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# Driver injury severity in single-vehicle run off road crash on 2-lanes and 4-lanes highway in Thailand

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**Abstract**

The aim of this study was to identify factors such as: roadway operational characteristic, crash characteristic, surrounded environment, vehicle type, driver information, severity level of driver, and temporal information, affecting driver injury severity involving in single-vehicle run off road accident occurred on 2-lanes highways and 4-lanes highway using Multinomial Logit model. The analyses used secondary data obtained from police accident record (extracted from Highway Accident Information Management System (HAIMS)).The variables were found to increase chance of fatality are driver older than 55-year-old, driver under influence of alcohol, drowsiness driver, run off road on straight and curve, accident on highways with depressed median and accident on concrete pavement. The variables were found to mitigate severity are adult driver 25-35-year-old, using seat belt, accident on highway with raised median and hit fixed object accident. The contributions of this study were drawn: Thailand related authorities such as Department of Highway or Royal Thai Police should emphasize their effort on education campaigns on road safety for all road users, especially old drivers, enforce the law on drunk driving and seatbelt; and for road design perspective: monitor and build roadside safety features such as safety barrier alongside the highway particularly run off road black spot and curve roads. The study also mentions the safety benefit of asphalt pavement over concrete pavement and safety planner should consider implementing raised median in urban area for safety purpose.

**Keywords:** Severity level**,** Thailand**,** 2-Lanes highway**,** 4-Lanes highway**,** Multinomial logit

## 1. Introduction

According to the global status report on road safety 2018 of World Health Organization (WHO) [1], cause of death due to traffic accident is still in increasing trend from 1.25 million (2013) to 1.35 million (2016) and has been occurring in most of low and middle-income countries across the world. Being one of the middle-income countries, Thailand is reported to be top 10 countries with most accident death rate every year by WHO. Last 5 years, in 2015 fatalities rate due to traffic accident in Thailand was 36.2 (rank second in the world after Libya) and has dropped to only 32.7 in 2018 (rank ninth in the world) per 100, 000 population.

Considering the accidents type in Thailand, run off roadway accident represented the highest in term of occurrences rate [2]. From the police report between 2011-2017, according to Figure 1 run off roadway crash in Thailand accounted for 52% out of the total number of crashes (accident data extracted from Highway Accident Information Management System (HAIMS)). This crash type accident was evidently considered as the highest frequency rate and lead to a significant number of injuries and fatalities [3-4]. While these accident statistics continue be over-presented, every corner of safety research is definitely worth contributing to seek various safety-countermeasure policies and engineering standpoint in order to radically lower these number.

In single-vehicle run off road crash research, many studies have developed the model to identify the relationship between driver injury severity versus accident related factors such as roadway characteristic, crash characteristic, driver information, vehicle factor and environmental and temporal factor [4-6]. While these researches provide great contribution, they had limitation due to accounting all crash on all highway that have different number of lanes in a single analysis. The number of lanes of highway might have effect on driver's speed, crash characteristic, performance of the vehicle and different roadway characteristic design that might also have effect on driver injury severity in case of accident. Cross section and geometric elements of the highway has also been found to significantly affect the driver behaviors [7], which consist of some of the most outstanding factors affecting crash severity such as age group, gender, and especially speed utility. The study of accident severity analysis had brought out the potential factor that have significantly relationship with injury severity. With these known safety issue, it can help the safety planner to draw out the countermeasures (redesign the road, monitor traffic

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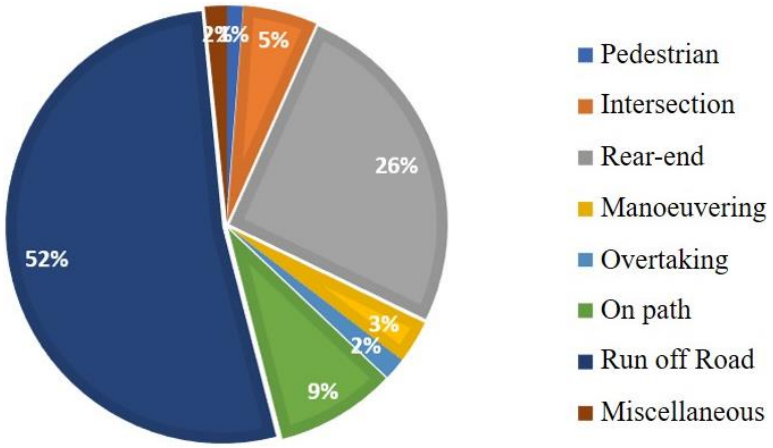


**Figure 1** Percentage of crash type occurred between 2011 – 2017 (HAIMS)

**Table 1** Accident frequency on 2-lanes road and 4-lanes road

| Number of Lane | Minor injury | Severe injury | Fatal | Total |
|---|---|---|---|---|
| 2-Lanes Road | 1873 | 371 | 449 | 2693 |
| 4-Lanes Road | 4275 | 851 | 761 | 5887 |
| Total | 6148 | 1222 | 1210 | 8580 |

safety device, black spot monitoring, and other traffic law for driver) that potentially mitigate severity in the accident for specific region.

The Awadzi, et al. [8] studied about relationship among crash related factor and the younger and older adult injury in fatal motor vehicle accident. The result show that the number of lanes have the possibility to reduce driver injuries and fatalities. Specifically, the crashes on 2-lanes highway increase higher chance or more severe injury of accident up to 81%, but on 4-lanes highway severity of the accident increase only 23%. Another study by Kashani and Mohaymany [9] conduct the research study on traffic injury severity on 2-lanes rural road and the result show that improper overtaking and unequip seatbelt are the most important factor affecting the severity of injuries. However, there are no previous study that identify the factors predicting driver injury severity on 4-lanes highways yet. Therefore, this research was the first attempt to differentiate driver injury severity analysis between the single-vehicle run off road on 2-lanes highway and 4-lanes highway.

In term of methodological approach in accident analysis, severity outcomes can be treated as unordered category or natural ordering to analyze the unordered response model and ordered response model, respectively. Numbers of researcher also utilized ordered framework for their accident severity analysis, namely generalized ordered logit [10-12], heteroscedastic ordered logit [13-14] and ordered probit [15]. However, one of the most commonly used unordered respond framework; multinomial logit, was used to identify the risk factors affecting severity of motorcycle crash [16], injury severity of the road accident in the Erzurum and Kars province of Turkey [17], and pedestrian-vehicle crash severity [18]. The advantages of the unordered response model over the ordered response model are providing more flexible control over the interior category probability as state in [17] and no need to account for ordinal categorical outcome while the ordered response model occasionally urge unrealistic parameter restriction [19]. Therefore, in this study, Multinomial logit is adopted for single-vehicle run off road crash driver injury severity analysis for Thailand Highway. The mains objectives of this study are to use multinomial logit model to identify the relationship between crash related factor (roadway characteristic, crash characteristic, driver characteristic, vehicle; and environmental and temporal characteristic) with driver injury severity involved in single vehicle run off road accident on 2-lanes highway and 4-lanes highway; and provide potential safety countermeasure for related authorities and safety planner base on the finding of the current study

## 2. Material and method

### *2.1 Data collection*

This study proposes to investigate the driver injury severity of single-vehicle run off road accident occurred on 2-lanes highway and 4-lanes highway by using the secondary data obtained from police accident record (Highway Accident Information Management System (HAIMS)) that contained the detail information about each accident case such as crash type (rear-end, run off road, pedestrian, intersection, overtaking, on path, etc.), surrounded environment (raining, wet road, dusty road, etc.), vehicle type, driver information (sex, age, driver condition, etc.), level of severity of the driver (minor injury, severe injury, die at hospital and die at accident point), highway information (road condition, median type, U-turn, pavement type, horizontal and vertical alignment etc.), and temporal information (time of accident, day/night, and date of accident). Same as many previous researches, this study use three level of driver injury severity: fatal (driver who either die at accident point or at hospital), severe injury (driver who severely injured in the accident and need hospitalization), minor injury ( driver who result in minor injury due to accident and don't need hospitalization, or properties damage only (PDO)). Then data is further extracted only single-vehicle run off road crash from the whole data set. This study gather data from past 7 years from 2011 to 2017. After that, data is divided into two data subset bases on number of lanes which were single-vehicle accident on 2-lanes highway and single-vehicle accident on 4-lanes highway. According to Table 1, there were 2693 single-

**Table 2** Explanatory variable description

| Variable | Description |
|---|---|
| Driver Characteristic | |
| AGE_26_35 | 1 = Driver age was between 26-35, 0 = Otherwise |
| AGE_36_45 | 1 = Driver age was between 36-45, 0 = Otherwise |
| AGE_46_55 | 1 = Driver age was between 46-55, 0 = Otherwise |
| AGE_56_UP | 1 = Driver age was older than 55, 0 = Otherwise |
| Gender | 1 = Male driver, 0 = Female driver |
| SAF_EQ | 1 = Driver use seatbelt, 0 = Otherwise |
| ALCOHOL | 1 = Driver under effect of alcohols, 0 = Otherwise |
| EXEED_SPEED | 1 = Driver drive with exceed speed limit, 0 = Otherwise |
| FALL_ASLEEP | 1 = Driver fall asleep while driving, 0 = Otherwise |
| Road Characteristic | |
| R_COND | 1 = Accident occur at area of road maintenance, 0 = Otherwise |
| R_SURF | 1 = Pavement type is asphalt, 0 = Pavement type is concrete |
| HORIZONTAL | 1 = Accident occur on the curve road section, 0 = Otherwise |
| VERTICAL | 1 = Accident occur on the graded road section, 0 = Otherwise |
| INTERSECTION | 1 = Accident occur within Intersection, 0 = Otherwise |
| U_TURN | 1 = Accident occur within U-turn, 0 = Otherwise |
| COMMUNITY | 1 = Accident occur within community area, 0 = Otherwise |
| NO_MEDIAN | 1 = Accident occur on road without median, 0 = Otherwise |
| RAISED_MEDIAN | 1 = Accident occur on road with raised median, 0 = Otherwise |
| DEPRES_MEDIAN | 1 = Accident occur on road with depressed median, 0 = Otherwise |
| Vehicle Characteristic | |
| PASSENGER_CAR | 1 = Vehicle in accident is passenger car, 0 = Otherwise |
| PICKUP_INVOLVE | 1 = Vehicle in accident is pickup truck with 4 wheels, 0 = Otherwise |
| TRUCK_INVOLVE | 1 = Vehicle in accident is heavy truck and trailer, 0 = Otherwise |
| Crash Characteristic | |
| MOUNT_ISLAND | 1 = If the vehicle mounted the traffic island, 0 = Otherwise |
| PASS_INFRONT | 1 = Accident occur due to something pass in front, 0 = Otherwise |
| DEFECT_CAR | 1 = Accident occur due to defective car device, 0 = Otherwise |
| OFF_LEFT_STRAIGHT | 1 = Vehicle run off road to the left on straight, 0 = Otherwise |
| OFF_RIGHT_STRAIGHT | 1 = Vehicle run off road to the right on straight, 0 = Otherwise |
| LEFT_FIXED_STRAIGHT | 1 = Vehicle run off road to the left and hit fixed object, 0 = Otherwise |
| RIGHT_FIXED_STRAIGHT | 1 = Vehicle run off to road the right and hit fixed object, 0 = Otherwise |
| ACROSS_MEDIAN | 1 = Vehicle run off road and across median, 0 = Otherwise |
| OFF_LEFT_CUVE | 1 = Vehicle run off road during on left bend, 0 = Otherwise |
| OFF_RIGHT_CUVE | 1 = Vehicle run off road during on right bend, 0 = Otherwise |
| LEFT_FIXED_CURVE | 1 = Vehicle run off during left bend and hit fixed object, 0 = Otherwise |
| RIGHT_FIXED_CURVE | 1 = Vehicle run off during right bend and hit fixed object, 0 = Otherwise |
| Environmental and Temporal Characteristic | |
| EN_SURF | 1 = Accident occur on wet road, 0 = Accident occur on dry road |
| EN_STAT | 1 = Accident occur on wavy or dirty road, 0 = Otherwise |
| EN_WEATHER | 1 = Accident occur during raining, dust, foggy, 0 = Otherwise |
| EN_LIGHT | 1= Accident occur during nighttime, 0 = Otherwise |
| TIMEGROUP | 1 = Accident happened between 6 pm and midnight, 0 = Otherwise |
| APRIL_ACCIDENT | 1 = Accident happened in April, 0 = Otherwise |

vehicle accident case on 2-lane highway and killed 449 drivers; and, 5887 single-vehicle accident case on 4-lane highway and killed 761 drivers. Table 2 presents description of all variables that were considered in the analysis and Table 3 shows frequency of each crash related factor.

*2.2 Methodology*

In econometric study, the injury severity study is commonly well suited with discrete outcome model [20], since level of injury sustained is classified as one of three dichotomous injury severity categories: Minor injury, severe injury, and fatality. When classification of injury severity is more than two level, multinomial logit is well applicable and has been widely used by many previous research study [20-23]. Therefore, this study developed the multinomial logit model for analysis to identify the potential factors affecting the driver severity of single-vehicle run off road crash on 4-lanes highway and on 2-lanes highway. Severity of the driver is specified into three level: Minor Injury (include properties damage only), Severe injury (seriously injured), Fatal (died at hospital/at accident point). As well discussed by [23-24]:

**Table 3** Data description

| Variable | 2-lane highway accident | | | | | | 4-lane highway accident | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fatal | | Severe | | Minor | | Fatal | | Severe | | Minor | |
| AGE_26_36 | 118 | 4.38% | 112 | 4.16% | 639 | 23.73% | 248 | 4.21% | 285 | 4.84% | 1470 | 26.31% |
| AGE_36_46 | 115 | 4.27% | 101 | 3.75% | 461 | 17.12% | 192 | 3.26% | 210 | 3.57% | 1040 | 18.61% |
| AGE_46_56 | 82 | 3.04% | 56 | 2.08% | 317 | 11.77% | 129 | 2.19% | 136 | 2.31% | 648 | 11.60% |
| AGE_56_UP | 50 | 1.86% | 32 | 1.19% | 162 | 6.02% | 71 | 1.21% | 58 | 0.99% | 343 | 6.14% |
| GENDER (female) | 43 | 1.60% | 38 | 1.41% | 221 | 8.21% | 83 | 1.41% | 102 | 1.73% | 598 | 10.70% |
| GENDER (male) | 406 | 15.08% | 333 | 12.37% | 1652 | 61.34% | 678 | 11.52% | 749 | 12.72% | 3677 | 65.81% |
| SAF_EQ | 146 | 5.42% | 124 | 4.60% | 813 | 30.19% | 279 | 4.74% | 360 | 6.12% | 1832 | 32.79% |
| ALCOHOL | 26 | 0.97% | 14 | 0.52% | 47 | 1.75% | 15 | 0.25% | 14 | 0.24% | 40 | 0.72% |
| EXEED_SPEED | 297 | 11.03% | 273 | 10.14% | 1358 | 50.43% | 559 | 9.50% | 683 | 11.60% | 3450 | 61.75% |
| FALL_ASLEEP | 78 | 2.90% | 46 | 1.71% | 229 | 8.50% | 139 | 2.36% | 106 | 1.80% | 482 | 8.63% |
| R_COND | 18 | 0.67% | 18 | 0.67% | 42 | 1.56% | 14 | 0.24% | 11 | 0.19% | 82 | 1.47% |
| R_SURF (concrete) | 9 | 0.33% | 4 | 0.15% | 32 | 1.19% | 59 | 1.00% | 77 | 1.31% | 226 | 4.05% |
| R_SURF (asphalt) | 440 | 16.34% | 367 | 13.63% | 1841 | 68.36% | 702 | 11.92% | 774 | 13.15% | 4009 | 71.76% |
| HORIZONTAL | 220 | 8.17% | 152 | 5.64% | 882 | 32.75% | 190 | 3.23% | 196 | 3.33% | 1071 | 19.17% |
| VERTICAL | 93 | 3.45% | 74 | 2.75% | 365 | 13.55% | 47 | 0.80% | 64 | 1.09% | 284 | 5.08% |
| INTERSECTION | 19 | 0.71% | 18 | 0.67% | 144 | 5.35% | 31 | 0.53% | 53 | 0.90% | 296 | 5.30% |
| U_TURN | 3 | 0.11% | 2 | 0.07% | 29 | 1.08% | 44 | 0.75% | 99 | 1.68% | 526 | 9.41% |
| COMMUNITY | 4 | 0.15% | 3 | 0.11% | 17 | 0.63% | 6 | 0.10% | 12 | 0.20% | 40 | 0.72% |
| NO_MEDIAN | 422 | 15.67% | 335 | 12.44% | 1705 | 63.31% | 53 | 0.90% | 53 | 0.90% | 245 | 4.39% |
| RAISED_MEDIAN | 5 | 0.19% | 17 | 0.63% | 65 | 2.41% | 190 | 3.23% | 276 | 4.69% | 1457 | 26.08% |
| DEPRES_MEDIAN | 9 | 0.33% | 7 | 0.26% | 34 | 1.26% | 453 | 7.69% | 449 | 7.63% | 2126 | 38.05% |
| PASSENGER_CAR | 138 | 5.12% | 112 | 4.16% | 611 | 22.69% | 256 | 4.35% | 333 | 5.66% | 1526 | 27.31% |
| PICKUP_INVOLVE | 198 | 7.35% | 175 | 6.50% | 851 | 31.60% | 326 | 5.54% | 360 | 6.12% | 1936 | 34.65% |
| TRUCK_INVOLVE | 85 | 3.16% | 55 | 2.04% | 319 | 11.85% | 90 | 1.53% | 88 | 1.49% | 566 | 10.13% |
| MOUNT_ISLAND | 11 | 0.41% | 24 | 0.89% | 96 | 3.56% | 119 | 2.02% | 251 | 4.26% | 1366 | 24.45% |
| PASS_INFRONT | 7 | 0.26% | 7 | 0.26% | 46 | 1.71% | 14 | 0.24% | 14 | 0.24% | 94 | 1.68% |
| DEFECT_CAR | 21 | 0.78% | 22 | 0.82% | 82 | 3.04% | 20 | 0.34% | 16 | 0.27% | 134 | 2.40% |
| OFF_LEFT_STRAIGHT | 103 | 3.82% | 69 | 2.56% | 173 | 6.42% | 146 | 2.48% | 81 | 1.38% | 234 | 4.19% |
| OFF_RIGHT_STRAIGHT | 53 | 1.97% | 19 | 0.71% | 56 | 2.08% | 107 | 1.82% | 55 | 0.93% | 179 | 3.20% |
| LEFT_FIXED_STRAIGHT | 46 | 1.71% | 69 | 2.56% | 446 | 16.56% | 81 | 1.38% | 123 | 2.09% | 685 | 12.26% |
| RIGHT_FIXED_STRAIGHT | 20 | 0.74% | 43 | 1.60% | 226 | 8.39% | 89 | 1.51% | 135 | 2.29% | 728 | 13.03% |
| ACROSS_MEDIAN | 2 | 0.07% | 0 | 0.00% | 8 | 0.30% | 30 | 0.51% | 29 | 0.49% | 93 | 1.66% |
| OFF_LEFT_CUVE | 51 | 1.89% | 21 | 0.78% | 92 | 3.42% | 36 | 0.61% | 17 | 0.29% | 100 | 1.79% |
| OFF_RIGHT_CUVE | 37 | 1.37% | 29 | 1.08% | 70 | 2.60% | 33 | 0.56% | 18 | 0.31% | 92 | 1.65% |
| LEFT_FIXED_CURVE | 47 | 1.75% | 44 | 1.63% | 298 | 11.07% | 50 | 0.85% | 62 | 1.05% | 342 | 6.12% |
| RIGHT_FIXED_CURVE | 60 | 2.23% | 41 | 1.52% | 357 | 13.26% | 49 | 0.83% | 70 | 1.19% | 381 | 6.82% |
| EN_SURF (dry) | 388 | 14.41% | 310 | 11.51% | 1529 | 56.78% | 49 | 0.83% | 70 | 1.19% | 281 | 5.03% |
| EN_SURF (wet) | 61 | 2.27% | 61 | 2.27% | 344 | 12.77% | 157 | 2.67% | 168 | 2.85% | 943 | 16.88% |
| EN_STAT | 4 | 0.15% | 1 | 0.04% | 7 | 0.26% | 2 | 0.03% | 4 | 0.07% | 15 | 0.27% |
| EN_WEATHER | 72 | 2.67% | 72 | 2.67% | 383 | 14.22% | 162 | 2.75% | 171 | 2.90% | 1000 | 17.90% |
| EN_LIGHT | 223 | 8.28% | 174 | 6.46% | 859 | 31.90% | 335 | 5.69% | 408 | 6.93% | 1952 | 34.94% |
| TIMEGROUP | 94 | 3.49% | 74 | 2.75% | 364 | 13.52% | 113 | 1.92% | 150 | 2.55% | 684 | 12.24% |
| APRIL_ACCIDENT | 75 | 2.78% | 76 | 2.82% | 256 | 9.51% | 105 | 1.78% | 110 | 1.87% | 416 | 7.45% |

suppose that $T_{ij}$ is the linear function that determine the severity level j and $P_{ij}$ is the probability of a driver i have severity j, thus $T_{ij}$ and $P_{ij}$ and can be derived as in equation (1) and (2):

$$Tij = \beta jXij + \varepsilon ij \quad (1)$$

$$Pij = \frac{EXP[\beta jXij]}{\sum_j EXP[\beta jXij]} \quad (2)$$

Where $\beta_j$ is a vector of the coefficients to be estimated for injury severity outcome j, $X_{ij}$ is the vector of explanatory variable and $\varepsilon_{ij}$ is the unobserved random error. Odd ratio is the exponential of value βj (exp(βj)) of each significant risk factors and was used to interprets the estimated results. Odd ratio > 1 indicates an increase probability and odd ration < 1 indicates a decrease of probability of that injury severity relative to base category injury severity.

## 3. Result and discussion

In this study, the program R version 3.6.1 was used to analyses two separate model: the single-vehicle run off road on 2-lanes highway model and on 4-lanes highway accident model. Minimum recommend sample size of multinomial logit is 2000 observations which help confident interval get smaller and stays stable around true value and eliminate biases in estimating mean value of variables for all coefficients [25], thus this study sample size was warranted. First, all the explanatory variables were included in the analysis; and then, final models were conducted by excluding the explanatory variable that were not statistically significant at 0.10 from the fist analysis. The model fit information show that: accident on the 2-lanes highway model has Log-Likelihood (convergence): -2072, Likelihood ratio test: $\chi^2 = 409.36$ (sig < 0.000); McFadden $R^2$: 0.066 and the 4-lane model has Log-Likelihood(convergence): -4366, Likelihood ratio test: $\chi^2 = 295.65$ (sig < 0.000); McFadden $R^2$: 0.045. Both McFadden $R^2$ in the model are small because the value of likelihood at convergence (LL(C)) is close to likelihood null model (LL(0)) that explain the weak relationship between dependent and independent variable ( $R^2$ = 1-LL(C)/LL(0)) but acceptable as in the past study [26-27]. The variables that significantly affect driver severity at 0.1 significant level (90% confidence level) are obtained for result interpretation, which was also used in previous studies [2, 28]. The model results are presented in Table 4 and Table 5.

### *3.1 Driver factors*

Driver characteristic were found to significantly affect injury severity in any type of crashes [15, 29-30]. In this

**Table 4** Estimated result of multinomial logit for 4-lanes highway Accident model

| Variable | Estimate (Std. Error) | Odd Ratio |
|---|---|---|
| Minor:(intercept) | 1.545 (0.238) *** | - |
| Severe:(intercept) | 0.305 (0.290) | - |
| Severe: AGE_56_UP | -0.352 (0.188) * | 0.70 |
| Minor: GENDER | -0.304 (0.132) ** | 0.74 |
| Minor: SAF_EQ | 0.342 (0.086) *** | 1.41 |
| Severe: SAF_EQ | 0.310 (0.106) *** | 1.36 |
| Minor: ALCOHOL | -0.770 (0.324) ** | 0.46 |
| Minor: FALL_ASLEEP | -0.376 (0.112) *** | 0.69 |
| Severe: FALL_ASLEEP | -0.308 (0.144) ** | 0.74 |
| Minor: R_SURF | 0.281 (0.156) * | 1.32 |
| Minor: U_TURN | 0.473 (0.166) *** | 1.60 |
| Severe: U_TURN | 0.473 (0.192) ** | 1.60 |
| Minor: DEPRES_MEDIAN | -0.213 (0.086) ** | 0.81 |
| Minor: PASSENGER_CAR | 0.592 (0.148) *** | 1.81 |
| Severe: PASSENGER_CAR | 0.384 (0.185) ** | 1.47 |
| Minor: PICKUP_INVOLVE | 0.612 (0.144) *** | 1.84 |
| Minor: TRUCK_INVOLVE | 0.748 (0.175) *** | 2.11 |
| Minor: OFF_LEFT_CUVE | -1.077 (0.203) *** | 0.34 |
| Severe: OFF_LEFT_CUVE | -1.164 (0.302) *** | 0.31 |
| Minor: OFF_RIGHT_CUVE | -1.094 (0.212) *** | 0.34 |
| Severe: OFF_RIGHT_CUVE | -1.025 (0.301) *** | 0.36 |
| Minor: OFF_LEFT_STRAIGHT | -1.545 (0.120) *** | 0.21 |
| Severe: OFF_LEFT_STRAIGHT | -0.934 (0.154) *** | 0.39 |
| Minor: OFF_RIGHT_STRAIGHT | -1.461 (0.137) *** | 0.23 |
| Severe: OFF_RIGHT_STRAIGHT | -0.986 (0.182) *** | 0.38 |
| Base category: Fatal | | |
| Significant codes: '***' 0.01; '**' 0.05; '*' 0.1 | | |
| Log-Likelihood(convergence): -4366 | | |
| Log-Likelihood(null): -4571 | | |
| McFadden $R^2$: 0.045 | | |
| Likelihood ratio test: $\chi^2$ = 409.36 (sig = < 0.000) | | |

**Table 5** Estimated result of multinomial logit for 2 lanes highway Accident

| Variable | Estimate (Std. Error) | Odd Ratio |
|---|---|---|
| Minor:(intercept) | 1.465 (0.111) *** | - |
| Severe:(intercept) | -0.276 (0.149) * | - |
| Minor: AGE_26_35 | 0.426 (0.124) *** | 1.53 |
| Minor: SAF_EQ | 0.477 (0.116) *** | 1.61 |
| Minor: ALCOHOL | -0.877 (0.271) *** | 0.42 |
| Minor: FALL_ASLEEP | -0.370 (0.155) ** | 0.69 |
| Severe: FALL_ASLEEP | -0.419 (0.207) ** | 0.66 |
| Minor: RAISED_MEDIAN | 0.912 (0.475) * | 2.49 |
| Severe: RAISED_MEDIAN | 1.417 (0.520) *** | 4.12 |
| Minor: OFF_LEFT_CUVE | -1.124 (0.200) *** | 0.33 |
| Severe: OFF_LEFT_CUVE | -0.729 (0.290) ** | 0.49 |
| Minor: OFF_RIGHT_CUVE | -1.129 (0.226) *** | 0.33 |
| Minor: OFF_LEFT_STRAIGHT | -1.136 (0.158) *** | 0.32 |
| Minor: OFF_RIGHT_STRAIGHT | -1.633 (0.217) *** | 0.20 |
| Severe: OFF_RIGHT_STRAIGHT | -0.843 (0.299) *** | 0.43 |
| Minor: LEFT_FIXED_STRAIGHT | 0.585 (0.182) *** | 1.79 |
| Severe: LEFT_FIXED_STRAIGHT | 0.618 (0.229) *** | 1.86 |
| Minor: RIGHT_FIXED_STRAIGHT | 0.735 (0.252) *** | 2.09 |
| Severe: RIGHT_FIXED_STRAIGHT | 0.979 (0.299) *** | 2.66 |
| Severe: APRIL_ACCIDENT | 0.439 (0.188) ** | 1.55 |
| Base category: Fatal | | |
| Significant. codes: '***' 0.01; '**' 0.05; '*' 0.1 | | |
| Log-Likelihood (convergence): -2072 | | |
| Log-Likelihood (null): -2220 | | |
| McFadden $R^2$: 0.066 | | |
| Likelihood ratio test: $\chi^2$ = 295.65 (sig = < 0.000) | | |

study analysis, young driver (age less than 26 years old is coded as "otherwise" in each age group) was chosen to be reference level to interpret result of all other age group result. According to the result, in single-vehicle accident on 4-lanes highway, the variable AGE_56_UP have the negative coefficient. This show that the driver whose age older than 55 years old have higher possibility (Odd ratio Severe: AGE_56_UP = 0.7) of fatal in the accident. In contrast, the variable AGE_26_35 was found to have positive coefficient meaning that young driver age between 26-35 years old tend

to mitigate severity (Odd ratio Minor: AGE_26_35 = 1.53) in single-vehicle accident on 2-lane Highways. In both analysis model, the result of the variable ALCOHOL and FALL_ASLEEP show that driver involved in the accident due to effect of alcohol and drowsiness have higher chance (4-lanes accident Odd ratio Minor: ALCOHOL = 0.46, Odd ratio Minor: FALL_ASLEEP = 0.69, Odd ratio Severe: FALL_ASLEEP = 0.74 and 2-lanes accident Odd ratio Minor: ALCOHOL = 0.42, Odd ratio Minor: FALL_ASLEEP = 069, Odd ratio Severe: FALL_ASLEEP = 0.66) getting into fatal crash rather than injury crash. The result of variable SAF_EQ show that drivers who uses seatbelt are more likely to escape fatal chance (4-lanes accident Odd ratio Minor: SAF_EQ = 1.41, Severe: SAF_EQ = 1.36; and 2-lanes accident Minor: SAF_ EQ = 1.61) than driver who did not use seatbelt. These results confirm the finding of Xie, et al. [5] which suggest that young driver tend to receive less severe injury, old driver are likely to involve in more severe crash, driver under influence tend to involve in severe or fatal crash, and seatbelt could mitigate driver injury severity. The effect of fatigue increasing the chance of fatal crash is in line with the finding of [31-32].

### *3.2 Road factors*

Road characteristic were also found to be correlated with driver injury severity for both models. In single-vehicle accident on 4-lane highway, the result show that: the positive coefficient of variable R_SURF suggest that accident on concrete pavement tend to be more severe (Odd ratio Minor: R_SURF = 1.32) than those that happened on asphalt pavement. Pavement is generally known as the factor relate to the quality of the ride, but there is limited understanding its relationship to the traffic crash. This result is consensus with the finding of the study of Li, et al. [33] that found that accident happened on Jointed Concrete Pavement (JCP) had significant higher severity outcome and the reason is probably because JCP pavement failures are frequently located at pavement joints and such failures sometimes result in major impact to the driving condition. Vehicles maneuvering to avoid failure areas while driving at a relatively high speed on JCP pavements could lead to severe crashes, especially 2 lane highway. However, this result is doubtful and further research investigation between extra detail information of pavement and accident outcome is recommended. Accident within U-turn area, drivers tend to sustain injury (Odd ration Minor: U_TURN = 1.6, Severe: U_TURN = 1.6) with respect to fatal crash. In Thailand, most of the U-turns are opened on road with low traffic volume, residential area and urban street. This could be because driver tend to drive at slow speed when approaching U-turn area due to their awareness of the vehicle queued to make U-turn. The Variable DEPRES_MEDIAN (Odd ration Minor: DEPRES_MEDIAN = 0.81) coefficient shows that driver have higher possibility of getting in fatal crash with respect to minor injury. While the 2-lane accident model result show that positive coefficient of variable RAISED_MEDIAN (Odd ration Minor: RAISED_MEDIAN = 2.49, Severe: RAISED_MEDIAN = 4.12) suggest that there are higher chance of driver being in minor or sever injury rather than die in the accident (2.49 and 4.12 times higher respectively). The possible explanation of the accident on 4 lane highway with depressed median increasing chance of fatality is that when the vehicle drive at high speed and run of roadway into depressed median, vehicle tend to rollover in the crash due to inclination of the slope. The rollover crash was more likely to be more severe type of crash due to its extreme crash characteristic. However, raised median are frequently used in the urban arterial streets [34]. The reason raised median help driver mitigate severity is that it acts as traffic-calming device that is installed to reduce the vehicle speed. This finding is consensus with result of previous studies [35-36].

### *3.3 Vehicle factors*

From the police reports, the only vehicle factor known was vehicle type. Only on the 4-lane highway accident model were found that vehicle type has statistical relationship with driver injury severity. The positive coefficient show that passenger car, pickup truck, and truck driver sustain injury severity (Odd ratio Minor: PASSENGER_CAR = 1.81, Minor: PICKUP_INVOLVE) =1.84 and Minor: TRUCK_INVOLVE = 2.11). This result is in line with the finding of [37] that found that light-duty truck (minivans, SUVs, and pickups truck) appear to protect the driver from more severe injury.

### *3.4 Crash factors*

4-lane and 2-lane accident crash model: Run off road on horizontal curve increase the chance of fatal crash (with the share of odd ratio approximately 0.31). This result indicates that single-vehicle accident on horizontal curve is 1/0.31 = 3.22 times higher chance to die in the crash relative to both minor and severe injury. This finding is consensus with the study of [38] that also found that roadway alignment with curve were significantly associated with high risk of fatal crash. In the result of 4-lanes highway accident model: Run off road to left/right on straight increase the chance of fatal crash (Odd Ration approximately 0.23). 2-lane accident crash model: the variable Minor: OFF_RIGHT_STRAIGHT have odd ratio of 0.2 (5 times higher chance) Minor: OFF_LEFT_STRAIGHT have odd ratio of 0.33 (3 times higher chance). Both results indicate that single-vehicle to both directions increase the chance of fatality. However, when the run off road to the right side, it creates higher chance of fatality to the driver. Noticeably, the odd ratio of variable minor and sever of LEFT_FIXED_STRAIGHT is 1.79 and 1.86 respectively; and odd ratio of variable minor and sever of RIGHT_FIXED_STRAIGHT is 2.09 and 2.66 respectively on only 2-lanes accident model.

### *3.5 Temporal factor*

In Thailand, Songkran is the nation holiday last for 3 days every year between 13$^{th}$ April till 15$^{th}$ April. During this time period, the road accident reaches its peek frequency due to an increasing number of car travel on the highway. Thai authorities, every year, launch road safety campaign prior to the holiday in order to reduce accidents. The police also strictly enforce the traffic law and put firmly attention on the focus on driver under influence of alcohol. Drunk driving and speeding were the foremost causes of accident. On the other hand, in the 4-lanes highway accident model there were no significant factor; but, in 2-lane highway accident model's result show that accident during April, driver increase chance of get into severe injury (Odd ratio = 1.55) relative to fatality in the accident. However, there was no significant between minor injury relative to fatality.

## 4. Conclusion

This paper used the statistical model to find potential crash related factor such as: driver, road geometry, crash

characteristic, vehicle, and environment and temporal factor that significantly influence on driver injury in single vehicle run off road crash on 2-lane highway and 4-lane highway. Accident data was extracted from the police report of Highway Accident Information Management System (HAIMS). Arrangement of data was structured to fit the one of the most commonly used discrete outcome model, multinomial logit model. Time frame of data to be used in the analysis was between 2011 – 2017). There were 2693 single-vehicle accident case on 2-lane highway and 5887 single-vehicle accident case on 4-lane highway.

The important findings of this study showed that driver older than 55 years tend to involve in more severe crash in the single vehicle run off road crash on 4 lanes highway and young driver between 25-35 years old were likely to mitigate severity on 2-lane highway. Accident on both type of highway, using seatbelt was also found to help the driver sustain their injury in the crash and drowsiness and drunk driver were found to have strongly associated with the fatal single-vehicle crash. The 4-lane highway accident with depressed median increase chance of fatality, but 2-lanes highway accident with raised median reduce chance of fatality. The accident on concrete pavement was found to increase chance that driver dies in the accident. In term of crash characteristic, single-vehicle accident on both highways were found to increase the chance of fatality on both curve road and on straight road section. However, if the vehicle run off road to hit the fixed objection on the side of the road, this manner was found to help driver sustain the injury severity.

Base on the finding, this study gives the recommendation as follow: Thailand authorities such as DOH (Department of Highway) and Royal Thai Police should emphasize their effort on improving education campaigns on road safety for all road users, especially older drivers and enforce the law on drunk driving and seatbelt. Additionally, roadside safety features such as safety barrier alongside the highway particularly run off road black spot and curve roads. This study also recommend that asphalt pavement is safer than the concrete pavement or additional benefit of the concrete pavement could be obtained by providing additional layer of asphalt on top the concrete slab; however, further research investigation should be carried out by using addition detail information about pavement at accident location in order to obtain more accurate result. Lastly, within all urban area, safety planner should consider implementing raised median to improve safety for driver in case of accident.

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