patients, 30,559 had been involved in MVCs. After excluding those aged <15 years (n = 1482), not in-car accidents (n = 17,764), and unknown seat belt information (n = 3135), 8178 patients remained in the final analysis (Fig. 1).

Table 1 shows the demographic characteristics of seat belt use. Among 8178 eligible patients, 6314 (77.2 %) and 1864 (29.5 %) patients were wearing seat belts and not wearing seat belts, respectively. The "no seat belt use" group had fewer males (59.4 % vs. 63.9 %, p < 0.001), more younger passengers (median [IQR] 51 [32–63] vs. 54 [39–62]), and more incidents reported in the evening and night. The immediate cardiac arrest rate was higher in the "no seat belt use" group than in the "seat belt use" group (9.2 % vs. 3.9 %, p < 0.001). The rates of in-hospital mortality and death or severe disability were higher in the "no seat belt use" group than in the "seat belt use" group (12.4 % vs. 6.2 %, p < 0.001; 17.7 % vs. 9.9 %, p < 0.001, respectively) (Table 1). All patients who experienced immediate cardiac arrest died in the hospital.

Table 2 shows the demographic characteristics of the patients with immediate cardiac arrest; they were less likely to have seat belts on (59.2 % vs. 88.2 %, p < 0.001), to be male (77.8 % vs. 62.0 %, p < 0.001), and to be older than those without immediate cardiac arrest (median [IQR] 56 [44–63] vs. 53 [37–62], p < 0.001). Drivers were more likely to have immediate cardiac arrest than other passengers (78.8 % vs. 66.9 %, p < 0.001).

3.2. Main analysis

The results of the logistic regression analysis are presented in Table 3. The "no seat belt use" group was more likely to experience immediate cardiac arrest (adjusted ORs [95 % CI]:3.29 [2.65–4.08]), have higher in-hospital mortality (adjusted ORs [95 % CI]:2.72

Table 1
Demographic findings of the study population according to the seat belt use.

	Total	Seat belt use	No seat belt use	*P*-value
	N (%)	N (%)	N (%)	
Total	8178	6314	1864	
Male	5140 (62.9)	4033 (63.9)	1107 (59.4)	<0.001
Age, years, Median (IQR)	53 (37–62)	54 (39–62)	51 (32–63)	<0.001
Elixhauser comorbidity score, Mean (SD)[a]	0.45 (2.05)	0.47 (2.11)	0.39 (1.86)	0.192
Season				0.084
Spring	2110 (25.8)	1621 (25.7)	489 (26.2)	
Summer	2306 (28.2)	1799 (28.5)	507 (27.2)	
Fall	2153 (26.3)	1686 (26.7)	467 (25.1)	
Winter	1609 (19.7)	1208 (19.1)	401 (21.5)	
Time of incidents				<0.001
Night	1357 (16.6)	970 (15.4)	387 (20.8)	
Morning	2315 (28.3)	1816 (28.8)	499 (26.8)	
Afternoon	2656 (32.5)	2127 (33.7)	529 (28.4)	
Evening	1850 (22.6)	1401 (22.2)	449 (24.1)	
Urbanisation level of incidents				0.035
Metropolitan	3056 (37.4)	2386 (37.8)	670 (35.9)	
Urban	3273 (40.0)	2479 (39.3)	794 (42.6)	
Rural	1849 (22.6)	1449 (22.9)	400 (21.5)	
Seating position				<0.001
Driver	5517 (67.5)	4652 (73.7)	865 (46.4)	
Passenger	2661 (32.5)	1662 (26.3)	999 (53.6)	
Alcohol use	487 (6.0)	287 (4.5)	200 (10.7)	<0.001
Injury severity score				<0.001
Median (IQR)	4 (1–10)	4 (1–10)	5 (2–13)	<0.001
Missing	506	307	199	
Ambulance response time, min, median (IQR)	9 (6–14)	9 (6–14)	8 (6–13)	<0.001
Hospital management				
Operation	1471 (18.0)	1101 (17.4)	370 (19.8)	0.017
Embolization	98 (1.2)	73 (1.2)	25 (1.3)	0.519
Outcomes				
Immediate cardiac arrest	419 (5.1)	248 (3.9)	171 (9.2)	<0.001
In-hospital mortality	623 (7.6)	392 (6.2)	231 (12.4)	<0.001
Death or severe disability	951 (11.6)	622 (9.9)	329 (17.7)	<0.001

SD, standard deviation; IQR, interquartile range.
[a] We presented the mean (SD) of the Elixir comorbidity score because the first, second, and third quartiles of the variable are all zero.

Table 2
Characteristics of the study population according to the immediate cardiac arrest.

	Total	No immediate cardiac arrest	Immediate cardiac arrest	*P*-value
	N (%)	N (%)	N (%)	
Total	8178	7759	419	
Seat belt use	6314 (87.2)	6066 (88.2)	248 (59.2)	<0.001
Male	5140 (62.9)	4814 (62.0)	326 (77.8)	<0.001
Age, years, Median (IQR)	53 (37–62)	53 (37–62)	56 (44–63)	<0.001
Elixhauser comorbidity score, mean (SD)[a]	0.45 (2.05)	0.47 (2.09)	0.17 (1.13)	0.192
Season				<0.001
Spring	2110 (25.8)	2030 (26.2)	80 (19.1)	
Summer	2306 (28.2)	2196 (28.3)	110 (26.3)	
Fall	2153 (26.3)	2032 (26.2)	121 (28.9)	
Winter	1609 (19.7)	1501 (19.3)	108 (25.8)	
Time of incidents				0.040
Night	1357 (16.6)	1269 (16.4)	88 (21.0)	
Morning	2315 (28.3)	2202 (28.4)	113 (27.0)	
Afternoon	2656 (32.5)	2538 (32.7)	118 (28.2)	
Evening	1850 (22.6)	1750 (22.6)	100 (23.9)	
Urbanisation level of incidents				<0.001
Metropolitan	3056 (37.4)	2846 (36.7)	210 (50.1)	
Urban	3273 (40.0)	3133 (40.4)	140 (33.4)	
Rural	1849 (22.6)	1780 (22.9)	69 (16.5)	
Seating position				<0.001
Driver	5517 (67.5)	5187 (66.9)	330 (78.8)	
Passenger	2661 (32.5)	2572 (33.1)	89 (21.2)	
Alcohol use	487 (6.0)	481 (6.2)	6 (1.4)	<0.001
Ambulance Response time, min, median (IQR)	9 (6–14)	9 (6–14)	10 (6–14)	<0.001
Hospital management				
Operation	1471 (18.0)	1460 (18.8)	11 (2.6)	<0.001
Embolization	98 (1.2)	96 (1.2)	2 (0.5)	0.164
Outcomes				
In-hospital mortality	623 (7.6)	221 (2.8)	402 (95.9)	<0.001
Death or severe disability	951 (11.6)	539 (6.9)	412 (98.3)	<0.001

SD, standard deviation; IQR, interquartile range.
[a] We presented the mean (SD) of the Elixir comorbidity score because the first, second, and third quartiles of the variable are all zero.

[2.26–3.27]), and have higher rates of death or severe disability than the "seat belt use" group (adjusted ORs [95 % CI]:2.40 [2.05–2.80]) (Table 3).

In the interaction analysis using seating position, the risk of immediate cardiac arrest with no seat belt use was higher in the driver seat (adjusted ORs [95 % CI]:3.96 [3.11–5.05]) than in the passenger seat (adjusted ORs [95 % CI]:1.83 [1.19–2.80], p = 0.002). Age, sex, the time of incidents, and the urbanisation level of incidents showed no significant interaction effect on the association between seat belt use and immediate cardiac arrest (Table 4).

4. Discussion

This study used data from a nationwide, EMS-based severe injury registry to evaluate the association between seat belt use and

Table 3
Logistic regression analysis of study outcomes according to the seat belt use.

Group	Total	Outcome	Unadjusted		Adjusted[a]	
	N	N (%)	OR	95 % CI	OR	95 % CI
Immediate cardiac arrest						
All	8178	419 (5.1 %)				
Seat belt use	6314	248 (3.9 %)	1.00		1.00	
No Seat belt use	1864	171 (9.2 %)	2.47	(2.02–3.02)	3.29	(2.65–4.08)
In-hospital mortality						
All	8178	623 (7.6 %)				
Seat belt use	6314	392 (6.2 %)	1.00		1.00	
No Seat belt use	1864	231 (12.4 %)	2.14	(1.80–2.54)	2.72	(2.26–3.27)
Death or severe disability						
All	8178	951 (11.6 %)				
Seat belt use	6314	622 (9.9 %)	1.00		1.00	
No Seat belt use	1864	329 (17.7 %)	1.96	(1.70–2.27)	2.40	(2.05–2.80)

OR, odds ratio; CI, confidence interval.
[a] Adjusted for age, sex, Elixhauser comorbidity score, season, time of incidents, urbanisation level of incidents, alcohol use, and seating position.

Table 4
Interaction analysis on immediate cardiac arrest according to seat position, age group, urbanisation level of the location of incidents, sex, and time of incidents.

		n/N (%)	Adjusted OR (95 % CI)[a]	*P* for interaction
Age				
≤65 years	Seat belt use	199/5225 (3.8)	1.00	0.428
	No seat belt use	131/1500 (8.7)	3.01 (2.37–3.83)	
>65 years	Seat belt use	49/1059 (4.6)	1.00	
	No seat belt use	40/364 (11.0)	3.70 (2.35–5.82)	
Sex				
Male	Seat belt use	194/4033 (4.8)	1.00	0.565
	No seat belt use	132/1107 (11.9)	3.40 (2.67–4.33)	
Female	Seat belt use	54/2281 (2.4)	1.00	
	No seat belt use	39/757 (5.2)	2.94 (1.90–4.55)	
Time of incidents				
6a.m.-6p.m.	Seat belt use	206/5344 (3.9)	1.00	0.234
	No seat belt use	125/1477 (8.5)	3.09 (2.43–3.94)	
6p.m.-6a.m.	Seat belt use	42/970 (4.3)	1.00	
	No seat belt use	46/387 (11.9)	4.21 (2.67–6.63)	
Urbanisation level of incidents				
Metropolitan/Urban	Seat belt use	212/4865 (4.4)	1.00	0.230
	No seat belt use	138/1464 (9.4)	3.12 (2.46–3.95)	
Rural	Seat belt use	36/1449 (2.5)	1.00	
	No seat belt use	33/400 (8.3)	4.35 (2.65–7.14)	
Seating position				
Driver	Seat belt use	203/4652 (4.4)	1.00	
	No seat belt use	127/865 (14.7)	3.96 (3.11–5.05)	
Passenger	Seat belt use	45/1662 (2.7)	1.00	0.002
	No seat belt use	44/999 (4.4)	1.83 (1.19–2.80)	

OR, odds ratio; CI, confidence interval.
[a] Adjusted for age, sex, Elixhauser comorbidity sore, season, time of incidents, urbanisation level of incidents, alcohol use, and seating position.

immediate cardiac arrest. Not wearing seat belts increased the risk of immediate cardiac arrest, in-hospital mortality, and severe disability. The harmful effects of no seat belt use were consistent regardless of age, sex, time of incidents, and urbanisation level of incidents. In addition, the harmful effect of no seat belt use was higher among drivers than among passengers.

Traumatic cardiac arrest is fatal [6,18]. In a recent meta-analysis, the overall survival rate for traumatic cardiac arrest was 3.8 % in studies that included prehospital deaths and 7.7 % in studies that excluded prehospital deaths [19]. Recent guidelines recommend controlling external haemorrhage, securing the airway, bilateral chest decompression, relieving tamponade, and transfusion or resuscitative endovascular balloon occlusion of the aorta (REBOA) in patients with traumatic cardiac arrest, but most methods are difficult to apply in non-physician-based prehospital settings [20]. The definitive or bridging treatment for traumatic cardiac arrest could be surgery or embolization, but the likelihood of receiving such treatment after cardiac arrest is minimal. We also observed that only 11 (2.6 %) and 2 (0.5 %) patients with immediate cardiac arrest were treated with surgery and embolization, respectively, which was lower than the rates of 1460 (18.8 %) and 96 (1.2 %) for patients without immediate cardiac arrest. Since traumatic out-of-hospital cardiac arrest can have fatal outcomes, preventing immediate cardiac arrest after MVC is the most important method to save those patients [4,21,22].

Seat belts are known to reduce rapid deceleration by holding the occupant in place and moving the occupant along with the car [23], resulting in the prevention of various types of injuries. Immediate traumatic arrest after MVC could occur via severe injuries, such as traumatic brain injury, spinal cord injury, aortic injury, or haemorrhage [24,25]. Seat belt use could prevent such fatal injuries and, therefore, prevent immediate cardiac arrest [9–11]. Seat belts can reduce traumatic brain injuries by preventing head impact within the vehicle [10,23]. Thoracic aortic injury is associated with sudden deceleration injury and can also be prevented by using seat belts [11,26]. Injury to the high spinal cord could lead to cardiac arrest [27], and seat belts are reported to reduce cervical spine injury [9]. The results of this study are consistent with those of other studies on the preventive effect of seat belts on mortality and disability [8,10,28,29].

In the interaction analysis, we found that drivers had a higher risk of immediate cardiac arrest than passengers without seat belts. An analysis of crash records in the United States showed that the presence of passengers increased the likelihood of safe driving behaviour and reduced the risk of driver injury and fatalities [30]. People driving with passengers may drive more safely than people driving alone. A previous study showed that driving with a passenger was associated with a lower crash risk than driving alone [31]. The driver group would have included individuals who were driving alone and engaging in more dangerous behaviours, whereas all drivers in the with-passenger group may have driven safely because of the presence of passengers. Except for the seating position, our interaction analysis showed no significant difference in the effect of seat belts based on the variables of daytime driving, sex, or urbanisation level of the location of incidents. Therefore, it is important to emphasise the use of seat belts in all situations.

Information on immediate cardiac arrest should be used actively in MVC prevention programs. Traditional measures of in-hospital mortality from MVCs can be difficult to collect in a timely manner, and interpretation can be complicated because various EMS or hospital components are involved [32]. Police reports alone are insufficient to capture the full extent of severe MVCs [33]. However, immediate cardiac arrest data after MVCs can be collected regularly and in a timely manner using prehospital clinical records [34]. In addition, immediate cardiac arrest would more directly reflect factors related to the traffic environment, such as seat belt use, vehicle safety, and road conditions, which are closely related to laws and regulations. The use of immediate cardiac arrest after MVCs in the evaluation of new laws and regulations could contribute to a timely and objective evaluation [35]. Our study has demonstrated, using national-scale data, that seat belts in MVCs are associated with a reduction in immediate cardiac arrests, an outcome that can be promptly quantified. We anticipate that these findings would be informative for the establishment and evaluation of future preventative policies.

This study had several limitations. First, information about seat belt usage was collected through medical records, which may have introduced bias. This method is less accurate than direct observation or data from police records. Second, detailed information on seat belts, including the type of seat belt, was not collected. Third, information about the circumstances of a crash, such as speed, geographical location of the collision, weather conditions, and airbag deployment, was not collected. Fourth, only information on the drivers and passengers of the vehicle was gathered, and the position of the seat was not reported. Fifth, although unlikely, there is a possibility that the cardiac arrest could have precipitated the accident. With retrospective medical record reviews, it can be difficult to distinguish between cardiac arrests caused by the accident and those that triggered the accident. Sixth, given the nature of our study as observational, residual confounding from unmeasured variables may influence the observed association between seat belt use and cardiac arrest. Finally, this was a cross-sectional study using retrospectively collected nationwide data in Korea; therefore, it may be difficult to generalise these results to other countries with different laws regarding mandatory wearing of seat belts on roads, as well as different road conditions and vehicle safety standards.

5. Conclusions

The findings from this study indicate an association between wearing seat belts and a reduction in immediate cardiac arrest, in-hospital mortality, and severe disability. The effect was consistent across age, sexes, different times of day, and urbanisation levels; seat belt use had a more preventive effect for drivers than for passengers. Preventing immediate cardiac arrest is crucial to decrease the number of deaths and disabilities resulting from MVCs. Information related to immediate cardiac arrest after MVCs should be actively monitored and utilized. Further research is needed to determine effective preventive strategies using various records.

Funding

This study was supported by grant no '07-2020-5034' from the Ministry of Land, Infrastructure and Transport (MOLIT) Research Fund.

Data availability statement

The authors participated in the data collection and quality control process as a team of researchers in the database construction project. However, ownership of the final database is held by the Korea Disease Control and prevention Agency who have authority for the nationwide dataset in South Korea. Permission is required to use the dataset and can be requested by website (website: https://www.kdca.go.kr/injury/).

CRediT authorship contribution statement

Yeongho Choi: Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis. **Jeong Ho Park:** Writing – review & editing, Writing – original draft, Validation, Methodology, Formal analysis, Data curation, Conceptualization. **Young Sun Ro:** Writing – review & editing, Validation, Methodology, Formal analysis, Conceptualization. **Joo Jeong:** Writing – review & editing, Writing – original draft, Validation, Supervision, Resources, Methodology, Investigation. **Yu Jin Kim:** Writing – review & editing, Supervision, Methodology. **Kyoung Jun Song:** Writing – review & editing, Resources, Project administration, Conceptualization. **Sang Do Shin:** Writing – review & editing, Supervision, Project administration, Formal analysis, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Jeong Ho Park reports financial support was provided by Ministry of Land, Infrastructure and Transport (MOLIT). If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

This study was supported by the Korea Disease Control and Prevention Agency (KDCA) and National Fire Agency (NFA).

References

[1] S.L. James, L.R. Lucchesi, C. Bisignano, C.D. Castle, Z.V. Dingels, J.T. Fox, et al., Morbidity and mortality from road injuries: results from the global burden of disease study 2017, Inj. Prev. 26 (Supp 1) (2020) i46–i56, https://doi.org/10.1136/injuryprev-2019-043302.
[2] S. Roy, M.D. Hossain Hawlader, M.H. Nabi, P.A. Chakraborty, S. Zaman, M.M. Alam, Patterns of injuries and injury severity among hospitalized road traffic injury (RTI) patients in Bangladesh, Heliyon 7 (3) (2021) e06440, https://doi.org/10.1016/j.heliyon.2021.e06440.
[3] T. Houwen, Z. Popal, M.A.N. de Bruijn, A.R. Leemeyer, J.H. Peters, M. Terra, et al., Outcomes after prehospital traumatic cardiac arrest in The Netherlands: a retrospective cohort study, Injury 52 (5) (2021) 1117–1122, https://doi.org/10.1016/j.injury.2021.02.088.
[4] J.G. Kim, J. Lee, H.Y. Choi, W. Kim, J. Kim, S. Moon, et al., Outcome analysis of traumatic out-of-hospital cardiac arrest patients according to the mechanism of injury: a nationwide observation study, Medicine (Baltim.) 99 (45) (2020) e23095, https://doi.org/10.1097/MD.0000000000023095.
[5] D. Lockey, K. Crewdson, G. Davies, Traumatic cardiac arrest: who are the survivors? Ann. Emerg. Med. 48 (3) (2006) 240–244, https://doi.org/10.1016/j.annemergmed.2006.03.015.
[6] A. Khalifa, J.B. Avraham, K.Z. Kramer, F. Bajani, C.Y. Fu, A. Pires-Menard, et al., Surviving traumatic cardiac arrest: identification of factors associated with survival, Am. J. Emerg. Med. 43 (2021) 83–87, https://doi.org/10.1016/j.ajem.2021.01.020.
[7] D. Shi, C. McLaren, C. Evans, Neurological outcomes after traumatic cardiopulmonary arrest: a systematic review, Trauma Surg Acute Care Open 6 (1) (2021) e000817, https://doi.org/10.1136/tsaco-2021-000817.
[8] A.K. Abbas, A.F. Hefny, F.M. Abu-Zidan, Seatbelts and road traffic collision injuries, World J. Emerg. Surg. 6 (1) (2011) 18, https://doi.org/10.1186/1749-7922-6-18.
[9] C.S. Parenteau, D.C. Viano, Spinal fracture-dislocations and spinal cord injuries in motor vehicle crashes, Traffic Inj. Prev. 15 (7) (2014) 694–700, https://doi.org/10.1080/15389588.2013.867434.
[10] J.M. Kim, S.C. Kim, K.H. Lee, H.J. Kim, H. Kim, S.W. Lee, et al., Preventive effects of seat belts on traumatic brain injury in motor vehicle collisions classified by crash severities and collision directions, Eur. J. Trauma Emerg. Surg. 47 (5) (2021) 1437–1449, https://doi.org/10.1007/s00068-019-01095-4.
[11] K.J. Brasel, R. Quickel, N. Yoganandan, J.A. Weigelt, Seat belts are more effective than airbags in reducing thoracic aortic injury in frontal motor vehicle crashes, J. Trauma Acute Care Surg. 53 (2) (2002) 309–313. https://journals.lww.com/jtrauma/Fulltext/2002/08000/Seat_Belts_Are_More_Effective_than_Airbags_in.20.aspx.
[12] G.M. Han, A. Newmyer, M. Qu, Seat belt use to save face: impact on drivers' body region and nature of injury in motor vehicle crashes, Traffic Inj. Prev. 16 (6) (2015) 605–610, https://doi.org/10.1080/15389588.2014.999856.
[13] S.M. Sasser, R.C. Hunt, E.E. Sullivent, M.M. Wald, J. Mitchko, G.J. Jurkovich, et al., Guidelines for field triage of injured patients. Recommendations of the national expert panel on field triage, MMWR Recomm. Rep. (Morb. Mortal. Wkly. Rep.) 58 (RR-1) (2009) 1–35. https://www.ncbi.nlm.nih.gov/pubmed/19165138.
[14] J.H. Park, K.J. Song, S.D. Shin, K.J. Hong, Y.S. Ro, J. Jeong, Y.H. Choi, Epidemiology and outcomes of severe injury patients: nationwide community-based study in Korea, Injury 53 (6) (2022) 1935–1946, https://doi.org/10.1016/j.injury.2022.03.013.
[15] A. Elixhauser, C. Steiner, D.R. Harris, R.M. Coffey, Comorbidity measures for use with administrative data, Med. Care 36 (1) (1998) 8–27, https://doi.org/10.1097/00005650-199801000-00004.
[16] C. van Walraven, P.C. Austin, A. Jennings, H. Quan, A.J. Forster, A modification of the Elixhauser comorbidity measures into a point system for hospital death using administrative data, Med. Care 47 (6) (2009) 626–633, https://doi.org/10.1097/MLR.0b013e31819432e5.
[17] J.Y. Ahn, H.W. Ryoo, J.B. Park, J.K. Kim, M.J. Lee, D.E. Lee, et al., Comparison of traffic collision victims between older and younger drivers in South Korea: epidemiologic characteristics, risk factors and types of collisions, PLoS One 14 (4) (2019) e0214205, https://doi.org/10.1371/journal.pone.0214205.
[18] M.G. Millin, S.M. Galvagno, S.R. Khandker, A. Malki, E.M. Bulger, Standards, et al., Withholding and termination of resuscitation of adult cardiopulmonary arrest secondary to trauma: resource document to the joint NAEMSP-ACSCOT position statements, J. Trauma Acute Care Surg. 75 (3) (2013) 459–467, https://doi.org/10.1097/TA.0b013e31829cfaea.
[19] N.J. Vianen, E.M.M. Van Lieshout, I.M. Maissan, W.M. Bramer, D.D. Hartog, M.H.J. Verhofstad, M.G. Van Vledder, Prehospital traumatic cardiac arrest: a systematic review and meta-analysis, Eur. J. Trauma Emerg. Surg. 48 (4) (2022) 3357–3372, https://doi.org/10.1007/s00068-022-01941-y.
[20] C. Lott, A. Truhlar, A. Alfonzo, A. Barelli, V. Gonzalez-Salvado, J. Hinkelbein, et al., European resuscitation council guidelines 2021: cardiac arrest in special circumstances, Resuscitation 161 (2021) 152–219, https://doi.org/10.1016/j.resuscitation.2021.02.011.
[21] F.D. Battistella, W. Nugent, J.T. Owings, J.T. Anderson, Field triage of the pulseless trauma patient, Arch. Surg. 134 (7) (1999) 742–745, https://doi.org/10.1001/archsurg.134.7.742. ; discussion 5-6.
[22] J.T. Grasner, J. Herlitz, I.B.M. Tjelmeland, J. Wnent, S. Masterson, G. Lilja, et al., European resuscitation council guidelines 2021: epidemiology of cardiac arrest in europe, Resuscitation 161 (2021) 61–79, https://doi.org/10.1016/j.resuscitation.2021.02.007.
[23] M. Mackay, Engineering in accidents: vehicle design and injuries, Injury 25 (9) (1994) 615–621, https://doi.org/10.1016/0020-1383(94)90037-x.
[24] S. O'Donovan, C. van den Heuvel, M. Baldock, R.W. Byard, Causes of fatalities in motor vehicle occupants: an overview, Forensic Sci. Med. Pathol. 18 (4) (2022) 511–515, https://doi.org/10.1007/s12024-022-00503-3.
[25] D. Rao, Fatal road traffic collisions-an autopsy based study, Ip International journal of forensic medicine and toxicological sciences 6 (3) (2021) 113–117.
[26] W.R. Jamieson, M.T. Janusz, V.M. Gudas, L.H. Burr, G.J. Fradet, C. Henderson, Traumatic rupture of the thoracic aorta: third decade of experience, Am. J. Surg. 183 (5) (2002) 571–575, https://doi.org/10.1016/s0002-9610(02)00851-6.
[27] K.G. Lehmann, J.G. Lane, J.M. Piepmeier, W.P. Batsford, Cardiovascular abnormalities accompanying acute spinal cord injury in humans: incidence, time course and severity, J. Am. Coll. Cardiol. 10 (1) (1987) 46–52, https://doi.org/10.1016/s0735-1097(87)80158-4.
[28] Y. Katayama, T. Kitamura, K. Kiyohara, J. Sado, T. Hirose, T. Matsuyama, et al., Prehospital factors associated with death on hospital arrival after traffic crash in Japan: a national observational study, BMJ Open 9 (1) (2019) e025350, https://doi.org/10.1136/bmjopen-2018-025350.
[29] J.C. Pressley, E. Pawlowski, L.M. Hines, S. Bhatta, M.J. Bauer, Motor vehicle crash and hospital charges in front- and rear-seated restrained and unrestrained adult motor vehicle occupants, Int. J. Environ. Res. Publ. Health 19 (20) (2022), https://doi.org/10.3390/ijerph192013674.
[30] C. Lee, M. Abdel-Aty, Presence of passengers: does it increase or reduce driver's crash potential? Accid. Anal. Prev. 40 (5) (2008) 1703–1712, https://doi.org/10.1016/j.aap.2008.06.006.
[31] T. Rueda-Domingo, P. Lardelli-Claret, D. Luna-del-Castillo Jde, J.J. Jimenez-Moleon, M. Garcia-Martin, A. Bueno-Cavanillas, The influence of passengers on the risk of the driver causing a car collision in Spain. Analysis of collisions from 1990 to 1999, Accid. Anal. Prev. 36 (3) (2004) 481–489, https://doi.org/10.1016/S0001-4575(03)00043-5.
[32] C.C. Diamond, F. Mostashari, C. Shirky, Collecting and sharing data for population Health: a new paradigm, Health Aff. 28 (2) (2009) 454–466, https://doi.org/10.1377/hlthaff.28.2.454.
[33] L.R. Cercarelli, D.L. Rosman, G.A. Ryan, Comparison of accident and emergency with police road injury data, J. Trauma 40 (5) (1996) 805–809, https://doi.org/10.1097/00005373-199605000-00021.
[34] N.C. Mann, J.R. Hedges, The role of prehospital care providers in the advancement of public Health, Prehosp. Emerg. Care 6 (sup2) (2002) S63–S67, https://doi.org/10.3109/10903120209102685.
[35] F. Tainter, C. Fitzpatrick, J. Gazillo, R. Riessman, M. Knodler Jr., Using a novel data linkage approach to investigate potential reductions in motor vehicle crash severity - an evaluation of strategic highway safety plan emphasis areas, J. Saf. Res. 74 (2020) 9–15, https://doi.org/10.1016/j.jsr.2020.04.012.