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Keywords:	driving under the influence, alcohol, mortality, helmet use, airbag

The effect of lowering the legal blood alcohol concentration limit on driving under the influence (DUI) in southern Taiwan – a cross-sectional retrospective analysis

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Abstract

Objectives: To profile the epidemiological changes of driving under the influence (DUI) in southern Taiwan after lowing the legal blood alcohol concentration (BAC) limit from 50 to 30 mg/dL In 2013.

Setting: Level 1 trauma medical center in southern Taiwan.

Participants: Data from 7,447 patients (4,375 males and 3,072 females) were retrieved from the Trauma Registry System of a single trauma center to examine DUI status, patient characteristics, and accident-related factors before and after the sanction change. The factors include gender, age, vehicle type, airbag use in car accidents and helmet use in motorcycle accidents, time of accident, BAC, Abbreviated Injury Score (AIS), injury severity score (ISS), and mortality.

Results: Our results indicated that the percentage of DUI patients declined from 10.99% (n=373) to 6.64% (n=269) with the lowered BAC limit. Use of airbags in car accidents (OR: 0.30, 95% CI: 0.10-0.88, $p = 0.007$) and helmet use in motorcycle accidents (OR: 0.20, 95% CI: 0.15-0.26, $p < 0.001$) was less in DUI patients compared to that in non-DUI patients after sanction change with significant negative correlation. DUI behavior increased accident mortality risk before the sanction (OR: 4.33, 95% CI: 2.20-8.54) and even more so after the sanction (OR: 5.60, 95% CI: 3.16-9.93). The difference in OR for mortality before and after the sanction was not significant ($p = 0.568$).

Conclusion: This study revealed that lowering the BAC limit to 30 mg/dL significantly reduced the number of DUI events, but failed to result in a significant reduction in mortality in these trauma patients.

Keywords driving under the influence; alcohol; mortality; helmet use; airbag

Strengths and limitations of this study

1. This study revealed that, with the legal blood alcohol concentration limit lowered from 50 to 30 mg/dL, the percentage of patients driving under the influence of alcohol declined, the percentage of airbag use in car accidents decreased, while helmet use in motorcycle accidents increased.
2. However, the lowering legal blood alcohol concentration limit from 50 to 30 mg/dL did not significantly reduce the odds of mortality in the patients after sanction change.
3. This study was limited by its retrospective design and the data collected from one level I regional trauma center.

INTRODUCTION

According to the World Health Organization (WHO), over 1.2 million people die each year in road traffic accidents, with 75% of road traffic fatalities occurring in men in the economically active age ranges [1]. It is estimated that over 90% of road traffic deaths occur in low-income and middle-income countries, causing significant GDP losses of up to 5% [2]. Alcohol intoxication has been proposed as one of the primary causes of all road accidents. Driving under the influence (DUI) of alcohol increases the risk of accident as well as the severity of the accident injury, and results in longer hospital stays, higher healthcare costs, and poorer outcomes compared to drivers in non-DUI accidents [3-6]. When the driver's blood alcohol concentration (BAC) exceeds 50 mg/dL, the risk and severity of traffic accidents increase remarkably [7-10].

To reduce alcohol-impaired driving, stricter laws have been implemented including minimum legal drinking ages, taxes on beer, BAC limits, the provision of alcohol education, and the establishment of drug and alcohol treatment programs [11]. Based on the deterrence theory, changes to existing sanctions, such as the lowering of BAC limits, are commonly used to reduce DUI. DUI-related traffic accidents have caused over 3000 deaths and approximately 110,000 injuries in Taiwan over the past decade (2007-2016) [12], Nevertheless, DUI was not deemed a serious crime prior to April 1999. It was legal to drive with breath alcohol content (BrAC) of up to 0.25 mg/L (i.e., BAC of 50 mg/dL). Drivers with BrAC between 0.25 and 0.55 mg/L (i.e., BAC between 50 and 110 mg/dL) would violate Road Traffic Security Rules, and would face license suspension, revocation, or pecuniary punishment. Only drivers with BrAC > 0.55 mg/L (i.e., BAC > 110 mg/dL) violated Article 185 of the Criminal Law, but would face imprisonment of less than a year and fines of less than New

Taiwan Dollars (NTD) 30,000 (~ US dollars 1,000).

In recent years, DUI has received increased media attention as alcohol-impaired traffic accidents are frequently reported. A series of amendments were made to the Road Traffic Management and Penalty Act, Road Traffic Security Rules, and Article 185 of the Criminal Law [13], including the most recent amendment to Road Traffic Security Rules in 2013, which lowers the BrAC limit from 0.25 mg/L (BAC 50 mg/dL) to 0.15 mg/L (BAC 30 mg/dL). In addition, penalties were increased from NTD 15,000-60,000 (~ US $500-2,000) to NTD 15,000-90,000 (~ US $500-3,000). According to the national statistics, drunk-driving casualties reduced after these sanctions [13]. However, data on monthly injuries and deaths caused by DUI-related accidents and number of monthly DUI violations comes from sobriety checkpoints by the police. Specific data on the impact of DUI on medical service utilization after changes to sanctions are not available. The purpose of this study was to compare the epidemiological profile of DUI in southern Taiwan before (July 2009 to December 2012) and after (July 2013 to December 2016) the changes to sanctions using data from the Trauma Registry System. We examined the profiles of DUI patients before and after the sanction change, as well as DUI accident characteristics to define the prognosis and risk factors of DUI related injury and the effect of sanction change on these factors.

PATIENTS AND METHODS

We conducted a retrospective study of patient data collected by the Trauma Registry System between July 2009 and December 2016 to investigate clinical outcomes and baseline features of DUI before and after changes to sanctions. Only patients who were drivers in car/motorcycle accidents that occurred in Kaohsiung and Pingtung areas of Taiwan and were hospitalized after their emergency room (ER) visit were included in the study. Patients with incomplete data were excluded, as well as those whose visit took place between January 2013 and June 2013, the period when amendments to the Road Traffic Management and Penalty Act were announced and implemented. This study was approved by the institutional review board (IRB) of the Kaohsiung Chang Gung Memorial Hospital (reference number 201701844B0), a 2686-bed facility and Level I regional trauma center that provides primary care to trauma patients primarily from southern Taiwan [14,15]. Data from 7,447 patients were used for the analysis.

BAC tests are ordered for patients in the ER with clinical suspicion of DUI. For the study, patients with BAC > 30 mg/dL (the threshold for DUI) were categorized into two groups according to when their visit took place: July 2009 to December 2012 (before increased sanctions; total 3,395 patients), and July 2013 to December 2016 (after increased sanctions; total 4,052 patients). Detailed patient information was retrieved from the Trauma Registry System of our institution, and included the following variables: age, gender, type of vehicle accident, time and location of accident, airbag use in car accidents, helmet use in motorcycle accidents, BAC, hospital length of stay (LOS), in-hospital mortality, and associated trauma in each body region. The Abbreviated Injury Score (AIS) was used to evaluate injury severity in the following regions: head/neck, face, chest, abdomen, extremities (including pelvis), and external. Some groups of patients with higher AIS scores would be combined for analysis due to inadequate patient number. The Injury Severity Score (ISS) was calculated by summing the square of the three highest AIS scores in each region [16].

Demographic traits and clinical variables were compared before and after sanction change using the Chi-square test, Student's *t*-test and Mann-Whiney U-test. Differences in parameters between DUI and non-DUI groups were also examined. Parameters were presented as numbers (percentage), median ± interquartile range (IQR), or mean ± standard deviation (SD). Logistic regression was used to define changes in baseline traits and clinical outcomes in the DUI and non-DUI groups before and after increased sanctions. Breslow-Day statistics testing was performed to examine homogeneity in different stratifications. R software (Version 3.3.3; package = cartography, method = choroLayer) was used to geographically present the change in the number of patients with DUI in southern Taiwan. The trend in the number of DUI patients from 2009 to 2016 was also demonstrated. All other analysis was performed using SAS software (Version 9.4). Statistical significance was defined as $p < 0.05$.

Patient and Public Involvement

Patients and or public were not involved please state this.

Results

A total of 7,447 patients, including 4,375 males and 3,072 females, were included in this study. The mean age at the time of accident was 43.68 ± 18.70 (range:

11-90 years). Of these patients, 642 (8.6%) were classified as DUI according to the amended definition of BAC ≥ 30 mg/dL. The majority of the traffic accidents were motorcycle accidents (7,237 patients; 97.2%), and often happened between 6 AM – 2 PM (3,173 patients; 42.6%). Motorcyclists were wearing a helmet at the time of the accident in 88.93% (n = 7,237) of the patients, whereas 63.81% (n = 134) of car drivers had airbag protection. The average mortality was 1.34%, and median hospital LOS was six days.

As shown in Table 1, 3,395 patients were sent to our ER before the sanction change and 4,052 patients after. In both time periods, patients tended to be males between the ages of 40-45. The percentage of DUI declined from 10.99% (n = 373) to 6.64% (n = 269) after sanction, and the average BAC decreased from 21.19 mg/dL to 12.31 mg/dL. The declining trend of monthly DUI patients after sanction change is depicted in Figure 1. This trend was observed across different regions in southern Taiwan, as shown in Figure 2. The percentage of airbag use in car accidents decreased, while helmet use in motorcycle accidents increased. No significant changes in mortality and hospital stay were found in our analysis. Patient numbers do not vary by season or day of the week, although a slight decrease was observed in the spring before sanction.

Examination of demographic features and clinical outcomes in DUI and non-DUI patients revealed that patients in the DUI group were mostly male (88.47%) compared to the non-DUI group (55.94%) (Table 2). Patients in the DUI group were significantly younger than those in the non-DUI ($p < 0.001$) group. Reduced use of airbags in car accidents and helmets in motorcycle accidents was found in higher proportion in the DUI group than in the non-DUI group. DUI patients tended to have significantly higher ISS (13 vs. 9, respectively, $p < 0.001$) and longer hospital stay (8 days vs. 6 days, respectively, $p < 0.001$) than non-DUI patients. A significantly higher mortality rate was found in DUI patients than in non-DUI (4.67% vs. 1.03%, respectively, $p < 0.001$). No significant seasonal differences were found in our analysis between the DUI and non-DUI groups. Time of visit to the ER differed for the DUI patients compared to the non-DUI patients. Most DUI patients visited ER between 10 PM and 6 AM (50.31%), while only 13.33% of non-DUI patients visited at this time. Additionally, DUI accidents tended to occur on weekends (18.69% on Saturday and 19.31% on Sunday).

Table 3 compares odds ratios (OR) for different stratified parameters before and after sanction. Males still showed increased risk of DUI (Crude OR 6.01, 95% CI: 4.69-7.69), but sanction change showed no significant effect on gender in terms of DUI behavior. DUI behavior increased the accident mortality risk before sanction (OR: 4.33, 95% CI: 2.20-8.54), and even more so after sanction (OR: 5.60, 95% CI: 3.16-9.93). Difference in OR of mortality before and after sanction change was not significant ($p = 0.568$). Regarding time of accident, a greater number of DUI patients appeared between 10 PM and 6 AM (OR 12.70) than between 2 PM and 10 PM (3.04) and between 6 AM and 2 PM (baseline). This trend was significantly exaggerated after sanction, which showed OR of 20.76 in the period 10 PM - 6 AM and OR 5.50 in the period 2 PM - 10 PM compared to the baseline OR in the period 6 AM - 2 PM. There was no significant correlation between airbag protection and DUI behavior in car accidents (OR 0.49, 95% CI: 0.20-1.18) before sanction. However, car accidents with airbag protection were less frequent in DUI patients than in non-DUI patients after sanction (OR: 0.30, 95% CI: 0.10-0.88) with a significantly negative correlation. Similar results were found in motorcycle accidents. Helmet use in motorcycle accidents was a protective factor with a negative correlation to DUI behavior. This negative correlation was reinforced by sanction change. The OR of helmet use and DUI was 0.42 (95% CI: 0.32-0.55) before sanction and 0.30 (95% CI: 0.15-0.26) after sanction with significant difference ($p < 0.001$). Season of accident had no effect on DUI behavior before sanction or after sanction. Workdays were significantly negatively correlated with DUI behavior as compared to weekends (Saturday and Sunday) both before and after sanction change.

The AIS of different regions were examined on DUI and non-DUI patients, and they indicated that DUI patients were more susceptible to injuries to the head and neck, face, thorax, and abdomen than non-DUI patients (Table 4). No significant difference was found in the external injuries between DUI and non-DUI patients. However, patients with DUI were less likely than non-DUI patients to suffer from severe injury to the extremities.

Discussion

Our analysis presented various factors associated with DUI behavior, including gender, mortality, time of the day, day of the week, use of airbags in cars, and use of helmets among motorcyclists. In this study, females accounted for a minor proportion (12%) of DUI patients, consistent with previous research [17]. Complex causal relationships in physiological and social factors may account for the difference in males and females involved in DUI. Our previous studies also reported more males than females with traffic accidents sent to our emergency room [14,18]. Compared to females, males had a higher risk of motorcycle accidents [19,20], which accounted for approximately 60% of injuries in southern Taiwan [14,18]. Male/female differences in alcoholic liver injury [21], alcohol-induced brain injury [22], and alcohol-related behavioral and medical problems have also been reported [23-25]. Increased vehicle performance and a higher number of safety features lead to greater risk-taking behavior by the driver [26], and our results indicated that drivers using airbags in their vehicles show a significantly lower OR of being in a DUI accident. This finding could indicate a relationship between the value placed on safety (e.g., purchase cars with more safety features) and the avoidance of risk-taking behaviors such as DUI. Our study also examined helmet use in motorcyclists. It has been mandatory for motorcyclists in Taiwan to wear helmets since June 1997, and helmets were used by 90% of patients in this study. Previous studies have reported helmet use to be a protective factor or strong predictor of motorcycle accidents [19,27-29]. Our study also found that helmet use plays a significantly protective role in DUI accidents, supporting findings from Ohio, USA and Iran that suggest that motorcyclists involved in alcohol-involved crashes are significantly less likely to wear a helmet [30,31].

Our analysis is consistent with findings in Taiwan based on national statistics [13] that report a significant reduction in DUI events after sanction change. Previous studies report reductions in both accidents and fatalities when legal limits for BAC are lowered to 50 mg/dL [32,33]. A significant decrease of 3.7% (95% CI: 0.9–6.5%) in fatally injured drivers with a BAC level equal to or greater than 50 mg/dL was found following the sanction change [34]. A recent meta-analysis examined the impact of lowering the legal BAC limit to 50 mg/dL, and found an 11.1% decrease in rates of fatal alcohol-related crashes [35]. In this study, the proportion of male and female DUI patients and overall mortality rate did not change after the sanction change. However, while the proportions of males and females did not change, other elements of the patient composition changed with BAC 30 mg/dL. In our study, the percentage of DUI patients decreased from 11.0% to 6.6% and was accompanied by a decline in average BAC. The decline in DUI events can be seen in the different geographical regions of Kaohsiung and Pingtung surrounding our hospital. Time of injury appears to play a role in severity of injury. It has been reported that drivers not under the influence of alcohol suffer more severe injuries between midnight and early morning compared to early night-time [36]. Findings from other studies have indicated that injuries involving drunk drivers are influenced less by geographic and environmental factors than by the nature of collision and time of accident [37]. Our results indicate different temporal distribution (in weekday and time of day, but not in seasons) in the DUI and non-DUI groups. Most non-DUI patients visited the ER between early morning and afternoon (6 AM – 2 PM), but DUI patients tend to search for medical aid between 10 PM to 6 AM (50.31%). A previous study in Hong Kong indicated a similar temporal pattern in DUI using a slightly different time framework [38]. This study found that most DUI events occurred between 3 PM – 11 PM (39.5%) and 11

PM - 7 AM (29.8%). Consistent with our findings, a higher prevalence of DUI on weekends than on weekdays is reported in other studies [39].

Although our study found that DUI events significantly decreased after sanction change, the increased point estimate for OR of DUI on mortality was not significant. Studies have shown that alcohol impairs driving ability, and that the intoxicated driver is more likely to cause fatal road traffic accidents [40], while other research has found the risk of mortality is not higher in patients with positive BAC [3]. Some studies have found that serum ethanol is independently associated with increased mortality [41,42]. Furthermore, some studies have proposed alcohol use can have a protective effect in trauma patients [3,43,44]. In this study, we did not find a protective role for DUI in our analysis of the association between DUI and AIS. These findings indicated that BAC limit, consistent with deterrence theory, can reduce alcohol-impaired driving [45,46], but may be not enough to result in a significant reduction in mortality of those trauma patients. This may indicate that other preventative policies, such as beer taxes, minimum legal drinking ages, and administrative license revocation, should be considered [47].

There are some limitations to our study. First, the analysis was based on data from the trauma registry system of a level I regional trauma center in southern Taiwan. These results may not be externally valid. Second, there were differences in the baseline characteristics of patients admitted after traffic accident before and after sanction change. The differences in baseline characteristics may have confounded results and observed differences may have implied the effect of sanction change. Third, the combined use of psychoactive medication and alcohol may increase the risk of having an accident [48,49]. This confounder was not controlled in our study, although this bias is random. Fourth, patients seeking medical care due to traffic accident did not routinely receive a blood alcohol test unless they showed symptoms of being alcohol-impaired. This may underestimate the effect of DUI in our analysis. Fifth, our registry system is not able to report exact time elapsed from injury to an alcohol test. However, the mean transport time for the patients transported by emergency medical service to the hospital was 18.3 ± 7.9 min according to our data and about 12 min according to Taiwan government data from January 2009 to June 2009. Thus, the bias may be minimal. Finally, our registry system did not exclude the repeated DUI patients. Although these drivers may be a small group in our study subjects, they may confound our statistical results.

CONCLUSION

This study revealed that lowering the legal limit for BAC to 30 mg/dL significantly reduced DUI events. Airbag use in car accidents and helmet use in motorcycle accidents after sanction change was less in DUI patients than in non-DUI patients with significant negative correlation. Sanction change failed to result in a significant reduction in mortality in these trauma patients.

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Author Contributions

Y.-C.T. wrote the manuscript, J.-F.H. assisted with the study design, S.C.H. K. was involved in the literature review, C.-S.R. was responsible for the integrity of registered data, P.-C.C performed the statistical analyses and edited the tables, H.-Y.H. proofread the manuscript, and C.-H.H. designed the study and contributed to the data analysis and interpretation. All authors read and approved the final manuscript.

Conflicts Of Interest

The authors report no conflicts of interest in this work

Data Sharing

No additional data are available.

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Table 1. Demographic features and DUI-related variables before and after sanction

	Before sanction	After sanction	*p*
Gender, n (%)			0.028
Male	2,041 (60.12%)	2,334 (57.6%)	
Female	1,354 (39.88%)	1,718 (42.4%)	
Age (years)	42.77 (18.34)	44.45 (18.97)	<0.001[a]
DUI, n (%)			<0.001
Yes	373 (10.99%)	269 (6.64%)	
No	3,022 (89.01%)	3,783 (93.36%)	
BAC (mg/dL)	21.19 (62.49)	12.31 (47.12)	<0.001[a]
Car, n (%)			0.057
Airbag	73 (70.19%)	61 (57.55%)	
No airbag	31 (29.81%)	45 (42.45%)	
Motorcycle, n (%)			<0.001
Helmet	2,876 (87.39%)	3,560 (90.22%)	
No Helmet	415 (12.61%)	386 (9.78%)	
ISS	9 (9)	9 (9)	0.041[a]
Hospital stay (days)	6 (7)	7 (8)	0.198[a]
Mortality, n (%)			0.125
Alive	3,357 (98.88%)	3,990 (98.47%)	
Death	38 (1.12%)	62 (1.53%)	
Seasons, n (%)			<0.001
Spring	605 (17.82%)	994 (24.53%)	
Summer	874 (25.74%)	1,008 (24.88%)	
Autumn	970 (28.57%)	962 (23.74%)	
Winter	946 (27.86%)	1,088 (26.85%)	

Time, n (%)			<0.001
6AM - 2PM	1,351 (39.79%)	1,822 (44.97%)	
2PM - 10PM	1,436 (42.30%)	1,608 (39.68%)	
10PM - 6AM	608 (17.91%)	622 (15.35%)	
Weekdays, n (%)			0.012
Monday	487 (14.34%)	639 (15.77%)	
Tuesday	553 (16.29%)	558 (13.77%)	
Wednesday	440 (12.96%)	587 (14.49%)	
Thursday	494 (14.55%)	590 (14.56%)	
Friday	480 (14.14%)	613 (15.13%)	
Saturday	504 (14.85%)	582 (14.36%)	
Sunday	437 (12.87%)	483 (11.92%)	

[a] Mann-Whitney test

Table 2. Demographic features and clinical outcome in DUI and non-DUI patients

	DUI	Non-DUI	*p*
Gender, n (%)			<0.001
Male	568 (88.47%)	3,807 (55.94%)	
Female	74 (11.53%)	2,998 (44.06%)	
Age (years)	39.64 (12.76)	44.07 (19.13)	<0.001[a]
Car, n (%)			0.020
Airbag	25 (50.00%)	109 (68.13%)	
No airbag	25 (50.00%)	51 (31.88%)	
Motorcycle, n (%)			<0.001
Helmet	433 (73.14%)	6,003 (90.34%)	
No Helmet	159 (26.86%)	642 (9.66%)	
ISS	13 (14)	9 (7)	<0.001[a]
Hospital stay (days)	8 (11)	6 (7)	<0.001[a]
Mortality, n (%)			<0.001
Alive	612 (95.33%)	6,735 (98.97%)	
Death	30 (4.67%)	70 (1.03%)	
Seasons, n (%)			0.522
Spring	135 (21.03%)	1,464 (21.51%)	
Summer	153 (23.83%)	1,729 (25.41%)	
Autumn	163 (25.39%)	1,769 (26.00%)	
Winter	191 (29.75%)	1,843 (27.08%)	
Time, n (%)			<0.001
6AM - 2PM	70 (10.90%)	3,103 (45.60%)	
2PM - 10PM	249 (38.79%)	2,795 (41.07%)	
10PM - 6AM	323 (50.31%)	907 (13.33%)	

Weekdays, n (%)			<0.001
Monday	81 (12.62%)	1,045 (15.36%)	
Tuesday	72 (11.21%)	1,039 (15.27%)	
Wednesday	85 (13.24%)	942 (13.84%)	
Thursday	79 (12.31%)	1,005 (14.77%)	
Friday	81 (12.62%)	1,012 (14.87%)	
Saturday	120 (18.69%)	966 (14.20%)	
Sunday	124 (19.31%)	796 (11.70%)	

[a] Mann-Whitney test

Table 3. Homogeneity analysis of factors related to DUI before and after sanction

	Before sanction			After sanction			Crude OR	*p*
	DUI	Non-DUI	OR (95% CI)	DUI	Non-DUI	OR (95% CI)	(95% CI)	
Gender, n (%)								
Male	331 (9.75%)	1710 (50.37%)	6.05 (4.35-8.40)	237 (5.85%)	2097 (51.75%)	5.96 (4.09-8.66)	6.01 (4.69-7.69)	0.952
Female	42 (1.24%)	1312 (38.65%)		32 (0.79%)	1686 (41.61%)			
Mortality, n (%)								
Alive	360 (10.60%)	2997 (88.28%)	4.33 (2.20-8.54)	252 (6.22%)	3738 (92.25%)	5.60 (3.16-9.93)	4.98 (3.21-7.73)	0.568
Death	13 (0.38)	25 (0.74%)		17 (0.42%)	45 (1.11%)			
Time, n (%)								<0.001
6AM – 2PM	46 (12.33%)	1305 (43.18%)	1	24 (8.92%)	1798 (47.53%)	1		
2PM – 10PM	139 (37.27%)	1297 (42.92%)	3.04 (2.16-4.28)	110 (40.89%)	1498 (39.60%)	5.50 (3.52-8.60)		
10PM – 6AM	188 (50.40%)	420 (13.90%)	12.70 (9.03-17.85)	135 (50.19%)	487 (12.87%)	20.76 (13.30-32.41)		
Car, n (%)								
Airbag	19 (59.38%)	54 (75.00%)	0.49 (0.20-1.18)	6 (33.33%)	55 (62.50%)	0.30 (0.10-0.88)		0.007
No airbag	13 (40.63%)	18 (25.00%)		12 (66.67%)	33 (37.50%)			

Saturday	72 (19.30%)	432 (14.30%)	0.83 (0.58-1.18)	48 (17.84%)	534 (14.12%)	0.76 (0.50-1.15)		
Motorcycle n (%)								<0.001
Helmet	261 (76.54%)	2615 (88.64%)	0.42 (0.32-0.55)	172 (68.53%)	3388 (91.69%)	0.20 (0.15-0.26)		
No Helmet	80 (23.46%)	335 (11.36%)		79 (31.47%)	307 (8.31%)			
Seasons, n (%)								0.456
Spring	63 (16.89%)	542 (17.94%)	1	72 (26.77%)	922 (24.37%)	1		
Summer	98 (26.27%)	776 (25.68%)	1.09 (0.78-1.52)	55 (20.45%)	953 (25.19%)	0.74 (0.51-1.06)	0.96 (0.75-1.22)	
Autumn	94 (25.20%)	876 (28.99%)	0.92 (0.66-1.29)	69 (25.65%)	893 (23.61%)	0.99 (0.70-1.39)	1.00 (0.79-1.27)	
Winter	118 (31.64%)	828 (27.40%)	1.23 (0.89-1.70)	73 (27.14%)	1015 (26.83%)	0.92 (0.66-1.29)	1.12 (0.89-1.42)	
Weekdays, n (%)								<0.001
Sunday	73 (19.57%)	364 (12.05%)	1	51 (18.96%)	432 (11.42%)	1		
Monday	40 (10.72%)	447 (14.79%)	0.45 (0.30-0.67)	41 (15.24%)	598 (15.81%)	0.58 (0.38-0.89)		
Tuesday	45 (12.06%)	508 (16.81%)	0.44 (0.30-0.66)	27 (10.04%)	531 (14.04%)	0.43 (0.27-0.70)		
Wednesday	47 (12.60%)	393 (13.00%)	0.60 (0.40-0.88)	38 (14.13%)	549 (14.51)	0.57 (0.38-0.91)		
Thursday	50 (13.40%)	444 (14.69%)	0.56 (0.38-0.83)	29 (10.78%)	561 (14.83%)	0.44 (0.27-0.70)		
Friday	46 (12.33%)	434 (14.36%)	0.53 (0.36-0.78)	35 (13.01%)	578 (15.28%)	0.51 (0.33-0.80)		

[a] Breslow-Day statistic

Table 4. The distribution of Abbreviated Injury Scale (AIS) score in DUI/non-DUI patients

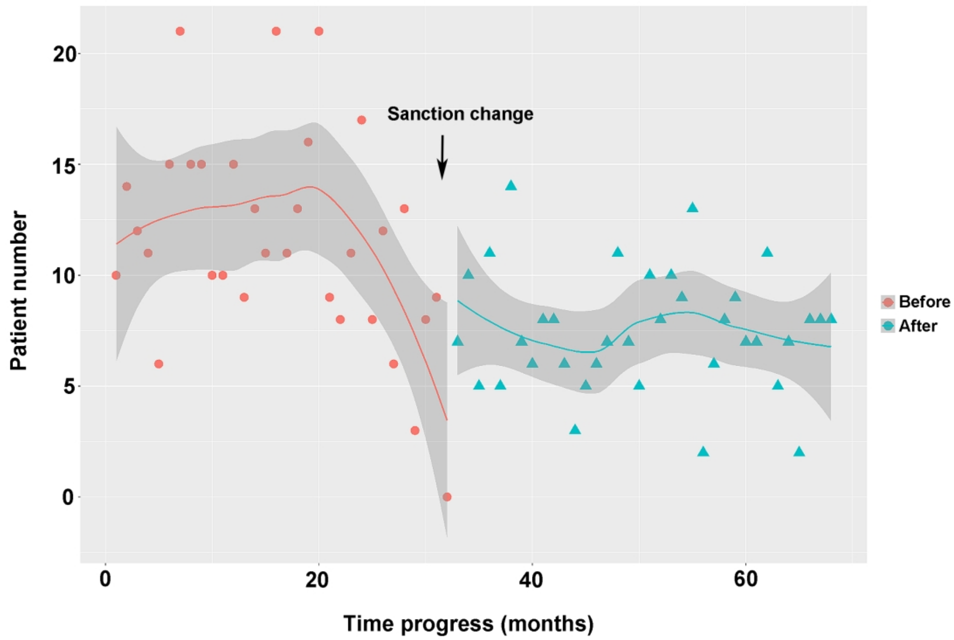
	DUI	Non-DUI	OR (95% CI)	p
Head/Neck				< 0.0001
0	269 (41.90%)	4799 (70.52%)	1	
1	94 (14.64%)	638 (9.38%)	2.63 (2.05-3.37)	
2	22 (3.43%)	105 (1.54%)	3.74 (2.32-6.02)	
3	81 (12.62%)	506 (7.44%)	2.86 (2.19-3.72)	
4	131 (20.40%)	597 (8.77%)	3.92 (3.12-4.91)	
5-6	45 (7.01%)	1160 (2.35%)	0.69 (0.50-0.96)	
Face				< 0.0001
0	361 (56.23%)	5342 (78.50%)	1	
1	64 (9.97%)	493 (7.24%)	1.921 (1.45-2.55)	
2	215 (33.49%)	949 (13.95%)	3.353 (2.79-4.02)	
3	2 (0.31%)	21 (0.31%)	1.409 (0.33-6.03)	
Thorax				< 0.0001
0	488 (76.01%)	5640 (82.88%)	1	
1	31 (4.83%)	220 (3.23%)	1.63 (1.11-2.40)	
2	27 (4.21%)	306 (4.50%)	1.02 (0.681-1.53)	
3	57 (8.88%)	437 (6.42%)	1.51 (1.13-2.02)	
4	37 (5.76%)	196 (2.88%)	2.18 (1.52-3.14)	
5-6	2 (0.32%)	6 (0.08%)	3.85 (0.78-19.14)	
Abdomen				< 0.0001
0	552 (85.98%)	6319 (92.86%)	1	
1	7 (1.09%)	38 (0.56%)	2.109 (0.94-4.74)	
2	42 (6.54%)	222 (3.26%)	2.166 (1.57-3.05)	

3	23 (3.58%)	141 (2.07%)	1.867 (1.19-2.93)	
4	13 (2.02%)	69 (1.01%)	2.157 (1.19-3.93)	
5	5 (0.78%)	16 (0.24%)	3.583 (1.31-9.81)	
Extremities				< 0.0001
0	261 (40.65%)	1839 (29.02%)	1	
1	63 (9.81%)	435 (6.39%)	1.020 (0.76-1.37)	
2	185 (28.82%)	2973 (43.69%)	0.438 (0.36-0.53)	
3-5	133 (20.72%)	1558 (22.89%)	0.61 (0.48-0.75)	
External				0.195
0	536 (83.49%)	5799 (85.22%)	1	
1	102 (15.89%)	981 (14.42%)	1.125 (0.90-1.41)	
2	4 (0.62%)	25 (0.37%)	1.731 (0.60-4.99)	

Figure legend

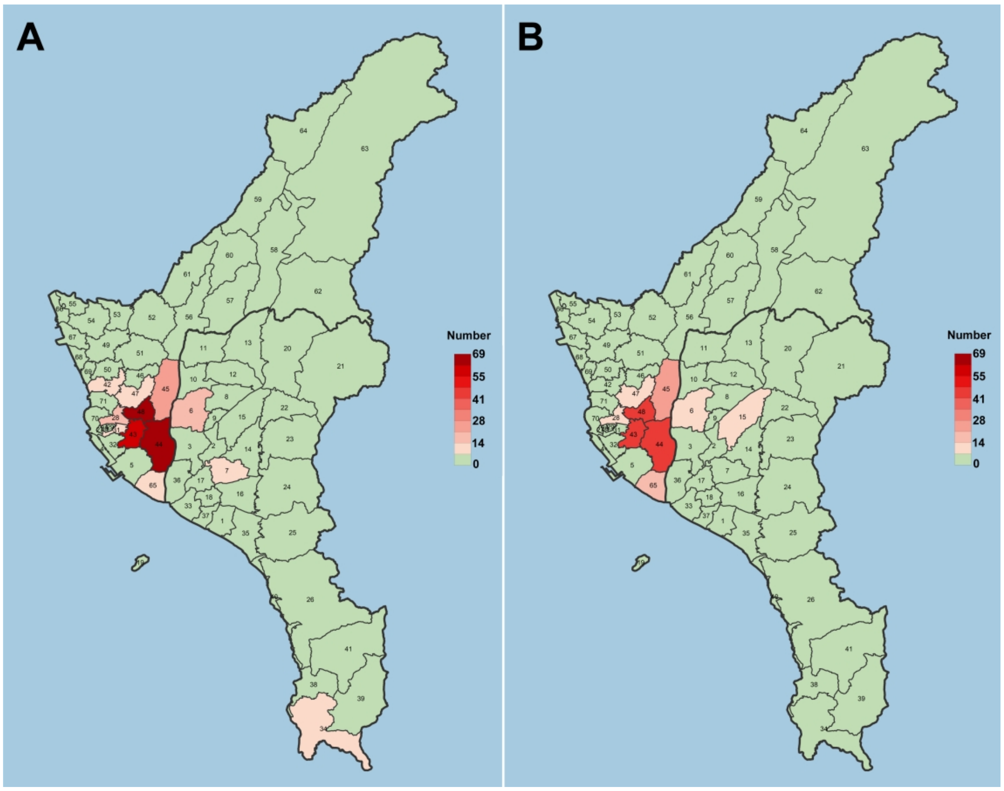
Figure 1. The monthly DUI patient number before (July 2009 to December 2012) and after (July 2013 to December 2016) sanction change with multivariate regression line

Figure 2. DUI event density over the 71 district areas of southern Taiwan (A. before sanction change; B. after sanction change)



The monthly DUI patient number before (July 2009 to December 2012) and after (July 2013 to December 2016) sanction change with multivariate regression line

224x153mm (300 x 300 DPI)



DUI event density over the 71 district areas of southern Taiwan (A. before sanction change; B. after sanction change)

350x273mm (300 x 300 DPI)

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7
Bias	9	Describe any efforts to address potential sources of bias	-
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7
		(*b*) Describe any methods used to examine subgroups and interactions	7
		(*c*) Explain how missing data were addressed	6
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	-
		(*e*) Describe any sensitivity analyses	6
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6
		(b) Give reasons for non-participation at each stage	-
		(c) Consider use of a flow diagram	-
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8-10
		(b) Indicate number of participants with missing data for each variable of interest	-
Outcome data	15*	Report numbers of outcome events or summary measures	8-10
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	8-10

		(*b*) Report category boundaries when continuous variables were categorized	-
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	-
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	-
Discussion			
Key results	18	Summarise key results with reference to study objectives	11
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	13-14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	11
Generalisability	21	Discuss the generalisability (external validity) of the study results	-
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	14

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

The effect of lowering the legal blood alcohol concentration limit on driving under the influence (DUI) in southern Taiwan – a cross-sectional retrospective analysis

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Primary Subject Heading:	Public health
Secondary Subject Heading:	Addiction, Epidemiology, Public health
Keywords:	driving under the influence, alcohol, mortality, helmet use, airbag

The effect of lowering the legal blood alcohol concentration limit on driving under the influence (DUI) in southern Taiwan – a cross-sectional retrospective analysis

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ABSTRACT

Objectives: To profile the epidemiological changes of driving under the influence (DUI) in southern Taiwan after lowering the legal blood alcohol concentration (BAC) limit from 50 to 30 mg/dL in 2013.

Setting: Level 1 trauma medical center in southern Taiwan.

Participants: Data from 7,447 patients (4,375 males and 3,072 females) were retrieved from the Trauma Registry System of a single trauma center to examine DUI status, patient characteristics, and accident-related factors before and after the sanction change. The factors include gender, age, vehicle type, airbag use in car crashes and helmet use in motorcycle crashes, time of crashes, BAC, Abbreviated Injury Score (AIS), injury severity score (ISS), and mortality.

Results: Our results indicated that the percentage of DUI patients significantly declined from 10.99% (n=373) to 6.64% (n=269) with the lowered BAC limit. Use of airbags in car crashes (OR: 0.30, 95% CI: 0.10-0.88, p = 0.007) and helmet use in motorcycle crashes (OR: 0.20, 95% CI: 0.15-0.26, p < 0.001) was less in DUI patients compared to that in non-DUI patients after sanction change with significant negative correlation. DUI behavior increased accident mortality risk before the sanction (OR: 4.33, 95% CI: 2.20-8.54) and even more so after the sanction (OR: 5.60, 95% CI: 3.16-9.93). The difference in OR for mortality before and after the sanction was not significant (p = 0.568).

Conclusion: This study revealed that lowering the BAC limit to 30 mg/dL significantly

reduced the number of DUI events, but failed to result in a significant reduction in mortality in these trauma patients.

Keywords driving under the influence; alcohol; mortality; helmet use; airbag

Strengths and limitations of this study

1. This study revealed that, with the legal blood alcohol concentration limit lowered from 50 to 30 mg/dL, the percentage of patients driving under the influence of alcohol declined, the percentage of airbag use in car crashes decreased, while helmet use in motorcycle crashes increased.
2. However, the lowering legal blood alcohol concentration limit from 50 to 30 mg/dL did not significantly reduce the odds of mortality in the patients after sanction change.
3. This study was limited by its retrospective design and the data collected from one level I regional trauma center.

Introduction

According to the World Health Organization (WHO), over 1.2 million people die each year in road traffic accidents, with 75% of road traffic fatalities occurring in men in the economically active age ranges [1]. It is estimated that over 90% of road traffic deaths occur in low-income and middle-income countries, causing significant GDP losses of up to 5% [2]. Alcohol intoxication has been proposed as one of the primary causes of all road accidents. Driving under the influence (DUI) of alcohol increases the risk of accident as well as the severity of the accident injury, and results in longer hospital stays, higher healthcare costs, and poorer outcomes compared to drivers in non-DUI accidents [3-6]. When the driver's blood alcohol concentration (BAC) exceeds 50 mg/dL, the risk and severity of traffic accidents increase remarkably [7-10].

To reduce alcohol-impaired driving, stricter laws have been implemented including minimum legal drinking ages, taxes on beer, BAC limits, the provision of alcohol education, and the establishment of drug and alcohol treatment programs [11]. Based on the deterrence theory, changes to existing sanctions, such as the lowering of BAC limits, are commonly used to reduce DUI. DUI-related traffic accidents have caused over 3000 deaths and approximately 110,000 injuries in Taiwan over the past decade (2007-2016) [12], Nevertheless, DUI was not deemed a serious crime prior to April 1999. It was legal to drive with BAC of 50 mg/dL. Drivers with BAC between 50 and 110 mg/dL would violate Road Traffic Security Rules, and would face license suspension, revocation, or pecuniary punishment. Only drivers with BAC > 110 mg/dL violated Article 185 of the Criminal Law, but would face imprisonment of less than a year and fines of less than New Taiwan Dollars (NTD) 30,000 (~ US dollars 1,000).

In recent years, DUI has received increased media attention as alcohol-impaired traffic crashes are frequently reported. A series of amendments were made to the Road Traffic Management and Penalty Act, Road Traffic Security Rules, and Article 185 of the Criminal Law [13], including the most recent amendment to Road Traffic Security Rules in 2013, which lowers the BAC limit from 50 mg/dL to 30 mg/dL. In addition, penalties were increased from NTD 15,000-60,000 (~ US $500-2,000) to NTD 15,000-90,000 (~ US $500-3,000). According to the national statistics, drunk-driving casualties reduced after these sanctions [13]. However, data on monthly injuries and deaths caused by DUI-related crashes and number of monthly DUI violations comes from sobriety checkpoints by the police. Specific data on the impact of DUI on medical service utilization after changes to sanctions are not available. The purpose of this study was to compare the epidemiological profile of DUI in southern Taiwan before (July 2009 to December 2012) and after (July 2013 to December 2016) the changes to sanctions using data from the Trauma Registry System. We examined the profiles of DUI patients before and after the sanction change, as well as DUI crash characteristics to define the prognosis and risk factors of DUI related injury and the effect of sanction change on these factors.

Patients and methods

Patient and Public Involvement.

The patients and the public were not involved in this study.

Methods

We conducted a retrospective study of patient data collected by the Trauma Registry System between July 2009 and December 2016 to investigate clinical outcomes and baseline features of DUI before and after changes to sanctions. Only patients who were drivers in car/motorcycle crashes that occurred in Kaohsiung and Pingtung areas of Taiwan and were hospitalized after their emergency room (ER) visit were included in the study. Twenty-three patients with incomplete data were excluded, as well as those whose visit took place between January 2013 and June 2013, the period when amendments to the Road Traffic Management and Penalty Act were announced and implemented. This study was approved by the institutional review board (IRB) of the Kaohsiung Chang Gung Memorial Hospital (reference number 201701844B0), a 2686-bed facility and Level I regional trauma center that provides primary care to trauma patients primarily from southern Taiwan [14,15]. Data from 7,447 patients were used for the analysis.

BAC tests are ordered for patients in the ER with clinical suspicion of DUI. For the study, patients with BAC > 30 mg/dL (the threshold for DUI) were categorized into two groups according to when their visit took place: July 2009 to December 2012 (before increased sanctions; total 3,395 patients), and July 2013 to December 2016 (after increased sanctions; total 4,052 patients). Detailed patient information was retrieved from the Trauma Registry System of our institution, and included the following variables: age, gender, type of vehicle crashes, time and location of crashes, airbag use in car crashes, helmet use in motorcycle crashes, BAC, hospital length of stay (LOS), in-hospital mortality, and associated trauma in each body region. The Abbreviated Injury Score (AIS) was used to evaluate injury severity in the following regions: head/neck, face, chest, abdomen, extremities (including pelvis), and external. Some groups of patients with higher AIS scores would be combined for analysis due to inadequate patient number. The Injury Severity Score (ISS) was calculated by summing the square of the three highest AIS scores in each region [16].

Demographic traits and clinical variables were compared before and after sanction change using the Chi-square test, Student's *t*-test and Mann-Whiney U-test. Differences in parameters between DUI and non-DUI groups were also examined. Parameters were presented as numbers (percentage), median ± interquartile range (IQR), or mean ± standard deviation (SD). Logistic regression was used to define changes in baseline traits and clinical outcomes in the DUI and non-DUI groups before and after increased sanctions. Breslow-Day statistics testing was performed to examine homogeneity in different stratifications. Besides, we also analyzed the ratio of single vehicle nighttime (SVN) crashes to multiple vehicle daytime (MVD) crashes as a proxy measure used in many studies for alcohol involvement [17,18]. R software (Version 3.3.3; package = cartography, method = choroLayer) was used to geographically present the change in the number of patients with DUI in southern Taiwan. The trend in the number of DUI patients from 2009 to 2016 was also demonstrated. All other analysis was performed using SAS software (Version 9.4). Statistical significance was defined as $p < 0.05$.

RESULTS

A total of 7,447 patients, including 4,375 males and 3,072 females, were included in this study. The average age at the time of crash was 43.68 ± 18.70 (range: 11-90 years). Of these patients, 642 (8.6%) were classified as DUI according to the amended definition of BAC ≥ 30 mg/dL. Most of the traffic accidents were motorcycle crashes (7,237 patients; 97.2%), and often happened between 6 AM – 2 PM (3,173 patients; 42.6%). Motorcyclists were wearing a helmet at the time of the crash in 88.93% (n = 7,237) of the patients, whereas 63.81% (n = 134) of car drivers had airbag protection. The average mortality was 1.34%, and median hospital LOS was six days.

As shown in Table 1, 3,395 patients were sent to our ER before the sanction change and 4,052 patients after. In both time periods, patients tended to be males between the ages of 40-45. The percentage of DUI significantly declined from 10.99% (n = 373) to 6.64% (n = 269) after sanction (Figure 1), and the average BAC decreased from 21.19 mg/dL to 12.31 mg/dL. This trend was observed across different regions in southern Taiwan, as shown in Figure 2. The percentage of airbag use in car accidents decreased, while helmet use in motorcycle accidents increased. No significant changes in mortality and hospital stay were found in our analysis. Patient numbers do not vary by season or day of the week, although a slight decrease was observed in the spring before sanction.

Examination of demographic features and clinical outcomes in DUI and non-DUI patients revealed that patients in the DUI group were mostly male (88.47%) compared to the non-DUI group (55.94%) (Table 2). Patients in the DUI group were significantly younger than those in the non-DUI ($p < 0.001$) group. Reduced use of airbags in car crashes and helmets in motorcycle crashes was found in higher proportion in the DUI group than in the non-DUI group. DUI patients tended to have significantly higher ISS

(13 vs. 9, respectively, p < 0.001) and longer hospital stay (8 days vs. 6 days, respectively, p < 0.001) than non-DUI patients. A significantly higher mortality rate was found in DUI patients than in non-DUI (4.67% vs. 1.03%, respectively, p < 0.001). No significant seasonal differences were found in our analysis between the DUI and non-DUI groups. Time of visit to the ER differed for the DUI patients compared to the non-DUI patients. Most DUI patients visited ER between 10 PM and 6 AM (50.31%), while only 13.33% of non-DUI patients visited at this time. Additionally, DUI crashes tended to occur on weekends (18.69% on Saturday and 19.31% on Sunday).

Table 3 compares odds ratios (OR) for different stratified parameters before and after sanction. Males still showed increased odds of DUI (Crude OR 6.01, 95% CI: 4.69-7.69), but sanction change showed no significant effect on gender in terms of DUI behavior. DUI behavior increased the crash mortality risk before sanction (OR: 4.33, 95% CI: 2.20-8.54), and even more so after sanction (OR: 5.60, 95% CI: 3.16-9.93). Difference in OR of mortality before and after sanction change was not significant (p = 0.568). Regarding time of crash, a greater number of DUI patients appeared between 10 PM and 6 AM (OR 12.70) than between 2 PM and 10 PM (3.04) and between 6 AM and 2 PM (baseline). This trend was significantly exaggerated after sanction, which showed OR of 20.76 in the period 10 PM - 6 AM and OR 5.50 in the period 2 PM - 10 PM compared to the baseline OR in the period 6 AM - 2 PM. There was no significant correlation between airbag protection and DUI behavior in car crashes (OR 0.49, 95% CI: 0.20-1.18) before sanction. However, car crashes with airbag protection were less frequent in DUI patients than in non-DUI patients after sanction (OR: 0.30, 95% CI: 0.10-0.88) with a significantly negative correlation. Similar results were found in motorcycle crashes. Helmet use in motorcycle crashes was a protective factor with a negative correlation to DUI behavior. This negative correlation was reinforced by sanction change. The OR of helmet use and DUI was 0.42 (95% CI: 0.32-0.55) before sanction and 0.30 (95% CI: 0.15-0.26) after sanction with significant difference ($p < 0.001$). Season of crash had no effect on DUI behavior before sanction or after sanction. Workdays were significantly negatively correlated with DUI behavior as compared to weekends (Saturday and Sunday) both before and after sanction change.

The AIS of different regions were examined on DUI and non-DUI patients, and they indicated that DUI patients were more susceptible to injuries to the head and neck, face, thorax, and abdomen than non-DUI patients (Table 4). No significant difference was found in the external injuries between DUI and non-DUI patients. However, patients with DUI were less likely than non-DUI patients to suffer from severe injury to the extremities.

Discussion

Our analysis presented various factors associated with DUI behavior, including gender, mortality, time of the day, day of the week, use of airbags in cars, and use of helmets among motorcyclists. In this study, females accounted for a minor proportion (12%) of DUI patients, consistent with previous research [19]. Complex causal relationships in physiological and social factors may account for the difference in males and females involved in DUI. Our previous studies also reported more males than females with traffic crashes sent to our emergency room [14,20]. Compared to females, males had a higher risk of motorcycle accidents [21,22], which accounted for approximately 60% of injuries in southern Taiwan [14,20]. Male/female differences in alcoholic liver injury [23], alcohol-induced brain injury [24], and alcohol-related behavioral and medical problems have also been reported [25-27]. Increased vehicle performance and a higher number of safety features lead to greater risk-taking behavior by the driver [28], and our results indicated that drivers using airbags in their vehicles show a significantly lower OR of being in a DUI crash. Although the use of airbags going down may be due to the reason that DUI drivers tend to drive older vehicles, not wear a safety belt, and speed, this finding could indicate a relationship between the value placed on safety (e.g., purchase cars with more safety features) and the avoidance of risk-taking behaviors such as DUI. Our study also examined helmet use in motorcyclists. It has been mandatory for motorcyclists in Taiwan to wear helmets since June 1997, and helmets were used by 90% of patients in this study. Previous studies have reported helmet use to be a protective factor or strong predictor of motorcycle accidents [21,29-31]. Our study also found that helmet use plays a significantly protective role in DUI crashes, supporting findings from Ohio, USA and Iran that suggest that motorcyclists involved in alcohol-involved crashes are significantly less likely to wear a helmet [32,33]. This decreased post-sanction helmet use rate in our data may contributed to our higher mortality in post-sanction change DUI drivers.

Our analysis is consistent with findings in Taiwan based on national statistics [13] that report a significant reduction in DUI events after sanction change. Previous studies report reductions in both accidents and fatalities when legal limits for BAC are lowered to 50 mg/dL [34,35]. A significant decrease of 3.7% (95% CI: 0.9–6.5%) in fatally injured drivers with a BAC level equal to or greater than 50 mg/dL was found following the sanction change [36]. A recent meta-analysis examined the impact of lowering the legal BAC limit to 50 mg/dL, and found an 11.1% decrease in rates of fatal alcohol-related crashes [37]. In this study, the proportion of male and female DUI patients and overall mortality rate did not change after the sanction change. However, while the proportions of males and females did not change, other elements of the patient composition changed with BAC 30 mg/dL. In our study, the percentage of DUI patients significantly decreased from 10.99% to 6.6% and was accompanied by a decline in average BAC. The decline in DUI events can be seen in the different geographical regions of Kaohsiung and Pingtung surrounding our hospital. Time of injury appears to play a role in severity of injury. It has been reported that drivers not under the influence of alcohol suffer more severe injuries between midnight and early morning compared to early night-time [38]. Findings from other studies have indicated that injuries involving drunk drivers are influenced less by geographic and environmental factors than by the nature of collision and time of accident [39]. Our results indicate different temporal distribution (in weekday and time of day, but not in seasons) in the DUI and non-DUI groups. Most non-DUI patients visited the ER between early morning and afternoon (6 AM – 2 PM), but DUI patients tend to search for medical aid between 10 PM to 6 AM (50.31%). A previous study in Hong Kong indicated a similar temporal pattern in DUI using a slightly different time framework [40]. This study found that most DUI events occurred between 3 PM – 11 PM (39.5%) and 11 PM - 7 AM (29.8%). Consistent with our findings, a higher prevalence of DUI on weekends than on weekdays is reported in other studies [41]. In addition to above analysis, there were similar numbers over SVNs pre- and post-sanction change. Post-sanction SVN/MVD ratio significant drop to 0.48 from pre-sanction SVN/MVD ratio with 0.60. It also indicated sanction change had effect on the reduction of DUI behavior.

Although our study found that DUI events significantly decreased after sanction change, the increased point estimate for OR of DUI on mortality was not significant. Moreover, the post-sanction mortality OR in DUI was significantly higher than pre-sanction-DUI. It may be explained by these DUI drivers after sanction change is more addicted to alcohol and was associated with lower helmet use rate. Studies have shown that alcohol impairs driving ability, and that the intoxicated driver is more likely to cause fatal road traffic accidents [42], while other research has found the risk of mortality is not higher in patients with positive BAC [3]. Some studies have found that serum ethanol is independently associated with increased mortality [43,44]. Furthermore, some studies have proposed alcohol use can have a protective effect in trauma patients [3,45,46]. In this study, we did not find a protective role for DUI in our analysis of the association between DUI and AIS. These findings indicated that BAC limit, consistent with deterrence theory, can reduce alcohol-impaired driving [47,48], but may be not enough to result in a significant reduction in mortality of those trauma patients. This may indicate that other preventative policies, such as beer taxes, minimum legal drinking ages, and administrative license revocation, should be considered [49].In fact, drivers with or without DUI had more heterogeneity in the factors that may affect injury severity [50]. The bias may exist in the analysis with multivariate logistic regression for the association between the injury severity and the drivers with or without DUI, thus may comprise a limitation in this study.

There are some other limitations to our study. First, the analysis was based on data from the trauma registry system of a level I regional trauma center in southern Taiwan. These results may not be externally valid. Besides, our selected statistical methods with limited parameters may not clarify the contributing factors and outcomes of DUI crashes due to its complex interaction [51]. Second, there were differences in the baseline characteristics of patients admitted after traffic crashes before and after sanction change. The differences in baseline characteristics may have confounded results and observed differences may have implied the effect of sanction change. Third, the combined use of psychoactive medication and alcohol may increase the risk of having an accident [52,53]. This confounder was not controlled in our study, although this bias is random. Fourth, patients seeking medical care due to traffic accident did not routinely receive a blood alcohol test unless they showed symptoms of being alcohol-impaired or unconsciousness. This may underestimate the effect of DUI in our analysis. Fifth, our registry system is not able to report exact time elapsed from injury to an alcohol test. However, the mean transport time for the patients transported by emergency medical service to the hospital was 18.3 ± 7.9 min according to our data and about 12 min according to Taiwan government data from January 2009 to June 2009. Thus, the bias may be minimal. Furthermore, our registry system did not exclude the repeated DUI patients, although these drivers may be a small group in our study subjects, they may confound our statistical results. Finally, there may exist bias in the outcome assessment with control of alcohol consumption, vehicle miles travelled, and vehicles and motorcycles registered, which were lack in the registered trauma database.

Conclusion

This study revealed that lowering the legal limit for BAC to 30 mg/dL significantly reduced DUI events. Airbag use in car accidents and helmet use in motorcycle accidents after sanction change was less in DUI patients than in non-DUI patients with significant negative correlation. Sanction change failed to result in a significant reduction in mortality in these trauma patients.

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Author Contributions

Y.-C.T. wrote the manuscript, S.-C.W. revised the manuscript, J.-F.H. assisted with the study design, S.C.H. K. was involved in the literature review, C.-S.R. was responsible for the integrity of registered data, P.-C.C performed the statistical analyses and edited the tables, H.-Y.H. proofread the manuscript, and C.-H.H. designed the study and contributed to the data analysis and interpretation. All authors read and approved the final manuscript.

Conflicts Of Interest

The authors report no conflicts of interest in this work

Data Sharing

No additional data are available.

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Table 1. Demographic features and DUI-related variables before and after sanction

	Before sanction	After sanction	*p*
Gender, n (%)			0.028
Male	2,041 (60.12%)	2,334 (57.6%)	
Female	1,354 (39.88%)	1,718 (42.4%)	
Age (years)	42.77 (18.34)	44.45 (18.97)	<0.001[a]
DUI, n (%)			<0.001
Yes	373 (10.99%)	269 (6.64%)	
No	3,022 (89.01%)	3,783 (93.36%)	
BAC (mg/dL)	21.19 (62.49)	12.31 (47.12)	<0.001[a]
Car, n (%)			0.057
Airbag	73 (70.19%)	61 (57.55%)	
No airbag	31 (29.81%)	45 (42.45%)	
Motorcycle, n (%)			<0.001
Helmet	2,876 (87.39%)	3,560 (90.22%)	
No Helmet	415 (12.61%)	386 (9.78%)	
ISS	9 (9)	9 (9)	0.041[a]
Hospital stay (days)	6 (7)	7 (8)	0.198[a]
Mortality, n (%)			0.125
Alive	3,357 (98.88%)	3,990 (98.47%)	
Death	38 (1.12%)	62 (1.53%)	
Seasons, n (%)			<0.001
Spring	605 (17.82%)	994 (24.53%)	
Summer	874 (25.74%)	1,008 (24.88%)	
Autumn	970 (28.57%)	962 (23.74%)	
Winter	946 (27.86%)	1,088 (26.85%)	

Time, n (%)			<0.001
6AM - 2PM	1,351 (39.79%)	1,822 (44.97%)	
2PM - 10PM	1,436 (42.30%)	1,608 (39.68%)	
10PM - 6AM	608 (17.91%)	622 (15.35%)	
Weekdays, n (%)			0.012
Monday	487 (14.34%)	639 (15.77%)	
Tuesday	553 (16.29%)	558 (13.77%)	
Wednesday	440 (12.96%)	587 (14.49%)	
Thursday	494 (14.55%)	590 (14.56%)	
Friday	480 (14.14%)	613 (15.13%)	
Saturday	504 (14.85%)	582 (14.36%)	
Sunday	437 (12.87%)	483 (11.92%)	

[a] Mann-Whitney test

Table 2. Demographic features and clinical outcome in DUI and non-DUI patients

	DUI	Non-DUI	*p*
Gender, n (%)			<0.001
Male	568 (88.47%)	3,807 (55.94%)	
Female	74 (11.53%)	2,998 (44.06%)	
Age (years)	39.64 (12.76)	44.07 (19.13)	<0.001[a]
Car, n (%)			0.020
Airbag	25 (50.00%)	109 (68.13%)	
No airbag	25 (50.00%)	51 (31.88%)	
Motorcycle, n (%)			<0.001
Helmet	433 (73.14%)	6,003 (90.34%)	
No Helmet	159 (26.86%)	642 (9.66%)	
ISS	13 (14)	9 (7)	<0.001[a]
Hospital stay (days)	8 (11)	6 (7)	<0.001[a]
Mortality, n (%)			<0.001
Alive	612 (95.33%)	6,735 (98.97%)	
Death	30 (4.67%)	70 (1.03%)	
Seasons, n (%)			0.522
Spring	135 (21.03%)	1,464 (21.51%)	
Summer	153 (23.83%)	1,729 (25.41%)	
Autumn	163 (25.39%)	1,769 (26.00%)	
Winter	191 (29.75%)	1,843 (27.08%)	
Time, n (%)			<0.001
6AM - 2PM	70 (10.90%)	3,103 (45.60%)	
2PM - 10PM	249 (38.79%)	2,795 (41.07%)	
10PM - 6AM	323 (50.31%)	907 (13.33%)	

Weekdays, n (%)			<0.001
Monday	81 (12.62%)	1,045 (15.36%)	
Tuesday	72 (11.21%)	1,039 (15.27%)	
Wednesday	85 (13.24%)	942 (13.84%)	
Thursday	79 (12.31%)	1,005 (14.77%)	
Friday	81 (12.62%)	1,012 (14.87%)	
Saturday	120 (18.69%)	966 (14.20%)	
Sunday	124 (19.31%)	796 (11.70%)	

[a] Mann-Whitney test

Table 3. Homogeneity analysis of factors related to DUI before and after sanction

	Before sanction			After sanction			Crude OR	*p*
	DUI	Non-DUI	OR (95% CI)	DUI	Non-DUI	OR (95% CI)	(95% CI)	
Gender, n (%)								
Male	331 (9.75%)	1710 (50.37%)	6.05 (4.35-8.40)	237 (5.85%)	2097 (51.75%)	5.96 (4.09-8.66)	6.01 (4.69-7.69)	0.952
Female	42 (1.24%)	1312 (38.65%)		32 (0.79%)	1686 (41.61%)			
Mortality, n (%)								
Alive	360 (10.60%)	2997 (88.28%)	4.33 (2.20-8.54)	252 (6.22%)	3738 (92.25%)	5.60 (3.16-9.93)	4.98 (3.21-7.73)	0.568
Death	13 (0.38)	25 (0.74%)		17 (0.42%)	45 (1.11%)			
Time, n (%)								<0.001
6AM – 2PM	46 (12.33%)	1305 (43.18%)	1	24 (8.92%)	1798 (47.53%)	1		
2PM – 10PM	139 (37.27%)	1297 (42.92%)	3.04 (2.16-4.28)	110 (40.89%)	1498 (39.60%)	5.50 (3.52-8.60)		
10PM – 6AM	188 (50.40%)	420 (13.90%)	12.70 (9.03-17.85)	135 (50.19%)	487 (12.87%)	20.76 (13.30-32.41)		
Car, n (%)								
Airbag	19 (59.38%)	54 (75.00%)	0.49 (0.20-1.18)	6 (33.33%)	55 (62.50%)	0.30 (0.10-0.88)		0.007
No airbag	13 (40.63%)	18 (25.00%)		12 (66.67%)	33 (37.50%)			

Saturday	72 (19.30%)	432 (14.30%)	0.83 (0.58-1.18)	48 (17.84%)	534 (14.12%)	0.76 (0.50-1.15)		
Motorcycle n (%)								<0.001
Helmet	261 (76.54%)	2615 (88.64%)	0.42 (0.32-0.55)	172 (68.53%)	3388 (91.69%)	0.20 (0.15-0.26)		
No Helmet	80 (23.46%)	335 (11.36%)		79 (31.47%)	307 (8.31%)			
Seasons, n (%)								0.456
Spring	63 (16.89%)	542 (17.94%)	1	72 (26.77%)	922 (24.37%)	1		
Summer	98 (26.27%)	776 (25.68%)	1.09 (0.78-1.52)	55 (20.45%)	953 (25.19%)	0.74 (0.51-1.06)	0.96 (0.75-1.22)	
Autumn	94 (25.20%)	876 (28.99%)	0.92 (0.66-1.29)	69 (25.65%)	893 (23.61%)	0.99 (0.70-1.39)	1.00 (0.79-1.27)	
Winter	118 (31.64%)	828 (27.40%)	1.23 (0.89-1.70)	73 (27.14%)	1015 (26.83%)	0.92 (0.66-1.29)	1.12 (0.89-1.42)	
Weekdays, n (%)								<0.001
Sunday	73 (19.57%)	364 (12.05%)	1	51 (18.96%)	432 (11.42%)	1		
Monday	40 (10.72%)	447 (14.79%)	0.45 (0.30-0.67)	41 (15.24%)	598 (15.81%)	0.58 (0.38-0.89)		
Tuesday	45 (12.06%)	508 (16.81%)	0.44 (0.30-0.66)	27 (10.04%)	531 (14.04%)	0.43 (0.27-0.70)		
Wednesday	47 (12.60%)	393 (13.00%)	0.60 (0.40-0.88)	38 (14.13%)	549 (14.51)	0.57 (0.38-0.91)		
Thursday	50 (13.40%)	444 (14.69%)	0.56 (0.38-0.83)	29 (10.78%)	561 (14.83%)	0.44 (0.27-0.70)		
Friday	46 (12.33%)	434 (14.36%)	0.53 (0.36-0.78)	35 (13.01%)	578 (15.28%)	0.51 (0.33-0.80)		

[a] Breslow-Day statistic

Table 4. The distribution of Abbreviated Injury Scale (AIS) score in DUI/non-DUI patients

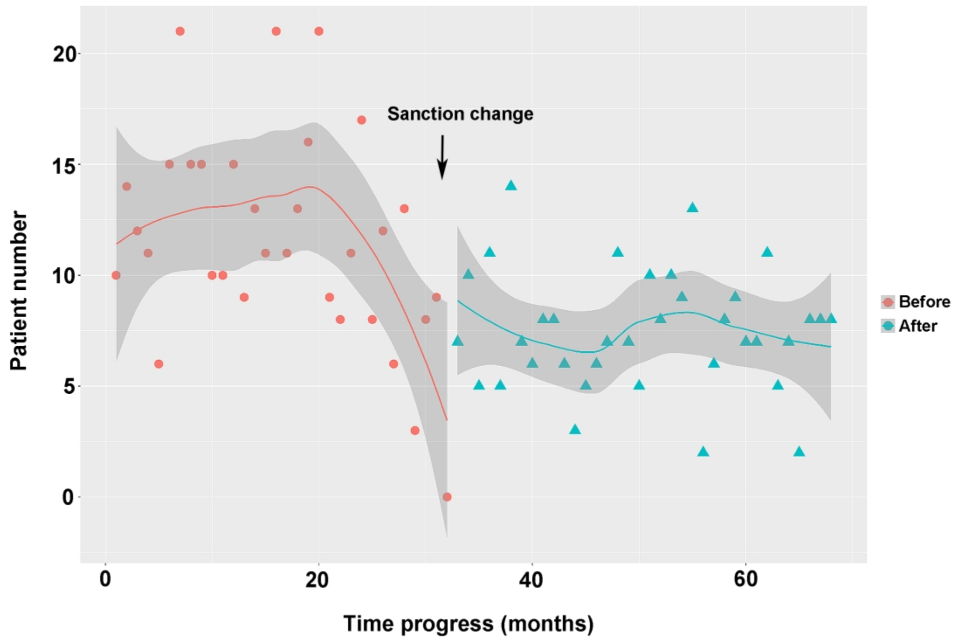
	DUI	Non-DUI	OR (95% CI)	*p*
Head/Neck				< 0.0001
0	269 (41.90%)	4799 (70.52%)	1	
1	94 (14.64%)	638 (9.38%)	2.63 (2.05-3.37)	
2	22 (3.43%)	105 (1.54%)	3.74 (2.32-6.02)	
3	81 (12.62%)	506 (7.44%)	2.86 (2.19-3.72)	
4	131 (20.40%)	597 (8.77%)	3.92 (3.12-4.91)	
5-6	45 (7.01%)	1160 (2.35%)	0.69 (0.50-0.96)	
Face				< 0.0001
0	361 (56.23%)	5342 (78.50%)	1	
1	64 (9.97%)	493 (7.24%)	1.921 (1.45-2.55)	
2	215 (33.49%)	949 (13.95%)	3.353 (2.79-4.02)	
3	2 (0.31%)	21 (0.31%)	1.409 (0.33-6.03)	
Thorax				< 0.0001
0	488 (76.01%)	5640 (82.88%)	1	
1	31 (4.83%)	220 (3.23%)	1.63 (1.11-2.40)	
2	27 (4.21%)	306 (4.50%)	1.02 (0.681-1.53)	
3	57 (8.88%)	437 (6.42%)	1.51 (1.13-2.02)	
4	37 (5.76%)	196 (2.88%)	2.18 (1.52-3.14)	
5-6	2 (0.32%)	6 (0.08%)	3.85 (0.78-19.14)	
Abdomen				< 0.0001
0	552 (85.98%)	6319 (92.86%)	1	
1	7 (1.09%)	38 (0.56%)	2.109 (0.94-4.74)	
2	42 (6.54%)	222 (3.26%)	2.166 (1.57-3.05)	

3	23 (3.58%)	141 (2.07%)	1.867 (1.19-2.93)	
4	13 (2.02%)	69 (1.01%)	2.157 (1.19-3.93)	
5	5 (0.78%)	16 (0.24%)	3.583 (1.31-9.81)	
Extremities				< 0.0001
0	261 (40.65%)	1839 (29.02%)	1	
1	63 (9.81%)	435 (6.39%)	1.020 (0.76-1.37)	
2	185 (28.82%)	2973 (43.69%)	0.438 (0.36-0.53)	
3-5	133 (20.72%)	1558 (22.89%)	0.61 (0.48-0.75)	
External				0.195
0	536 (83.49%)	5799 (85.22%)	1	
1	102 (15.89%)	981 (14.42%)	1.125 (0.90-1.41)	
2	4 (0.62%)	25 (0.37%)	1.731 (0.60-4.99)	

Figure legend

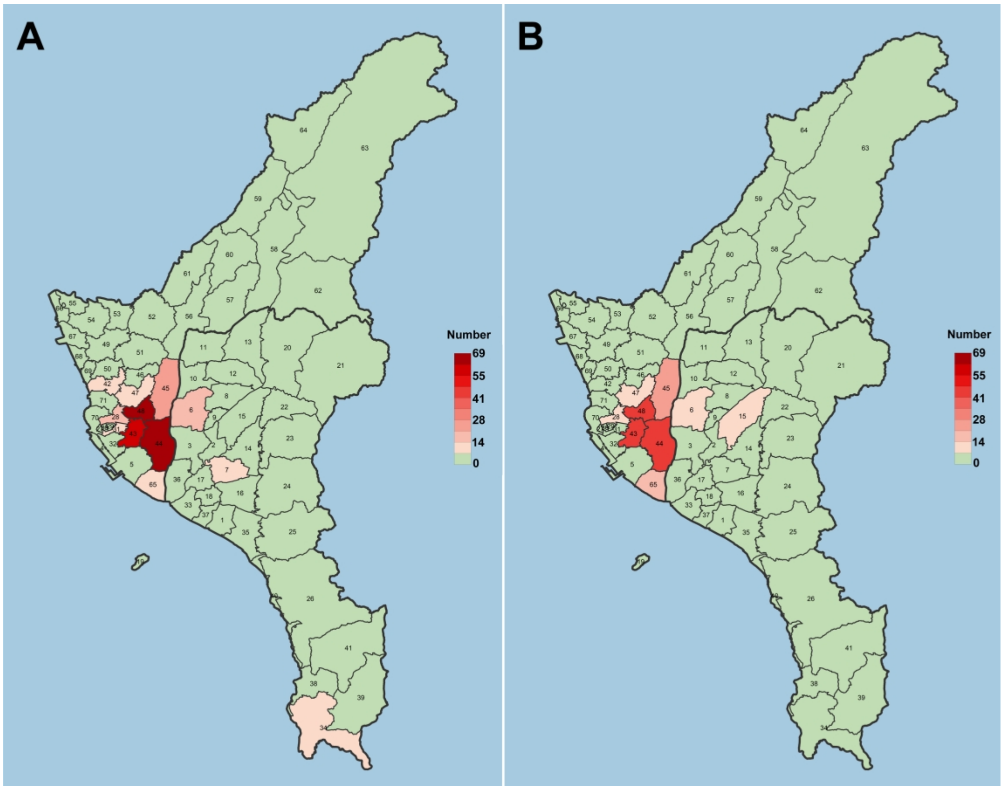
Figure 1. The monthly DUI patient number before and after sanction change.

Figure 2. DUI event density over the 71 district areas of southern Taiwan (A. before sanction change; B. after sanction change)



The monthly DUI patient number before (July 2009 to December 2012) and after (July 2013 to December 2016) sanction change with multivariate regression line

224x153mm (300 x 300 DPI)



DUI event density over the 71 district areas of southern Taiwan (A. before sanction change; B. after sanction change)

350x273mm (300 x 300 DPI)

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7
Bias	9	Describe any efforts to address potential sources of bias	-
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7
		(*b*) Describe any methods used to examine subgroups and interactions	7
		(*c*) Explain how missing data were addressed	6
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	-
		(*e*) Describe any sensitivity analyses	6
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6
		(b) Give reasons for non-participation at each stage	-
		(c) Consider use of a flow diagram	-
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8-10
		(b) Indicate number of participants with missing data for each variable of interest	-
Outcome data	15*	Report numbers of outcome events or summary measures	8-10
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	8-10

		(*b*) Report category boundaries when continuous variables were categorized	-
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	-
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	-
Discussion			
Key results	18	Summarise key results with reference to study objectives	11
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	13-14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	11
Generalisability	21	Discuss the generalisability (external validity) of the study results	-
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	14

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

The effect of lowering the legal blood alcohol concentration limit on driving under the influence (DUI) in southern Taiwan – a cross-sectional retrospective analysis

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The effect of lowering the legal blood alcohol concentration limit on driving under the influence (DUI) in southern Taiwan – a cross-sectional retrospective analysis

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ABSTRACT

Objectives: We aimed to profile the epidemiological changes of driving under the influence (DUI) in southern Taiwan after the legal blood alcohol concentration (BAC) limit was lowered from 50 to 30 mg/dL in 2013.

Setting: Level 1 trauma medical center in southern Taiwan.

Participants: Data from 7,447 patients (4,375 males and 3,072 females) were retrieved from the Trauma Registry System of a single trauma center to examine patient characteristics (gender, age, and BAC), clinical outcome variables (Abbreviated Injury Score (AIS), Injury Severity Score (ISS), and mortality), and vehicular crash-related factors (vehicle type, airbag use in car crashes, helmet use in motorcycle crashes, and time of crash) before and after the BAC limit change.

Results: Our results indicated that the percentage of DUI patients significantly declined from 10.99% (n=373) to 6.64% (n=269) after the BAC limit was lowered. Airbag use in car crashes (OR: 0.30, 95% CI: 0.10-0.88, p=0.007) and helmet use in motorcycle crashes (OR: 0.20, 95% CI: 0.15-0.26, p <0.001) was lower in DUI patients compared to non-DUI patients after the BAC limit change, with significant negative correlation. DUI behavior increased crash mortality risk before the BAC limit change (OR: 4.33, 95% CI: 2.20-8.54), and even more so after (OR: 5.60, 95% CI: 3.16-9.93). The difference in ORs for mortality before and after the change in the BAC legal limit was not significant (p = 0.568).

Conclusion: This study revealed that lowering the BAC limit to 30 mg/dL significantly reduced the number of DUI events, but failed to result in a significant reduction in mortality in these trauma patients.

Keywords driving under the influence; alcohol; mortality; helmet use; airbag

Strengths and limitations of this study

1. This study revealed that, with the legal blood alcohol concentration limit lowered from 50 to 30 mg/dL, the percentage of patients driving under the influence of alcohol declined, the percentage of airbag use in car crashes decreased, while helmet use in motorcycle crashes increased.
2. However, lowering the legal blood alcohol concentration limit from 50 to 30 mg/dL did not significantly reduce the odds of mortality.
3. This study was limited by its retrospective design and data collection from one level I regional trauma center.

Introduction

According to the World Health Organization (WHO), over 1.2 million people die each year in road traffic crashes, with 75% of the fatalities occurring in men in the economically active age range [1]. It is estimated that over 90% of road traffic deaths occur in low-income and middle-income countries, causing significant GDP losses of up to 5% [2]. Driving under the influence (DUI) of alcohol increases the risk of crash as well as the severity of crash-related injuries, and results in longer hospital stays, higher healthcare costs, and poorer outcomes compared to drivers in non-DUI-related crashes [3-6]. In particular, when the driver's blood alcohol concentration (BAC) exceeds 50 mg/dL, the risk and severity of traffic crashes increase remarkably [7-10] Efforts to reduce alcohol-impaired driving have included implementing laws regarding minimum legal drinking age and BAC limit when driving, taxation of alcohol, providing alcohol education, and establishing alcohol treatment programs [11].

Over the past decade (2007-2016), DUI-related traffic crashes have caused over 3000 deaths and approximately 110,000 injuries in Taiwan [12]. Nevertheless, prior to April 1999, DUI was not deemed a serious crime in Taiwan: it was legal to drive with BAC of 50 mg/dL; drivers with BAC between 50 and 110 mg/dL violated Road Traffic Security Rules and faced license suspension or revocation, or a financial penalty; drivers with BAC >110 mg/dL violated Article 185 of the Criminal Law, but would only face imprisonment of less than a year and fines of less than 30,000 New Taiwan Dollars (NTD) (~1,000 US dollars). In more recent years, DUI has received increased media attention, as alcohol-impaired traffic crashes are frequently reported. A series of amendments were made to the Road Traffic Management and Penalty Act, Road Traffic Security Rules, and Article 185 of the Criminal Law [13], including the most recent amendment to Road Traffic Security Rules in 2013, which lowered the legal BAC limit from 50 mg/dL to 30 mg/dL. In addition, financial penalties were increased by up to 50%. According to national statistics, alcohol-impaired driving casualties reduced after these regulation and law changes [13]. However, data on monthly injuries and deaths resulting from DUI-related crashes and number of monthly DUI violations are obtained from sobriety checkpoints by the police, and specific data regarding the impact of DUI on medical service utilization after change in the legal BAC limit are not available. Therefore, we aimed to compare the epidemiological profile of DUI in southern Taiwan before and after the 2013 change in legal BAC limit using data from the Trauma Registry System. We examined patient demographics and outcomes, DUI status, crash-related factors, as well as outcomes before and after the limit change to define the prognosis and risk factors for DUI-related injury and mortality, and assess the effect of BAC limit change on these factors.

Patients and methods

Patient and Public Involvement.

The patients and the public were not involved in this study.

We retrospectively collected patient data from the Trauma Registry System of the Kaohsiung Chang Gung Memorial Hospital, a 2686-bed Level I regional trauma center that provides emergent care to trauma patients primarily from southern Taiwan [14,15,] . Only drivers in car and motorcycle crashes that occurred in the Kaohsiung and Pingtung areas of Taiwan who were hospitalized between July 2009 and December 2016 were included. Twenty-three patients with incomplete data were excluded, as well as those whose hospital visit took place between January 2013 and June 2013, the period when amendments to the Road Traffic Management and Penalty Act were announced and implemented. This study was approved by the institutional review board (IRB) of the Kaohsiung Chang Gung Memorial Hospital (reference number 201701844B0). Data from 7,447 patients were used for the analysis.

BAC tests were routinely ordered for patients in the emergency room (ER) with clinical suspicion of DUI. Patients with BAC >30 mg/dL (the threshold for DUI after January 2013) were categorized into two groups according to when their visit took place: before BAC limit change (July 2009 to December 2012; n=3,395 patients), and after BAC limit change (July 2013 to December 2016; n=4,052 patients).. Detailed patient information was recorded and included the following variables: age, gender, type of vehicle crash, time and location of crash, airbag use (car crashes only), helmet use (motorcycle crashes only), BAC, hospital length of stay (LOS), in-hospital mortality, and crash-related trauma by body region. The Abbreviated Injury Score

(AIS) was used to evaluate injury severity in the following regions: head/neck, face, chest, abdomen, extremities (including pelvis), and external. Patients with higher AIS were combined for analysis in some regional subgroups due to inadequate patient numbers. The Injury Severity Score (ISS) was calculated by summing the square of the three highest AIS scores in each region [16].

Patient characteristics, clinical outcome variables, and vehicular crash-related factors, were compared before and after the BAC limit change using the Chi-square test, Student's *t*-test and Mann-Whiney U-test. Differences in characteristics between patients in DUI (BAC ≥30 mg/dL) and non-DUI groups were also examined. Parameters were presented as numbers (percentage), median ± interquartile range (IQR), or mean ± standard deviation (SD). Logistic regression was used to define changes in baseline traits and clinical outcomes in the DUI and non-DUI groups before and after the BAC limit change. Breslow-Day statistics testing was performed to examine homogeneity in different stratifications. We also analyzed the ratio of single-vehicle nighttime (SVN) crashes to multiple-vehicle daytime (MVD) crashes as a proxy measure used in many studies for alcohol involvement [17,18]. R Statistical Software (Version 3.3.3) was used to geographically present the change in DUI event density in southern Taiwan, and demonstrate the monthly trend in the number of DUI patients from 2009 to 2016. All other analyses were performed using SAS software (Version 9.4). Statistical significance was defined as $p < 0.05$.

RESULTS

The average age at the time of crash was 43.68 ± 18.70 (range: 11-90 years). Of these patients, 642 (8.6%) were classified as DUI (BAC ≥ 30 mg/dL). Most crashes were with a motorcycle vehicle (7,237 patients; 97.2%), and occurred between 6 AM – 2 PM (3,173 patients; 42.6%). Motorcyclists were wearing a helmet at the time of the crash in 88.93% (n = 7,237) of the patients, whereas 63.81% (n = 134) of car drivers had airbag protection. The average mortality was 1.34%, and median hospital LOS was six days.

As shown in Table 1, 3,395 patients were admitted to our hospital before the BAC limit change, and 4,052 patients after. In both time periods, patients tended to be males between the ages of 40-45. The percentage of DUI patients significantly declined from 10.99% (n = 373) to 6.64% (n = 269) after the BAC limit change (Figure 1), and the average BAC at admission decreased from 21.19 mg/dL to 12.31 mg/dL. This trend was observed across different regions in southern Taiwan, as shown in Figure 2. The percentage of airbag use in car crashes decreased, while helmet use in motorcycle crashes increased. No significant changes in mortality and hospital stay were found in our analyses. Patient numbers did not vary by season or day of the week, although a slight decrease was observed in the spring before the BAC limit change.

Examination of patient characteristics, crash-related factors, and clinical outcomes in DUI and non-DUI patients revealed that patients in the DUI group were mostly male (88.47%) compared to the non-DUI group (55.94%) (Table 2). Patients in the DUI group were significantly younger ($p < 0.001$). Reduced use of airbags in car crashes and helmets in motorcycle crashes were found in higher proportion in the DUI group than in the non-DUI group. DUI patients tended to have significantly higher ISS (13 vs. 9, $p < 0.001$) and longer hospital stay (8 days vs. 6 days, $p < 0.001$)

than non-DUI patients. A significantly higher mortality rate was found in DUI patients than in non-DUI (4.67% vs. 1.03%, $p < 0.001$). No significant seasonal differences were found between the groups. Time of visit to the ER differed for the DUI patients compared to the non-DUI patients. Most DUI patients visited the ER between 10 PM and 6 AM (50.31%), while only 13.33% of non-DUI patients visited at this time. Additionally, DUI crashes tended to occur on weekends (18.69% on Saturday and 19.31% on Sunday).

Table 3 compares odds ratios (OR) for different stratified parameters before and after the BAC limit change. Males still showed increased odds of DUI (Crude OR: 6.01, 95% CI: 4.69-7.69), but the BAC limit change showed no significant effect on DUI behavior between genders. DUI behavior increased the crash mortality risk before the BAC limit change, (OR: 4.33, 95% CI: 2.20-8.54), and even more so after (OR: 5.60, 95% CI: 3.16-9.93). The difference in these ORs was not significant ($p = 0.568$). Regarding time of crash, a greater number of DUI patients appeared between 10 PM and 6 AM (OR 12.70) than between 2 PM and 10 PM (3.04) and between 6 AM and 2 PM (baseline). This trend was significantly increased after the BAC limit change, which showed ORs of 20.76 and 5.50, respectively. There was no significant correlation between airbag use and DUI behavior in car crashes (OR 0.49, 95% CI: 0.20-1.18) before the change in BAC limit. However, car crashes with airbag use were less frequent in DUI patients than in non-DUI patients after the BAC limit change (OR: 0.30, 95% CI: 0.10-0.88), with a significantly negative correlation. Similar results were found in motorcycle crashes. Helmet use in motorcycle crashes was a protective factor with a negative correlation to DUI behavior. This negative correlation was reinforced by the change in BAC limit. The OR of helmet use and

DUI was 0.42 (95% CI: 0.32-0.55) before the change and 0.30 (95% CI: 0.15-0.26) after, with significant difference between them ($p < 0.001$). Season of crash had no effect on DUI behavior either before or after the BAC limit change. Workdays were significantly negatively correlated with DUI behavior as compared to weekends (Saturday and Sunday) both before and after BAC limit change. In addition, the SVN/MVD ratio significantly dropped to 0.48 from 0.60 after the change in BAC limit was implemented, indicating that the change had the effect of reducing DUI behavior.

The AIS of different regions were examined in DUI and non-DUI patients, and indicated that DUI patients were more likely to sustain injuries to the head and neck, face, thorax, and abdomen than non-DUI patients (Table 4). No significant difference was found in external injuries between DUI and non-DUI patients. However, patients with DUI were less likely than non-DUI patients to suffer from severe injury to the extremities.

DISCUSSION

Our analyses presented various factors associated with DUI behavior, including gender, mortality, time of day and day of week of the crash, use of airbags in cars, and use of helmets in motorcyclists. In this study, females accounted for a minor proportion (12%) of DUI patients, consistent with previous research [19]. Complex causal relationships in physiological and social factors may account for the difference in males and females involved in DUI. Our previous studies also reported more males than females with vehicular crashes sent to our emergency room [14,20]. Compared to females, males had a higher risk of motorcycle crashes [21,22], which accounted for approximately 60% of injuries in southern Taiwan [14,20]. Male/female differences in alcoholic liver injury [23], alcohol-induced brain injury [24], and alcohol-related behavioral and medical problems have also been reported [25-27]. Increased vehicle performance and a higher number of safety features lead to greater risk-taking behavior by the driver [28], and our results indicated that drivers using airbags in their vehicles show a significantly lower OR of being in a DUI crash. Although the decreased use of airbags may be due to the fact that DUI drivers tend to drive older vehicles, not wear a safety belt, and drive over the speed limit, this finding could indicate a relationship between the value placed on safety (e.g., purchase cars with more safety features) and the avoidance of risk-taking behaviors such as DUI. Our study also examined helmet use in motorcyclists, which has been mandatory for motorcyclists in Taiwan since June 1997; helmets were used by 90% of patients driving a motorcycle in this study. Previous studies have reported helmet use to be a protective factor or strong predictor of motorcycle crashes [21,29-31]. Our study also found that helmet use plays a significantly protective role in DUI crashes, supporting findings from Ohio, USA and Iran that suggest that motorcyclists involved in alcohol-involved crashes are significantly less likely to wear a helmet [32,33]. The decreased helmet use rate in our data may have contributed to the higher mortality that we saw in DUI motorcycle drivers after the legal BAC limit was lowered to 30 mg/dL.

Our analysis is consistent with findings in Taiwan based on national statistics [13] that report a significant reduction in DUI events after the BAC limit change. Previous studies report reductions in both crashes and fatalities when legal limits for BAC are lowered to 50 mg/dL [34,35]. A significant decrease of 3.7% (95% CI: 0.9–6.5%) in fatally injured drivers with a BAC level equal to or greater than 50 mg/dL was found following the change [36]. A recent meta-analysis examined the impact of lowering the legal BAC limit to 50 mg/dL, and found an 11.1% decrease in rates of fatal alcohol-related crashes [37]. In this study, the proportion of male and female DUI patients and overall mortality rate did not change after the legal limit change. However, while the proportion of males and females did not change, other elements in patient characteristics changed in our study after the legal BAC was lowered to 30 mg/dL: the percentage of DUI patients significantly decreased from 10.99% to 6.6% and average BAC at admission decreased from 21.19 mg/dL to 12.31 mg/dL. The decline in DUI events can be seen in the different geographical regions of Kaohsiung and Pingtung surrounding our hospital. Time of injury appears to play a role in severity of injury. It has been reported that drivers not under the influence of alcohol suffer more severe injuries between midnight and early morning compared to early night-time [38]. Findings from other studies have indicated that injuries involving alcohol-intoxicated drivers are influenced less by geographic and environmental factors than by the nature of collision and time of crash [39]. Our results indicate different temporal distribution (in weekday and time of day, but not in seasons) in the DUI and non-DUI groups. Most non-DUI patients visited the ER between early morning and afternoon (6 AM – 2 PM), but DUI patients tend to search for medical aid between 10 PM to 6 AM (50.31%). A previous study in Hong Kong indicated a similar temporal pattern in DUI using a slightly different time framework [40]. This study found that most DUI events occurred between 3 PM – 11 PM (39.5%) and 11 PM - 7 AM (29.8%). Consistent with our findings, a higher prevalence of DUI on weekends than on weekdays is reported in other studies [41]. In addition, the significant drop in SVN/MVD ratio after the legal BAC limit was lowered indicated that the limit change had an effect on the reduction in DUI behavior.

Although our study found that DUI events significantly decreased after the legal BAC limit was lowered, the increased point estimate for OR of DUI on mortality was not significant. Moreover, in DUI patients, the post-limit change mortality OR was significantly higher than pre-limit change. This may be explained by the possibility that DUI drivers after the change were more addicted to alcohol and had a lower helmet use rate. Studies have shown that alcohol impairs driving ability, and that the intoxicated driver is more likely to cause fatal road traffic crashes [42], while other research has found the risk of mortality is not higher in patients with positive BAC [3]. Some studies have found that serum ethanol is independently associated with increased mortality [43,44]. Furthermore, some studies have proposed alcohol use can have a protective effect in trauma patients [3,45,46]. In this study, we did not find a protective role for DUI in our analysis of the association between DUI and AIS. These findings indicated that lowering the legal BAC limit can reduce alcohol-impaired driving [47,48], but may be not enough to result in a significant reduction in mortality of those trauma patients. This may indicate that other preventative policies, such as taxes on alcohol, minimum legal drinking ages, and administrative license revocation, should be considered [49]. In fact, drivers with or without DUI had more heterogeneity in the factors that may affect injury severity [50]. Bias may exist in the analysis with multivariate logistic regression for the association between the injury severity and the drivers with or without DUI, which may comprise a limitation in this study.

There are some other limitations to our study. First, the analysis was based on data from the trauma registry system of a level I regional trauma center in southern Taiwan. These results may not be externally valid. Besides, our selected statistical methods with limited parameters may not clarify the contributing factors and outcomes of DUI crashes due to its complex interaction [51]. Second, there were differences in the baseline characteristics of patients admitted after traffic crashes before and after sanction change. The differences in baseline characteristics may have confounded results and observed differences may have implied the effect of sanction change. Third, the combined use of psychoactive medication and alcohol may increase the risk of having a crash [52,53]. This confounder was not controlled in our study, although this bias is random. Fourth, patients seeking medical care due to a traffic crash did not routinely receive a blood alcohol test unless they showed symptoms of being alcohol-impaired or unconsciousness. This may underestimate the effect of DUI in our analysis. Fifth, our registry system is not able to report exact time elapsed from injury to an alcohol test. However, the mean transport time for the patients transported by emergency medical service to the hospital was 18.3 ± 7.9 min according to our data and approximately 12 min according to Taiwan government data from January 2009 to June 2009. Thus, the bias may be minimal. In addition, driver use of safety belt was not registered in the trauma database, so we could not investigate this important variable. Furthermore, our registry system did not exclude the repeated DUI patients; although these drivers may be a small group in our study subjects, they may confound our statistical results. Finally, there may exist bias in the outcome assessment with control of alcohol consumption, vehicle miles travelled, and vehicles and motorcycles registered, which were lacking in the registered trauma database.

CONCLUSION

This study revealed that lowering the legal limit for BAC to 30 mg/dL significantly reduced DUI events, but failed to result in a significant reduction in traffic crash mortality. Airbag use in car crashes and helmet use in motorcycle crashes after the limit change was less in DUI patients than in non-DUI patients, with significant negative correlation.

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AUTHOR CONTRIBUTIONS

Y.-C.T. wrote the manuscript, S.-C.W. revised the manuscript, J.-F.H. assisted with the study design, S.C.H. K. was involved in the literature review, C.-S.R. was responsible for the integrity of registered data, P.-C.C performed the statistical analyses and edited the tables, H.-Y.H. proofread the manuscript, and C.-H.H. designed the study and contributed to the data analysis and interpretation. All authors read and approved the final manuscript.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

DATA SHARING

No additional data are available.

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Table 1. Patient characteristics, clinical variables, and vehicular crash-related variables before and after BAC limit change.

	Before BAC limit change	After BAC limit change	*p*
Gender, n (%)			0.028
Male	2,041 (60.12%)	2,334 (57.6%)	
Female	1,354 (39.88%)	1,718 (42.4%)	
Age (years)	42.77 (18.34)	44.45 (18.97)	<0.001[a]
DUI, n (%)			<0.001
Yes	373 (10.99%)	269 (6.64%)	
No	3,022 (89.01%)	3,783 (93.36%)	
BAC (mg/dL)	21.19 (62.49)	12.31 (47.12)	<0.001[a]
Car, n (%)			0.057
Airbag	73 (70.19%)	61 (57.55%)	
No airbag	31 (29.81%)	45 (42.45%)	
Motorcycle, n (%)			<0.001
Helmet	2,876 (87.39%)	3,560 (90.22%)	
No Helmet	415 (12.61%)	386 (9.78%)	
ISS	9 (9)	9 (9)	0.041[a]
Hospital stay (days)	6 (7)	7 (8)	0.198[a]
Mortality, n (%)			0.125
Alive	3,357 (98.88%)	3,990 (98.47%)	
Death	38 (1.12%)	62 (1.53%)	
Seasons, n (%)			<0.001
Spring	605 (17.82%)	994 (24.53%)	
Summer	874 (25.74%)	1,008 (24.88%)	

Autumn	970 (28.57%)	962 (23.74%)	
Winter	946 (27.86%)	1,088 (26.85%)	
Time, n (%)			<0.001
6AM - 2PM	1,351 (39.79%)	1,822 (44.97%)	
2PM - 10PM	1,436 (42.30%)	1,608 (39.68%)	
10PM - 6AM	608 (17.91%)	622 (15.35%)	
Weekdays, n (%)			0.012
Monday	487 (14.34%)	639 (15.77%)	
Tuesday	553 (16.29%)	558 (13.77%)	
Wednesday	440 (12.96%)	587 (14.49%)	
Thursday	494 (14.55%)	590 (14.56%)	
Friday	480 (14.14%)	613 (15.13%)	
Saturday	504 (14.85%)	582 (14.36%)	
Sunday	437 (12.87%)	483 (11.92%)	

[a] Mann-Whitney test

Table 2. Patient characteristics, clinical variables, and crash-related variables in DUI (BAC ≥30 mg/dL) and non-DUI patients.

	DUI	Non-DUI	*p*
Gender, n (%)			<0.001
Male	568 (88.47%)	3,807 (55.94%)	
Female	74 (11.53%)	2,998 (44.06%)	
Age (years)	39.64 (12.76)	44.07 (19.13)	<0.001[a]
Car, n (%)			0.020
Airbag	25 (50.00%)	109 (68.13%)	
No airbag	25 (50.00%)	51 (31.88%)	
Motorcycle, n (%)			<0.001
Helmet	433 (73.14%)	6,003 (90.34%)	
No Helmet	159 (26.86%)	642 (9.66%)	
ISS	13 (14)	9 (7)	<0.001[a]
Hospital stay (days)	8 (11)	6 (7)	<0.001[a]
Mortality, n (%)			<0.001
Alive	612 (95.33%)	6,735 (98.97%)	
Death	30 (4.67%)	70 (1.03%)	
Seasons, n (%)			0.522
Spring	135 (21.03%)	1,464 (21.51%)	
Summer	153 (23.83%)	1,729 (25.41%)	
Autumn	163 (25.39%)	1,769 (26.00%)	
Winter	191 (29.75%)	1,843 (27.08%)	
Time, n (%)			<0.001
6AM - 2PM	70 (10.90%)	3,103 (45.60%)	
2PM - 10PM	249 (38.79%)	2,795 (41.07%)	

10PM - 6AM	323 (50.31%)	907 (13.33%)	
Weekdays, n (%)			<0.001
Monday	81 (12.62%)	1,045 (15.36%)	
Tuesday	72 (11.21%)	1,039 (15.27%)	
Wednesday	85 (13.24%)	942 (13.84%)	
Thursday	79 (12.31%)	1,005 (14.77%)	
Friday	81 (12.62%)	1,012 (14.87%)	
Saturday	120 (18.69%)	966 (14.20%)	
Sunday	124 (19.31%)	796 (11.70%)	

[a] Mann-Whitney test

Table 3. Homogeneity analysis of variables related to DUI before and after BAC limit change.

	Before BAC limit change			After BAC limit change			Crude OR (95% CI)	*p*
	DUI	Non-DUI	OR (95% CI)	DUI	Non-DUI	OR (95% CI)		
Gender, n (%)								
Male	331 (9.75%)	1710 (50.37%)	6.05 (4.35-8.40)	237 (5.85%)	2097 (51.75%)	5.96 (4.09-8.66)	6.01 (4.69-7.69)	0.952
Female	42 (1.24%)	1312 (38.65%)		32 (0.79%)	1686 (41.61%)			
Mortality, n (%)								
Alive	360 (10.60%)	2997 (88.28%)	4.33 (2.20-8.54)	252 (6.22%)	3738 (92.25%)	5.60 (3.16-9.93)	4.98 (3.21-7.73)	0.568
Death	13 (0.38)	25 (0.74%)		17 (0.42%)	45 (1.11%)			
Time, n (%)								<0.001
6AM – 2PM	46 (12.33%)	1305 (43.18%)	1	24 (8.92%)	1798 (47.53%)	1		
2PM – 10PM	139 (37.27%)	1297 (42.92%)	3.04 (2.16-4.28)	110 (40.89%)	1498 (39.60%)	5.50 (3.52-8.60)		
10PM – 6AM	188 (50.40%)	420 (13.90%)	12.70 (9.03-17.85)	135 (50.19%)	487 (12.87%)	20.76 (13.30-32.41)		
Car, n (%)								
Airbag	19 (59.38%)	54 (75.00%)	0.49 (0.20-1.18)	6 (33.33%)	55 (62.50%)	0.30 (0.10-0.88)		0.007
No airbag	13 (40.63%)	18 (25.00%)		12 (66.67%)	33 (37.50%)			

Saturday	72 (19.30%)	432 (14.30%)	0.83 (0.58-1.18)	48 (17.84%)	534 (14.12%)	0.76 (0.50-1.15)		
Motorcycle n (%)								<0.001
Helmet	261 (76.54%)	2615 (88.64%)	0.42 (0.32-0.55)	172 (68.53%)	3388 (91.69%)	0.20 (0.15-0.26)		
No Helmet	80 (23.46%)	335 (11.36%)		79 (31.47%)	307 (8.31%)			
Seasons, n (%)								0.456
Spring	63 (16.89%)	542 (17.94%)	1	72 (26.77%)	922 (24.37%)	1		
Summer	98 (26.27%)	776 (25.68%)	1.09 (0.78-1.52)	55 (20.45%)	953 (25.19%)	0.74 (0.51-1.06)	0.96 (0.75-1.22)	
Autumn	94 (25.20%)	876 (28.99%)	0.92 (0.66-1.29)	69 (25.65%)	893 (23.61%)	0.99 (0.70-1.39)	1.00 (0.79-1.27)	
Winter	118 (31.64%)	828 (27.40%)	1.23 (0.89-1.70)	73 (27.14%)	1015 (26.83%)	0.92 (0.66-1.29)	1.12 (0.89-1.42)	
Weekdays, n (%)								<0.001
Sunday	73 (19.57%)	364 (12.05%)	1	51 (18.96%)	432 (11.42%)	1		
Monday	40 (10.72%)	447 (14.79%)	0.45 (0.30-0.67)	41 (15.24%)	598 (15.81%)	0.58 (0.38-0.89)		
Tuesday	45 (12.06%)	508 (16.81%)	0.44 (0.30-0.66)	27 (10.04%)	531 (14.04%)	0.43 (0.27-0.70)		
Wednesday	47 (12.60%)	393 (13.00%)	0.60 (0.40-0.88)	38 (14.13%)	549 (14.51)	0.57 (0.38-0.91)		
Thursday	50 (13.40%)	444 (14.69%)	0.56 (0.38-0.83)	29 (10.78%)	561 (14.83%)	0.44 (0.27-0.70)		
Friday	46 (12.33%)	434 (14.36%)	0.53 (0.36-0.78)	35 (13.01%)	578 (15.28%)	0.51 (0.33-0.80)		

[a] Breslow-Day statistic

Table 4. The distribution of Abbreviated Injury Scale (AIS) score by region in DUI (BAC ≥30 mg/dL) and non-DUI patients.

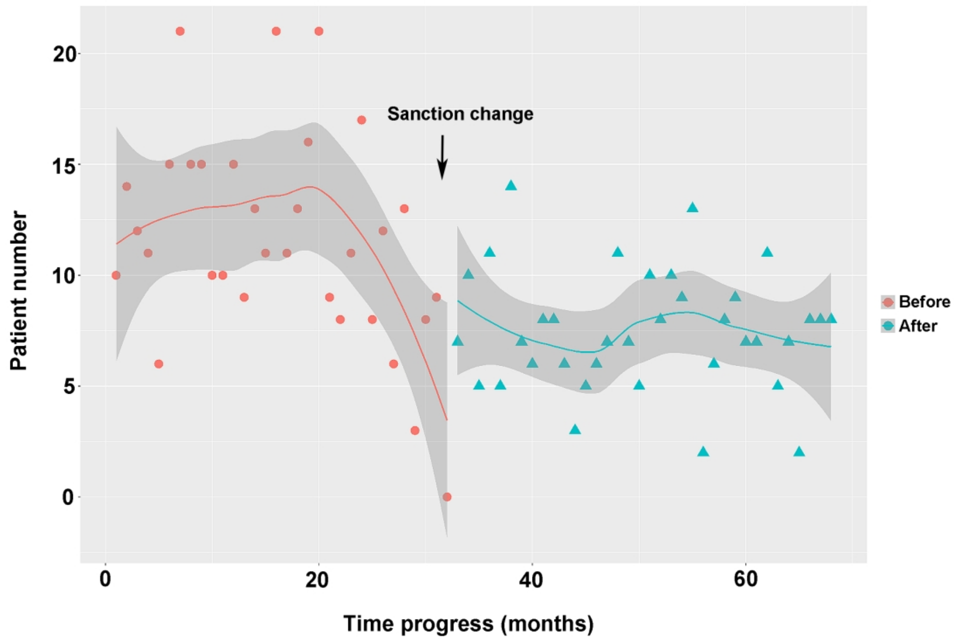
	DUI	Non-DUI	OR (95% CI)	*p*
Head/Neck				< 0.0001
0	269 (41.90%)	4799 (70.52%)	1	
1	94 (14.64%)	638 (9.38%)	2.63 (2.05-3.37)	
2	22 (3.43%)	105 (1.54%)	3.74 (2.32-6.02)	
3	81 (12.62%)	506 (7.44%)	2.86 (2.19-3.72)	
4	131 (20.40%)	597 (8.77%)	3.92 (3.12-4.91)	
5-6	45 (7.01%)	1160 (2.35%)	0.69 (0.50-0.96)	
Face				< 0.0001
0	361 (56.23%)	5342 (78.50%)	1	
1	64 (9.97%)	493 (7.24%)	1.921 (1.45-2.55)	
2	215 (33.49%)	949 (13.95%)	3.353 (2.79-4.02)	
3	2 (0.31%)	21 (0.31%)	1.409 (0.33-6.03)	
Thorax				< 0.0001
0	488 (76.01%)	5640 (82.88%)	1	
1	31 (4.83%)	220 (3.23%)	1.63 (1.11-2.40)	
2	27 (4.21%)	306 (4.50%)	1.02 (0.681-1.53)	
3	57 (8.88%)	437 (6.42%)	1.51 (1.13-2.02)	
4	37 (5.76%)	196 (2.88%)	2.18 (1.52-3.14)	
5-6	2 (0.32%)	6 (0.08%)	3.85 (0.78-19.14)	
Abdomen				< 0.0001
0	552 (85.98%)	6319 (92.86%)	1	
1	7 (1.09%)	38 (0.56%)	2.109 (0.94-4.74)	

2	42 (6.54%)	222 (3.26%)	2.166 (1.57-3.05)	
3	23 (3.58%)	141 (2.07%)	1.867 (1.19-2.93)	
4	13 (2.02%)	69 (1.01%)	2.157 (1.19-3.93)	
5	5 (0.78%)	16 (0.24%)	3.583 (1.31-9.81)	
Extremities				< 0.0001
0	261 (40.65%)	1839 (29.02%)	1	
1	63 (9.81%)	435 (6.39%)	1.020 (0.76-1.37)	
2	185 (28.82%)	2973 (43.69%)	0.438 (0.36-0.53)	
3-5	133 (20.72%)	1558 (22.89%)	0.61 (0.48-0.75)	
14				0.195
0	536 (83.49%)	5799 (85.22%)	1	
1	102 (15.89%)	981 (14.42%)	1.125 (0.90-1.41)	
2	4 (0.62%)	25 (0.37%)	1.731 (0.60-4.99)	

Figure legends

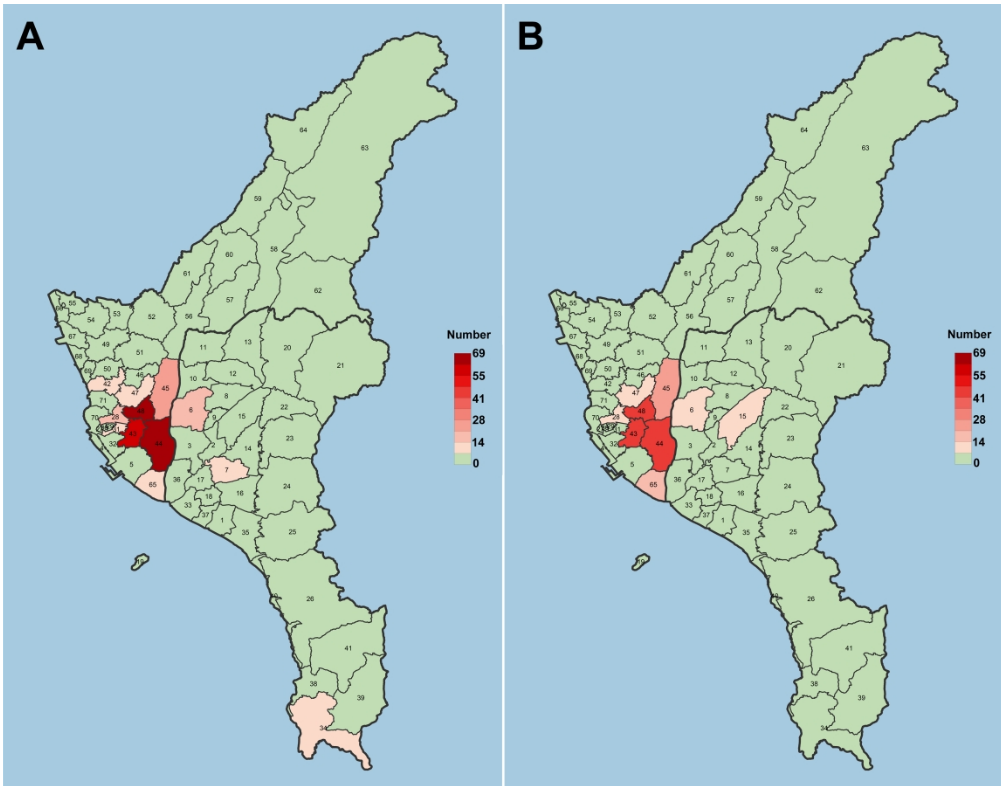
Figure 1. Monthly number of DUI (BAC ≥30 mg/dL) patients before and after BAC limit change.

Figure 2. DUI (BAC ≥30 mg/dL) event density over the 71 district areas of southern Taiwan (A, before BAC limit change; B, after BAC limit change).



The monthly DUI patient number before (July 2009 to December 2012) and after (July 2013 to December 2016) sanction change with multivariate regression line

224x153mm (300 x 300 DPI)



DUI event density over the 71 district areas of southern Taiwan (A. before sanction change; B. after sanction change)

350x273mm (300 x 300 DPI)

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7
Bias	9	Describe any efforts to address potential sources of bias	-
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7
		(*b*) Describe any methods used to examine subgroups and interactions	7
		(*c*) Explain how missing data were addressed	6
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	-
		(*e*) Describe any sensitivity analyses	6
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6
		(b) Give reasons for non-participation at each stage	-
		(c) Consider use of a flow diagram	-
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8-10
		(b) Indicate number of participants with missing data for each variable of interest	-
Outcome data	15*	Report numbers of outcome events or summary measures	8-10
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	8-10

		(*b*) Report category boundaries when continuous variables were categorized	-
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	-
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	-
Discussion			
Key results	18	Summarise key results with reference to study objectives	11
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	13-14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	11
Generalisability	21	Discuss the generalisability (external validity) of the study results	-
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	14

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

The effect of lowering the legal blood alcohol concentration limit on driving under the influence (DUI) in southern Taiwan – a cross-sectional retrospective analysis

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Secondary Subject Heading:	Addiction, Epidemiology, Public health
Keywords:	driving under the influence, alcohol, mortality, helmet use, airbag

The effect of lowering the legal blood alcohol concentration limit on driving under the influence (DUI) in southern Taiwan – a cross-sectional retrospective analysis

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ABSTRACT

Objectives: We aimed to profile the epidemiological changes of driving under the influence (DUI) in southern Taiwan after the legal blood alcohol concentration (BAC) limit was lowered from 50 to 30 mg/dL in 2013.

Setting: Level 1 trauma medical center in southern Taiwan.

Participants: Data from 7,447 patients (4,375 males and 3,072 females) were retrieved from the Trauma Registry System of a single trauma center to examine patient characteristics (gender, age, and BAC), clinical outcome variables (Abbreviated Injury Score (AIS), Injury Severity Score (ISS), and mortality), and vehicular crash-related factors (vehicle type, airbag use in car crashes, helmet use in motorcycle crashes, and time of crash) before and after the BAC limit change.

Results: Our results indicated that the percentage of DUI patients significantly declined from 10.99% (n=373) to 6.64% (n=269) after the BAC limit was lowered. Airbag use in car crashes (OR: 0.30, 95% CI: 0.10-0.88, p=0.007) and helmet use in motorcycle crashes (OR: 0.20, 95% CI: 0.15-0.26, p <0.001) was lower in DUI patients compared to non-DUI patients after the BAC limit change, with significant negative correlation. DUI behavior increased crash mortality risk before the BAC limit change (OR: 4.33, 95% CI: 2.20-8.54), and even more so after (OR: 5.60, 95% CI: 3.16-9.93). The difference in ORs for mortality before and after the change in the BAC legal limit was not significant (p = 0.568).

Conclusion: This study revealed that lowering the BAC limit to 30 mg/dL significantly reduced the number of DUI events, but failed to result in a significant reduction in mortality in these trauma patients.

Keywords driving under the influence; alcohol; mortality; helmet use; airbag

Strengths and limitations of this study

1. The data were retrieved from the registered trauma database which data was prospectively collected with internal validation.
2. This study compared the same span of time before and after BAC limit change.
3. This study was limited by its retrospective design.
4. Some confounders like baseline characteristics, the use of psychoactive medication, and the exact time elapsed from injury to an alcohol test may lead to a bias in assessment.
5. Data from one trauma center may not indicate the observed effect could be generalized to other regions or countries.

INTRODUCTION

According to the World Health Organization (WHO), over 1.2 million people die each year in road traffic crashes, with 75% of the fatalities occurring in men in the economically active age range [1]. It is estimated that over 90% of road traffic deaths occur in low-income and middle-income countries, causing significant GDP losses of up to 5% [2]. Driving under the influence (DUI) of alcohol increases the risk of crash as well as the severity of crash-related injuries, and results in longer hospital stays, higher healthcare costs, and poorer outcomes compared to drivers in non-DUI-related crashes [3-6]. In particular, when the driver's blood alcohol concentration (BAC) exceeds 50 mg/dL, the risk and severity of traffic crashes increase remarkably [7-10] Efforts to reduce alcohol-impaired driving have included implementing laws regarding minimum legal drinking age and BAC limit when driving, taxation of alcohol, providing alcohol education, and establishing alcohol treatment programs [11].

Over the past decade (2007-2016), DUI-related traffic crashes have caused over 3000 deaths and approximately 110,000 injuries in Taiwan [12]. Nevertheless, prior to April 1999, DUI was not deemed a serious crime in Taiwan: it was legal to drive with BAC of 50 mg/dL; drivers with BAC between 50 and 110 mg/dL violated Road Traffic Security Rules and faced license suspension or revocation, or a financial penalty; drivers with BAC >110 mg/dL violated Article 185 of the Criminal Law, but would only face imprisonment of less than a year and fines of less than 30,000 New Taiwan Dollars (NTD) (~1,000 US dollars). In more recent years, DUI has received increased media attention, as alcohol-impaired traffic crashes are frequently reported. A series of amendments were made to the Road Traffic Management and Penalty Act, Road Traffic Security Rules, and Article 185 of the Criminal Law [13], including the most recent amendment to Road Traffic Security Rules in 2013, which lowered the legal BAC limit from 50 mg/dL to 30 mg/dL. In addition, financial penalties were increased by up to 50%. According to national statistics, alcohol-impaired driving casualties reduced after these regulation and law changes [13]. However, data on monthly injuries and deaths resulting from DUI-related crashes and number of monthly DUI violations are obtained from sobriety checkpoints by the police, and specific data regarding the impact of DUI on medical service utilization after change in the legal BAC limit are not available. Therefore, we aimed to compare the epidemiological profile of DUI in southern Taiwan before and after the 2013 change in legal BAC limit using data from the Trauma Registry System. We examined patient demographics and outcomes, DUI status, crash-related factors, as well as outcomes before and after the limit change to define the prognosis and risk factors for DUI-related injury and mortality, and assess the effect of BAC limit change on these factors.

Patients and methods

Patient and Public Involvement.

The patients and the public were not involved in this study.

We retrospectively collected patient data from the Trauma Registry System of the Kaohsiung Chang Gung Memorial Hospital, a 2686-bed Level I regional trauma center that provides emergent care to trauma patients primarily from southern Taiwan [14,15,] . Only drivers in car and motorcycle crashes that occurred in the Kaohsiung and Pingtung areas of Taiwan who were hospitalized between July 2009 and December 2016 were included. Twenty-three patients with incomplete data were excluded, as well as those whose hospital visit took place between January 2013 and June 2013, the period when amendments to the Road Traffic Management and Penalty Act were announced and implemented. This study was approved by the institutional review board (IRB) of the Kaohsiung Chang Gung Memorial Hospital (reference number 201701844B0). Data from 7,447 patients were used for the analysis.

BAC tests were routinely ordered for patients in the emergency room (ER) with clinical suspicion of DUI. Patients with BAC >30 mg/dL (the threshold for DUI after January 2013) were categorized into two groups according to when their visit took place: before BAC limit change (July 2009 to December 2012; n=3,395 patients), and after BAC limit change (July 2013 to December 2016; n=4,052 patients). Detailed patient information was recorded and included the following variables: age, gender, type of vehicle crash, time and location of crash, airbag use (car crashes only), helmet use (motorcycle crashes only), BAC, hospital length of stay (LOS), in-hospital mortality, and crash-related trauma by body region. The Abbreviated Injury Score

(AIS) was used to evaluate injury severity in the following regions: head/neck, face, chest, abdomen, extremities (including pelvis), and external. Patients with higher AIS were combined for analysis in some regional subgroups due to inadequate patient numbers. The Injury Severity Score (ISS) was calculated by summing the square of the three highest AIS scores in each region [16].

Patient characteristics, clinical outcome variables, and vehicular crash-related factors, were compared before and after the BAC limit change using the Chi-square test, Student's *t*-test and Mann-Whiney U-test. Differences in characteristics between patients in DUI (BAC ≥30 mg/dL) and non-DUI groups were also examined. Parameters were presented as numbers (percentage), median ± interquartile range (IQR), or mean ± standard deviation (SD). Logistic regression was used to define changes in baseline traits and clinical outcomes in the DUI and non-DUI groups before and after the BAC limit change. Breslow-Day statistics testing was performed to examine homogeneity in different stratifications. We also analyzed the ratio of single-vehicle nighttime (SVN) crashes to multiple-vehicle daytime (MVD) crashes as a proxy measure used in many studies for alcohol involvement [17,18]. R Statistical Software (Version 3.3.3) was used to geographically present the change in DUI event density in southern Taiwan, and demonstrate the monthly trend in the number of DUI patients from 2009 to 2016. All other analyses were performed using SAS software (Version 9.4). Statistical significance was defined as $p < 0.05$.

RESULTS

The average age at the time of crash was 43.68 ± 18.70 (range: 11-90 years). Of these patients, 642 (8.6%) were classified as DUI (BAC ≥ 30 mg/dL). Most crashes were with a motorcycle vehicle (7,237 patients; 97.2%), and occurred between 6 AM – 2 PM (3,173 patients; 42.6%). Motorcyclists were wearing a helmet at the time of the crash in 88.93% (n = 7,237) of the patients, whereas 63.81% (n = 134) of car drivers had airbag protection. The average mortality was 1.34%, and median hospital LOS was six days.

As shown in Table 1, 3,395 patients were admitted to our hospital before the BAC limit change, and 4,052 patients after. In both time periods, patients tended to be males between the ages of 40-45. The percentage of DUI patients significantly declined from 10.99% (n = 373) to 6.64% (n = 269) after the BAC limit change (Figure 1), and the average BAC at admission decreased from 21.19 mg/dL to 12.31 mg/dL. This trend was observed across different regions in southern Taiwan, as shown in Figure 2. The percentage of airbag use in car crashes decreased, while helmet use in motorcycle crashes increased. No significant changes in mortality and hospital stay were found in our analyses. Patient numbers did not vary by season or day of the week, although a slight decrease was observed in the spring before the BAC limit change.

Examination of patient characteristics, crash-related factors, and clinical outcomes in DUI and non-DUI patients revealed that patients in the DUI group were mostly male (88.47%) compared to the non-DUI group (55.94%) (Table 2). Patients in the DUI group were significantly younger ($p < 0.001$). Reduced use of airbags in car crashes and helmets in motorcycle crashes were found in higher proportion in the DUI group than in the non-DUI group. DUI patients tended to have significantly higher ISS (13 vs. 9, $p < 0.001$) and longer hospital stay (8 days vs. 6 days, $p < 0.001$)

than non-DUI patients. A significantly higher mortality rate was found in DUI patients than in non-DUI (4.67% vs. 1.03%, $p < 0.001$). No significant seasonal differences were found between the groups. Time of visit to the ER differed for the DUI patients compared to the non-DUI patients. Most DUI patients visited the ER between 10 PM and 6 AM (50.31%), while only 13.33% of non-DUI patients visited at this time. Additionally, DUI crashes tended to occur on weekends (18.69% on Saturday and 19.31% on Sunday).

Table 3 compares odds ratios (OR) for different stratified parameters before and after the BAC limit change. Males still showed increased odds of DUI (Crude OR: 6.01, 95% CI: 4.69-7.69), but the BAC limit change showed no significant effect on DUI behavior between genders. DUI behavior increased the crash mortality risk before the BAC limit change, (OR: 4.33, 95% CI: 2.20-8.54), and even more so after (OR: 5.60, 95% CI: 3.16-9.93). The difference in these ORs was not significant (p = 0.568). Regarding time of crash, a greater number of DUI patients appeared between 10 PM and 6 AM (OR 12.70) than between 2 PM and 10 PM (3.04) and between 6 AM and 2 PM (baseline). This trend was significantly increased after the BAC limit change, which showed ORs of 20.76 and 5.50, respectively. There was no significant correlation between airbag use and DUI behavior in car crashes (OR 0.49, 95% CI: 0.20-1.18) before the change in BAC limit. However, car crashes with airbag use were less frequent in DUI patients than in non-DUI patients after the BAC limit change (OR: 0.30, 95% CI: 0.10-0.88), with a significantly negative correlation. Similar results were found in motorcycle crashes. Helmet use in motorcycle crashes was a protective factor with a negative correlation to DUI behavior. This negative correlation was reinforced by the change in BAC limit. The OR of helmet use and

DUI was 0.42 (95% CI: 0.32-0.55) before the change and 0.30 (95% CI: 0.15-0.26) after, with significant difference between them ($p < 0.001$). Season of crash had no effect on DUI behavior either before or after the BAC limit change. Workdays were significantly negatively correlated with DUI behavior as compared to weekends (Saturday and Sunday) both before and after BAC limit change. In addition, the SVN/MVD ratio significantly dropped to 0.48 from 0.60 after the change in BAC limit was implemented, indicating that the change had the effect of reducing DUI behavior.

The AIS of different regions were examined in DUI and non-DUI patients, and indicated that DUI patients were more likely to sustain injuries to the head and neck, face, thorax, and abdomen than non-DUI patients (Table 4). No significant difference was found in external injuries between DUI and non-DUI patients. However, patients with DUI were less likely than non-DUI patients to suffer from severe injury to the extremities.

DISCUSSION

Our analyses presented various factors associated with DUI behavior, including gender, mortality, time of day and day of week of the crash, use of airbags in cars, and use of helmets in motorcyclists. In this study, females accounted for a minor proportion (12%) of DUI patients, consistent with previous research [19]. Complex causal relationships in physiological and social factors may account for the difference in males and females involved in DUI. Our previous studies also reported more males than females with vehicular crashes sent to our emergency room [14,20]. Compared to females, males had a higher risk of motorcycle crashes [21,22], which accounted for approximately 60% of injuries in southern Taiwan [14,20]. Male/female differences in alcoholic liver injury [23], alcohol-induced brain injury [24], and alcohol-related behavioral and medical problems have also been reported [25-27]. Increased vehicle performance and a higher number of safety features lead to greater risk-taking behavior by the driver [28], and our results indicated that drivers using airbags in their vehicles show a significantly lower OR of being in a DUI crash. Although the decreased use of airbags may be due to the fact that DUI drivers tend to drive older vehicles, not wear a safety belt, and drive over the speed limit, this finding could indicate a relationship between the value placed on safety (e.g., purchase cars with more safety features) and the avoidance of risk-taking behaviors such as DUI. Our study also examined helmet use in motorcyclists, which has been mandatory for motorcyclists in Taiwan since June 1997; helmets were used by 90% of patients driving a motorcycle in this study. Previous studies have reported helmet use to be a protective factor or strong predictor of motorcycle crashes [21,29-31]. Our study also found that helmet use plays a significantly protective role in DUI crashes, supporting findings from Ohio, USA and Iran that suggest that motorcyclists involved in alcohol-involved crashes are significantly less likely to wear a helmet [32,33]. The decreased helmet use rate in our data may have contributed to the higher mortality that we saw in DUI motorcycle drivers after the legal BAC limit was lowered to 30 mg/dL.

Our analysis is consistent with findings in Taiwan based on national statistics [13] that report a significant reduction in DUI events after the BAC limit change. Previous studies report reductions in both crashes and fatalities when legal limits for BAC are lowered to 50 mg/dL [34,35]. A significant decrease of 3.7% (95% CI: 0.9–6.5%) in fatally injured drivers with a BAC level equal to or greater than 50 mg/dL was found following the change [36]. A recent meta-analysis examined the impact of lowering the legal BAC limit to 50 mg/dL, and found an 11.1% decrease in rates of fatal alcohol-related crashes [37]. In this study, the proportion of male and female DUI patients and overall mortality rate did not change after the legal limit change. However, while the proportion of males and females did not change, other elements in patient characteristics changed in our study after the legal BAC was lowered to 30 mg/dL: the percentage of DUI patients significantly decreased from 10.99% to 6.6% and average BAC at admission decreased from 21.19 mg/dL to 12.31 mg/dL. The decline in DUI events can be seen in the different geographical regions of Kaohsiung and Pingtung surrounding our hospital. Time of injury appears to play a role in severity of injury. It has been reported that drivers not under the influence of alcohol suffer more severe injuries between midnight and early morning compared to early night-time [38]. Findings from other studies have indicated that injuries involving alcohol-intoxicated drivers are influenced less by geographic and environmental factors than by the nature of collision and time of crash [39]. Our results indicate different temporal distribution (in weekday and time of day, but not in seasons) in the DUI and non-DUI groups. Most non-DUI patients visited the ER between early morning and afternoon (6 AM – 2 PM), but DUI patients tend to search for medical aid between 10 PM to 6 AM (50.31%). A previous study in Hong Kong indicated a similar temporal pattern in DUI using a slightly different time framework [40]. This study found that most DUI events occurred between 3 PM – 11 PM (39.5%) and 11 PM - 7 AM (29.8%). Consistent with our findings, a higher prevalence of DUI on weekends than on weekdays is reported in other studies [41]. In addition, the significant drop in SVN/MVD ratio after the legal BAC limit was lowered indicated that the limit change had an effect on the reduction in DUI behavior.

Although our study found that DUI events significantly decreased after the legal BAC limit was lowered, the increased point estimate for OR of DUI on mortality was not significant. Moreover, in DUI patients, the post-limit change mortality OR was significantly higher than pre-limit change. This may be explained by the possibility that DUI drivers after the change were more addicted to alcohol and had a lower helmet use rate. Studies have shown that alcohol impairs driving ability, and that the intoxicated driver is more likely to cause fatal road traffic crashes [42], while other research has found the risk of mortality is not higher in patients with positive BAC [3]. Some studies have found that serum ethanol is independently associated with increased mortality [43,44]. Furthermore, some studies have proposed alcohol use can have a protective effect in trauma patients [3,45,46]. In this study, we did not find a protective role for DUI in our analysis of the association between DUI and AIS. These findings indicated that lowering the legal BAC limit can reduce alcohol-impaired driving [47,48], but may be not enough to result in a significant reduction in mortality of those trauma patients. This may indicate that other preventative policies, such as taxes on alcohol, minimum legal drinking ages, and administrative license revocation, should be considered [49]. In fact, drivers with or without DUI had more heterogeneity in the factors that may affect injury severity [50]. Bias may exist in the analysis with multivariate logistic regression for the association between the injury severity and the drivers with or without DUI, which may comprise a limitation in this study.

There are some other limitations to our study. First, the analysis was based on data from the trauma registry system of a level I regional trauma center in southern Taiwan. These results may not be externally valid. Besides, our selected statistical methods with limited parameters may not clarify the contributing factors and outcomes of DUI crashes due to its complex interaction [51]. Second, there were differences in the baseline characteristics of patients admitted after traffic crashes before and after sanction change. The differences in baseline characteristics may have confounded results and observed differences may have implied the effect of sanction change. Third, the combined use of psychoactive medication and alcohol may increase the risk of having a crash [52,53]. This confounder was not controlled in our study, although this bias is random. Fourth, patients seeking medical care due to a traffic crash did not routinely receive a blood alcohol test unless they showed symptoms of being alcohol-impaired or unconsciousness. This may underestimate the effect of DUI in our analysis. Fifth, our registry system is not able to report exact time elapsed from injury to an alcohol test. However, the mean transport time for the patients transported by emergency medical service to the hospital was 18.3 ± 7.9 min according to our data and approximately 12 min according to Taiwan government data from January 2009 to June 2009. Thus, the bias may be minimal. In addition, driver use of safety belt was not registered in the trauma database, so we could not investigate this important variable. Furthermore, our registry system did not exclude the repeated DUI patients; although these drivers may be a small group in our study subjects, they may confound our statistical results. Finally, there may exist bias in the outcome assessment with control of alcohol consumption, vehicle miles travelled, and vehicles and motorcycles registered, which were lacking in the registered trauma database.

CONCLUSION

This study revealed that lowering the legal limit for BAC to 30 mg/dL significantly reduced DUI events, but failed to result in a significant reduction in traffic crash mortality. Airbag use in car crashes and helmet use in motorcycle crashes after the limit change was less in DUI patients than in non-DUI patients, with significant negative correlation.

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AUTHOR CONTRIBUTIONS

Y.-C.T. wrote the manuscript, S.-C.W. revised the manuscript, J.-F.H. assisted with the study design, S.C.H. K. was involved in the literature review, C.-S.R. was responsible for the integrity of registered data, P.-C.C performed the statistical analyses and edited the tables, H.-Y.H. proofread the manuscript, and C.-H.H. designed the study and contributed to the data analysis and interpretation. All authors read and approved the final manuscript.

Conflicts Of Interest

The authors declare no conflict of interest.

Data Sharing

No additional data are available.

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Table 1. Patient characteristics, clinical variables, and vehicular crash-related variables before and after BAC limit change.

	Before BAC limit change	After BAC limit change	*p*
Gender, n (%)			0.028
Male	2,041 (60.12%)	2,334 (57.6%)	
Female	1,354 (39.88%)	1,718 (42.4%)	
Age (years)	42.77 (18.34)	44.45 (18.97)	<0.001[a]
DUI, n (%)			<0.001
Yes	373 (10.99%)	269 (6.64%)	
No	3,022 (89.01%)	3,783 (93.36%)	
BAC (mg/dL)	21.19 (62.49)	12.31 (47.12)	<0.001[a]
Car, n (%)			0.057
Airbag	73 (70.19%)	61 (57.55%)	
No airbag	31 (29.81%)	45 (42.45%)	
Motorcycle, n (%)			<0.001
Helmet	2,876 (87.39%)	3,560 (90.22%)	
No Helmet	415 (12.61%)	386 (9.78%)	
ISS	9 (9)	9 (9)	0.041[a]
Hospital stay (days)	6 (7)	7 (8)	0.198[a]
Mortality, n (%)			0.125
Alive	3,357 (98.88%)	3,990 (98.47%)	
Death	38 (1.12%)	62 (1.53%)	
Seasons, n (%)			<0.001
Spring	605 (17.82%)	994 (24.53%)	
Summer	874 (25.74%)	1,008 (24.88%)	

Autumn	970 (28.57%)	962 (23.74%)	
Winter	946 (27.86%)	1,088 (26.85%)	
Time, n (%)			<0.001
6AM - 2PM	1,351 (39.79%)	1,822 (44.97%)	
2PM - 10PM	1,436 (42.30%)	1,608 (39.68%)	
10PM - 6AM	608 (17.91%)	622 (15.35%)	
Weekdays, n (%)			0.012
Monday	487 (14.34%)	639 (15.77%)	
Tuesday	553 (16.29%)	558 (13.77%)	
Wednesday	440 (12.96%)	587 (14.49%)	
Thursday	494 (14.55%)	590 (14.56%)	
Friday	480 (14.14%)	613 (15.13%)	
Saturday	504 (14.85%)	582 (14.36%)	
Sunday	437 (12.87%)	483 (11.92%)	

[a] Mann-Whitney test

Table 2. Patient characteristics, clinical variables, and crash-related variables in DUI (BAC ≥30 mg/dL) and non-DUI patients.

	DUI	Non-DUI	*p*
Gender, n (%)			<0.001
Male	568 (88.47%)	3,807 (55.94%)	
Female	74 (11.53%)	2,998 (44.06%)	
Age (years)	39.64 (12.76)	44.07 (19.13)	<0.001[a]
Car, n (%)			0.020
Airbag	25 (50.00%)	109 (68.13%)	
No airbag	25 (50.00%)	51 (31.88%)	
Motorcycle, n (%)			<0.001
Helmet	433 (73.14%)	6,003 (90.34%)	
No Helmet	159 (26.86%)	642 (9.66%)	
ISS	13 (14)	9 (7)	<0.001[a]
Hospital stay (days)	8 (11)	6 (7)	<0.001[a]
Mortality, n (%)			<0.001
Alive	612 (95.33%)	6,735 (98.97%)	
Death	30 (4.67%)	70 (1.03%)	
Seasons, n (%)			0.522
Spring	135 (21.03%)	1,464 (21.51%)	
Summer	153 (23.83%)	1,729 (25.41%)	
Autumn	163 (25.39%)	1,769 (26.00%)	
Winter	191 (29.75%)	1,843 (27.08%)	
Time, n (%)			<0.001
6AM - 2PM	70 (10.90%)	3,103 (45.60%)	
2PM - 10PM	249 (38.79%)	2,795 (41.07%)	

10PM - 6AM	323 (50.31%)	907 (13.33%)	
Weekdays, n (%)			<0.001
Monday	81 (12.62%)	1,045 (15.36%)	
Tuesday	72 (11.21%)	1,039 (15.27%)	
Wednesday	85 (13.24%)	942 (13.84%)	
Thursday	79 (12.31%)	1,005 (14.77%)	
Friday	81 (12.62%)	1,012 (14.87%)	
Saturday	120 (18.69%)	966 (14.20%)	
Sunday	124 (19.31%)	796 (11.70%)	

[a] Mann-Whitney test

Table 3. Homogeneity analysis of variables related to DUI before and after BAC limit change.

	Before BAC limit change			After BAC limit change			Crude OR	*p*
	DUI	Non-DUI	OR (95% CI)	DUI	Non-DUI	OR (95% CI)	(95% CI)	
Gender, n (%)								
Male	331 (9.75%)	1710 (50.37%)	6.05 (4.35-8.40)	237 (5.85%)	2097 (51.75%)	5.96 (4.09-8.66)	6.01 (4.69-7.69)	0.952
Female	42 (1.24%)	1312 (38.65%)		32 (0.79%)	1686 (41.61%)			
Mortality, n (%)								
Alive	360 (10.60%)	2997 (88.28%)	4.33 (2.20-8.54)	252 (6.22%)	3738 (92.25%)	5.60 (3.16-9.93)	4.98 (3.21-7.73)	0.568
Death	13 (0.38)	25 (0.74%)		17 (0.42%)	45 (1.11%)			
Time, n (%)								<0.001
6AM – 2PM	46 (12.33%)	1305 (43.18%)	1	24 (8.92%)	1798 (47.53%)	1		
2PM – 10PM	139 (37.27%)	1297 (42.92%)	3.04 (2.16-4.28)	110 (40.89%)	1498 (39.60%)	5.50 (3.52-8.60)		
10PM – 6AM	188 (50.40%)	420 (13.90%)	12.70 (9.03-17.85)	135 (50.19%)	487 (12.87%)	20.76 (13.30-32.41)		
Car, n (%)								
Airbag	19 (59.38%)	54 (75.00%)	0.49 (0.20-1.18)	6 (33.33%)	55 (62.50%)	0.30 (0.10-0.88)		0.007
No airbag	13 (40.63%)	18 (25.00%)		12 (66.67%)	33 (37.50%)			

Saturday	72 (19.30%)	432 (14.30%)	0.83 (0.58-1.18)	48 (17.84%)	534 (14.12%)	0.76 (0.50-1.15)		
Motorcycle n (%)								<0.001
Helmet	261 (76.54%)	2615 (88.64%)	0.42 (0.32-0.55)	172 (68.53%)	3388 (91.69%)	0.20 (0.15-0.26)		
No Helmet	80 (23.46%)	335 (11.36%)		79 (31.47%)	307 (8.31%)			
Seasons, n (%)								0.456
Spring	63 (16.89%)	542 (17.94%)	1	72 (26.77%)	922 (24.37%)	1		
Summer	98 (26.27%)	776 (25.68%)	1.09 (0.78-1.52)	55 (20.45%)	953 (25.19%)	0.74 (0.51-1.06)	0.96 (0.75-1.22)	
Autumn	94 (25.20%)	876 (28.99%)	0.92 (0.66-1.29)	69 (25.65%)	893 (23.61%)	0.99 (0.70-1.39)	1.00 (0.79-1.27)	
Winter	118 (31.64%)	828 (27.40%)	1.23 (0.89-1.70)	73 (27.14%)	1015 (26.83%)	0.92 (0.66-1.29)	1.12 (0.89-1.42)	
Weekdays, n (%)								<0.001
Sunday	73 (19.57%)	364 (12.05%)	1	51 (18.96%)	432 (11.42%)	1		
Monday	40 (10.72%)	447 (14.79%)	0.45 (0.30-0.67)	41 (15.24%)	598 (15.81%)	0.58 (0.38-0.89)		
Tuesday	45 (12.06%)	508 (16.81%)	0.44 (0.30-0.66)	27 (10.04%)	531 (14.04%)	0.43 (0.27-0.70)		
Wednesday	47 (12.60%)	393 (13.00%)	0.60 (0.40-0.88)	38 (14.13%)	549 (14.51)	0.57 (0.38-0.91)		
Thursday	50 (13.40%)	444 (14.69%)	0.56 (0.38-0.83)	29 (10.78%)	561 (14.83%)	0.44 (0.27-0.70)		
Friday	46 (12.33%)	434 (14.36%)	0.53 (0.36-0.78)	35 (13.01%)	578 (15.28%)	0.51 (0.33-0.80)		

[a] Breslow-Day statistic

Table 4. The distribution of Abbreviated Injury Scale (AIS) score by region in DUI (BAC ≥30 mg/dL) and non-DUI patients.

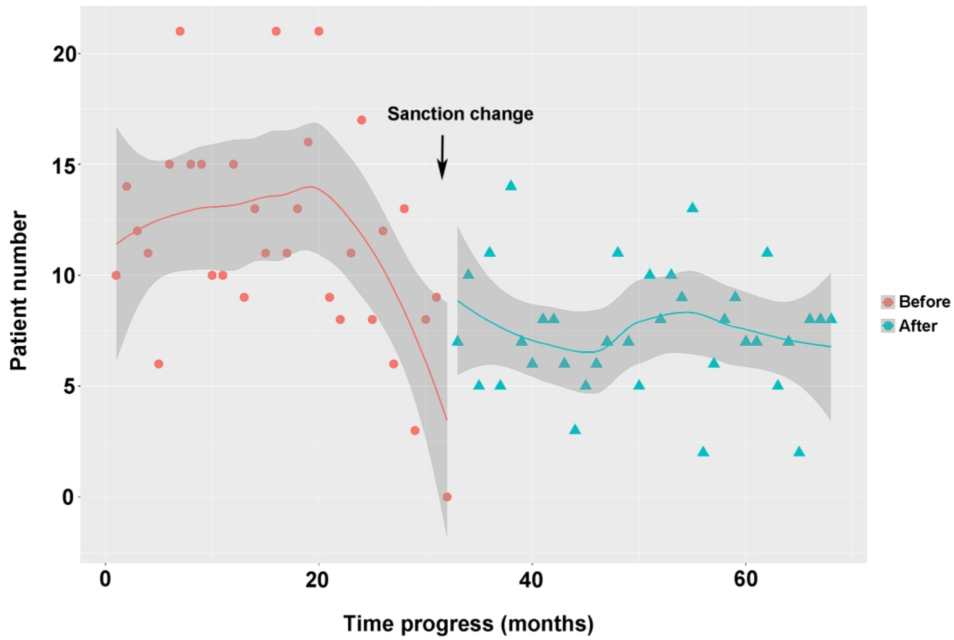
	DUI	Non-DUI	OR (95% CI)	*p*
Head/Neck				< 0.0001
0	269 (41.90%)	4799 (70.52%)	1	
1	94 (14.64%)	638 (9.38%)	2.63 (2.05-3.37)	
2	22 (3.43%)	105 (1.54%)	3.74 (2.32-6.02)	
3	81 (12.62%)	506 (7.44%)	2.86 (2.19-3.72)	
4	131 (20.40%)	597 (8.77%)	3.92 (3.12-4.91)	
5-6	45 (7.01%)	1160 (2.35%)	0.69 (0.50-0.96)	
Face				< 0.0001
0	361 (56.23%)	5342 (78.50%)	1	
1	64 (9.97%)	493 (7.24%)	1.921 (1.45-2.55)	
2	215 (33.49%)	949 (13.95%)	3.353 (2.79-4.02)	
3	2 (0.31%)	21 (0.31%)	1.409 (0.33-6.03)	
Thorax				< 0.0001
0	488 (76.01%)	5640 (82.88%)	1	
1	31 (4.83%)	220 (3.23%)	1.63 (1.11-2.40)	
2	27 (4.21%)	306 (4.50%)	1.02 (0.681-1.53)	
3	57 (8.88%)	437 (6.42%)	1.51 (1.13-2.02)	
4	37 (5.76%)	196 (2.88%)	2.18 (1.52-3.14)	
5-6	2 (0.32%)	6 (0.08%)	3.85 (0.78-19.14)	
Abdomen				< 0.0001
0	552 (85.98%)	6319 (92.86%)	1	
1	7 (1.09%)	38 (0.56%)	2.109 (0.94-4.74)	

2	42 (6.54%)	222 (3.26%)	2.166 (1.57-3.05)	
3	23 (3.58%)	141 (2.07%)	1.867 (1.19-2.93)	
4	13 (2.02%)	69 (1.01%)	2.157 (1.19-3.93)	
5	5 (0.78%)	16 (0.24%)	3.583 (1.31-9.81)	
Extremities				< 0.0001
0	261 (40.65%)	1839 (29.02%)	1	
1	63 (9.81%)	435 (6.39%)	1.020 (0.76-1.37)	
2	185 (28.82%)	2973 (43.69%)	0.438 (0.36-0.53)	
3-5	133 (20.72%)	1558 (22.89%)	0.61 (0.48-0.75)	
14				0.195
0	536 (83.49%)	5799 (85.22%)	1	
1	102 (15.89%)	981 (14.42%)	1.125 (0.90-1.41)	
2	4 (0.62%)	25 (0.37%)	1.731 (0.60-4.99)	

Figure legends

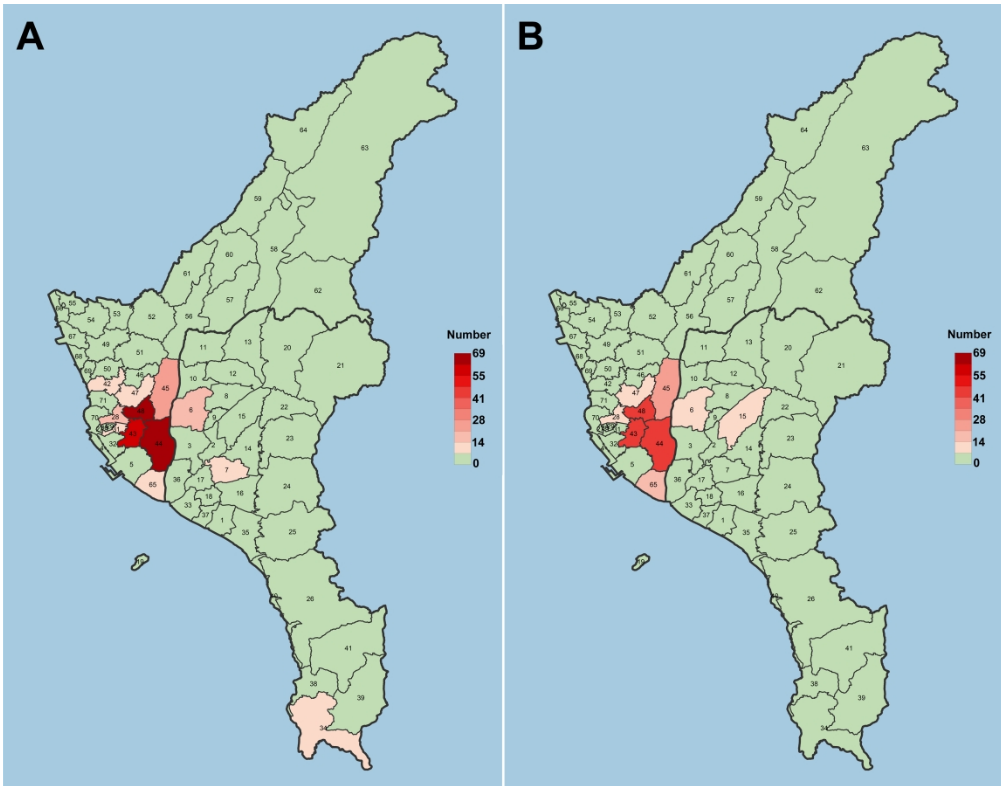
Figure 1. Monthly number of DUI (BAC ≥30 mg/dL) patients before and after BAC limit change.

Figure 2. DUI (BAC ≥30 mg/dL) event density over the 71 district areas of southern Taiwan (A, before BAC limit change; B, after BAC limit change).



The monthly DUI patient number before (July 2009 to December 2012) and after (July 2013 to December 2016) sanction change with multivariate regression line

224x153mm (300 x 300 DPI)



DUI event density over the 71 district areas of southern Taiwan (A. before sanction change; B. after sanction change)

350x273mm (300 x 300 DPI)

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7
Bias	9	Describe any efforts to address potential sources of bias	-
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7
		(*b*) Describe any methods used to examine subgroups and interactions	7
		(*c*) Explain how missing data were addressed	6
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	-
		(*e*) Describe any sensitivity analyses	6
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6
		(b) Give reasons for non-participation at each stage	-
		(c) Consider use of a flow diagram	-
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8-10
		(b) Indicate number of participants with missing data for each variable of interest	-
Outcome data	15*	Report numbers of outcome events or summary measures	8-10
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	8-10

		(*b*) Report category boundaries when continuous variables were categorized	-
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	-
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	-
Discussion			
Key results	18	Summarise key results with reference to study objectives	11
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	13-14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	11
Generalisability	21	Discuss the generalisability (external validity) of the study results	-
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	14

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.