Title:

Type 2 diabetes mellitus increases the severity of non-fatality injury but not the risk of fatal injury among driver victims of motor vehicle crashes

Brief title:

Injury severity in type 2 diabetes with MVCs

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Manuscript word count: 2,791 words
Number of tables and figures: 2 tables, 1 figure, and 2 supplementary tables

ETHICS STATEMENT

This study was approved by the Institutional Review Board of National Cheng Kung University Hospital (No. B-ER-109-088).

CONFLICT OF INTEREST

All authors have disclosed no potential conflicts of interest involving in this work.

FUNDING

This study was funded by a grant from Taiwan's Ministry of Science and Technology (MOST 109-2314-B-006-044-MY3). The funder had no role in conducting and submitting this work. The guarantor, CY Li, takes full responsibility for the work as a whole, including the study design, data access, and the decision to submit and publish the manuscript.

ACKNOWLEDGMENTS

The authors are also grateful to Health Data Science Center, National Cheng Kung University Hospital for providing administrative and technical support.

AUTHOR CONTRIBUTIONS

Conceptualization: ILH, WHH, YHC, CYL. Data curation: ILH, YHC. Formal analysis: ILH, YHC, CYL. Funding acquisition: CYL. Methodology: YHC, WHH, CYL. Project administration: YHC. Visualization: YHC, WHH, CYL. Writing–original draft: YHC, WHH. Writing–revision, review & editing: ILH, WHH, CYL.

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ABSTRACT

OBJECTIVE: Limited information is available on whether diabetes may increase the severity of injury from motor vehicle crashes (MVCs). This study aimed to investigate the levels of injury severity associated with type 2 diabetes among driver victims of MVCs.

METHODS: This cohort study involved 75,737 adult driver victims with type 2 diabetes from Taiwan's Police-reported Traffic Accident Registry in 2015–2017, along with 150,911 sex-, age-, and calendar year-matched controls. The severity level of non-fatal injury was derived from the International Classification of Diseases Programs for Injury Categorization based on the diagnostic codes of National Health Insurance claims within 3 days after MVC. Information on fatal injury within 3 days after MVC was obtained from the Taiwan Death Registry. Logistic regression models were used to estimate the odds ratios (ORs) and the corresponding 95% confidence interval (CI) of injury severity in association with type 2 diabetes.

RESULTS: After adjusting for potential confounders, driver victims with type 2 diabetes experienced significantly increased risks of mild and severe non-fatal injuries at a covariate-adjusted OR of 1.08 (95% CI: 1.05–1.11) and 1.28 (95 % CI: 1.20–1.37), respectively. By contrast, the adjusted OR for fatal injury was not significantly increased at 1.02 (95% CI: 0.89–1.18). Similar results were found when car and scooter driver victims were analyzed separately.

CONCLUSIONS: Type 2 diabetes was found to moderately increase the severity of non-fatal injury from MVCs among car and scooter driver victims.

KEY WORDS: Diabetes mellitus, Motor vehicles, Traffic accidents, Cohort studies,

Injury severity, Mortality

INTRODUCTION

Patients with diabetes mellitus tend to suffer from various health conditions that may impair their driving ability including polyneuropathy, retinopathy, amputation, and vascular diseases [1,2]. Moreover, transient cognitive dysfunction or loss of consciousness from certain antihyperglycemic drugs-induced sleep apnea and hypoglycemia further adversely affect driving performance [3]. Safe driving is dependent on many functions that can be impaired by hypoglycemia, with impaired driving performance and safety regulation violation being observed during hypoglycemic states in driving simulation studies [4]. Additionally, hypoglycemia can lead to loss of control, behavioral disorders, impaired consciousness, or even syncope, which may result in serious motor vehicle crashes (MVCs).

Although several population-based epidemiological studies have investigated driving impairment and collision risk in relation to diabetes, the results are frequently contradictory [2,5]. Such inconsistency is primarily due to heterogeneity in the design and samples adopted in these studies. For example, some drivers with diabetes may restrict or cease their driving activities due to deteriorating eyesight and cognition [6]. In addition, road traffic crash rate is largely influenced by young people, particularly male drivers, a population in which the prevalence of diabetes is considerably lower compared with older age groups [7]. Nonetheless, simulation studies have clearly demonstrated that people with diabetes tend to exhibit poor performance in muscle functioning, ankle proprioception, and accelerator pedal control [8]. Moreover, compared with nondiabetic individuals with equal confidence in their driving skills, patients with type 2 diabetes exhibit worse driving performance as evident in larger centerline deviation, longer brake reaction time, and shorter minimum time-to-collision [9].

While diabetes may increase the number of crashes (crash involvement) due to impaired driving performance, crashes involving diabetes might more serious (crash severity) because of poor judgment among diabetic drivers. Moreover, patients with diabetes tend to suffer from certain health conditions (e.g., hypoglycemia, depression, and impaired cognition) which could affect driver's consciousness, impair his/her control of the car, and possibly result in high-speed (energy) collision. Most previous studies have investigated whether the risk of MVCs increased in patients with diabetes, whereas very few population-based studies (if any) have examined whether and to what extent diabetes is associated with a greater severity of injury from MVCs [10]. The aim of this population-based cohort study was to examine whether type 2 diabetes is associated with a greater severity of injury among driver victims of MVCs.

MATERIALS AND METHODS

Source of data

This study was approved by the Institutional Review Board of National Cheng Kung University Hospital (No. B-ER-109-088).

Data from the Police-reported Traffic Accident Registry (PTAR) (2008–2017), National Health Insurance (NHI) medical claims (2014–2017), and Taiwan Death Registry (TDR) (2015–2018) were analyzed in this study. PTAR is recorded by the National Police Agency of Taiwan. After a road traffic crash is made known to the police department, certified police accident investigators examine the accident scene and complete accident reports, which comprise information relevant to the MVC [11,12]. NHI medical claims are retrieved from Taiwan's NHI program, which is implemented and supervised by the National Health Insurance Administration that also performs quarterly expert reviews on random samples of medical claims to ensure the accuracy of such claims [13]. In Taiwan, all live births and deaths should be registered within 10 days after birth or death as a legal requirement. The completeness of TDR was evaluated and considered high [14].

Data analyzed in this study including PTAR, NHI, and TDR databases at the individual level can be inter-linked using personal identifiers. Access to the aforementioned databases was approved by the Health and Welfare Data Science Center (HWDSC) of the Ministry of Health and Welfare. To protect the data, the data management and statistical analyses involved in this study were conducted on-site at HWDSC.

Design and participants

This retrospective cohort study initially included all 5,367,962 MVC events retrieved from PTAR between 2008 and 2017. After excluding duplicate records and MVC events involving passengers or pedestrians, vehicle types other than cars or scooters, and driver victims aged <18 years, 4,564,639 MVC events by 3,599,576 adult driver victims were left. We further limited driver victims to those who had MVC events (n=1,137,577) in 2015–2017, and kept the first MVC event (i.e., index MVC event) for victims with multiple MVC events during this period. The utilization of data in more recent years may provide updated information. By linking to the NHI inpatient/outpatient claims, we identified 75,737 driver victims with type 2 diabetes diagnosis codes (ICD-9-CM 250.×0, ICD-9-CM 250.×2, or ICD-10-CM E11) in ≥2 outpatient claims or ≥1 inpatient claims within a 1-year period prior to the index MVC. Limiting type 2 diabetes patients to those with ≥2 outpatient claims or ≥1 inpatient claims within a 1-year period avoided erroneous disease coding in medical claims [13]. Because the earliest inpatient/outpatient data of NHI available in this study were those claims made in 2005, we were able to determine the duration of type 2 diabetes based on the claim data.

For each type 2 diabetes driver victim, we randomly selected two control driver victims by matching age (±3 years), sex, and calendar year of the index MVC event. Eligible controls must be alive on the day of the index MVC event and must be free from any clinical diagnoses of type 1 or type 2 diabetes within a 3-year period prior to the date of the index MVC event. A total of 150,911 control driver victims were selected. The flowchart of enrolling the study participants is shown in Figure 1.

Outcome variables

The study outcome variable was categorized into fatal injury, mild non-fatal

injury, severe non-fatal injury, and no injury (reference outcome). The study cohort was linked to TDR for possible fatal injuries within 3 days after an MVC. Non-fatal injuries were determined according to the International Classification of Diseases (ICD) Programs for Injury Categorization (ICDPIC), a statistical program based on the ICD-9-CM or ICD-10-CM diagnostic codes of Taiwan's NHI claims [15]. For each injured individual, ICDPIC determined the maximum abbreviated injury scale (MAIS) on the basis of the diagnostic codes from NHI emergency and inpatient claims within 3 days after an MVC. MAIS classification considers the three most severely injured forms and seven body regions (i.e., head, neck, face, thorax, abdomen, extremity, and external). Individuals with an MAIS score of ≥3 were considered severely injured, and those with an MAIS score of 1 or 2 were classified as mildly injured. The reference outcome (i.e., no injury) included people who had no clinical visits or made clinical visits but showed a MAIS score of 0 in 3 days after motor vehicle crashes.

Covariates

In addition to the matching variables, a number of potential confounders were considered, including number of MVC events within 3 years prior to the index MVC, Charlson Comorbidity Index (CCI) [16] based on inpatient/outpatient claims in one year prior to the index MVC, and urbanization / geographic area / district/township specific median family income of the residence. The information of residence was obtained from the NHI at the city district / township level. Urbanization level for each of the 316 city districts and townships in Taiwan was based on a composite index of population density, education, proportion of elderly people, proportion of the agricultural workforce, and the density of physicians [17]. Information of the median family income for each of the 316 cities and townships in 2015 was obtained from the

Government Open Data (http://data.gov.tw/node/17983).

Previous studies have showed an evident urban–rural disparity in the health consequences of road traffic crash, in which higher MVC-related mortality was observed in less urbanized areas [18]. This finding is possibly attributed to greater exposure to severe crashes [19], higher crash speeds [20], and less accessibility to healthcare, particularly longer emergency medical service response and transport time to higher-level trauma centers, in less urbanized areas [21,22].

Statistical analysis

We first compared the characteristics between driver victims with and without type 2 diabetes by using either two independent samples *t*-test or χ^2 test. The covariate-adjusted odds ratio (OR) and the corresponding 95% confidence interval (CI) of various levels of severity (i.e., mild non-fatal injury, severe non-fatal injury, and fatal injury) associated with MVCs were estimated from the conditional multiple logistic regression model that sequentially adjusted the covariates listed in Table 1. Model 1 adjusted for gender, age, calendar year of MVCs, and type of vehicle. Model 2 additionally adjusted for urbanization status of residence, median family income quartiles, and geographic area. Model 3 further included CCI and past MVC event number in the regression equation. Analyses were further stratified in accordance with vehicle type (i.e., car or scooter).

Because some of the selected covariates are inter-correlated, which raises concern about co-linearity among those covariates simultaneously adjusted in the model. We assessed this potential statistical problems by examining the variance inflation factors (VIFs) of all covariates in the full model, and found all VIFs are < 2, suggesting no sign of co-linearity (Supplementary Table 1). Statistical analyses were

conducted with SAS version 9.4 (SAS Institute, Cary, NC), and the level of significance was set as α=0.05.

RESULTS

Table 1 compares the characteristics between driver victims with type 2 diabetes and the matched controls. The study sample was dominated by males, with a mean age of 59 years in both groups. Patients with type 2 diabetes had higher MVC event number within the past 3 years and greater CCI scores. People with type 2 diabetes tended to live in the eastern part of Taiwan and in remote islands, with less urbanization levels and lower family incomes. A higher proportion of scooter driver victims was observed in patients with type 2 diabetes than in the controls (62.65% versus 58.16%). Moreover, 26.44% of the patients with type 2 diabetes had the disease for more than 10 years.

Compared with the control victims, driver victims with type 2 diabetes had a higher risk of mild non-fatal injury (52.71% versus 59.80%), severe non-fatal injury (2.63% versus 3.41%), and fatal-injury (0.52% versus 0.56%), with a significantly increased crude OR of 1.38 (95% CI: 1.36–1.41), 1.58 (95% CI: 1.50–1.66), and 1.32 (95% CI: 1.17–1.49), respectively. Similar results were found in both car and scooter driver victims when they were analyzed separately (Table 2).

Results from both Models 1 and 2 in Table 3 showed that driver victims with type 2 diabetes suffered from significantly increased adjusted ORs (aORs) of non-fatal and fatal injuries after MVCs. When further adjustment of CCI and past MVC event number (Model 3), the aORs for non-fatal and fatal injuries all attenuated, but the mild and severe non-fatal injuries were still significantly elevated at 1.08 (95% CI: 1.05–1.11) and 1.28 (95% CI: 1.20–1.37), respectively. On the other hand, the aOR of fatal injury in association with type 2 diabetes was compared to null statistically at 1.02 (95% CI: 0.89–1.18). No clear evidence for the dose-gradient

relationships between type 2 diabetes disease duration and the aORs of non-fatal or fatal injuries (Table 3). The complete results from the multivariate logistic regression models are provided in Supplementary Table 1.

Table 3 also provides vehicle type specific analyses. Among car driver victims with type 2 diabetes, the aOR for mild non-fatal injury significantly increased at 1.08 (95% CI: 1.04–1.13). The aORs for severe non-fatal injury (1.17, 95% CI: 0.88–1.55) and fatal injury (1.26, 95% CI: 0.84–1.89), on the other hand, were not significantly increased. The corresponding aORs of mild non-fatal injury, severe non-fatal injury, and fatal injury were 1.06 (95% CI: 1.02-1.1), 1.27 (95% CI: 1.18-1.36), and 0.98 (95% CI: 0.84-1.14).

DISCUSSION

This study found increased risks of mild and severe non-fatal injuries among driver victims with type 2 diabetes mellitus that are independent of sociodemographic characteristics, comorbidities, and urbanization level/geographic area of residence. However, type 2 diabetes did not significantly increase the risk of fatal injury within 3 days after vehicle collision. Additionally, similar risk estimations were observed for car and scooter victims with type 2 diabetes. This study further advanced insights into outcomes of motor vehicle collision among driver victims with type 2 diabetes.

Impaired awareness of hypoglycemia and lack of knowledge that certain diabetes related health conditions such as depression and impaired cognition may increase the risk of MVCs are not uncommon among patients with type 2 diabetes. Hypoglycemia is a risk factor for driving related traumatic injuries in patients with diabetes; it poses a significant burden as a risk factor and predictor of worse outcomes of traumatic injuries [23]. Previous studies showed increased risks of depression and impaired cognition in patients with type 2 diabetes [24,25], and both health conditions were associated with higher risk of MVCs. In a driving simulation study, Bulmash et al. reported that depression impairs driving behavior by exhibiting slower steering reaction times and a greater number of crashes [26]. In a meta-analysis of 113 studies, major depressive disorder was found to be associated with impaired performance on neuropsychological measures of executive functions [27]. In addition, Alzheimer's patients were found to make more turning mistakes and orientation lost while driving even in the early stage of disease [28]. Moreover, a meta-analysis showed that about 14% of patients with very mild dementia and 33% with mild dementia failed an on-road driving test, while only 1.6% failed in the control group [29].

The above-mentioned health conditions may affect driver's consciousness and impair his/her control of the car, possibly resulting in high-speed (energy) collision. Additionally, Ma et al. [9] conducted a simulation study and found that compared with healthy individuals, drivers with type 2 diabetes exhibited worse driving performance as evident in larger centerline deviation, longer brake reaction time, and shorter minimum time-to-collision. Collisions with higher energy may be partly responsible for the increased risks of mild and severe non-fatal injuries among driver victims with type 2 diabetes noted in the current study.

In addition to the energy of collision, patients with diabetes may also face a higher risk of sustaining fractures after MVCs. A recent meta-analysis of 37 studies with 3,123,382 participants revealed a pooled relative risk of 1.5 (95% CI: 1.3–1.8) for any fracture in patients with diabetes [30]. It also showed that diabetes is an independent risk factor for low-energy fracture, and this relationship is more pronounced in hip fracture [30]. In an earlier meta-analysis, Wang et al. [31] reported that patients with diabetes experienced higher risks of total, hip, upper arm, and ankle fractures, with type 1 diabetes having a more harmful effect than type 2 diabetes. Vulnerability to fracture of patients with diabetes could have also contributed to the increased risk of injury severity among driver victims with type 2 diabetes.

Patients with a longer duration of diabetes are expected to suffer more diabetic complications [14] and other comorbidities (e.g., hypoglycemia and fracture), possibly increasing injury severity after MVCs. However, our results did not observe a dose-gradient relationship between type 2 diabetes duration and injury severity. Our study did show the crude ORs of mild non-fatal injury and fatal injury increased with duration of diabetes, but such dose-relationships disappeared when CCI and past MVC event number were adjusted, which highlighted the importance of comorbidity

in increasing risk of injury after MVCs. Additionally, advances in diabetes care technology and an understanding of the safety consequences of diabetes have expanded available techniques to limit the risks of driving with diabetes and the consequences of collisions, probably diluting the adverse effect of longer type 2 diabetes duration on injury severity from MVCs [32].

Our study did not show a significant increase in risk of fatal-injury in 3 days after MVCs among driver victims with type 2 diabetes. Diabetes significantly increases rates of malunion, infection, and reoperation in patients with surgically treated lower extremity fractures, which is a common condition that results from MVCs [33]. Diabetes also substantially alters bone metabolism and soft tissue healing, posing a risk of adverse fracture healing and other complications [33]. A recent meta-analysis reported that the overall complication risk after ankle fracture was two times higher among diabetic patients than among nondiabetic individuals (OR: 1.9; 95% CI: 1.7–2.03). The increased complication risk was even higher in patients with advanced diabetes (OR: 8.4; 95% CI: 2.9–24.5). Moreover, the risk of infection was three times higher in diabetic patients than in nondiabetic individuals (OR: 3.4; 95% CI: 2.9–9.8) [34]. Alkhouli et al. [35] reported considerably higher in-hospital mortality among patients who experienced MVCs and suffered from acute myocardial infarction (AMI), a cardiovascular complication of diabetes, compared with MVC victims without AMI (21.7% versus 2.7%). Despite strong associations were previously noted between MVCs and certain medical conditions, our study showed only a mild increase in risk of non-fatal injury since we used the Abbreviated Injury Scale (AIS) severity score which is an ordinal scale of 1 to 6 (1 indicating a minor injury and 6 being maximal). A casualty that sustains an injury with a score of 3 or higher on the AIS is classified as clinically seriously injured (MAIS3+) [15]. Our

data showed only 2.8% of all participants in this study suffered from MAIS3+. A small variation in AIS severity score resulted in smaller relative risk estimates.

In fact, our data showed a significantly higher risk of fatal injury within 3 days after MVC, with a crude OR of 1.32 (95% CI: 1.17–1.49). In the sequential adjustment for covariates, we found significantly increased risk of fatal injury persisted after adjustment for sociodemographic characteristics, vehicle type, and urbanization was made. Nonetheless, the significant increase in 3-day fatal injury disappeared after adjustment for CCI and past MVC event number was further made. The CCI could serve as proxy measures of the aforementioned medical conditions that contributed to the increased risk of fatal injury after MVCs.

The strengths of the current study included the large size of study participants, which allowed adequate statistical power for detecting a small magnitude of increased risks of mild and severe non-fatal injuries. The large sample size also permitted the assessment of dose-response relationships between type 2 diabetes duration and injury severity, along with separate analyses of car and scooter driver victims. Second, the study cohort (i.e., driver victims) was retrieved from PTAR, which is a population-based registry that covers nearly all road traffic crashes, including those without injury. An analyses that is limited to the comparison between driver victims with and without diabetes in hospital settings is likely to be subject to referral bias because driver victims who require treatment after MVC tend to exhibit smaller variability in injury severity [12] Nonetheless, the police-reported road traffic crash data could under-report some minor motor vehicle collisions, which involve no injury or property damage or loss [36]. Third, this study interlinked among PTAR, NHI medical claims, and TDR, considerably reducing the likelihood of incomplete information due to follow-up loss.

Despite the aforementioned strengths, several weaknesses involving this study should be noted. First, sole reliance on diagnostic codes to identify patients with type 2 diabetes may be subject to disease misclassification because a portion of type 2 diabetes may remain underdiagnosed. However, we limited type 2 diabetes to those with ≥2 outpatient claims or ≥1 inpatient claim within 1 year prior to the MVC, largely avoiding erroneous type 2 diabetes coding in medical claims and disease misclassification bias [13]. Moreover, disease misclassification (if any) in this study is likely to be non-differential, which will underestimate rather than overestimate the true association of type 2 diabetes with injury severity after MVC. Second, due to a lack of detailed information on the potential mechanisms involving MVCs, such as use of seatbelt or other restrain equipment, vehicle speed at the time of crashes, and time of transportation from crash scenes to medical institutions, we were unable to consider these variables in the analyses, which of course limits the specific interpretations of study findings. Third, we ascertained MVC related fatal and non-fatal injuries in a 3-day period after collisions to assure that the injuries captured were likely to be caused by that MVC. A study looked at the time of death from vehicle crashes in the 1990s, and showed that 46% of deaths occurred within 30 minutes, 24% between 30 minutes and 1.5 hours, and 90% within 24 hours [37]. In addition, a recent Australian study defined vehicle crash related hospital admissions were those happening on the same day or within one day of a record in the police reported crash data [38]. Nonetheless, comparison of our study findings with international data is limited because most of the major road safety related organizations define traffic accident deaths as deaths within 30 days after the accident [39]. Fourth, this study confined the analysis of driver victims with type 2 diabetes, which is likely to underestimate the overall burden of type 2 diabetes related MVCs because people with type 2 diabetes could be other traffic crash victims such as pedestrians and

passengers. Additionally, the opponent vehicle drivers who might not suffer from type 2 diabetes could also be victims involving the MVCs. Fifth, the generalizability of the study results from Taiwan to other countries may not be straightforward because of possible similarities in road conditions, emergency medical service provision, and health care systems among countries.

CONCLUSIONS

We noted a small increase in risks of mild and severe non-fatal injuries among driver victims with type 2 diabetes after MVCs. In addition, our data showed that patients with type 2 diabetes in Taiwan tended to have a lower socioeconomic background, more rural residences, and extra scooter accidents. Such socioeconomic and urban-rural inequality in MVCs associated with type 2 diabetes may be a concern from both research and policy points of view.

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Table 1. Comparison of characteristics between driver victims with and without type 2 diabetes

Characteristics	Type 2 diabetes		Matched controls		P value
	n	%	*n*	%	
Total	75,464	100.00	150,911	100.00	
Gender [a]					
Male	51,699	68.51	103,398	68.52	0.970
Female	23,765	31.49	47,513	31.48	
Age (years) [a]					
<45	8,808	11.67	17,946	11.89	0.175
45–54	15,082	19.99	29,947	19.84	
55–64	25,923	34.35	51,355	34.03	
≥65	25,651	33.99	51,663	34.23	
Mean ± SD	59.07	12.13	59.18	12.39	0.044
Calendar year of MVCs [1]					
2015	25,589	33.91	51,176	33.91	>0.999
2016	25,416	33.68	50,828	33.68	
2017	24,459	32.41	48,907	32.41	
Past MVC event number [2]					
0	74,722	99.02	149,595	99.13	0.005
1	698	0.92	1,262	0.84	
2+	44	0.06	54	0.04	
CCI [3]					<0.0001
0	3833	5.08	84166	55.77	
1	40091	53.13	52586	34.85	
>=2	31540	41.79	14159	9.38	
Urbanization status of residence					
Urban	22,451	29.75	47,550	31.51	<0.0001
Satellite	24,902	33.00	49,933	33.09	
Rural	28,111	37.25	53,428	35.41	
Median family income quartiles [4]					
Min.–Q1	19,727	26.14	37,377	24.77	<0.0001
Q1–Q3	36,809	48.78	72,050	47.74	
Q3–max.	18,928	25.08	41,484	27.49	
Geographic area of residence					
North	25,176	33.36	52,855	35.02	<0.0001

Central	21,707	28.76	43,771	29.00	
South	25,510	33.80	48,765	32.31	
East and islands	3,071	4.07	5,520	3.66	
Type of vehicle					
Car	28,185	37.35	63,147	41.84	<0.0001
Scooter	47,279	62.65	87,764	58.16	
Type 2 diabetes duration (year)					
None	0	0.00	150,911	100.00	<0.0001
0–4	24,190	32.06	0	0.00	
5–9	31,323	41.51	0	0.00	
10+	19,951	26.44	0	0.00	

[1] Matching variables

[2] Within a 3-year period prior to the index (first) MVC in 2015–2017

[3] Charlson Comorbidity Index, based on inpatient/outpatient claims in a 1-year period prior to the index (first) MVC in 2015–2017

[4] Q1=565,000 New Taiwan Dollars (NTD), Q3=642,000 NTD; 1 USD ≅ 28 NTD

Table 2. Vehicle type specific number of injuries and crude odds ratios of injury severity in relation to type 2 diabetes among driver victims of MVCs

	Total number of study subjects	Number of subjects injured by level of severity				cOR (95% CI)		
		Reference[1]	Non-fatal injury[2]		Fatal injury[3]	Non-fatal injury[2]		Fatal injury[3]
			Mild	Severe		Mild	Severe	
	N	*n*	*n*	*n*	*n*			
Total	226,375	93,951	124,677	6,548	1,199			
Car and scooter driver victims								
Type 2 diabetes								
No	150,911	66,607	79,552	3,974	778	1.00	1.00	1.00
Yes	75,464	27,344	45,125	2,574	421	1.38(1.36–1.41)	1.58(1.50–1.66)	1.32(1.17–1.49)
Duration (years)								
0–4	24,190	9,565	13,757	760	108	1.20(1.17–1.24)	1.33(1.23–1.44)	0.97(0.79–1.18)
5–9	31,323	11,333	18,401	1,418	171	1.36(1.33–1.39)	2.10(1.97–2.24)	1.29(1.09–1.53)
10+	19,951	6,446	12,967	396	142	1.68(1.63–1.74)	1.03(0.93–1.15)	1.89(1.57–2.26)
Car driver victims								
Total	91,332	70,264	20,597	323	148			
Type 2 diabetes								
No	63,147	49,962	12,888	207	90	1.00	1.00	1.00
Yes	28,185	20,302	7,709	116	58	1.47(1.42–1.52)	1.38(1.10–1.73)	1.59(1.14–2.21)
Duration (years)								
0–4	9,760	7,208	2,483	43	26	1.34(1.27–1.40)	1.44(1.04–2.00)	2.00(1.29–3.10)
5–9	11,672	8,433	3,168	52	19	1.46(1.39–1.52)	1.49(1.10–2.02)	1.25(0.76–2.05)
10+	6,753	4,661	2,058	21	13	1.71(1.62–1.81)	1.09(0.69–1.71)	1.55(0.86–2.77)
Scooter driver victims								
Total	135,043	23,687	104,080	6,225	1,051			
Type 2 diabetes								
No	87,764	16,645	66,664	3,767	688	1.00	1.00	1.00
Yes	47,279	7,042	37,416	2,458	363	1.33(1.29–1.37)	1.54(1.46–1.63)	1.25(1.09–1.42)
Duration (years)								

0–4	14,430	2,357	11,274	717	82	1.19(1.14–1.25)	1.34(1.23–1.47)	0.84(0.67–1.06)
5–9	19,651	2,900	15,233	1,366	152	1.31(1.26–1.37)	2.08(1.93–2.24)	1.27(1.06–1.52)
10+	13,198	1,785	10,909	375	129	1.53(1.45–1.61)	0.93(0.83–1.04)	1.75(1.44–2.12)

[1] The reference outcome included driver victims who had no clinical visits or who made clinical visits but showed a maximum abbreviated injury scale (MAIS) score of 0 (i.e., no injury diagnostic codes) in 3 days after motor vehicle crashes. Driver victims with reference outcome were also not dead in 3 days after crashes.
[2] Classification based on MAIS derived from medical claims.
[3] Death occurring in 3 days after motor vehicle crashes.
MVC, motor vehicle crash; cOR, crude odds ratio; CI, confidence interval.

Table 3. Covariate adjusted odds ratios and 95% confidence interval of injury severity in relation to type 2 diabetes among driver victims of MVCs

	Model 1[1]			Model 2[2]			Model 3[3]		
	Non-fatal injury[4]		Fatal injury[5]	Non-fatal injury[4]		Fatal injury[5]	Non-fatal injury[4]		Fatal injury[5]
	Mild	Severe		Mild	Severe		Mild	Severe	
Car and scooter driver victims									
Type 2 diabetes									
No	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Yes	1.30(1.27–1.33)	1.50(1.42–1.59)	1.27(1.12–1.44)	1.42(1.38-1.45)	1.63(1.54-1.73)	1.35(1.2-1.53)	1.08(1.05-1.11)	1.28(1.20-1.37)	1.02(0.89-1.18)
Duration (yrs)									
0–4	1.26(1.22-1.31)	1.46(1.33-1.59)	1.18(0.96-1.45)	1.25(1.21-1.30)	1.44(1.31-1.57)	1.14(0.93-1.41)	1.10(1.06-1.14)	1.29(1.18-1.42)	0.99(0.80-1.23)
5–9	1.27(1.23-1.32)	1.53(1.42-1.64)	1.18(1.00-1.41)	1.27(1.23-1.31)	1.51(1.41-1.63)	1.16(0.98-1.39)	1.04(1.00-1.08)	1.29(1.19-1.40)	0.94(0.78-1.14)
10+	1.40(1.34-1.46)	1.42(1.26-1.60)	1.50(1.24-1.81)	1.39(1.34-1.45)	1.42(1.26-1.59)	1.50(1.24-1.81)	1.11(1.06-1.16)	1.17(1.03-1.32)	1.17(0.96-1.44)
Car driver victims									
Total									
Type 2 diabetes									
No	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Yes	1.39(1.34-1.43)	1.32(1.05-1.66)	1.48(1.06-2.08)	1.48(1.43-1.53)	1.40(1.11-1.76)	1.54(1.10-2.16)	1.08(1.04-1.13)	1.17(0.88-1.55)	1.26(0.84-1.89)
Duration (yrs)									
0–4	1.32(1.25-1.39)	1.47(1.05-2.05)	2.16(1.38-3.39)	1.41(1.34-1.49)	1.54(1.11-2.16)	2.23(1.42-3.49)	1.08(1.03-1.14)	1.34(0.93-1.92)	1.87(1.15-3.03)
5–9	1.37(1.30-1.43)	1.18(0.87-1.61)	1.12(0.67-1.88)	1.46(1.40-1.53)	1.26(0.93-1.72)	1.19(0.71-1.98)	1.05(1.00-1.11)	1.04(0.73-1.47)	0.94(0.54-1.64)
10+	1.51(1.43-1.60)	1.40(0.87-2.24)	1.28(0.71-2.31)	1.61(1.52-1.71)	1.49(0.93-2.39)	1.32(0.73-2.38)	1.13(1.06-1.20)	1.20(0.72-1.99)	1.01(0.53-1.93)
Scooter driver victims									
Total									
Type 2 diabetes									
No	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Yes	1.21(1.17-1.25)	1.42(1.34-1.51)	1.17(1.03-1.34)	1.35(1.30-1.39)	1.58(1.48-1.68)	1.27(1.11-1.45)	1.06(1.02-1.1)	1.27(1.18-1.36)	0.98(0.84-1.14)
Duration (yrs)									
0–4	1.20(1.14-1.26)	1.39(1.26-1.53)	0.99(0.78-1.25)	1.34(1.27-1.41)	1.55(1.40-1.70)	1.06(0.84-1.35)	1.10(1.04-1.16)	1.29(1.16-1.43)	0.86(0.67-1.10)
5–9	1.18(1.13-1.24)	1.45(1.35-1.57)	1.12(0.93-1.35)	1.31(1.25-1.37)	1.61(1.49-1.74)	1.21(1.01-1.46)	1.01(0.96-1.07)	1.28(1.17-1.39)	0.93(0.76-1.13)
10+	1.28(1.21-1.36)	1.32(1.17-1.50)	1.42(1.16-1.74)	1.41(1.33-1.49)	1.46(1.29-1.65)	1.56(1.27-1.9)	1.07(1.01-1.14)	1.13(0.99-1.29)	1.16(0.93-1.44)

[1] Model 1 adjusted for gender, age, calendar year of MVCs, and type of vehicle

[2] In addition to the covariates adjusted in Model 1, Model 2 additionally adjusted for urbanization status of residence, median family income quartiles, and geographic area
[3] In addition to the covariates adjusted in Model 2, Model 3 additionally adjusted for Charlson Comorbidity Index and past MVC event number.
[4] Classification based on MAIS derived from medical claims.
[5] Fatal injury that occurred in 3 days after MVCs.

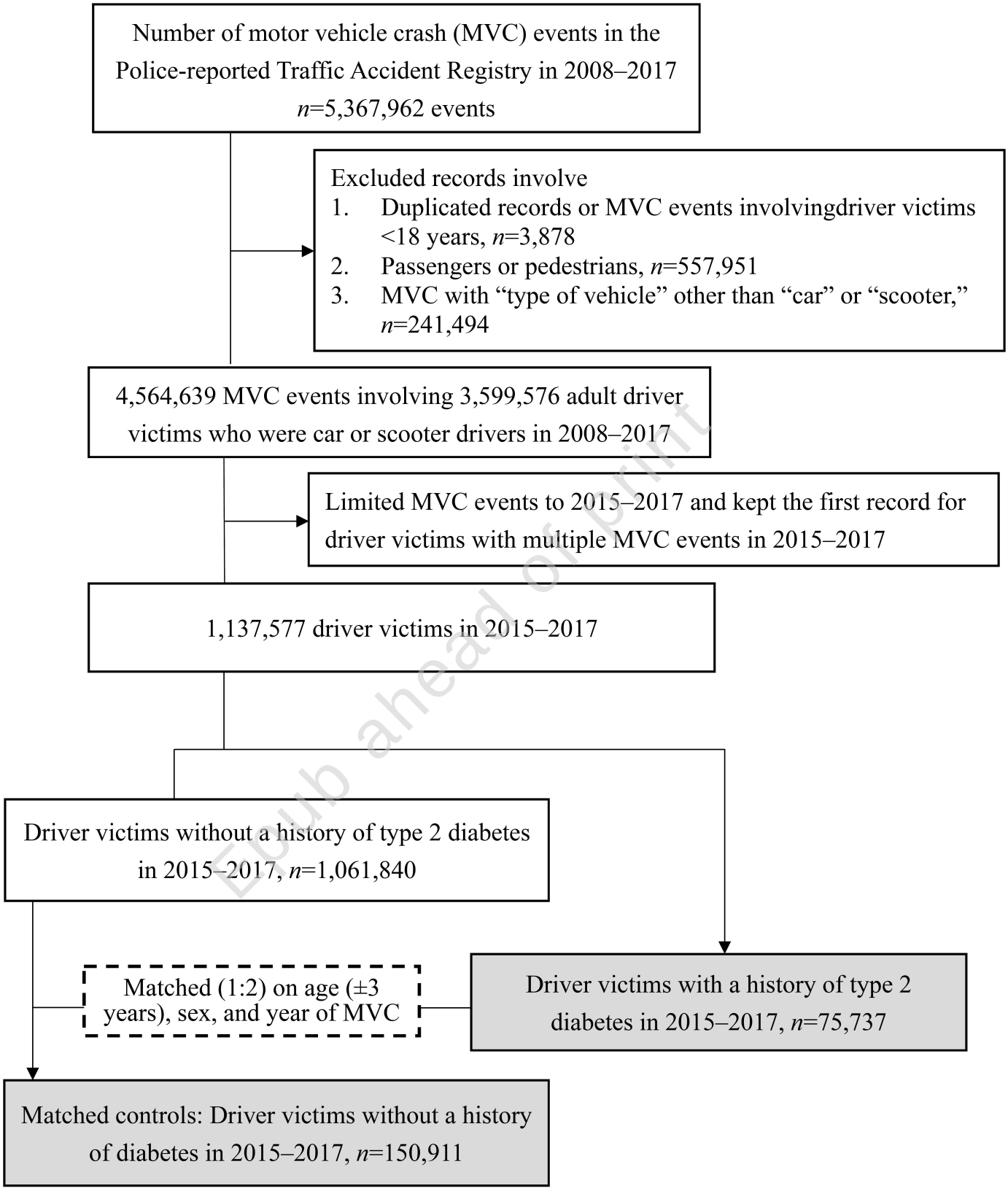

Figure 1. Flowchart of enrolling the study participants