REPORT OF RESEARCH RESULTS

(a) **Title**: Analysis of driver and passenger injuries severity in rear-end crashed factors for Thai highway using Structural equation modeling

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(c) **Summary**

(d) At present, there are a large number of fatalities from accidents. Around 36.2 of 100,000 people are ranked as the second largest number of road accidents in the world. When considering the kind of crashes, the crashes in the same direction has the highest proportion. To reduce the fatalities and the injuries, this research aims to study and analyze the factors affecting the severity of injuries from the rear-end accidents. Structural equation modeling (SEM) was used to be the tool for analyzing the factors affecting the injuries in the rear-end collision. After the acknowledgment of those factors, the involved organizations should play an important role in the road design and maintenance as well as the driver's training. The obtained results can be taken to reduce the severity of injuries. According to SEM results, the female drivers, the drivers aged between 35-55 years, high-speed use, the coexisting trucks in road accidents caused the drivers and the passengers' more serious injuries. For the road features, the road surface which is asphalt and divided roads can decrease the severity of injuries.

(e) **Aim of Research**

1. To study the types and the number of the rear –end crash accidents
2. To analyze the factors affecting the injury severity from the rear –end crash accidents
3. To build the model potentially predicting the injury severity from the rear – end crash accidents

(f) **Method of Research and Progression**

This research studies the factors affecting the injury severity of drivers and passengers using the data from Department of Highways by employing Structural Equation model (the main elements of Structural Equation model including exogenous variable and endogenous variable. The two variables consist of Latent variable and observed variable. A latent variable cannot be directly measured. It is measured by observed variable instead. For the subordinate model in Structural Equation Model when considering latent variable through each observed variable, it is called Measurement Model and when considering latent variable affecting another variable, it is called Structural Equation model.

For analysis, either factor or variable is not invented by Researcher but taken from the previous research both locally and internationally. For factors which are latent factors, the independent variables included Road Factor, Environment Factor, Driver Factor, and Type of crashed factor. The continuous factor searches for injury severity of drivers and passengers. For Measurement model, Dummy Variable is the method used for Structural Equation Model analysis due to the data group.

This research studies the factors affecting the injury severity of drivers and passengers using the data from Department of Highways. It will be analyzed by means of Structural equation model as follows;

1. Study the related research Study the research from both international and local journals by dividing the group of related research into 5 groups including 1) the factors affecting the accidental severity 2) the research involved in the rear-end crash accidents 3) the elements and the principles of using Structural Equation Model (SEM) 4) The analysis of affecting factor by using Structural Equation Model 5) the injury severity. In this research, the injury is divided into three degrees of severity which included slight injuries, critical injuries, and deceases.

2. Gather the authentic data and collect the data of the rear collision accidents from Department of Highways. The researcher will go to collect factual data on the existent rear-end crash accidents by asking witnesses on the scene for information to be used for analysis. Regarding the data received from Department of Highways, Researcher will select only the rear-end crash accident cases.

3. Select the variables or factors used for analysis to try to find the injury severity. All the variables used are taken from reviewed literature. Factors which are latent variables will be 4 factors including Driver factor, Road factor, Environmental factor, and Types of crashed car factor

4. Analyze and do factor analysis used for Structural Equation Model. When obtaining data, Factor analysis has to be carried out before conducting Structural Equation Model analysis to examine whether observed variables can be indicators of latent variables or not.

5. Analyze Structural Equation Model. After testing Factor analysis, the data are taken to conduct Correlation matrix in order to examine how much mutual relationship between observed variables. Then run SEM by using MPlus 7.2 program to obtain the results.

6. Interpret the results from Structural Equation Model. The interpretation of the results from SEM will be regarded as the value of Loading Factor of each mutually affecting variable. It will show as the standardized score. Considering what factor most affects the injury severity, it can be indicated by loading factor value.

(g) Results of Research

The overall view of data as **Table 1** showed the group of variables, the names of the variable, the type of variables explanation, and the mean of minor injuries, serious injuries, and fatalities (Dependent variables or Endogenous variables).

Table 1 Descriptive statistics

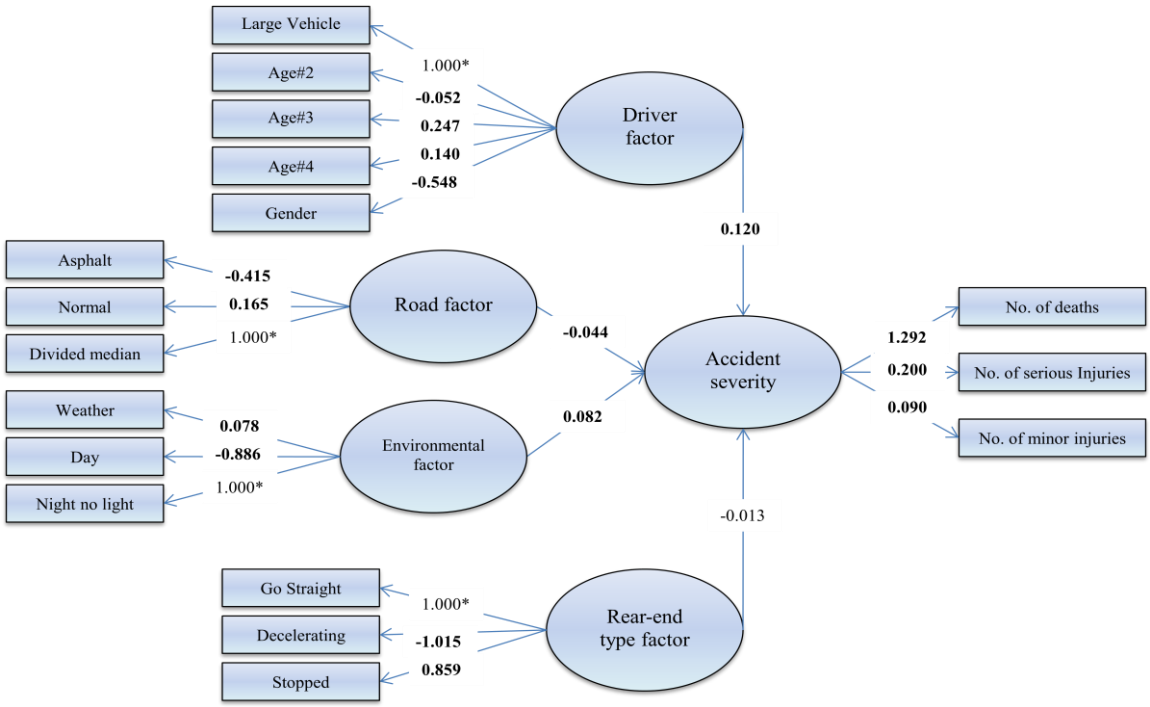
Descriptive Statistics					Mean (person)		
Group	Variable name	Descriptive	Value	Percentage	Slight injury	Serious injury	Fatality
Driver factor	Heavy vehicle	Heavy vehicle involvement (including bus, semi-truck and full truck)	1=Yes	14.4	1.63	0.47	0.58
			0=Other	85.5	1.29	0.43	0.30
	Driver's age#2	Age of driver between 26-35 Years	1=Yes	25.5	1.45	0.41	0.31
			0=Other	74.5	1.31	0.45	0.35
	Driver's age#3	Age of driver between 36-45 Years	1=Yes	37.6	1.35	0.39	0.35
			0=Other	62.3	1.33	0.46	0.33
	Driver's age#4	Age of driver between 46-55 Years	1=Yes	17.1	1.32	0.44	0.33
			0=Other	82.9	1.35	0.44	0.36
	Driver's gender	Gender of driver	1=Male	17.7	1.20	0.39	0.23
			0=Female	82.3	1.37	0.45	0.36
Road factor	Asphalt pavement	The pavement of road is asphalt concrete	1=Yes	88.2	1.36	0.45	0.35
			0=Other	11.8	1.20	0.35	0.26
	Normal road	The road dose not repairing (not work zone)	1=Yes	97.4	1.35	0.44	0.34
			0=Other	2.6	1.18	0.46	0.27
	Divided road	Separated traffic direction by road median (raised, flush, depressed and barrier median)	1=Yes	63.8	1.34	0.37	0.33
			0=No divided	36.2	1.35	0.55	0.35
Environmental factor	Weather	Weather condition	1=Clean	7.7	1.44	0.60	0.40
			0=Other	92.3	1.33	0.42	0.33
	Day	The collision happened at daylight	1=Day	33.0	1.39	0.46	0.29
			0=Other	67.0	1.25	0.38	0.42
	Dark	Accident happened at night time and there is no light	1=Yes	10.1	1.09	0.40	0.58
			0=Other	89.9	1.37	0.44	0.31
Rear-end type factor	Going straight	Leading vehicle did not take any decelerating action before the collision	1=Yes	65.2	1.46	0.44	0.34
			0=Other	34.8	1.13	0.42	0.33
	Decelerating in road	Leading vehicle was decelerating speed before collision	1=Yes	29.3	1.16	0.45	0.31
			0=Other	70.1	1.42	0.43	0.35
	Stopped in road	Leading vehicle had been stopped in road, velocity of the leading vehicle was zero	1=Yes	5.5	0.98	0.31	0.40
			0=Other	94.5	1.36	0.44	0.33

Note: Number accidents are 1,901 cases which was including 4,133 drivers

1. Descriptive data: Independent variables consisted of 14 variables including 1) individual factors including age, gender, and types of vehicles 2) Road factors including types of road surface condition and traffic islands for dividing the road for traffic 3) Environment factors including the condition of driver's visibility, time of getting injuries and the light during the night of injuries and 4) Collision factors which were divided into the speed of the front car including normal speed driving, slowing down before crashing and parking at pavements. The variables called disguise variables of injuries consisted of the number of fatalities, serious injuries, and minor injuries.

When considering the mean of the fatalities, it was found that the highest mean was caused by Environment factor consisting of the rear-end collision with normal visibility condition at 0.4, The accidents during the day at 0.29 and the accidents at night when there was no light at 0.58. For the second, Individual factor, the rear-end crashes accompanied with large trucks at mean 0.58, followed by the drivers in the range of 36-45 years at 0.35. Considering the driver's gender, women had chances of fatalities more than men at 0.36. Regarding the types of rear-end collision, crashes divided into the nature of car movement before crashes, it was found that the maximum mean of fatalities was the parking front car 0.4, followed by the slowing-down front car and the normal- speed driving front at 0.31.In terms of Road factor, the divided traffic roads by traffic islands had fatalities less than the undivided traffic roads and the normal road condition or the roads which were not repaired had the highest mean of fatalities at 0.34.

For the group of factors affecting the serious injuries, both Road factor and Environment factor were found the highest mean at 0.45, followed by Driver factor causing serious injuries at mean value 0.43, and the last was Collision factor affecting the severity of injuries at mean value 0.42. For minor injuries, their highest mean was initiated by Driver factor.



Note: **Bold text** denote loading factor between variable has statistical significant at 95%; * denote mean reference variable of each latent variables; Model fit information: Chi-square value = 151.667, degree of freedom = 98 (p-value = 0.000), Root mean square error of approximation (RMSEA) = 0.012, CFI = 0.988, TLI = 0.984, Weighted root mean square residual (WRMSR) = 0.987.

Fig. 1 SEM result model

2. The result of SEM and Discussion: From the analysis of the rear-end collision on highways data acquired from Department of Highways to find out the factor affecting the levels of drivers and passengers' injuries, the arranged factors were classified into 4 groups of latent variables including Individual factor, Road factor, Environmental factor and Collision factor. The model was compared with empirical data by considering model fit information value that showed in note of **Fig.1** chi-square statistic value = 151.667, df=98 (p-value = 0.000), RMSEA = 0.012, CFI=0.988, TLI = 0.984 and WRMSR = 0.987. Considering GOF value of this model with the cut off criteria of other research, it was in acceptance criteria and can be used to interpret the research results.

When considering the measurement model of accident size using 3 variables including the number of fatalities (reference variable), the number of serious injuries, and minor injuries, it was found that the number of the fatalities from each accident could evidently indicate the severity levels of injuries (loading factor = 1.292) followed by the number of serious injuries (loading factor = 0.20) and the number of minor injuries (loading factor = 0.09)

Considering Structural model, it was found that among 4 independent latent variables, the severity of the rear-end crash accidents was significantly affected by three factors regarding Individual factor, Environment factor, and Road factor. While Collision types did not significantly affect the severity of injuries, Individual factor mostly affected the injuries severity (loading factor = 0.12). When considering measurement model of *Driver factor* (latent variable) providing reference variable, *heavy vehicle,* which could be interpreted in case of coexisting trucks in that event, the accident would affect the increase of injury severities in accordance with the studies of Bianchi Piccinini et al. (2017); Christopher Wiacek et al. (2014); Qi et al. (2013). The violent effect might be originated from the huge size of trucks causing the strike force resulting

in more severity injuries. The driver's gender was the variable secondly affected the levels of injuries. It was found that the women got more serious injuries. The cause might be that female drivers got hurt easily than men conforming to Chen et al. (2015) who found that the male drivers were affected to get lower level of injuries. Another cause was the women's longer decision time to stop the car than men's (Warshawsky-Livne & Shinar, 2002). For the age factor, the drivers were compared by their age ranges including 26-35 years old, 36-45years old, and 46-55 years old. The drivers in the age range of 36-55 years affected the increasing more severity of accidents similar to Lee et al. (2008))'s study who found that the drivers in the age range of 40-50 years affected the increasing severity of injuries . In case of building the campaigns or training, the focus should be especially focused on the drivers in the mentioned age range.

For the Environment factor significantly affected the levels of injuries, (loading factor = 0.082) the measurement model of this factor determined *Dark* as a reference variable. It could be interpreted that if the accident occurring at night and no light available, it affected increasing level of injuries in accordance with many researches on low visibility leading to more serious injuries (Chen et al., 2015; Chen et al., 2016; John M. Sullivan & Michael J. Flannagan, 2003). Due to the small number of cars at night, the driver who carelessly drove his car at the high could not manage to stop the car and violently crashed the leading car using low speed. It was the cause of serious injuries conforming to the variable compared between nighttime and daytime crashes which found that the nighttime crash caused more severity than that of the daytime (Chen et al., 2015). For the driver's visibility factor, the condition of visibility with clearness, without dust, fog or smoke hindering vision affected more severity of injuries (Abdel-Aty & Abdelwahab, 2004)

When considering Road factor significantly affecting the levels of injuries (loading factor = -0.044), *divided road variable was* determined *as the variable comparing* between the rear-end collision on the roads with and without the availability of traffic islands, it was found that the road without traffic island availability affected the levels of injury severity in accordance with Das and Abdel-Aty (2011)'s study. For the normal roads which also affected the serious injuries, they were caused by the driver using the speed more than that on the repaired or maintained roads (Mohamed Shawky A. et al., 2017). For the road surface types, the surface which was not asphalt affected the increase of serious injuries in accordance with Lee et al. (2008) who found that the concrete surface affected the increasing severity of injuries.

(h) Future Area to Take Note of, and Going Forward

1) The organizations, involved in training and building the campaigns decreasing the severity of the rear-end crash accidents, should emphasize the careful driving at night, especially, the area where there is no light. Furthermore, the drivers in the age range of 36-55 years, the women drivers, and the truck drivers especially require more attention.

2) The departments which enforce the laws about the driving speed should be strict.

3) Department of Highways should use asphalt on road surface and if possible, the roads should be divided for the traffic island.

(i) Means of Official Announcement of Research Results

We have already submitted our research to distribute our work to the wider audience in "Traffic injury prevention".