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ATRANS

ASIAN TRANSPORTATION RESEARCH SOCIETY

Motorcycle Accidents: Understanding and Analysing the Accident Data

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Table of Contents

Page

Lists of Figures

Page

List of Tables

Page

List of Abbreviations and Acronyms

AGFI	Adjusted Goodness of Fit Index
ARMS	Information system for reporting accidents on rural roads
C.R.	Critical Ratio
CFA	Confirmatory Factor Analysis
CFI	Comparative Fit Index
DOH	Department of Highways
DRR	Department of Rural Roads.
EFA	Exploratory Factor Analysis
EMCO	Emergency Claim Online
GFI	Goodness of Fit Index
HAIMS	Highway Accident Information System
IS	Injury Surveillance
ITEMS	Information Technology for Emergency Medical System
KMO	Kaiser-Meyer-Oklin measure of Sample Adequacy
POLIS	Police Information System
RMR	Root Mean square Residual
RMSEA	Root Mean Square Error of Approximation
RVP	Road Accident Victims Protection Co., Ltd.
SEM	Structural Equation Model
S.E.	Standard Error
WHO	World Health Organization

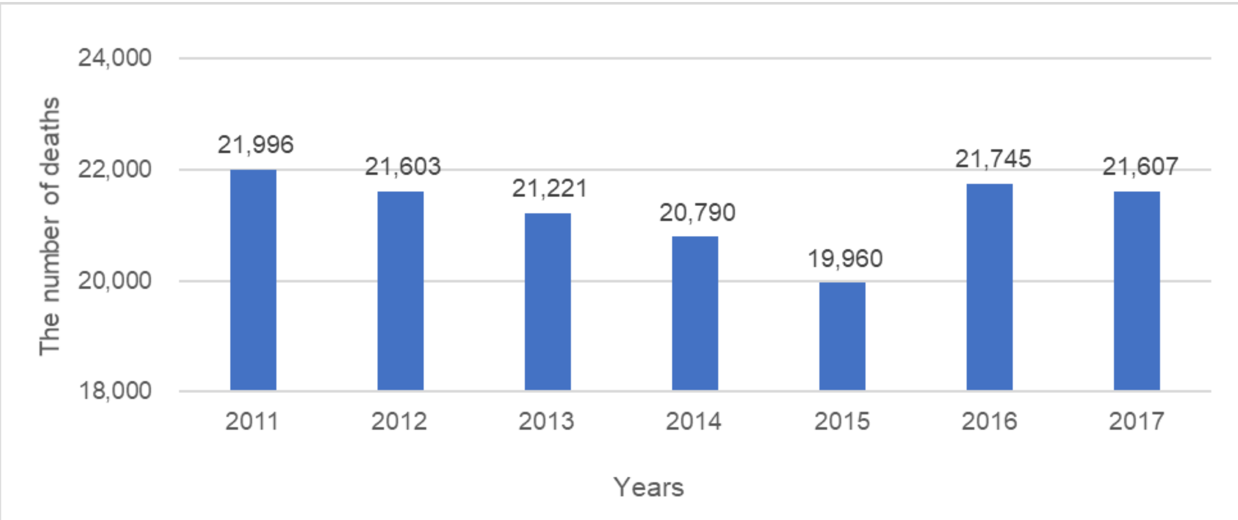
CHAPTER 1 INTRODUCTION

1.1 Background of the study

A road traffic accident is a major problem for many countries, resulting in death and damage for both people and economies. Serious injuries are often more costly to society because of long-time rehabilitation and healthcare needs. In order to reduce and prevent the road traffic accident, effective road safety management is required. Due to road safety management is the first pillar of the decade of Action's Global Plan (WHO, 2011). Road traffic accident data is used as a tool to identify the size of the road safety problem, and the cause of traffic accidents. These are useful for supporting the development, implementation, and assessment of road safety programs. Thus, comprehensive traffic accident data is required for effective road safety management

In Thailand, road accidents are one of a serious public health problem, with more than 20,000 people were killed in each year (Figure 1.1). The government determined that reducing road accidents is an urgent national agenda which needs. They established the Road Safety Center in 2008 to supervise various related agencies, and prepare an action plan of Decade of Road Safety 2011-2020, in order to reduce the number of deaths, with under 10 deaths/ 10,000 people within 2020.

Figure 1.1: The number of fatalities in Thailand (2011-2017)



Source: 3 Databases

Traffic accident data is key to road safety management strategy. There are currently ten data sources for road safety which are collected by seven agencies as presented in table 1. The data is been collecting in different details for a different purpose.

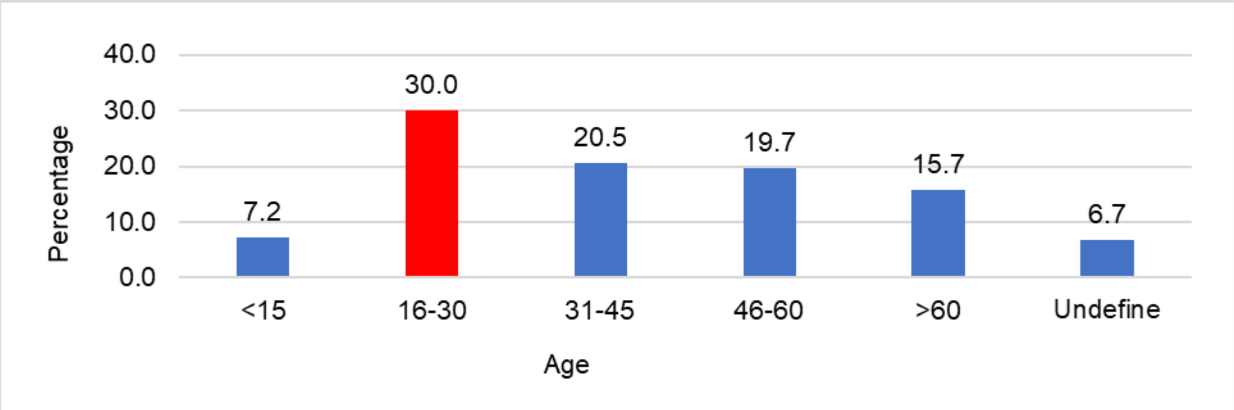
Table 1.1: Data sources for road traffic accidents in Thailand

Data	Source
Police Information System (POLIS)	Royal Thai Police
TRAMS	Ministry of Transport
E-Claim	Road Victim Protection Company
Injury Surveillance (IS)	Ministry of Public Health
Trauma Registry	Ministry of Public Health
19 External Causes of Injury	Ministry of Public Health
Information Technology for Emergency Medical System (ITEMS)	Emergency Medical Institute of Thailand
Emergency Claim Online (EMCO)	National Health Security Office
OP/PP Individual Record	National Health Security Office
Death Certificates	Ministry of Interior

Source: Road Safety Institutional and Legal Assessment, Thailand (2015)

Example of the accident information from 3 Databases which is integrated the data from police, public health, and insurance sector used to estimate mortality rate more precisely. We found that in 2017 people were killed more than half of all road traffic deaths occur among young adults ages 16-45. Almost 30% of those killed in Thailand roads were aged between 16 and 30, while the percentage of the age group that greater than 45 gradually falls down. This means that young people are much more at risk. The majority (94.5%) of people killed in road crashes were drivers, while only 9.5% were pedestrians.

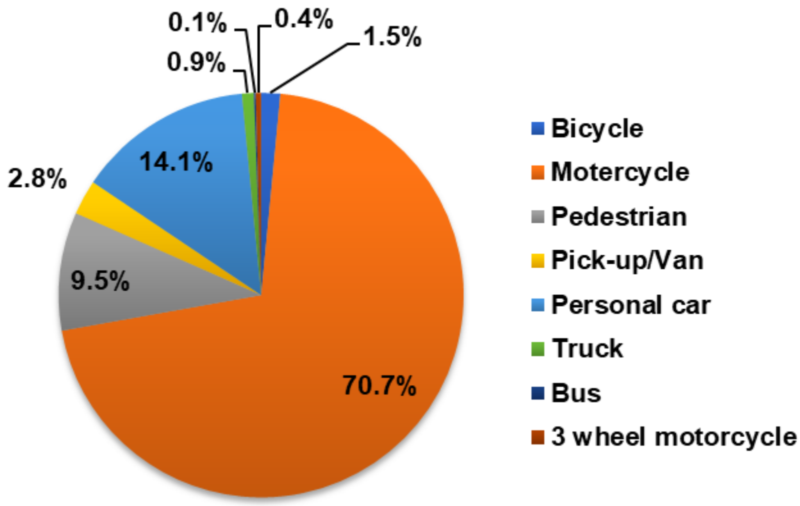
Figure 1.2: Road fatalities in Thailand by age in 2017



Source: 3 Databases

In 2017, 71.7% of all people killed on roads were motorcyclists. In general, motorcyclist fatalities have increased at a higher rate than for other road-users (by 10% from 2011 to 2017, compared to a total fatality decrease of 2%). People who death by using personal car accounted for 14.1% of all road accident victims in 2017. The number of pedestrians accounted for 9.5% of road accident fatalities.

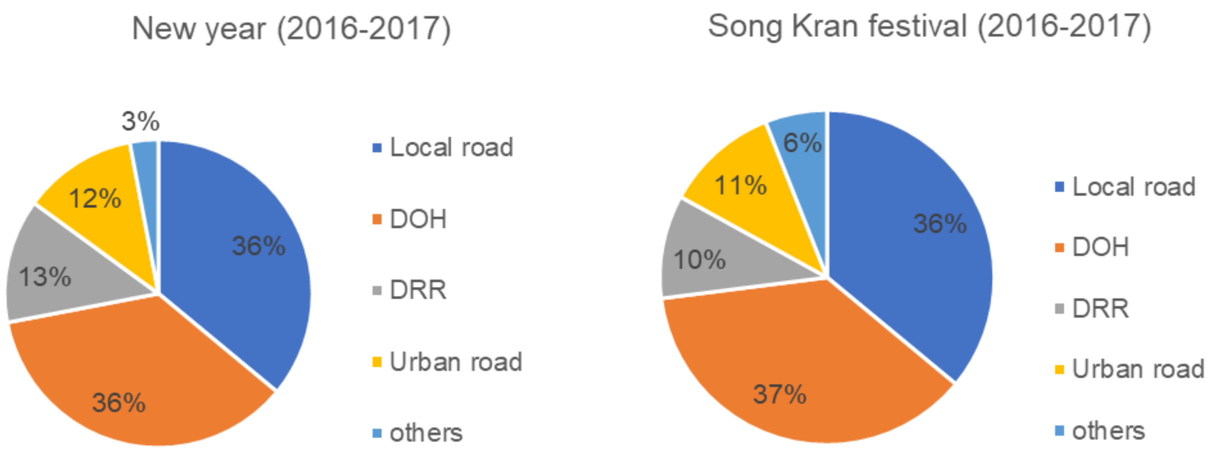
Figure 1.3: Road fatalities in the Thailand by transport mode in 2017



Source: 3 Databases (2017)

Moreover, there are two periods each year when the local media concentrate their attention towards the number of casualties on the road. There are the New Year, and the Songkran day. These constitute prolonged holidays. The government always makes sure people get safety at least 5 days off, so they can visit their relatives. Road Safety Center analyzed the frequency of accident on the type. They found that the road types that more than 70% of the accident occur on the local and urban road (Figure 1.4). While, Ministry of Transport also collect the accident on their road. They identify road characteristic of the accident, they found that the accident occurs on a straight road (Table 1.2).

Figure 1.4: Road fatalities in Thailand by type of road in 2017



Source: Road Safety Center, 2017

Table 1.2: Road fatalities in Thailand by road characteristics in 2017

Road characteristics	Percentage
Straight	75.6
Curve	18.0
Junction	3.2
Others	3.2

Source: TRAMS, 2017

In addition, Royal Thai Police record causes of the accident. The causes of accident are from human behavior and environment (road, weather) as follow table 1.3. Most of accident were happened by running pass in front of a car (18.4%). Secondly, driver drive over speed limit (16.3%).

Table 1.3: Road fatalities in Thailand by road characteristics in 2017

Cause	Percentage
Running pass in front of a car	18.4
Over speeding	16.3
Running close to a car in the front	15.3
Raining/Road is damaged	14.6
Unskilled on driving	7.0
Equipment got problems	6.3
Driving uncultured	6.1
Running in a wrong lane	4.2
Driving across the lane	2.5
Snoozing on the drive	1.7
Others	7.6

Source: Royal Thai Police, 2017

Although transportation agencies often try to identify the most dangerous road sites and put massive efforts into preventive measures, such as illumination and policy enforcement, the annual number of traffic crashes has not yet significantly decreased. Currently, 3 databases have integrated the data from police, public health, and insurance sector used to estimate mortality rate more precisely, but it is not enough for analysis the causes of the accidents.

Therefore, this study will identify key factors which able to improve the data collecting process and compiling data from various sources. In addition, understanding the root cause of the accidents could help policy-makers creating the measures for road accidents reduction.

1.2 Objectives of the study

The objective of this project is to review the existing procedure of collecting accidental data. Moreover, this project is going to identify key factors that effectively improve the data collection process and compile the data from various sources. The gathered data will enable to completely analyze crucial factors that are contributing to each accident. It is planned to study the process for collecting data in other countries for better understanding the causes of traffic accidents and identifying the root of the contributed factors in Thailand. Once the data are better collected, and authorities are able to analyze for a meaningful conclusion of each accident. They will be able to develop an effective technique and policy in order to prevent any accident effectively in the future.

1.3 Limitations of the study

We use road accident data from ATRANS Safety Map. The data used for the model calibration relate to the accidents happened in 2018 – 2019

1.4 Research framework

In order to achieve the objectives of this project, we employed a methodology comprised of four steps as shown in Figure 1.5

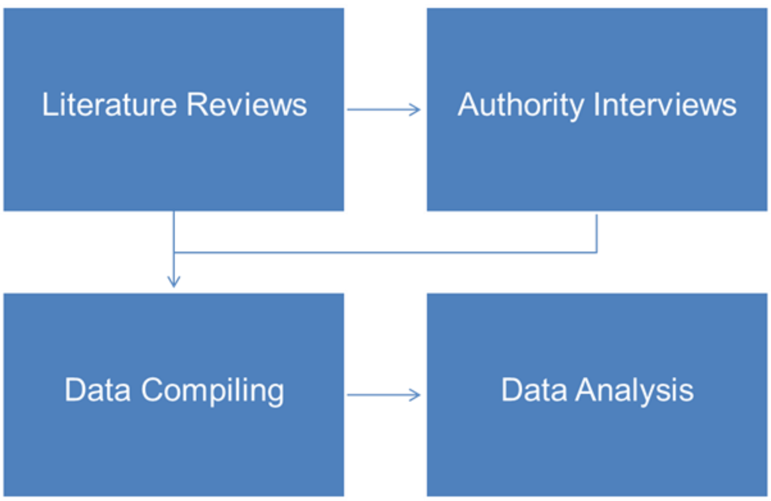
1st – An evidence reviews of the existing evidence relating to both the accident data collections and alternative specification model and technique

2nd – A detailed interview phase collating views and experiences from a range of related agencies in traffic accidents. In this step, we did a workshop at Hatyai, Songkhla Province. Aim to understand the limitation of accident data collection.

3rd – Based on the information gathered from step 1 and 2, we designed a revised relevant data.

4th – Analysis of the revised accident data was vital to ensure that it is useful and usable for developing road safety programs. We use ATRANS Safety Map for analysis the causes of the accidents by using Structural Equation Model (SEM)

Figure 1.5: Summary of method



1.5 Research schedule

This project was started on April 1, 2019; we review Thailand's data collection and write an inception report within April. After that, we review the existing evidence relating to both the accident data collections and analysis technique, and compile the accident data from May to July. Preliminary Data was analyzed in August. After we understand the key factors that effectively improve the data collection process and the compiling data from various sources, we did a workshop in Songkha Province on mid-November 2019. The report was written during October and Febuary, and then the report is submitted in March 2020.

Table 1.4: Schedule of the project

Schedule of the project	**2019**									**2020**		
	April	**May**	**June**	**July**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**
Inception report	■											
Compiling Data		■	■	■								
Preliminary Data Analysis					■							
Data Analysis						■	■	■				
Workshop in Selected Provinces								★				
Writing up report								■	■	■	■	
Final report presentation									★			
Final report submission												★

CHAPTER 2 SITUATION OF ROAD ACCIDENT DATA COLLLECTION

2.1 Accident data collection in Thailand

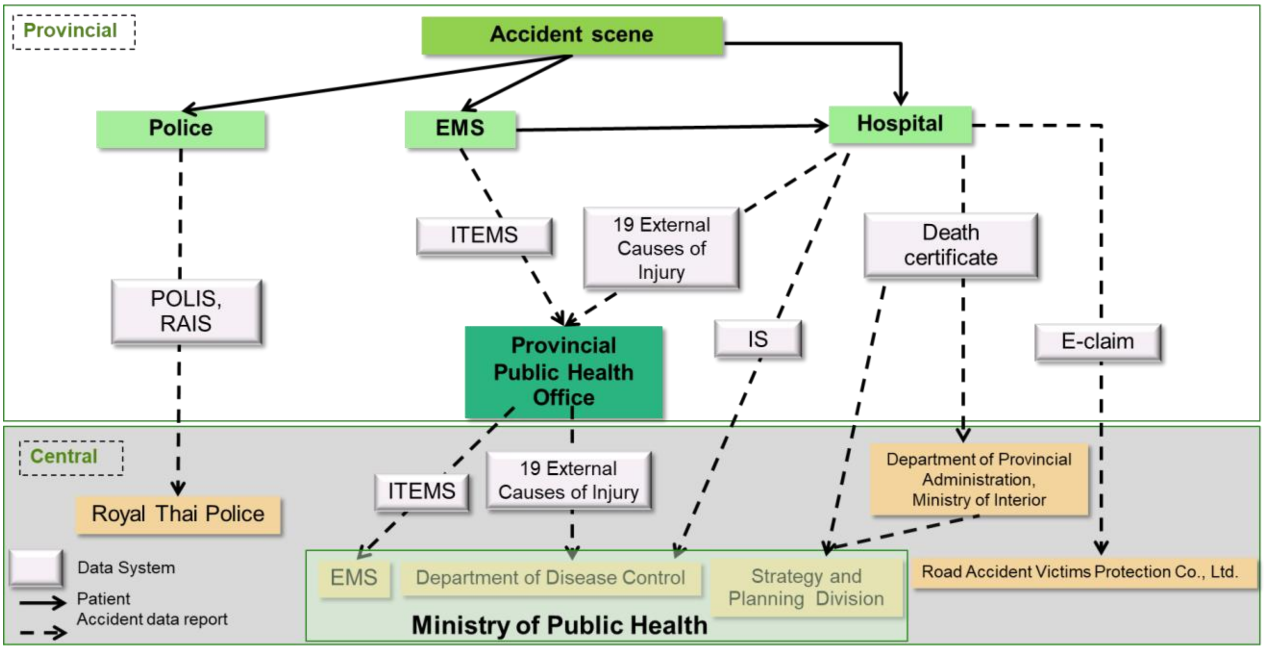
Injury and road accidents management requires the use of data analysis to identify problems and determine the objectives and direction of implementation and evaluation. In Thailand, there are various agencies that have road accidents information such as agencies under the Ministry of Transport (Department of Highways, Department of Rural Roads, and Department of Land Transport), agencies under the Royal Police Thailand, Road Victim Protection Company, and agencies under the ministry of public health agencies (both in the public and private sectors). Accident data collection have 2 levels. First, provincial level collects the data at accident scene. There are 3 stations to the care or treatment of the patient (police, Emergency Medical Services: EMS, and hospital). Each station has to collect the accident information then the data is reported back to central. The details are as follows figure 2.1. There are many systems for collecting the accident information, the purposes of accident recorded system are following.

1. **Police Information System (POLIS)**, the police are well placed to collect information on crashes as they are often called to a scene. Alternatively, they may receive information about the crash following the event. Attendance at the crash scene allows for the collection of detailed information that is useful for identifying crash causes and possible solutions.
2. **Information Technology for Emergency Medical System (ITEMS)** is an information system for medical emergency operations under the National Emergency Medical Institute. In order to support the emergency medical service system for helping the emergency patients in immediately, and manage resources appropriately.
3. **Injury Surveillance (IS)** is a surveillance system for patients who have been hospitalized in the hospital where have the Sentinel site. The Sentinel site is the system of the Bureau of Epidemiology under the Ministry of Public Health. The database is collected for patients service system and patient referral system developing.
4. **E-Claim** is a data recording system of the Road Accident Victims Protection Co., Ltd. The database used to help the victims for claim disbursement.
5. **Death Certificate Information** is a death registration system for the record the deceased person who has a death notification at the local/district registration office.
6. **The 19 External Causes of Injury** is an injury surveillance system from the 19 external causes of hospitalization under the Ministry of Public Health (Regional Hospital/General Hospital/Community Hospital) under the Bureau of Epidemiology. The database is used for predicting injury situations and defining the implementation.

7. **Thailand Road Accident Reporting System (TRAMS)** is a data collecting system under the Ministry of Transport. The data is collected at the scene on the responsible ways. There are 2 sub-agencies as following:
- **Highway Accident Information System (HAIMS)** is an accident data on the highway that is recorded on the online system.
- **Information system for reporting accidents on rural roads (ARMS)** is an accident data on rural roads that are recorded on the online system (http://arms.drr.go.th).

8. **Trauma Registry** is an injury collection system in the hospital registered in the Trauma center. The Trauma registry system was developed to improve the patient service system.
9. **Emergency Claim Online System (EMCO)** is the information system of the National Health Security Office, which is used for recording medical service information in the case of emergency illness of patients with rights in all 3 health security funds (health insurance, social security, civil servants).
10. **Health Service Information and Individual Health Promotion System (43 files)** is a system for collecting health services and promoting disease prevention at the health service unit.

Figure 2.1: Road accident data collection system in Thailand



Source: Division of Non-Communicable Disease, Ministry of Public Health (2013)

Road traffic accident data are typically collected by police. Many countries use the police data as the primary source and entered into crash database systems for easy analysis and annual reporting. In some circumstances, data are collected from hospitals. The use of health sector data for meaningful injury classification at country level is necessary to complement police data and to provide an optimal means of defining serious injury.

In Thailand, the 3 databases are integrated by the ministry of public health from 3 data sources which are POLIS, E-claim, and Public health sector.

- **The Royal Police Thailand (POLIS)**

The police are well placed to collect information on crashes as they are often called to the scene. Alternatively, they receive information about the crash following the event. Attendance at the crash scene allows for the collection of detailed information that is useful for identifying crash causes and possible solutions.

A crash report form is typically completed (traditionally a paper-based form, although recently computer-based systems have been used), allowing the collection of quite detailed information on the crash. Key variables typically collected include:

  - Crash location (including geographic coordinates)
  - Time and date of accident
  - Information on those who were involved (including road user type, age, gender, an injury sustained)
  - Details regarding the road (whether at an intersection, speed limit, curvature, traffic control, markings)
  - Details on the environment (light conditions, weather, road surface wet or dry)
  - Information regarding what happened in the crash (safety equipment, objects struck, and contributory factors such as speed, alcohol use or driver distraction)
  - Vehicle factors (a type of vehicles involved)

- **Ministry of public health**

Hospital data are used to identify levels of under-reporting or to obtain better information about the injury, particularly when police report data are not available or inadequate. The under-reporting of crash data, hospital data are a useful source of information for crash statistics. allowing the collection of detailed information on the crash. Key variables typically collected include:

  - Crash location (including geographic coordinates)
  - Date and time of notification, arrival on site, occupant rescue, hospital arrival
  - Factor impeding rescue (traffic congestion)
  - Cause of death
  - Hospitalization details (AIS-90, injury, surgery)

- **Road Accident Victims Protection Co., Ltd. (RVP)**

RVP provides various services to road accident victims in Thailand. Its services include providing support to the insurance industry, paying insurance compensation on behalf of various insurance companies, purchasing compulsory insurance for private and public/rental motorcycles, and providing coverage for compulsory motor insurance. Key variables for accident claim including:

  - crash location (including geographic coordinates)
  - Date and time (accident, notification)

- information on those who were involved (including driving license, age, gender, career, insurance information)
- information regarding what happened in the crash (offender, risk behavior)
- Hospitalization

We compare the current data and the desired data in Table 2.1. The desired data is divided into 6 sections including 1) general information, 2) human information, 3) road traffic environments, 4) vehicle, 5) injury characteristics and 6) emergency rescue.

We found that critical data have not been collected. The country needs to commence collecting at the spot of the actual cash occurring and behavior survey. Accident data needs supplemented information, including road inventory and survey data of key behaviors, enforcement data, road network, vehicle fleet safety, and emergency and medical system quality.

Table 2.1: Comparision accident data in Thailand

No.	Desire data	E-claim	Public health	POLIS	3 databases
General Information					
1	Date of Occurrence	✓	✓	✓	✓
2	Time of Occurrence	✓	✓	✓	✓
3	Place of Occurrence	✓	✓	✓	✓
4	Accident Description	✓			
5	Weather				
6	Summary of Occurrence	✓		✓	
7	Diagram of Circumstances of Occurrence			✓	
8	Number of Occupants	✓			
9	Number of Fatalities	✓			
10	Number of Injured				
11	Accident Type	✓	✓	✓	
12	Number of Vehicles Involved	✓		✓	
13	Speed in Accident (yourself)				
14	Speed in Accident (others)				
15	Who died/injured (driver or passenger)				
Human					
1	Age/Sex	✓		✓	✓
2	Height/Weight				
3	Driving Frequency				
4	Annual Distance Driven				
5	Years Since Obtaining License	✓			
6	History of Accidents and Infractions				
7	Physical Condition (Drunk, Falling Asleep or not)	✓			✓
8	Mental Condition				
9	Continuous Travel Time				
10	Awareness of Road Conditions				
11	Risk Perception Position				
12	Risk Perception Speed				
13	Risk Avoidance Behavior	✓			
14	Helmet wearing	✓			✓

No.	Desire data	E-claim	Public health	POLIS	3 databases
15	Type of Clothes (Long sleeve, Pants, or Skirt)				
16	Color of Clothes				
17	Gloves				
18	Type of Shoes				
Road Traffic Environment					
1	Road Shape			✓	
2	Road Line Shape			✓	
3	Road Surface Conditions			✓	
4	Lighting/Illumination			✓	
5	Roadside Conditions				
6	Traffic Signal			✓	
7	Traffic Signal Control			✓	
8	Signage and Visibility			✓	
9	Traffic Conditions				
10	Presence of Sidewalk				
11	Road Safety Facilities			✓	
12	Road Facilities			✓	
13	Road Specification (Limiting Speed)				
Vehicle (a. Structure/Specs)					
1	Body Shape				
2	Body Paint Color				
3	Steering Wheel Position				
4	Transmission Type				
5	Brakes				
6	Front Windshield				
7	Seatbelts				
8	Tires (Surface Condition)				
9	Drive Wheels				
10	Total Distance Traveled				
11	Body Modifications				
12	Airbags				
13	Child Seat				
14	ABS				
15	Car Phone				
16	Engine Capacity				
17	Head Light (ON or OFF)				
18	Head Light (work or not)				
19	Tail Light				
20	Blinker				
Vehicle (b. Damage)					
1	Body Deformation				
2	Interior Deformation				
3	Direction of Collision				
4	Collision Part				
5	Safety Equipment				
6	Damage				
7	Seatbelts				

No.	Desire data	E-claim	Public health	POLIS	3 databases
8	Steering				
9	Wheels				
10	Door Locks				
11	Glass				
12	Vehicle Fire				
13	Door Open				
Injury					
1	Cause of Death	✓	✓		
2	Site of Injury		✓		
3	Severity of Injury		✓		
4	Nature of Injury				
5	Site Most Injured				
6	Hospitalization	✓	✓		
7	Surgery		✓		
8	Days to Full Recovery				
9	Residual Disability				
10	AIS-90 (Abbreviated Injury Scale)				
11	Site of Caused Injury				
12	Site of Contact				
13	Condition of Site of Contact				
Emergency Rescue					
1	Date and Time of Notification		✓		
2	Time of Arrival on Site	✓	✓		
3	Time of Occupant Rescue		✓		
4	Time of Hospital Arrival		✓		
5	First-aid Measures		✓		
6	Factors Impeding Rescue		✓		
7	Traffic Congestion				

2.2 An example of the successful implementation of a crash data system (Sweden)

- **The problem**: Lack of reliable information on crashes, including information on injury outcomes.
- **The solution**: The Swedish Road Administration was established in October 1996 by the cooperation of the Swedish Police, the Swedish National Board of Health and Welfare, the Swedish Institute for Transport and Communications Analysis, Statistics Sweden, and the Swedish Association of Local Authorities and Regions. In order to initiate a new information system covering injuries and accidents in the entire road traffic system. They created Strada which is a based information report from two sources consisting of the Swedish police and hospitals. All police districts report the accident data to Strada on a national scale since 2003. The incorporation of hospital data makes this method different from earlier methods of registration of road injuries and road accidents. Strada also got more information from an increasing number of incorporation hospitals.

- **The result**: Strada provides more detailed information which has led to further knowledge of road traffic injuries and accidents. Incorporating the data obtained from the hospital increase the under-reporting of cash since the police have limited knowledge about some road traffic accidents. Furthermore, the hospitals' reporting of diagnosis covers the knowledge of the injuries and their degree of seriousness. Therefore, the data need to be input by the local police and hospitals. Up to the present, the level of accuracy in data matching between police and hospital is very high. A more complete description of the circumstances of the accident and related injuries can be obtained from the match data. In 2013, 9,800 cases were matched which are recorded by the police (15,000 accidents with 20,600 injured people. They were matched with 32,700 patient who sought treatment in the hospitals. This show that more accurate information about real traffic safety issues has been realized, which will facilitate the planning and prioritization of traffic safety measures.

2.3 Identifying data requirement for Thailnad

After reviewing the situation of the crash data system in Thailand and study the successful implementation of a crash data system in Sweden we found that an accurate and comprehensive road safety data can be used by many stakeholders to help improve road safety. Therefore, the establishment and improvement of accident data systems are necessary. The establishment and improvement include the assessment of existing data sources, development of a crash report form, engagement with key stakeholders, development of a crash data system, and ensuring the quality of the data. Keys of accident data improvement are following:

- The establishment and ongoing support of the road safety information system are important for effective road safety management.
- The lack of accurate information has a serious impact on effective management and delivery of positive road safety outcome. The problem of under-reporting in the country should be improved.
- Important safety information is exposure information (traffic volume, population data), final outcome data (death and injury), and intermediate results (average speed, safety devices and driving levels, network, and car safety quality).
- Other information is important for assessing and managing road safety such as Information about the elements and features of safe and secure road design, this information can be used to identify and maintain high-risk locations.
- Integration of the data from different resources can lead to a more comprehensive understanding of road safety issues and greater ability to perform effectively to resolve this issue.

CHAPTER 3 MACRO LEVEL PERSPECTIVE

In this chapter explain macro perspective of the crash from ATRANS Safety map and conclude the problems of the data collection in Hatyai, Songkhla province.

3.1 Statistical Analysis by ATRANS Safety Map

Thailand has many organizations collected accident data as mention in (Chapter 1), ATRANS Safety Map is contributed by police report. Road traffic accident data from ATRANS Safety Map was used in this study because it was complied and identified the key factor of the accident. The data of crash were collected 1,079 between 2018 and 2019. About 80% were collected from Phuket and 11% from Songkhla province. Among the casualties, about 1,110 people were slightly injured followed by no injury (882 persons), serious injury 361 persons and 155 people were death respectively. There are 1,904 vehicles involved.

A descriptive statistical analysis of the accident characteristics was carried out. Table 3.1 reported the characteristics diversifying accidents, and for each configuration the corresponding number and percentage of accidents are reported. Most of road traffic accidents occur on the straight road (39%) and most occur under the Department of Rural Roads (DRR) and Department of Highways (DOH). The percentages of road accidents are 39% and 27% respectively. The accidents on midblock become more serious problem which have a highest percentage of the accident (55%), while the percentage of accidents at intersection is 31%, on the connection road 3% and at U-turn is 3%. At the accident area are clear signposting and markig on the road. Moreover, the accident occure more on a clearly day in daytime.

Table 3.1: Descritive statistics analysis

Accident characteristic	Configuration	Number of accidents	Percentage of accidents
Road geometric characteristics (Point View Details)	Straight	416	39
	Crossroad	320	30
	Curve	197	18
	Community	30	3
	Undefined	116	11
Road classification (Road types)	Department of Highway (DOH)	419	39
	Local Road	100	9
	Alley Road	23	2
	Department of Rural Roads (DRR)	294	27
	Motorway	4	0
	Urban Road	134	12
	Private Road	35	3
	Undefined	70	6

Accident characteristic	Configuration	Number of accidents	Percentage of accidents
Road geometric characteristics (Point view)	U-turn	30	3
	Mid-block	336	55
	Connection	32	3
	Intersection	336	31
	Undefined	63	8
Road signposting	**Sign**		
	Clear	742	69
	No/Unclear	208	19
	Undefined	129	12
	Marking		
	Clear	936	87
	No/Unclear	54	5
	Undefined	89	8
Atmospheric condition	clearly	565	52
	cloudy	285	26
	rain	47	31
	Damp	6	0
	Undefined	176	16
Road bed condition	Damp	14	1
	Wet	76	7
	Dry	830	77
	Undefined	159	15
Accident time	Daytime	680	63
	Night time	320	30
	Undefined	79	7
Speed	≤30	55	5
	31-40	204	19
	41-50	293	27
	51-60	96	9
	61-70	3	0
	71-80	13	1
	>90	26	2
	Undefined	389	36
Road surface types	Concrete	676	63
	Asphaltic concrete	306	28
	Macadamized road	22	2
	Undefined	75	6
Road aspect	Flat	764	71
	Upgrade	105	10
	Downgrade	117	11
	Hill Top	5	0
	Undefined	88	8

3.2 Workshop at Songkha Province

We went to workshop about accident situation in Thailand and to present the project results and promote the ATRANS Safety Map Applica. We found that the problem of road accident data collection are following:

- Road accident data are fragmented and collected by variety of Authorities.
- Police did not collect all details in POLIS form. They collected only in big cases.
- Police collect the data in paper.
- Police collect data for judicial proceedings which do not support accident analysis.
- Some cases (small accident/ no injury) may not be collected in the system.
- Health authority has more details of fatalities.

As a result, the crash data is not complete and it cannot connect with others system.

CHAPTER 4 MICRO LEVEL PERSPECTIVE

There are some applications also in the field of safety, which have applied the factor analysis and Structural Equation Model (SEM). As an example, in Ulleberg and Rundmo (2003) a structural equation model suggested that the relation between the personality traits and risky driving behaviour is mediated through attitudes; in Vance et al. (2006) SEM was adopted in order to examine causal models of driving avoidance and exposure among older adults. In Paul and Maiti (2007) SEM was adopted in order to examine the role of behavioral factors on the occurrence of mine accidents and injuries, in Eboli, L., Mazzulla, G., & Pungillo, G. (2007) explored of the impact of the relationship between the accident severity and some accident characteristics in 2003 in Cosenza province, Italy. Therefore, SEM is proposed as tool for effecting road accident analysis in this study.

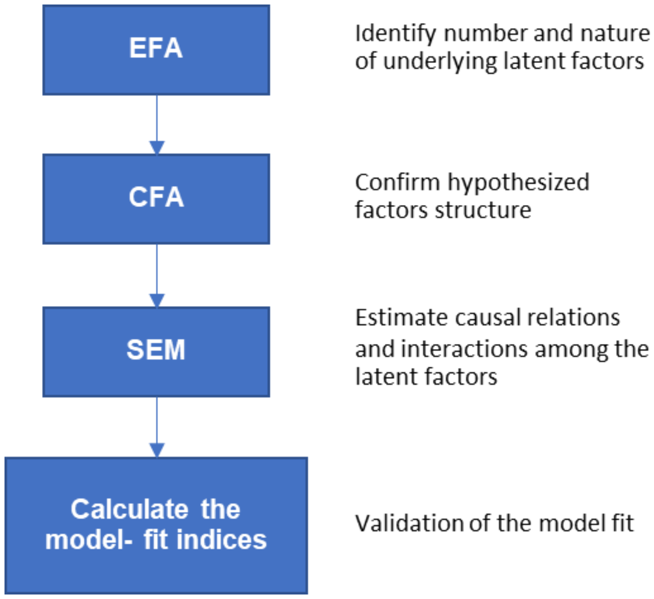
4.1 Structural Equation Model

Structural equation modelling (SEM) is a multivariate technique combining regression, factor analysis and analysis of variance in order to estimate interrelated dependence relationships simultaneously. SEM methodology is well-known and widely applied in several fields of research. This technique is the combination of factor analysis and multiple regression analysis, and it is used to analyze the structural relationship between measured variables and latent constructs. Latent variables are indirectly observed or measured, and hence are inferred from a set of observed variables that we actually measure using tests, surveys, and so on.

For example, the road characteristics is a latent variable that represents road condition. The observed, measured, or indicator variables are a set of variables that we use to define or infer the latent variable or construct. For example, Road surface types is an instrument that produces a measured variable which one uses to infer the road characteristics. Additional indicator variables, that is, road geometric characteristics, could be used to indicate or define the road characteristics (latent variable). Each of these observed or indicator variables represent one definition of the latent variable.

In the first step of SEM modeling design, an Exploratory Factor Analysis (EFA) is usually applied as a preliminary step needed to analyze the nature of the latent constructs and to provide a preliminary insight of the relationships between the measured variables and the corresponding latent factors. After that, the Confirmatory Factor Analysis (CFA) is also conducted, where the confirmation of the factor structures based on the EFA investigation and in the compliance with some theorical knowledge is verified. The result of CFA is related to the measurement part of the SEM model, which describes the loadings of the indicator variables on corresponding latent factors. Then, the measurement part and structural part of the SEM model are derived, which gives us all the estimated interrelations and causal relations between the treated variables. Finally, the quality of model fit to the real data is checked by the means of calculation of model-fit indices. If the latter indicate the poor model's performance, some additional modifications of the model must be done. As follow Figure 2.2

Figure 4.1: The basic steps of SEM modeling



Source: Dragan, Dejan & Topolšek, Darja. (2014)

4.2 General Structure

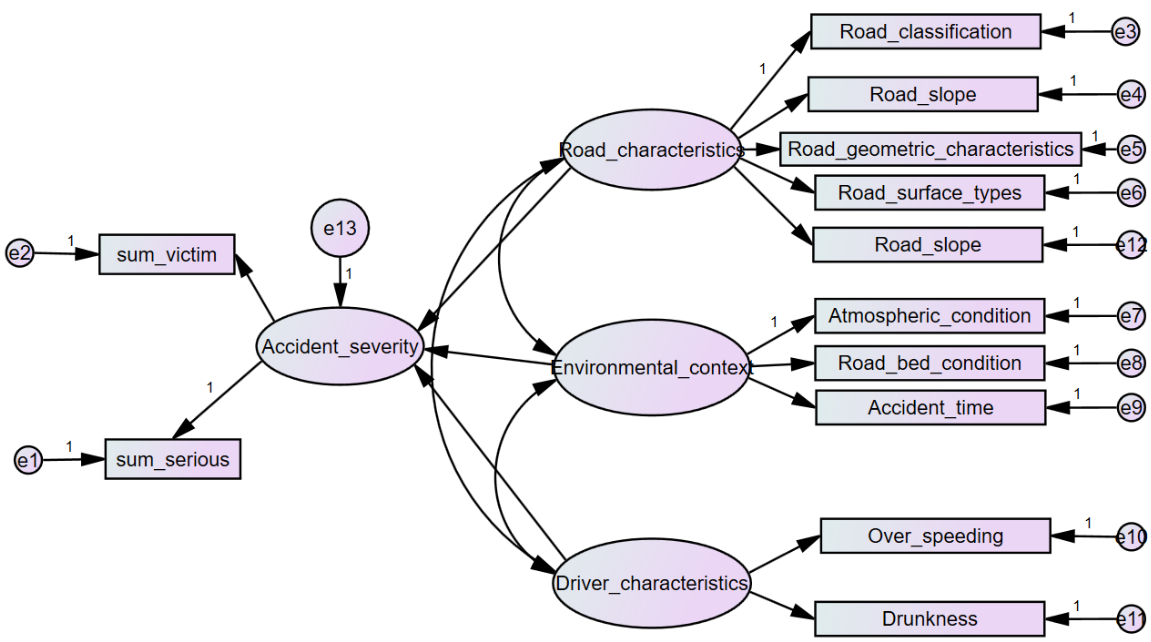
The proposed research model was tested using 833 samples to determine the relationship of human behavior, road, and environment context on road accident severity. AMOS 24.0 was used to test the hypotheses. The information relates to different factors, such as road characteristics, environmental context, and driver characteristics. The observed variables are the road accident characteristics described, and two indicators of the road accident severity which are number of injured and died in the accident. The configurations of the road geometric characteristics are straight stretch, curve, community, and crossing; the road classification includes alley road, local road, urban road, private road, road under the Department of Highway (DOH) and Department of Rural Roads (DRR); the configuration of the road signposting are relating to the presence/absence of signs; the atmospheric condition are serene, cloudy, rain; the road bed can be dry, or wet; the drivers are classified in terms of speeding ,and drunk driving. The latent variables are the unobserved road accident aspects that can be explained by the observed variables. in Table 4.1

Table 4.1: Variable involved

Latent variables	Variable	Level of variation
Road characteristics	Road geometric characteristics	Mid-block (0), Intersection (2), Junction (3)
	Road classification	DOH (0), DRR (1), Local Road (2)
	Road signposting	Clear (0), Unclear (1)
	Marking	Clear (0), Unclear (1)
	Safety equioment	No (0), Yes (1)
	Road surface type	Concrete (0), Asphaltic concrete (1), Macadamized road (2)
	Road_slope	Straight (0), Ascent (1)
Environmental context	Road bed condition	Dry (0), Wet (1)
	Accident time	Daytime (0), Night time (1)
	Atmospheric condition	Normally (0), Cloudy/Rain (1)
Driver characteristics	Speeding	No (0), Yes (1)
	Drunkenness	No (0), Yes (1)

The general structure of the model includes 3 latent variables (Figure 4.2). The first variable, named "Road characteristics", is linked to "Road geometric characteristics", "Road classification", "Road signposting", "Marking", "Safety equioment", and "Road surface type" observed variables. The second variable, named "Environment context", is linked to "Road bed condition", "Accident time" and "Atmospheric condition" observed variables. The third variable, named "Driver characteristics" is linked to assumption of driver behavior (speeding, drunkness). This model is a primary model.

Figure 4.2: General structure of the mode



The KMO test is tested to ensure that the data we have are suitable to run a factor analysis. The KMO value is 0.51, for this study we accept this value (> 0.5 is acceptable) because the limitation of the data. Normally, the KMO values less than 0.6 indicate the sampling is not adequate. The communality (Table 4.2) is also tested for measuring the correlations between each variable and individual factors. For better measurement of factor analysis communalities should be greater than 0.4. Therefore, suitable variables for analysis are accident time, road classification, road geometric characteristric, road slope, road surface types, road surface condition, road signposting, marking, and road safety equaipment. For the driver characteristics are not enough data for this analysis.

Table 4.2: Communalities result

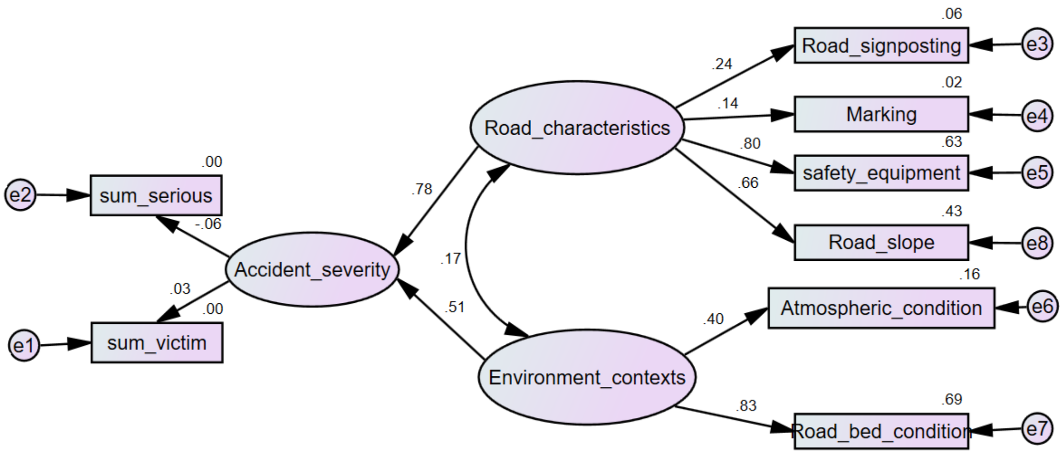
Communalities	Initial	Extraction
Accident_time	1.000	.82
Road_classification	1.000	.76
Road_geometric_characteristics	1.000	.58
Road_slope	1.000	.72
Road_surface_types	1.000	.41
Road_surface_condition	1.000	.61
Road_bed_condition	1.000	.69
Atmospheric_condition	1.000	.84
Road_signposting	1.000	.64
Marking	1.000	.63
safety_equipment	1.000	.66

Note: Extraction Method: Principal Component Analysis.

4.3 Confirmatory factor analysis

The collected data are also analyzed by confirmatory factor analysis method (CFA) using AMOS 24.0 to assess the all measurement scale of measurement model in order to test how well-measured our variables are (Hair et al., 2006). The measurement model assessment examines the goodness of fit. Factor loading is first considered to determine convergent validity. (Hair et al., 2006) recommended that standardized loading estimates should be at least 0.5 or higher, and ideally 0.7 or higher. In figure 4.3, some of the standard loading are lower than the recommendation.

Figure 4.3: Final structure of the model



The model results are shown in tables 4.3 and 4.4. Specifically, some tests on the goodness of fit are reported in table 4.3, the parameters estimated, the Standard Error (S.E.), the Critical Ratio (C.R.) and the level of statistical significance (P) of each variable are reported in table 4.4

The minimum value of the discrepancy function is 25.55; this value is statistically significant ($p>0.05$) according to the chi-squared test. The tests on the goodness of fit are quite satisfactory: the Goodness of Fit Index (GFI) is at 0.99, the Adjusted Goodness of Fit Index (AGFI) is 0.98, and the Comparative Fit Index (CFI) is 0.98. The best value can obtain with these indexes is unit; therefore, the indexes obtained from the model are very good. The Root Mean square Residual (RMR) index has a value of 0.01, and the Root Mean Square Error of Approximation (RMSEA) has a value of 0.03; the values of these indexes are low (<0.05) and therefore are quite good.

Table 4.3: Model Fit Summary

Model fit Index	result	Criteria
CMIN/DF	1.83	<2
Goodness of Fit Index (GFI)	0.99	≥0.95
Adjusted Goodness of Fit Index (AGFI)	0.98	≥0.95
Comparative Fit Index (CFI)	0.98	≥0.95
Root Mean square Residual (RMR)	0.01	<0.05
Root Mean Square Error of Approximation (RMSEA)	0.03	<0.05

Table 4.4: Parameter estimation and levels of statistical significance

Estimate			Unstandardized Weight	Standardized Weight	S.E.	C.R.	P
Accident_severity	<---	Environment_contexts	0.11	0.51	0.18	0.61	0.54
Accident_severity	<---	Road_characteristics	0.35	0.78	0.50	0.69	0.49
Sum_victim	<---	Accident_severity	1.00	0.03			
Sum_serious	<---	Accident_severity	-1.06	-0.06	1.90	-0.56	0.58
Road_signposting	<---	Road_characteristics	1.00	0.24			
Marking	<---	Road_characteristics	0.34	0.14	0.09	3.61	***
Safety_equipment	<---	Road_characteristics	3.63	0.80	0.72	5.02	***
Atmospheric_condition	<---	Environment_contexts	1.00	0.40			
Road_bed_condition	<---	Environment_contexts	1.21	0.83	0.67	1.79	0.03
Road_slope	<---	Road_characteristics	2.84	0.66	0.50	5.67	***

Note:*** p-value is less than 0.001

The latent variable with a major effect on road accident severity is "Road_characteristics", which have a coefficient value of 0.78 (standardized weight). The "Environmental" latent variable has a minor impact (0.51).

The "Safety_equipment" observed variable has a major impact on the "Road characteristics" exogenous latent variable (0.80); similarly, the "Road bed condition" factor has a major impact on the "Environmental context" latent variable (0.83). However, the endogenous latent variable, indicating road accident severity, is weak explained by the indicator of the number of victim, whose coefficient has a value of 0.03; the indicator of the number of serious in the accident also has a lower value (-0.06). Indirect effect of exogenous latent variable on the endogenous latent variable are shown in table 4.5

Table 4.5: Indirect effects of observed variables on endogenous latent variable

Latent variable	Indirect Effect	
	Road characteristics	Environmental contexts
Road_signposting	0.24×0.78=0.21	
Marking	0.14×0.7=0.11	
Safety_equipment	0.80×0.78=62	
Road_slope	-0.66×0.78= -0.51	
Atmospheric_condition		0.40×0.51=0.20
Road_bed_condition		0.83×0.51=0.42

CHAPTER 5 CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Road accident data collection issues are the different variables of each system, different name of elements, and different in details. Moreover, some variable cannot complete in the filling out in a form because some variables cannot be traced back. Accordingly, policy maker lack of the crash data for analysis and misunderstand the cause of the accident.

This study try to understand the cause of the accident by compling the crash data (ATRANS Safety map) and analyse the data. We use a Structural Equation Model (SEM) to analyze the impact of the relationship between the accident severity and some accident characteristics. We found that the majority factor of the accident is road characteristic and environment is a minor impact of the accident. However, driver behavior is not observed in this study because the data of diver behavior is not complete.

5.2 Reccommendation

The integrated accident data from various sources is a key of accident data analysis and improvement the system which need to have the authority that in charge of accident data collection. Injury and road accidents management requires the use of data analysis to identify problems, just a descriptive statistic analysis is not enough for understanding the root cause of the road accident problem. Moreover, the data of road user behavior need to collect and identify such as state of drunkness, use of helmet, use of safety belt, and speeding.

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