TRENDS AND FACTORS RELATED TO ROAD TRAFFIC FATAL CRASH IN THAILAND USING POLICE DATABASES

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TRENDS AND FACTORS RELATED TO ROAD TRAFFIC FATAL CRASH IN THAILAND USING POLICE DATABASES

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ABSTRACT

A cross-sectional study was conducted to identify injury and death rate trends among the provinces of Thailand, and factors related to fatal crashes on motorways.

Secondary data from the Police Information System center were collected from January 1995 to December 2002, and 205 crashes on motorways were collected from January to December 2002 including 638 motorway crashes in the fiscal year 2004. The police data were described in terms of trends of deaths and injuries per 10,000 vehicles, including the trends of factors related to road traffic accidents. Motorway data were used to identify the concentrations of crashes and analyzed for frequency distribution of factors related to injury crashes.

The result of the study revealed that the death and injury rates had declined during the end of the financial bubble and the economic crisis (1995-2000) and had increased during the economic recovery (2000-2002). For related factors, minor trends of decrease were found for males who died, were severely or mildly injured. There were minor trends of increase in all three indicators for females. For all indicators of injury severity, males were higher than females. For cause of accident, there was a minor trend of decrease for speeding, and a minor trend for increased drunk driving, and no trend for drowsy driving. For motorcycles, there was a minor trend of increase, whereas private car and truck involvement in road traffic accidents had minor trends of decline.

For accident-prone areas on motorways, crash clusters were found on road-surface-improved areas, temporary toll areas, nearby junction areas and interchange areas. For factors related to injury crashes, the result showed that the speeding driver in the period midnight to 07.59hr on motorway route 7, in the straight portion with no intersection or bridge in April, was more prone to a fatal crash without several and heavy vehicle involvement than the other groups. The causes and months of accident were statistically significantly associated with injury crash.

From the result of the study, recommendations include improving the pattern of recording of police officers, and strengthening mobile police patrol units.

KEY WORDS: TREND/ FACTOR RELATED/ CRASH/ MOTORWAYS/ THAILAND
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แนวโน้มและปัจจัยที่มีผลต่ออุบัติเหตุการตายทางรถยนต์ในประเทศไทยโดยใช้ฐานข้อมูลตำรวจ (**TRENDS AND FACTORS RELATED TO ROAD TRAFFIC FATAL CRASH IN THAILAND USING POLICE DATABASES)**

กิตินภา นภากร 4537210 TMTM/M

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บทคัดย่อ

งานวิจัยนี้เป็นการสำรวจหาแนวโน้มของอัตราการบาดเจ็บและอัตราการตายในประเทศไทยและปัจจัยที่มีผลต่ออุบัติเหตุการตายทางรถยนต์ที่เกิดขึ้นบนทางหลวงพิเศษระหว่างเมือง(มอเตอร์เวย์)

งานวิจัยนี้ใช้ข้อมูลทุติยภูมิจากศูนย์ข้อมูลข้อสนเทศ สำนักงานตำรวจแห่งชาติ ๖ปี (๒๕๓๙–๒๕๔๕)อธิบายแนวโน้มของจำนวนคนตายและบาดเจ็บต่อรถจดทะเบียนหนึ่งหมื่นคันรวมถึงแนวโน้มของปัจจัยอื่นๆที่มีผลต่ออุบัติเหตุทางรถยนต์ และใช้ข้อมูลอุบัติเหตุบนมอเตอร์เวย์ในปี๒๕๔๕และ๒๕๔๗ในการวิเคราะห์สัดส่วนของแต่ละปัจจัยที่มีผลต่อการชนที่ทำให้เกิดการบาดเจ็บหรือตายรวมถึงปัจจัยที่มีผลกับการบาดเจ็บหรือตายจากอุบัติเหตุ

ผลการศึกษาพบว่าอัตราการบาดเจ็บและอัตราการตายในประเทศไทยลดลงในช่วงเศรษฐกิจตกต่ำ(๒๕๓๘–๒๕๔๓) และเพิ่มขึ้นในช่วงเศรษฐกิจฟื้นตัว(๒๕๔๓–๒๕๔๕) สำหรับปัจจัยอื่นๆพบว่าในเพศชายมีความเสี่ยงสูงกว่าเพศหญิงและมีแนวโน้มของอัตราการตายการบาดเจ็บสาหัสและการบาดเจ็บเล็กน้อยลดลง การขับรถเร็วเกินอัตรายังคงเป็นสาเหตุหลักของการเกิดอุบัติเหตุแต่มีแนวโน้มลดลงเล็กน้อย สาเหตุรองลงมาเป็นการขับรถขณะมึนเมาและมีแนวโน้มเพิ่มขึ้น สาเหตุการขับรถขณะหลับในซึ่งไม่พบแนวโน้มว่ามีการเปลี่ยนแปลง มอเตอร์ไซด์เป็นสาเหตุหลักของการเกิดอุบัติเหตุและมีแนวโน้มเพิ่มขึ้นเล็กน้อย การเกิดอุบัติเหตุจากรถยนต์และรถบรรทุกมีแนวโน้มลดลงเล็กน้อย บริเวณที่เกิดอุบัติเหตุที่ทำให้การบาดเจ็บหรือตายสูงบนมอเตอร์เวย์ส่วนใหญ่คือจุดที่มีการปรับปรุงผิวถนน บริเวณด่านเก็บเงิน บริเวณทางร่วมทางแยกและบริเวณทางต่างระดับ สำหรับปัจจัยที่มีผลต่อการชนที่ทำให้เกิดการบาดเจ็บหรือตายนั้นพบว่าคนที่ขับรถความเร็วสูงในช่วงทางตรงที่ไม่มีสะพานหรือทางแยกระหว่างเที่ยงคืนถึง๗.๕๙นาฬิกาในเดือนเมษายนบนมอเตอร์เวย์สาย๗มีแนวโน้มจะเกิดมากกว่ากลุ่มอื่นโดยที่ไม่มีรถขนาดใหญ่และจำนวนหลายคันมาเกี่ยวข้อง และพบว่ารูปแบบการบันทึกข้อมูลของตำรวจและการสนับสนุนต่อตำรวจสายตรวจควรมีการปรับปรุง

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CHAPTER I
INTRODUCTION

1.1 Background and rationale of the study

Infectious disease has traditionally been the leading cause of death and disability in developing nations. In industrialized nations this pattern has changed significantly over the past century with a decrease in infectious diseases and an increase in chronic diseases and injuries. Currently, injuries is the leading cause of years of potential life lost (a measure of premature mortality) in most industrialized nations (Baker *et al*., 1992; Murray *et al*., 1990).

The Global Burden of Disease Study 2000 ranked road traffic injuries as the ninth leading cause of death and eighth leading cause of disability-adjusted life years (DALYs) lost globally (Murray *et al*., 2001). Compared to 1998 data, road traffic injuries moved up from tenth and ninth positions as leading cause of death and DALYs lost, respectively, and are projected to become the third leading cause of DALYs lost worldwide by 2020 if current trends continue (Krug, 1999; Murray *et al*., 1996). All regions of the world are affected by the epidemic of road traffic injuries. However, global estimates of number of people killed each year in road traffic crashes vary widely from 750,000-880,000 deaths according to Transport Research Laboratory (Jacobs *et al*., 2000) to 1.17 million by the World Health Organization and 10 to 15 million people injured or crippled every year, with 75% of the total deaths occurring in the developing countries (Krug, 1999; Global Road Safety Partnership, 1999).

Road traffics injuries have substantial impacts on both household income and the national economy. The costs of prolong medical care, or funeral costs, coupled with loss of income due to disability or loss of a family bread winner can push an affected household into poverty in many low- and middle-income countries. At a national level the burden on health budget and economy is high. The direct costs due to road crashes are estimated at 1-2% of the GNP (Gross National Product) annually in low- and middle- income countries (Jacobs *et al*., 2000).

In Thailand, a growing trend is observed as the country becomes more and more motorized. During the decade 1987-2003, there was a over five-fold increase in the number of registered motor vehicles from 4.9 million to 26.4 million (Department of Land Transport, 2004).

Transport system has been and continues to be a key element in the economic development of a country. In Thailand the current trend in population growth industrialization and urbanization are putting more pressure on transport network in general, and on roads in particular. As a result there are about 13,000 deaths and several hundred thousand injuries in road traffic accidents every year. Road traffic accidents are second most fatal non-infectious cause of death and disability within Thai population. Road traffic accidents account for 35% of the total accidents. The economic losses faced by Thailand every year due to the road traffic accident are over 100 billion bahts, that undoubtedly inhibits the socioeconomic growth of the country. Moreover the country is loosing productive year of life in these road traffic mishaps (Pattanothai, 2001).

Minister of Transport and Communications assigns Department of Highways to upgrade 11 main highways, which lead travelers to each part of Thailand, to be motorways in order to reduce travelling time especially in long-weekend festivals. Now it is during study in detail about project processing (Daily Manager Post, 2004). Motorway is one of the six categories of the roads in Thailand according to the Highway act, which have higher standard of design, particularly with respect to access to the carriage way and control of roadside activity and development (Suriyawongpaisal *et al*., 2003). These motorways make road travel convenient and quick, reducing the driving time but continuity, monotonous and high speed condition (Horne *et al*., 1995). Nowadays motorways consist of two routes, route 7 and 9. In the year 2002, average traffic flow was between 10.6 and 18 million vehicles per year or between 881 and 1500 thousand vehicles per month that meant average daily traffic (ADT) was between 28,965 and 49,309 vehicles. The hourly traffic flow was between 1,207 and 2,055 vehicles and 9-13% of which are trucks, respectively. In 2002, the number of people killed in road traffic crashes in Thailand using police reports was 13,116 compared to 29 persons (0.2 percent) killed in crashes on motorways. The fatal-nonfatal crash ratio on motorways for 2002 was 1 to 2.6. In 29th September 2005,

There will be new airport opening, Suvarnabhumi Airport, which covers an area of 8,000 acres. The new international airport is located about 15 km of on the east-bound Bangna-Trat Highway in Bang Phli District, Samut Prakarn Province and is about 25 km. from downtown Bangkok (Suvarnabhumi airport, 2004). It is accessible via five routes which includes motorway route 7 and 9. Both routes, which convey passengers to the airport, are renovating or increasing number of lanes in order to support transportation effectively. On motorways, the highest possible speed of vehicles should be limited to the highest speed limit. It is the important to make motorway users realize about their behavior in these driving conditions, in which average speed measured are high and distances between vehicles often surprisingly small (Aron *et al.*, 1999). So a reduction in the crash severity on motorways is a worthy and interesting in the study.

Information needed to study the impact of traffic injuries and trends is derived from two general sources of routinely collected data. Health staffs and police complete the records and reports that are the basis of the two data sources.

The first source includes data on mortality, morbidity, and disability derived from records of health professionals, including death certificates and coroners' reports for fatalities, and hospital discharges for severe nonfatal injuries. Other potential sources are special questions about injuries included in community health interview surveys.

The second general source of data on traffic injuries includes crash reports prepared by police. Individual crash data is used to identify hazardous environments. The police also has an important and often difficult role in the enforcement of regulations (Brass *et al.*, 1998).

The Thailand authorities have made concerted effort to introduce policies and programs to reduce the high rates of road traffic deaths and injuries in the country. The actions undertaken include upgrading of road networks, introduction of mass media, the crackdown on drunk driving and speed control. This is further exacerbated by the variable standards of road safety education across different subpopulations and unsafe roadside environments that expose road users to greater risks of injury and fatality (Bernard *et al.*, 2003). The mortality trend of road traffic is rapidly increasing- 21.2(1993), 22.8(1994), 24.4(1995), and 27.2(1996) per 100,000 (Medical Division of Public Health Ministry , 1999). Researcher from Chulalongkorn University estimated

the economic loss from road traffic accidents as around 40,000 million Baths in 1996(Tosutho R., 1998).

Two accident databases from Police Information System center and motorways in the form of linear record file system, which could give fundamental information about accident location and factors associated accident, enables an extensive amount of research to be undertaken using statistical methods. But both databases as well as the analyzed information lacked visibility, which is essential for better understanding and good decision-making. Several techniques for identification of accident locations have been established (Hauer, 1996), but Geographic Information System (GIS) has only been applied to display such locations (Chin *et al.*, 2001) and to analyze problematic cases (Miller, 2000). The technical focus is on GIS representation for better visualization. The GIS operating system employed for this purpose is MapInfo.

Fatal crashes in motor vehicle traffic accident are determined by a number of factors, including district, human, vehicle, safety, environmental and site factors (Yau, 2004). The type of road, as well as light and weather condition play an important role when analysing aspects of accident severity (Hijar *et al.*, 2000). Other factors such as the time of the day was identified as further significant factors influencing the severity of a traffic accident (Massie *et al.*, 1995; Hijar *et al.*, 2000; Valent *et al.*, 2002). The incidence of road traffic accidents also varies with such environmental factors as time of the day, day of the week and type of road design (Wongsuwan *et al.*, 1991).

Numerous factors may contribute to the 24-hour pattern of automobile accidents. One factor may be a time of day variation in driving ability (Lenne' *et al.*, 1997). Level of performance and psychological measures, such as subjective mood, have been found to exhibit reliable variations across the day (Colquhoun, 1981; Folkard, 1983). It has yet to be established whether driving performance also varies across the day (Lenne' *et al.*, 1997).

This study, therefore, attempts to identify the trends of injuries and deaths per 10,000 vehicles among the provinces of Thailand using time series data from the Royal Thai Police and to identify accident prone areas on the motorways in digital map. The study is also aimed to determine relating factors affecting fatal crashes on motorways and to analyze day of week and time of accidents involving casualties on motorways.

1.2 Research question

1.What are the trends over time of rate of death and injury among the provinces of Thailand going on ?

2.What is the concentration of the crash involving casualties on motorways?

3.What factors are affecting fatal crash on motorways?

1.3 Research objectives

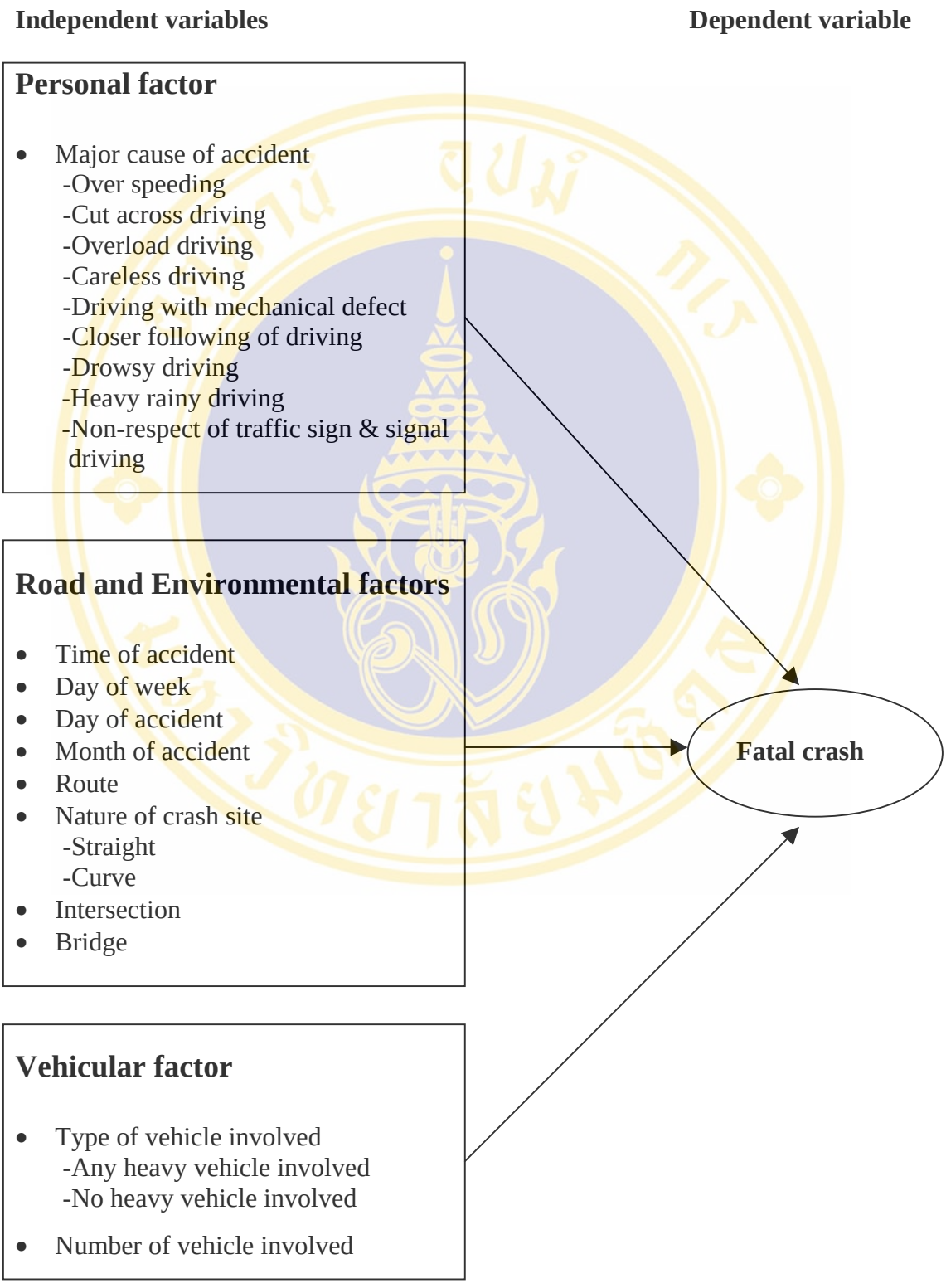
1.3.1 General objectives

1. To study trends of injury rate and death rate in Thailand during the period 1995 to 2002.
2. To develop map of road traffic accidents on motorways by using Geographic Information System.
3. To identify the factors that contribute to road traffic fatal crashes at those spots.

1.3.2 Specific objectives

1. To identify trends of injury rate and death rate among the provinces of Thailand during the period 1995 to 2002 by developing maps.
2. To develop map of accident-prone areas on motorways during the year 2002.
3. To investigate the distribution of accidents involving casualties on motorways during the year 2002 at different times of the day.
4. To compare number of accidents involving casualties per day occurring on weekdays and weekends on motorways during the year 2002.
5. To identify factors associated fatal crashes on motorways during the year 2002.

1.4 Conceptual framework



CHAPTER II
LITERATURE REVIEW

2.1 Definition of Accidents

World Health Organization defines accidents as “an unpremeditated event resulting in recognizable injury, or any event interrupting the normal work process caused by one or more unsafe acts (human failure) or unsafe condition (physical failure) or both that may or may not result in personal injury, property damage or both but has the potential to do so“(Cortina III, 1992).

The National safety council has defined that ” An accident is the occurrence in the sequences of events usually producing unintended injury, death, or property damage.” By this definition we can see that there are multiple causes that lead to accidents, which produce injury, disability, death, and property damage.

In addition, road traffic accident has been defined as “ any vehicular accident occurring on the public highway or street”. An accident is “any collision with an object (fixed, movable, or moving)”. In the absence of a collision, an accident may also be caused by overturning due to loss of control on a highway, street or roadway (WHO, 1992).

2.2 Type of Accidents

The International Statistics Classification of Disease and Related Health problems Tenth Revision (ICD 10) divided accidents into two main groups:

1. Transportation accidents -means that an event of a causal communication or transportation such as land accidents, marine accidents, airline accidents, and other includes unknown events.

2. Other external causes of accident injury.

Punyahotra (1986) and Piyasilpa (1984) classified accidents into the following groups:

1. Home or domestic accidents- is an event which occurs indoor or outdoor such as electric shock, scald, skid in the bathroom, miss the ladder, cut wound.
2. Occupational accidents- means that the event was caused or related to working or occupation such as building construction, the industrial work, so on.
3. Public accidents- means that the causes of the event occur in public areas such as in school, theater, which includes fire.
4. Natural disaster- such as flood, wildfire, earthquake, volcanic eruption.
5. Transportation accidents or traffic accidents – means that the events were caused by traffic or transportation such as land, marine, railway and airline accidents.

2.3 Brief history of vehicular accidents

Road traffic accidents are notorious for it fatality, they lead to disability, death, and damage to the economics of the country. Majority of the young people is involved in the accidents; hence there is great loss of youth in these road mishaps. Epidemics of different diseases are due to the external factors, but the man cause accidents himself. Two deaths were firstly registered in Crystal Palace, London, United Kingdom in August 17, 1896 due to the motor vehicle accident. One was registered in the United States in 1899; from there onwards the terrible stream of death, injuries, and disabilities has followed. In 1959 the U.S recorded its 1,000,000th deaths due to the road traffic accidents; similar condition was seen in the other motorized countries around the western world. Road traffic accidents have been used as indicators in evaluating success of accidents prevention program such as mass effort to promote use of helmet in motorcycle and seat belt in car (WHO, 1962).

2.4 Effects of Traffic Accidents

According to Punyahotra (1988), usually composed of the following:

1. Human loss – means that fatal and injured victims.
2. Psychological and social loss – is intangible loss, depends on victims' personality and sentiment. These loss such as pain, regret, mind suffer, fear,

become insane, mental derangement, out of social life and lonely, cannot work or survive.

3. Economic loss – estimated to be several thousand million baths each year due to accidents. Accident caused waste of time, law-suit, and loss of work, loss of income and traffic jam.

2.5 Global situation due to road traffic accidents

With the development of merged economies, advanced communication, and expanding travel access, we are moving from local, regional, and even national to global perspectives on many issues, including some regarding public health, Problems such as infection diseases and pollution have been recognized as worldwide health issues since longtime, but injuries and disabilities due to road traffic accidents still seen by most as a local issue, the result of a random event, not amenable to an organized approach to prevent and treatment. Everyone recognizes the death and disability from injury, but few equate this with a global health concern (Anthony AM, 1998).

Road traffic accidents are a worldwide problem, are result in over 1 million people killed and 10-15 million people injured or disabled on roads every year. About 75% of these accidents occur in developing countries, although they have only 32% of all the motor vehicle. In Asia pacific region alone, it is estimated that over 400,000 people are killed annually by road traffic accident and several million injured. Without effective action, the annual death toll is expected to exceed half a million within this decade. Furthermore, the victims of the accidents are the young people of the society, and there is a great loss of economically active segment of the country. Worldwide economic loss are estimated at more than 30 billion US$, and this huge money can be effectively used in the development of the poor countries. This undoubtedly inhibits the economic and social development of the region. Many Asian countries have experienced annual vehicle growth rates up to 16%, which means doubling of the vehicles fleets in five years and trebling in eight years. This explosive growth of vehicle ownership has combined with relatively young age driving population and wide mix of vehicle types create a significant worsening of road safety problem in the region.

Child victims – Over 163,000 children are killed and 1.5 million injured or disabled under the age of 15 worldwide.

Global annual cost – Global annual cost regarding accidents is very high, it was calculated that over 500 billion US$ are spent every year on traffic accidents.

Death and injuries in 1999 – it is reported that there were 750,000-880,000 worldwide deaths and 23-34 million people injured (MOTC, 2000).

2.6 Economic loss to developing world

In developing countries, road traffic accidents are also responsible for the loss of scarce financial resources that these countries can ill-afford. An analysis carried out by TRL showed that the road accidents cost were the equivalent in any country (developed or developing) to approximately 1 percent of its annual gross national product. In current prices, this suggest road accidents in Indonesia costing about 600 million pounds per year, 250 million pounds in Pakistan, 220 million pounds in Egypt, and 60 million pounds in Kenya. Accident characteristics are common in developing countries, and somewhat different from the developed countries. In developing countries, relatively high proportions of fatalities are pedestrians and children fewer than 16 years of age and majority of fatal accidents involves motorcycles. Developing countries are spending more than double the amount of assistance they are getting from the funding agencies of the world like IMF, WORLD BANK (United Nations,1977).

Research from John Hopkins University have studied about the economic losses due to accidents is as the surface of an iceberg. Direct loss, the obvious or manifested loss, is only 6% of the actual loss, and the part under water is the indirect loss is no less than 94%.

2.7 Situation of Road Traffic Accidents in Thailand

During the last decade, Thailand has under gone a period of transformation in which substantial economic and technological development has occurred. Transportation technology has given rapid rise to the number of motor vehicles, roadways and highways, which is of fundamental importance to the country's sustained development. Motor vehicles have played a crucial part in this

transformation, bringing both advantages as well as disaster to Thai daily life. According to health statistics division (1966:66) road accidents are second most fatal, noninfectious cause of death within the population. As the number of accidents continues on upward spiral (Hulthaitum, 1995) and it's claimed that at least 50 lives a day and several research studies have shown that most of the accidents were due to careless and undisciplined drivers. The study conducted by transport and communication ministry revealed that Thailand has the highest fatality rate from road traffic accidents as compared to its South East Asian neighbors. The numbers of accident cases are rising by an average of 32.7% each year (Wongsathien, 1998).

Road accidents are an issue of immense human properties in Thailand. Every year about 13,000 persons are killed in road accidents and several hundred thousands injured or crippled for the rest of their lives (Pattanothai, 2001). The incidence of road traffic accidents rises during weekend and holidays. Keeping in view the previous bitter experience different organizations planned preventive measures during this New Year holidays to reduce the number of casualties due to road traffic accidents, but all efforts failed and reported number of accident were very high as compared to the previous year. Thai Government has made concerted efforts to introduce policies and programs to reduce the high rates of road traffic injuries. The actions undertaken include upgrading of road networks, introduction of a mass transport system, road safety campaigns through mass media, a crackdown on speed control. There has been a commencement of the law enforcement against drinking and driving since the year 2000.The Government launched this national campaign to reduce number of deaths and injuries throughout this country. A review of the action plan for enforcing the law revealed many of the plan's shortcomings. Its goals were not measurable. There was not any indicator for monitoring and evaluation. Actions were roughly described that allowed for too much personal interpretation (Suriyawongpaisal *et al.*, 2003).

According to the data provided by the Narenthorn Center MOPH, about 20,000 accidents were reported throughout the country within a week of NEW YEAR celebrations, from 27th of December 2001 to 2nd January 2002. Death rate due to these accidents also increased from 3 persons/hour in 2001 to 3.7 persons/hour in 2002. About 500 people died in these road mishaps (MOPH, 2002). Studies regarding motor vehicle accident death rate are generally higher in areas of low population density,

especially in the rural areas due to wide-open roads and less traffic flow. The total number of accidents in Bangkok is higher than rest of the country, but average deaths in Bangkok is less than other provinces, because Bangkok has large number of vehicles and there is low traffic flow. So most of the time accidents are not of serious nature but there is loss of property is higher (Santikan, 1994).

Table 1. Situation of road traffic accident in Thailand, 1990-1999.

Year	Accident cases	Person damage		Property damage (mill-bahts)
		Fatalities	Injuries	
1990	40,481	5,765	18,252	259.80
1991	43,966	6,319	19,458	344.10
1992	61,329	8,184	20,702	607.80
1993	84,892	9496	25,330	1,021.50
1994	102,610	15,176	43,541	1,408.20
1995	94,362	16,727	50,718	1,631.12
1996	88,556	14,405	50,044	1,561.71
1997	82,336	13,836	48,711	1,571.79
1998	73,725	12,234	52,538	1,378.67
1999	67,800	12,040	47,770	1,345.984

Source: Information system center, The Royal Thai Police.

From the above table 1, it is quite clear that in 1990 the number of accidents were less as compared to the following years. 1995 is the year of maximum accident cases with fatality, injuries, and property damaged (Pattanothai, 2001). It is evident from the table that as during these mentioned years, Thailand has shown great development in the industrial field and due to that reason the transport system also expanded. According to the recent study by Harvard University for WHO stated that if this trend continues, by the year 2020 Ministries of health in developing countries will spend 25% of their annual budget on treatment of causalities alone. Due to tremendous increase in the number of accidents in the recent times, as compared to the other causes of infectious and parasitic origin with the wide spread development and industrialization preventive measures should be taken to overcome this great issue of human concern. Which is causing great loss to the country in term of socioeconomic

and productive resources of the country. This also increases the cost of medical and surgical treatment, which tends to increase the technical and sophisticated equipment need for the injured and disable person (Santikan, 1994). It was estimated that indirect costs of road traffic accidents in 1995 amounted to nearly 15,000,000,000 bahts (U.S.$600,000,000) when combined with direct losses (costs of health services and damage to property), the economic loss due to road traffic crashes amounted to around 40,000,000,000 bahts (U.S.$1,600,000,000) in 1995.This figure was equivalent to 23% of total health expenditure or 0.9% of Thailand's Gross Domestic Products in the same year (Tosutho R., 1998).

2.8 Road Network in Thailand

The roads in Thailand are classified into six categories according to the Highway act: (1) special highways or motorways, which have higher standards of design, particularly with respect to access to the carriage way and control of roadside activity and development, (2) national highways linking the regions, districts and important places, (3) rural road, (4) municipal roads, (5) sanity roads and (6) concession highways. Municipal roads are constructed and maintained by local authorities and concession highways are constructed and maintained by private agencies under a concession granted by the government (Suriyawongpaisal *et al*., 2003).

As of 2004, there are 2 routes of motorways in Thailand as follows.

1. Highway Route 7 between Bangkok - Chonburi starts from Sri Nakarindra road to meet the Chonburi - Pattaya Highway (Sai Mai) with 82 km. in distance. The highway is 4 standard lanes with 8 interchanges. The construction cost was 12,750 million bahts, mutually funded by the budget from the Department of Highways and the loan from Japan's Overseas Economic Cooperation Fund (OECF). Since the highway was constructed on the soft soil ground, the ground condition required improvement by the Prefabricated Vertical Drain (PVD) and ground surcharge to increase to the highest subsidence during construction period. The highway has been operated since February 4, 1998. There are 2 Toll Gates which locate at Lat Krabang km. 25 + 900 and Pan Tong km. 67 + 200. Each Toll Gate consists of 7 toll booths on inbound and outbound.

2. Highway Route 9 East Outer Ring along Bang Pa In - Lam Looka - Ram Indra - Bang Phli with 64 km. in distance. The highway is 4 standard lanes with 8 interchanges. The construction cost was 12,000 million bahts, mutually funded by the budget from the Department of Highways and the loan from Japan's Overseas Economic Cooperation Fund(OECF). Since the Highway was also constructed on the soft soil ground, an improvement of the ground condition was done by the Prefabricated Vertical Drain method and ground surcharge to increase to the highest subsidence during construction period. The highway has been operated since January 16, 1999. There are 2 Toll Gates which locate at Tanyaburi km. 25 + 000 and Tap Chang km. 51 + 325. Each Toll Gate consists of 7 toll booths on inbound and outbound (Intercity Motorways Office, 2004).

2.9 Epidemiology of Traffic injury (triad of traffic accident)

In epidemiology the disease is caused by the interplay among the host, agent, and environment. If this could apply to the traffic accident, then it is also caused by the interplay among the road user as host, road as environment, and the vehicle as agent.

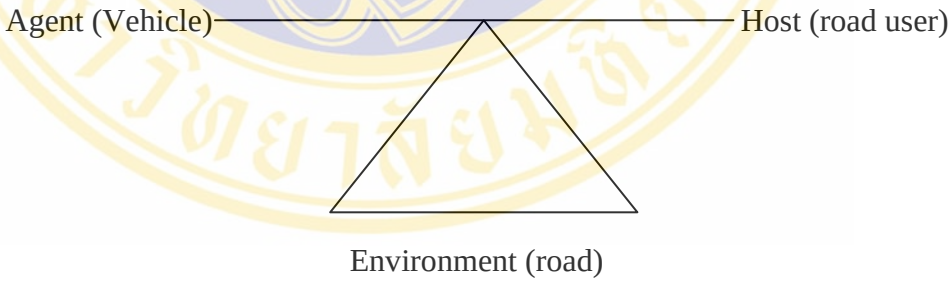


Figure 1. Triad of traffic accident

The above figure is to show the equilibrium or balance between the epidemiological factors, such as agent, host, and environment. If the balance is maintained there will be very less chance of accident to take place. So it is clear that accident takes place only when the balance is distorted by any of the above factors (Janjua, 2002).

2.10 The factors contributing to road traffic accidents

2.10.1 Personal factor

2.10.1.1 Gender

Gender is an important factor related to trauma mortality. The incidence of mortality and morbidity from trauma are almost three times higher than in males than in females. This is probably due to the women's lower rate of involvement in injury-prone activities, greater caution, and less alcohol consumption or other substance Abuse (Fife D, *et al.*, 1984). In 2002, males accounted for 73% of all road traffic deaths, with an over all rate almost three times that for females: 27.6 per 100,000 population and 10.4 per 100,000 population, respectively. Road traffic mortality rates are higher in men than in women in all regions regardless of income level, and also across all age groups. On average, males in the low-income and middle-income countries of the WHO Africa Region and the WHO Eastern Mediterranean Region have the highest road traffic injury mortality rate worldwide. The gender difference in mortality rates is probably related to both exposure and risk-taking behaviour.

Table 2 shows the burden of road traffic injuries in term of Disability-adjusted life years (DALYs) by sex. Morbidity rates for males are considerably higher than those for females. Furthermore, about 60% of the DALYs lost globally as a result of road traffic occurs among adults age between 15 and 44 years (Peden M. *et al.*, 2002).

Table 2

Road traffic injury burden (DALYs lost) by WHO region and sex, 2002

WHO region	Males	Females	Total
All	27,057,385	11,368,958	38,426,342
African Region	4,665,446	2,392,812	7,058,257
Region of Americans	3,109,183	1,141,861	4,251,044
South-East Asia Region	7,174,901	2,856,994	10,031,894
European Region	2,672,506	973,945	3,610,451
East Mediterranean Region	3,173,548	1,403,037	4,576,585
Western Pacific Region	6,621,800	2,636,309	8,898,110

Source: WHO Global Burden of Disease project, 2002, Version 1.

As expected, When analyzed by country, road traffic injury mortality rates are again substantially higher among males than among females. El Salvador's road traffic fatality rate for males, for instance, is 58.1 per 100,000, compare with 13.6 per

100,000 for female. In Latvia, there is a similar gender difference, with a rate of 42.7 per 100,000 for men and 11.4 peer 100,000 for females. Certain factors in some countries give rise to an even greater gap between the genders; females may excluded as drivers or passengers, and in general may face less exposure to road traffic crash risk for cultural or economic reasons.

A comprehensive review of 46 studies in low-income and middle-income countries found that, in terms of involvement in road traffic crashes, there was a consistent predominance of males over females; males were involved in a mean of 80% of crashes, and 87% of drivers were male (Odero W. *et al.*, 1997). Recent studies from China, Colombia, Ghana, Kenya, Mexico, Mozambique, the Republic of Korea, Thailand, Trinidad and Tobago, Vietnam and Zambia all indicate greater rates of male as opposed to female involvement in road traffic collisions (Nantulya VM *et al.*, 2003).

In Udine, Italy. Valent *et al*. conducted an analysis cross-sectional study from 10,320 accidents during the year 1991-1996 to identify the major factors associated with road traffic fatalities. They reported that in logistic regression model, women were less frequently involved in fatal accidents than men. When adjustment for other factors was allowed, the OR(odds ratio) increased with age (Valent *et al.*, 2002).

Rodriquez *et al*. reported in a cross-sectional study in Columbia that up to 231,974 road traffic crashes were reported for the year 2000, men accounted for 79.9% of the deaths and 67.2% of the traffic related injuries. This approximate ratio of 4 men to every 1 woman killed changes in relation to age. In all age groups, more men die and are injured than woman, but the greatest difference is witnessed among people aged 25-34 years. Men in this age group were 6 times more likely to die from road traffic injuries than women (Rodriquez *et al*., 2003).

Data on injuries in the year 1995 from the Ministry of Public Health, Thailand showed that men were at four to five times the risk of death and injury from road crashes than women (Ministry of Public Health, 2000).

Wong et al. reported in the retrospective study about road traffic accident mortality in Singapore in the year 1995. A total of 226 deaths occurred, 82.3% victims were men and 17.7% were women (Wong *et al.*, 2002).

2.10.1.2 Major cause of accident

According to the Health Statistic Division, 90% of all road traffic accidents are attributable to poor driving behaviors (Sangprasert, 2000).

Overspeed driving

The speed of motor vehicles is at the core of the road injury problem. Speed influences both crash risk and crash consequence. “Excess speed” is defined as a vehicle exceeding the relevant speed limit; “inappropriate speed” refers to a vehicle travelling at a speed unsuitable for the prevailing road and traffic conditions. While speed limits only declare higher speeds to be illegal it remains for each driver and rider to decide the appropriate speed within the limit (WHO, 2004). The driver must be held at least morally if not always legally responsible.

Table 3

Examples of factors affecting drivers’ choice of speed

Road and vehicle related	Traffic and environment related	Driver related
Road	Traffic	Age
Width	Density	Sex
Gradient	Composition	Reaction time
Alignment	Prevailing speed	Attitudes
Surroundings	Environment	Thrill-seeking
Layout	Weather	Risk acceptance
Markings	Surface condition	Hazard perception
Surface quality	Natural light	Alcohol level
Vehicle	Road lighting	Ownership of vehicle
Type	Signs	Circumstances of
Power/weight ratio	Speed limit	journey
Maximum speed	Enforcement	Occupancy of vehicle
Comfort		

Source: Allsop RE ed. European Transport Safety Council, 1995.

The speed drivers choose to travel at is influenced by many factors as shown in table 3. Modern cars have high rates of acceleration and can easily reach very high speeds in short distances. The physical layout of the road and its surroundings can both encourage and discourage speed. Crash risk increases as speed increases,

especially at road junctions and while overtaking – as road users underestimate the speed, and overestimate the distance, of an approaching vehicle.

Munden reported that in a variation in speeds between different vehicles travelling at different speeds within the traffic stream is also associated with crash occurrence (Munden, 1967).

Empirical evidence from speed studies in various countries has shown that an increase of 1 km/h in mean traffic speed typically results in a 3% increase in the incidence of injury crashes (or an increase of 4-5% for fatal crashes), and a decrease of 1km/h in mean traffic speed will result in a 3% decrease in the incidence of injury crashes (or a decrease of 4-5% for fatal crashes) (Finch DJ *et al*., 1994).

A meta-analysis of 36 studies on speed limit changes showed, at levels above 50 km/h, a decrease of 2% in the number of crashes for every 1 km/h reduction in the average speed (Elvik *et al.*, 1997).

Mao *et al.* reported in a case-control study during the year 1988 and 1993 about factors affecting the severity of motor vehicle traffic crash involving young drivers between the age of 16 and 20 in Ontario, Canada that there were 83,041 cases studied about cause of accident, crash on roads with higher speed limits(that is >=70 km/hour)were 2.4 times as likely to involve exceeding of speed limits as those on roads with lower speed limits and vehicles going straight ahead or overtaking another vehicle were more likely to be fatal than those where vehicles were slowing down. Making turn (right, left, U) and changing lanes were not statistically associated with increased risk of fatality (Mao *et al.*, 1997).

Qayed reported his findings in retrospective study about epidemiology of road traffic accidents in Saudi Arabia during June 1994 and July 1995 that a total of 6,117 accidents occurred, major causes of accident are overspeeding, disobeying the traffic signals and other vehicle proceeding incorrectly respectively (Qayed, 1998).

Taylor *et al.* concluded in the year 2000 and 2002 on different types of roads in the United Kingdom that for every 1 mile/h (1.6 km/h) reduction in average traffic speed, the highest reduction achievable in the volume of crashes was 6% (in the case of urban roads with low average speeds). These are typically busy main roads in towns with high levels of pedestrian activity, wide variations in speeds and high frequencies of crashes (Taylor *et al.*, 2000; 2002).

Speed has an exponentially detrimental effect on safety. As speeds increase, so do the number and severity of injuries (WHO, 2004).

For car occupants, the severity of crash injury depends on the change of speed during the impact, usually denoted as Δv. As Δv increases from about 20 km/h to 100 km/h, the probability of fatal injuries increases from close to zero to almost 100% (Mackay *et al*., 2000).

The probability of serious injury for belted front-seat occupants is three times as great at 30 miles/h (48 km/h) and four times as great at 40 miles/h (64 km/h), compared with the risk at 20 miles/h (32km/h) (Hobbs *et al*., 1984).

For car occupants in a crash with an impact speed of 50 miles/h (80 km/h), the likelihood of death is 20 times what it would have been at an impact speed of 20 miles/h (32 km/h) (IIHS Facts, 1987).

Pedestrians have a 90% chance of surviving car crashes at 30 km/h or below, but less than a 50% chance of surviving impact at 45 km/h or above (Pasanen, 1991; Ashton *et al*., 1983).

The probability of a pedestrian being killed rises by a factor of eight as the impact speed of the car increases from 30 km/h to 50 km/h (Ashton *et al*., 1979).

Excess and inappropriate speed contributes to around 30% of fatal crashes in high-income countries (European Road Safety, 2003).

In China, 1999, speed was the main reported cause of road traffic crashes (Wang *et al.,* 2003). Errors-such as loss of control of vehicle, speeding, misjudgement and improper overtaking- contributed to 44% of all police-reported crashes in Kenya (Odero *et al.,* 2003). Speed was identified as the main contributory factor in 50% of road crashes in Ghana between 1998 and 2000 (Afukaar, 2003).

Speed has also been identified as an important factor in crashes involving commercial road transport and public passenger vehicles (Odero *et al.,* 2003; Ministry of Transport, 2001). In South Africa, for instance, 50% of such crashes are related to speed (Ministry of Transport, 2001). While in many high-income countries, there is increasing use of in-built mechanisms in trucks and buses to restrict speeds above a certain limit, such devices are frequently resisted in low-income and middle-income countries for commercial reasons, or else, if installed, are disabled by the operators. Commercial operations are often based on timetables that put pressure on drivers to

speeds. In many low-income and middle-income countries, the pay of bus drivers is related to ticket receipts, which encourages high speeds (Nafukho *et al.*, 2002).

Everywhere, speed limits are wildly flouted (Allsop, 1995). At high speeds, environmental damage from exhaust emissions and traffic noise are greater at higher than at moderate speeds.

Drunk driving

Single most important human factor related to causation of traffic accident is consumption of alcohol before riding motorcycle. Alcohol consumption with acute intoxication produces dose-related impairment of motor functions, co-ordination reflex responses, resulting in tracking of performances, judgement, and consciousness, as well as divided attention. With the suppression of high cortical functions, there is an exaggeration of mood and related behavior that may be manifested by conviviality, depression, or aggression.

The blood alcohol level (in milligram percent) and the corresponding physical reaction are as follows:30mg%(mood elevator), 50mg%(impair movement and co-ordination, 100mg%(intoxication, loss of co-ordination), 200mg%(confusion state), 300mg%(drowsiness and stuporous), 400mg%(loss of consciousness)

A case-control study carried out in Michigan, United States, in 1964, known as the Grand Rapids study showed that drivers who had consumed alcohol had a higher risk of involvement in crashes than those with a zero blood alcohol concentration (BAC) and that this risk increased rapidly with BAC. These results provided the basis for the future setting of legal blood alcohol limits breath content limits in many countries around the world, typically at 80mg% (Borkenstein *et al*., 1964).

A conference on 4-7 November 1975 in Vienna, note that there was now widespread acceptance of the role of alcohol in increasing the risk of injuries resulted from road traffic accidents (WHO, 1976). Excessive consumption of alcohol, e.g. liquor, beer, wine, or whisky can lead to alcoholism, psychosis, paralysis and accident. Drunk driving is believed to be human behavioral risk factor in traffic-related injury and injury severity and death. Pre accident alcohol use not only by the motor vehicle driver but also by involved pedestrian or cyclist is an important risk factor in motor vehicle accident.

In 1981, an Australian study found that the risk of crash involvement was 1.83 times greater at a BAC of 50mg% than at a BAC of zero (McLean and Holubowycz., 1981). Re-analysis of the Grand Rapids data by Hurst et al. also concluded that the risks associated with lower BAC levels were greater than originally thought. This information, together with findings from behavioural and experimental studies, provided a justification for many countries to reduce their legal BAC limits to 50mg%(Hurst *et al.,* 1994; Moskowitz H *et al.*, 2000).

A major case-control study- using more robust research design and multivariate analytic techniques than the Grand Rapid study- has recently taken place to determine at what level of BAC an elevated crash risk begins. This study, involving 14,985 drivers, was conducted in the United States at Long Beach, California and Fort Lauderdale, Florida. The overall result was in agreement with previous studies showing increasing relative risk as levels of BAC increased. The study found that the relative risk of crash involvement starts to increase significantly at BAC level of 40mg% (Compton RP *et al.,* 2002).

An Australian study of alcohol and motorcycle crashes found that having a BAC level greater than zero was associated with five times the risk relative to a zero BAC (Haworth NL, 2000)

Alcohol consumption before motorcyclist riding in Thailand is higher than in Singapore according to Wong et al. Where it was reported that 10% of admitted cases consumed alcohol before riding (Wong et al., 1990). Bohning D et al. reported in a case-control study comparing traffic injury victims in selected Bangkok hospitals that those who have drank alcohol one hour before driving were three times more likely to be involved in traffic accidents than those who has not (OR= 3.01)(Bohning D *et al*., 1997). In post-crash phase, alcohol may contribute to the increase risk of injury death because it adds diagnostic and treatment problems. The surveillance data in Thailand shows that drivers who drank alcohol had 32.96% mortality rate and a risk 3 times higher compared to those who did not drink alcohol (Information of Accident and Disaster, 1999).

Kasantikul *et al.* conducted a cross-sectional study about the role of alcohol in Thailand motorcycle crashes during January 1990 to September 2000 and reported that 31.9% (345 of 1082) of the accident-involved riders had been drinking alcohol prior to

the crash and drinking riders were overwhelming male (98%). Alcohol accidents were more frequency on weekends and particularly at night (Kasantikul *et al.*, 2005).

Fatigue driving

Fatigue or sleepiness is associated with a range of factors as shown in table 4(Hartley *et al.*, 1996), including long-distance driving, sleep deprivation and the disruption of circadian rhythms.

Table 4

Factors that predispose a driver to fatigue

Drivers at risk of fatigue	Temporal factors Causing fatigue	Environmental factors in fatigue	Sleep-related factors
Young drivers (up to 25 years)	Driving between 02.00 and 05.00	Driving in remote area with featureless terrain	Driving with sleep dept
Drivers over 50 years	More than 16 hours of Wakefulness before trip	Monotonous roads	Driving with a sleep-related condition
Males	Long work period before trip	Main arterial roads	Driving with normally as sleep
Shift workers	Long time since start of trip	Long-haul driving	Drivers disposed to nodding off
Those for whom driving Is part of job	Irregular shift work before trip	Unexpected demands, breakdowns, etc.	Driving after poor -quality sleep
Those with medical conditions (such as narcolepsy)	Driving after successive nights of shift work	Extreme climatic conditions	
After consume alcohol	Driving under time pressure	Driving an unfamiliar route	
Driving after inadequate Rest and sleep	Some drivers are drowsy in the afternoon		

Source: WHO, 2004 reproduced from Hartley *et al.*, 1996,with minor editorial amendments, with the permission of the author.

Three high-risk groups have been identified (NHTSA, 1996) as

- young people, particularly males, aged 16-29 years
- shift workers whose sleep is disrupted by working at night or working long, irregular hours
- people with untreated sleep apnoea syndrome or narcolepsy.

Estimates of the proportion of car crashes attributable to driver sleepiness vary, depending on the type of study and the quality of data. A population based case-

control study in New Zealand found that factors that substantially increased the risk of a fatal crash or a crash with serious injuries were

- driving with feeling sleepy
- driving after less than five hours of sleep in the preceding 24 hours
- driving between 02.00 and 05.00

The study concluded that a reduction in all three of those behaviours could reduce the incidence of crashes involved injury by up to 19% (Connor *et al.*, 2002).

Surveys of commercial and public road transport in developing countries have revealed that transport owners, in pursuit of increased profits, frequently force their driver to drive excessive speeds, to work unduly long hours and to work when exhausted (Nafukho *et al.*, 2002; Nantulya *et al.*, 2001; Mock *et al.*, 1999).

Studies by the National Transportation Safety Board (NTSB) in the United States found that 52% of 107 single-vehicle crashes involving heavy trucks were fatigue-related and that in nearly 18% of the cases, the drivers admitted to having fallen asleep. The United States Department of Transportation's investigations into fatigue in the 1990s showed that fatigue was a factor in about 30% of fatal crashes involving heavy commercial transport (NTSB, 1990; 1995; 1999).

In Europe, studies have been less comprehensive, and have often involved retrospective accounts that were likely to underestimate the impact of fatigue. These limitations notwithstanding, research from some European countries suggests that driver fatigue is a significant factor in approximately 20% of commercial transport crashes. The results from a range of survey show that more than a half of long-haul drivers have at some time fallen asleep at the wheel (McDonald N, 2001).

Peak levels of fatigue-related crashes at night are often 10 times higher than daytime levels. Research in France on the working hours and habits of truck drivers showed that their risk of crashes related to fatigue increased when they were driving at night, the length of their working day had increased or they were working irregular hours (Hamelin P, 1987).

Tension and stress including fatigue of physical condition may be parts of causes of accidents. The long times driving particularly among traffic jam and disorderliness also effects the efficiency of perception of the sensory organs and result in inability of vehicle control. Several studies have shown that fatigue is also directly related to the

occurrence of the accident. It has been found that in 14.3% of accidents road user are very tired and could not response to the emergency situation (N.S.A.1960). Another study found that driver who drove more than 9 hours and fatigued, exhibited less responsive eye movement pattern(Wadhauakul K, 1996).

Smith *et al.* conducted analytic cross-sectional study about trends of behavioral risk factors in 4,219 motor vehicle crashes in Utah, USA, 1992-1997 by using generalized estimating equations for calculating odd ratios and 95% confidence intervals. They found that approximately 1% of crashes was distributed to driver fatigued but 10% of hospitalized or killed drivers has fatigue reported as a contributing factor in the crash. Fatigue showed a two-fold increase in the odds of hospitalization or death (Smith *et al.*, 2004).

2.10.2 Road and Environmental factors

The incidence of road traffic accidents also varies with such environmental factors as time of the day, day of the week and type of road design. Inadequacy of lighting system also predisposes to the occurrence of road accident at nighttime. A standard lighting pole should be 25 feet in length and light should make an angle of 70 degree vertical to prevent glaring effect (Wongsuwan *et al.*, 1991).

The study at Khon Kaen University, Thailand found that the most common incidence of road traffic accidents would be on Saturday and Sunday. The Usual time for accidents found in between 19.00p.m and 21.00 p.m. .The Junction was the most common place for accidents. April is the month of the maximum accidents and for the road surface condition that accidents mostly happened was asphalt (Trauma Registry 1992, Khon Kaen Regional Hospital, p.15-16).

From the cross-sectional study conducted during the year 1993 by using data from five main hospitals in Bangkok, Thailand Suksawasdi Na Ayuthaya found that accident mostly occurred in May and July and the common time of accidents occurred between 21.00-23.59 p.m.(Suksawasdi Na Ayuthaya, 1994).

Mao *et al.* also reported their findings about factors affecting the severity of motor vehicle traffic crash involving young drivers in Ontario, Canada during the year 1988 and 1993 that on the public road, crashes occurring between the hours of 20.00-

24.00 p.m. were 1.7 times as likely to be fatal crashes after controlling for all potential risk factors in the logistic model and major injury crashes were significantly more likely to occur in summer months and weekend (Mao *et al.*, 1997).

The descriptive study using data of the statistics department of both traffic and health authorities of Saudi Arabia during July 1994 and June 1995 of Qayed found that there are the highest rate of road traffic accidents on weekend and December is the month of highest distribution of accidents and about two-thirds of accidents occurred during daytime (Qayed, 1998).

Hijar *et al.* conducted a case-control study about risk factors in highway traffic accidents in Mexico during July to September, 1996 and reported that from 162 cases and 445 controls studied, accidents occurring on weekday were 1.84 times greater than weekend and during daylight hours 4.23 times greater than nightlight hours after adjusting for all potential risk factors in logistic regression model (Hijar *et al.*, 2000).

Martin JL. did an analytic cohort study about relationship between crash rate and hourly traffic flow on interurban motorways in France during 1997 and 1998 which 11,172 crashes occurred. By using logistic regression method, It was found that no difference between the number of daytime and night-time crashes. For an equivalent light traffic level, the number of crashes was higher at weekends but in heavy traffic level the number of crashes was higher on weekdays. Finally the probability of being the victim of a crash is higher when traffic was light, and more likely on a 3-lane motorway (Martin JL., 2002).

During the year 1991-1996 in Udine, Italy, Valent *et al*. also reported that in logistic regression model, the accident was more likely to be fatal from 18.00p.m. to 05.00a.m. and occurred in October to March. For truck driver, Saturday, Sunday and holidays are more dangerous than other days (Valent *et al.*, 2002).

Roberts *et al.* reported that road crashes tend not to be evenly distributed throughout the network. They occur in cluster at single sites, along particular sections of road, or scattered across whole residential neighbourhoods, especially in area of social deprivation (Roberts *et al.*, 1996).

Ogden KW. reported that while road engineering can greatly help in reducing the frequency and severity of road traffic crashes, poor engineering can contribute to

crashes. The road network has an effect on crash risk because it determines how road user perceive their environment and provides instruction for road users, through signs and traffic controls, on what they should be doing. Many traffic management and road safety engineering measures work through their influence on human behavior (Ogden KW, 1996).

Ross A *et al.* reported that in the planning, design and maintenance of the road network, four particular elements affecting road safety have been identified. These elements are safety-awareness in the planning of new network, the cooperation of safety features in the design of new roads, safety improvements to existing roads and remedial action at high- risk crash sites (Ross A *et al.,* 1991).

Yau K.K.W. reported that day of the week and time of accident were important factors affecting injury severity. Accident taking place after midnight (from 00.00-07.59) have a higher risk of the involvement of fatal and serious injuries (OR= 2.557, 90% CI=1.431-4.568). or while for private vehicles severe accidents usually occur from midnight to early morning (00.00-07.59) (Yau K.K.W., 2004).

2.10.3 Vehicular factors

The importance of the vehicle is that it is an analogous factor to an agent. The vehicles are defined by their types, private cars, bus, truck, motorcycle, tractor, and jeeps. Accidents mainly depend upon the design of the vehicle, mechanical fitness, driving experience, maintenance of the vehicle, regular check ups. Fast driving is also an important factor, which is entirely under the control of the driver. In U.S.the commonest cause of the accident is fast driving that contributes about 31% of the total accident in 1959. The severity of the accidents, and the mortality resulting from, that may be due to the structural defect like brakes, lights, tires, steering defects are evidently common. Regarding over speeding, racing, and wheeling done by youngster lead to fatal outcomes.

Power of machines is the most important factors in accidents. The severity of the accidents, and mortality resulting therefrom, may be affected by the structural design of the vehicle involved. Although it is not possible to measure precisely the contribution of vehicular defect to road accident, they probably play a considerable part in the pattern of causation of many accidents.

2.10.3.1 Type of vehicle involved

Compatibility means that passenger vehicles of disparate size provide an equal level of occupant protection in car-to-car collisions (NHTSA, 1996). The field data shows there are many vehicles which are incompatible with other vehicles. The incompatibility is induced by the difference in the mass, stiffness and geometry of both vehicles (Buzeman, 1997). Mass incompatibility causes high acceleration of the lighter car in collision. Stiffness incompatibility allows large deformation for the less stiff vehicle, which results in the risk of compartment intrusion. Override of the car in collision occurs by the incompatibility of the geometry of both vehicles. An incompatible vehicle induces high risks for the occupants in the other vehicles, which can be defined as aggressivity (Mizuno *et al*, 1999).

Barss *et al*. reported that bus with passengers, minibus and trucks are frequently involved in crashes in low-income countries. The use of open-backed vehicles for transporting passengers in rural areas is widespread and risks ejecting passengers (Barss *et al*., 1998). In New Delhi, India, around two-thirds of crashes involve buses or trucks (Mohan *et al.*, 1998).

In many low-income and middle-income countries, second-hand trucks and buses are imported without the crash-protective features-such as occupant restraints-that are present in high-income countries. Such vehicles have a poor crashworthiness performance, and also poor stability when fully laden or overloaded, as they frequently are.

The urban centers of low-income and middle-income countries typically contain a great mix of vehicles. Incompatibility of size between different classes of road vehicles is a major risk factor, especially in impacts between cars and large trucks. The power of the larger vehicle-its mass, geometry and structural properties- increases rates of injury and death many times compared with an equivalent car-to-car crash (Mackay *et al*., 2002; Joach, 2000). When large vehicles such as trucks or buses are involved, these crashes frequently lead to serious injuries or even fatalities among vulnerable road users, such as pedestrians, cyclists or drivers of motorized two-wheelers (Chawla *et al*., 2000).

Hurt *et.al*. reported that motorized two-wheelers, because of the size and shape, are less easy to see than other motor vehicles and have poor visibility in daytime (Hurt *et.al*.,1981). Radin Umar *et.al.* reported their findings that most motorcycle crashes were in daytime and that around two-thirds of the riders involved had the right of way (Radin Umar *et.al.*,1995).

In Columbia, Rodriques *et al.* reported their findings about road traffic injuries in 1996-2000 that in rural areas, almost 51% of vehicles involved in crashes were private vehicles (automobiles, light trucks, sports utility, off-road vehicle, etc.), 25% were commercial vehicles (trucks with two or more axles), 11% were public passenger vehicles (buses, vans and taxis), and 8% was motorcycle. In large cities such as Bogota', Medellin, Cali, 63% of all vehicles involved in crashes were private vehicles (automobiles, light trucks, sports utility, off-road vehicle, etc.), 7% were commercial vehicles, 19% were public passenger vehicles, and 5% was motorcycle (Rodriques *et al.*, 2003).

2.10.3.2 Number of vehicles involved

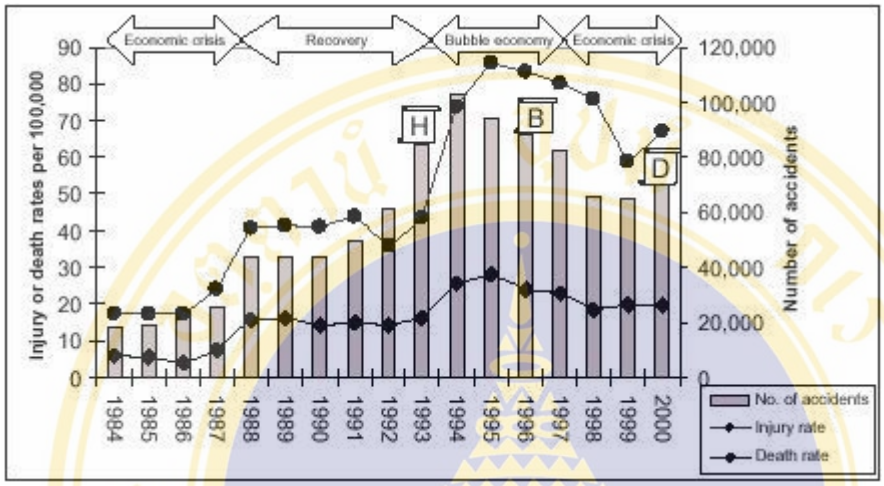
The number of vehicles involved is one variable characterizing a crash but tends to increase with traffic flow (Martin JL., 2002).

During 1997 and 1998, 92 motorway sections in France were observed and studied about relationship between crash rate and hourly traffic flow. Martin categorized crash type as crashes involving a single vehicle in right-hand, left-hand or central lane, crashes involving two vehicles in the same or different lanes and crashes occurring at motorway entrance and exits. It was found that crashes involving one single vehicle decrease as traffic flow increases and are replaced by crashes involving several vehicles and, more specifically, at highest traffic peaks, by crashes involving vehicle in different lanes (Martin JL., 2002).

2.11 Studies related to road traffic accidents

Suriyawongpaisal *et al.* reported in a cross-sectional study that the number and rate of traffic injury in Thailand swung from a record low during the economic recovery in the 1980's to record a high during the bubble economy, then declined with the economic crisis in 1997. The economic costs were estimated at U.S.$1.6 billion in

1995 and urban-rural difference in traffic injuries had been recorded with a higher rural case-fatality rate (Suriyawongpaisal *et al.*, 2003). Trends of road traffic injury in Thailand, 1984-2000 are shown in **Figure 2**.



Enforcement: H = helmet; B = seat belt; D = drunk driving

Source: Ministry of Public Health, Thailand Health Profile 1997-1998; available from www.police.go.th

Figure 2. Trends of road traffic injury in Thailand, 1984-2000

Siwirojana *et al.* conducted a cross-sectional study in 2003 about risk behavior of people and its relevant factors in 10 pilot provinces designated by the government in the strategic plan for elevating the road safety standard. 297 traffic injury victims who were hospitalization studied showed that most cases occurred at 7.00 pm and thereafter, most of victims were men who drove by yourselves. 48.8 and 53.2 % of cases had alcoholic breath odor and blood level over 50 mg% respectively (Road safety report card of Thailand, 2003).

Rodriquez *et al*. reported in a cross-sectional study in Columbia that from 1986 to 2000, road traffic crashes, injuries, fatalities increased 4, 4 and 2 fold respectively. Mapping by GIS technique and spatial analysis are used in this study. From comparison between average rate of traffic- related deaths and injuries per 100,000 population per year by regional capital, 1992-1999, They found that 60% of crashes occurred in the largest cities, Bogota', Medellin, and Cali; nearly 30% take place in intermediate cities and the remain 10% occurred on rural nation roads, mainly large inter-municipality highways and the highest crash fatality rates were recorded by

intermediate-size, small and large cities respectively. Mapping of Bogota showed that the crash were concentrated along main corridors and intersections of public transport networks (Rodriquez *et al*., 2003).

Wang *et al*. conducted a retrospective study of trends in road traffic crashes and associated injury and fatality in the People's Republic of China. They found that absolute numbers of crashes, fatalities, and injuries, as well as fatalities per 100,000 population and motorization were used as indices to measure trends. From 1951 to 1999, road traffic crashes, injuries, fatalities increased 68, 56 and 97 fold respectively. The crash, fatality and injury rates also increased after 1985, due to increase motorization spurred by rapid economic growth. Regional variations in trends and the characteristics of people injured and killed were also analyzed. They reported that mostly provinces having the high motorization indices also tended to record the high motor vehicle fatality per capita indices (Wang *et al*., 2003).

Yang *et al*. did a descriptive analysis of trends in crashes and injuries using time series data. They found that from 1970 to 2000 road traffic crashes, injuries, fatalities increased nearly 8, 10 and 3 fold respectively in Korea but crash, injury and fatality per million vehicle-kilometers declined substantially for 1995 to 2000 (Yang *et al*., 2003).

Bernard *et al*. did a descriptive study to summarize the trends in road traffic crashes, injuries, and fatalities in Trinidad and Tobago. They found a decline in fatality rates from 17 to 10 deaths per 100,000 population in 1960-2000 while motorization was rapidly increasing. It meant intensified effort to ensure safety for all road user including improved data collection, monitoring and evaluation of policy interventions (Bernard *et al.,* 2003).

El-Sadig *et al*.conducted a retrospective analytic study about trends of road traffic accidents in the United Arab Emirates during 1977-1998 by using linear regression analysis revealed that rising trends in the severity of road traffic accidents accompanied by declining trends in the rates of accidents, fatalities and injuries. The trend analysis of these rates, calculated on the basis of resident population and number of registered motor vehicles (El-Sadig *et al.*, 2002).

CHAPTER III
RESEARCH METHODOLOGY

3.1 Study Design

The studies comprised of 2 parts:

Part I : A descriptive study of trends in death rates and injury rates using time series data from Police Information System Center Data compiled during the period January 1995 to December 2002.

A descriptive study of accident prone area on motorways using secondary data from Special highway police station route 7 and 9 during the year 2002.

Part II : An analytic cross-sectional study using secondary data from special highway police station route 7 and 9 during the year 2002.

3.2 Data Sources

Police Information System Center source

Inclusion criteria:

Road accident episodes including all injuries or deaths were recorded by all provincial police stations of Thailand during the year 1995-2002.

Motorway source

Inclusion criteria:

All road accident episodes were recorded by special highway police stations route 7 and 9 during the year 2002.

3.3 Data flow

Data flow of both sources are shown in figure 3 and 4 respectively.

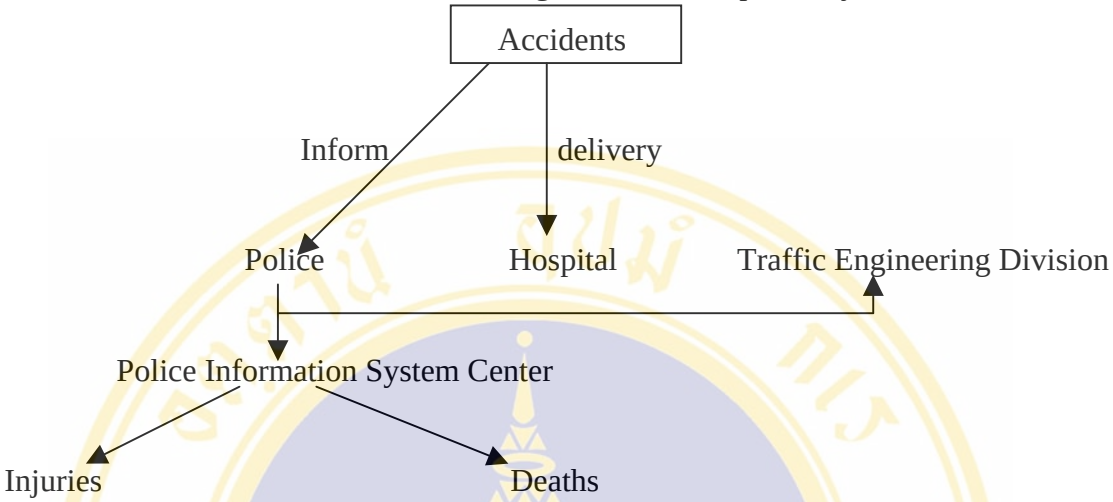


Figure 3. Data flow of Police Information System Center

When any road traffic accident occurs, there are three related sources: Police, Hospital and Traffic Engineering Division. The three sources are responsible in collecting accident in function. The info may or may not overlap with one another.

3.3.1 Hospital The casualties from road traffic accident are delivered to the hospital. Nurse with special training collect injury data based mainly on patient or others persons having relevant knowledge about the patient and injury.

3.3.2 Traffic Engineering Division, Department of Highways, Minister of Transport and Communication compiles highway data from two sources: police stations around the country and highway districts, which are responsible for road maintenance.

3.3.3 Polices are responsible for collecting crash data on spot. Police officer records daily the data in the standard report form, which is extracted from the activity logbook. The following variables recorded are number of vehicles and road users involved, probable causes, number of victims (killed, severely injured, mildly injured), sex, an estimated cost of damage to property, number and gender of alleged offender. All police stations throughout Thailand send monthly summary of traffic crash reports

to the Police Information System Center in Bangkok. The data are complied in form of annual reports and the variables which will be used in the study such as the number of injuries and deaths will be extracted from there.

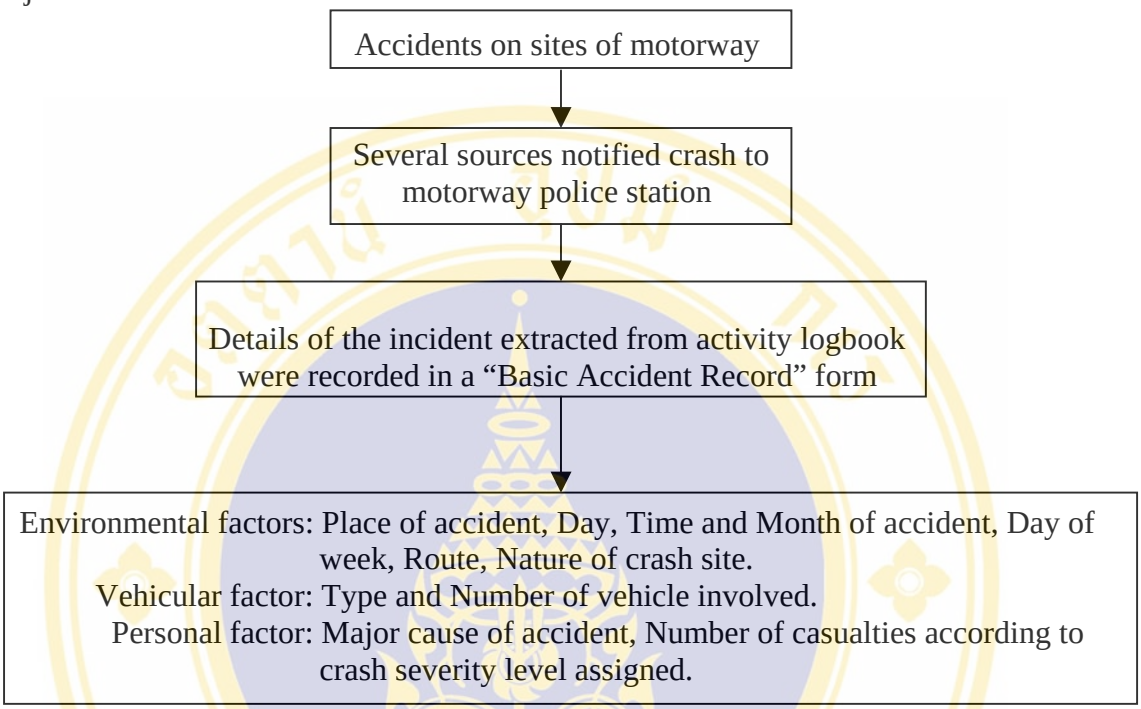


Figure 4. Data of special highway police station route 7 and 9

When any accident occurred on motorway, traffic police officer obtained crash notifications from several sources such as the parties of the accident, the accident encounter, Narenthorn center; Ministry of Public Health, accident–report radio program, Highway police information center or member of charity foundations of accident by telephone communication or monitoring police radio communication. After notification, Police officer reached to the crash scene. Once on-scene, he collected and recorded on-scene measurements, parties interviews and injury information in the logbook on that day. Once on-scene investigation was complete, the injured parties were followed through the medical system to determine the details of injury. The rest information would be collected after hospitalization of victims until he receives diagnostic report from doctor who was responsible on. The crash severity was classified by using Criminal Law section 297. The certain variables would be extracted into " Basic Accident Record Form". The following variables recorded were number and type of vehicles involved, probable causes, number of victims (killed, severely injured, mildly injured), sex, an estimated cost of damage to property and

number and gender of alleged offender. The variables involving fatal crash would be extracted from it.

3.4 Definition of Variables

Study variables

The dependent variables for this study are injury rate, death rate and fatal crash.

The independent variables are

1. Number of Injuries.
2. Number of deaths.
3. Number of registered vehicles.
4. Gender.
5. Time of accident.
6. Day of week.
7. Month of accident.
8. Place of accident.
9. Number of casualties.
10. Nature of crash site.
11. Major cause of accident.
12. Type of vehicle involved.
13. Route.
14. Day of accident

Operational Definitions

Accident	an unpremeditated event resulting into a recognizable injury and this includes all accidents like home, industrial, traffic, and other accidents.
Road	refers to the condition of the road like surface if rough or smooth, construction if standard width and proper bunking at curves and good lighting especially at intersections.
Road Traffic Accident	refers to any vehicles accident occurring on the public highway, or street involving collision with an object

	(fixed, movable or moving) or overturning (without collision) due to loss of control.
Motorways	refers to special highway route 7and 9.
Average Speed	refers to the regular or usual cruising speed as perceived by the drivers.
Casualties	refer to deaths and injuries due to an event of road traffic crash.
Injury crash	refers to combination between fatal crash and non-fatal crash
Death	refers to only cases where the victims encountered were dead upon arrival at an emergency room or during hospitalization were registered.
Severe Injury	refers to at least one person injured and require medical treatment in the hospital more than 20 days and the other descriptions that enforced in Criminal Law section 297.
Mild Injury	refers to at least one person requiring medical care but no fatalities or injuries requiring hospitalization more than 20 days or the descriptions that enforced in Criminal Law section 297.
Highway Accident Report	refers to a two-page record form, which is used to collect information on traffic crash events resulting in property damage and/or injuries/deaths. Key variables include site, date and time, type and standard of highways, nature of site of crash, (e.g., roundabout, bridge, straight, curve), traffic control, property damage, probable cause, visibility, severity, collision damage, and details of drivers and vehicles.
Day of week	refers to day of an accident occur on weekend or weekday.
Weekend	refers to Friday to Sunday including Public holiday.
Weekday	refers to Monday to Thursday.

Time of crash	refers to hour of day was classified into five groups in accordance with to working hours: 00.00-07.59 a.m., 08.00-11.59 a.m., 12.00-15.59 p.m., 16.00-19.59 p.m. and 20.00-23.59 p.m.
Place of accident	refers to the number of kilometer which any vehicle accident occurring on the motorways not involving property damage crash with no injury and death.
Fatal crash	refers to there is at least one fatality resulting from the crash.
Non-fatal crash	refers to the crash results in at least one injury but no fatality.
Major cause of accident	refers to the risk behavior of driver will be attributed to fatal crash.
Over speeding	refers to velocity that drivers used more than the regulation of vehicle type assigned depend on road type such as legal limit for highway; car 90 kilometers per hour, truck 80 kilometers per hour or for motorway; car and pick-up 120 kilometers per hour, bus and truck 90 kilometers per hour.
Overload	refers to vehicle weight more than the regulation assigned. Legal limit for tractor-trailer is 21 tons and for single-unit truck is 16 tons.
Drunk driving	refers to evaluation for driver about alcohol involvement by using Breath analysis on roadside and/or blood alcohol content (BAC) confirmation testing. The legal limit of quantitative of BAC in Thailand is less than or equal to 50 mg/dl.
Drowsy driving	refers to judgement of authority based on a face-to-face interview with driver or witness after crash.
Type of vehicles involved	refers to types of vehicle found at crash site, which are classified into 2 groups: 1.Any heavy vehicle involved in the accident.

	2. No heavy vehicle involved in the accident
Heavy vehicle	refers to van, light truck, heavy truck, passenger bus,etc.
Nature of crash site	refers to the character of road where the accident occurred such as straight, curve, bridge, intersection etc.

3.5 Method of data collection and data processing

Part I The study used data available at two sources: Police Information System Center and Department of Land Transport. The police data had been collected monthly from road traffic accidents of all provincial police stations by utilizing a form called the " Summarized road traffic accident report" (Appendix A). The study extracted totally number of deaths, severe injuries and mild injuries and those classified by gender, major type of vehicle and major cause of accident including total number of events from annual report during the year 1995-2002. Number of registered vehicles of all provinces had been extracted from annual reports of Department of Land Transport during the same year. After extracting the data, It was recorded into an Excel format.

Part II The study used data available at Special highway police station route 7 and 9. This information had been recorded daily from road traffic accidents on motorways by utilizing a form called the "Basic Accident Record"(Appendix B). This study extracted only road traffic accidents involving casualties excluding property damage crash with no injury and death, which completed all factors shown in Data flow Figure 4 as above. After extracting the data, It was recorded into an Excel format.

3.6 Data Analysis

3.6.1 Specific objective 1: to identify trends of injury rate and death rate among the provinces of Thailand during the period 1995 to 2002 by developing maps. Data was analyzed as follows;

The rates of injury and death using databases from Police Information System center and Department of Land Transport during the period 1995 to 2002 were calculated. Numerators were the numbers of road traffic casualties among the

provinces of Thailand and denominator was number of registered vehicle among the provinces of Thailand as well. MapInfo Professional version 6.0 was used to create maps during 1995-2002. Each province has a specific ID code, which serves as the link between attributable data and corresponding spatial area. The variables for each year were displayed simultaneously on the map, showing the trend of death rate (deaths per 10,000 registered vehicles) and injury rate (injuries per 10,000 registered vehicles) among the provinces of Thailand. Both rates were used as evaluation for measuring trends.

Additional data were obtained from Police annual report; Police Information System center. Interesting variables studied were

1) Gender
2) Type of vehicles
   - Motorcycle
   - Passenger car
   - Truck
3) Cause of accident
   - Over speeding
   - Drunk driving
   - Drowsy driving
   - Other

The percentage was used to determine trends of each factor during the period 1995-2002.

3.6.2 Specific objective 2: to develop map of accident-prone areas on motorways during the year 2002. Data was analyzed as follows;

Maps of accident- prone areas using all road traffic crashes and injury crashes on motorways was developed and presented by using MapInfo version 6.0 software. This tool used the address of the site where each road traffic crash occurred. Each kilometer has a specific ID code, which serves as the link between attributable data and corresponding spatial area. The crash site presented by number of crashes by count was displayed simultaneously on one single map. The percentage was used to present number of road crashes on that scene in order to see the concentration of the crashes.

3.6.3 Specific objective 3: to investigate the distribution of accidents involving casualties on motorways during the year 2002 at different times of the day. Data was analyzed as follows;

1) The percentage was used to present the proportion between number of injury crashes among different times of the day and total injury crashes during the year 2002.

2) Measure of central tendency and variability were used to determine the number of injury crashes per month among different times of the day.

3) Repeated Measures analysis was used to compare the effect of time on mean of number of injury crashes per month on motorways.

The statistical analysis was performed by the SPSS program.

3.6.4 Specific objective 4: to compare number of accidents involving casualties per day occurring on weekdays and weekends on motorways during the year 2002. Data was analyzed as follows;

1) The percentage was used to present the proportion between road traffic crashes involving casualties on weekdays and weekends and total injury crashes during the year 2002.

2) Measure of central tendency and variability were used to determine the number of road traffic crashes involving casualties per month per day occurring on weekday and weekend.

3) Paired t-test was used to compare means of road traffic crashes involving casualties per month per day occurring on weekdays and weekends.

The statistical analysis was performed by the SPSS program.

3.6.5 Specific objective 5: to identify factors associated fatal crashes on motorways during the year 2002. Data was analyzed as follows;

1) The frequency and the percentages were used to present factors relating road traffic crashes involving casualties

2) Cross-tabulation between fatal crash and each related factor was performed and Chi-square test was used to assess the association between road traffic crash factors related and Injury crash on motorways. Road traffic crash factors consisted of;

Personal factor

- Major cause of accident

Vehicular factors

- Type of vehicle involved
- Number of vehicle involved.

Environmental factors

- Day of crash
- Time of crash
- Month of crash
- Day of week of crash
- Route
- Nature of crash site

These analyses were supported by chi-square or Fisher's exact test with statistical significant level at 0.05.

3.7 Significance of the study

According to police who encountered the origin of accident more than the other authorities. Police data during the period 1995 to 2002 was taken to study trend overtime of death rate, injury rate, type of vehicle involving accidents and cause of accident. And motorway data in the year 2002 was used in identification of accident prone areas and determination of factors related to fatal crashes. Although the number of injury crashes were too few to find out the magnitude of the association between fatal crash and relating factors, but it could show the possibility that factors affecting to injury crashes on motorways.

So the result of this study might be the essential baseline information of future epidemiological study. While policy maker could know the incompleteness of police data and take it to further improve.

CHAPTER IV
RESULTS

4.1 Result for the specific objective 1; To identify trends of injury rate and death rate among the provinces of Thailand during the period 1995 to 2002 by developing maps.

Identification trends of injury rate and death rate among the provinces of Thailand during the period 1995 to 2002 by developing maps. From the past 8 years, road traffic crashes had slightly decreased from 94,362 in 1995 to 91,623 in 2002. Fatalities decreased from 14,404 in 1995 to 12,228 in 2002. Injuries slightly increased from 45,073 in 1995 to 65,865 in 2002. Registered vehicles increased between 1.7 fold from 14,081,719 to 24,517,250 over the 8-year period between 1995-2002. All indicators, number of fatalities, injuries and registered vehicles during the year 1995-2002, were showed in table 5. The decline was also evident in the death rate, which declined from around 10 deaths per 10,000 vehicles in 1995 to around 5 deaths per 10,000 vehicles in 1998 and would rather keep constant until 2002. Injury rate declined from 32 deaths per 10,000 vehicles in 1995 to around 22 deaths per 10,000 vehicles in 1999 and increased to around 27 deaths per 10,000 vehicles in 2002 as shown in table 6.

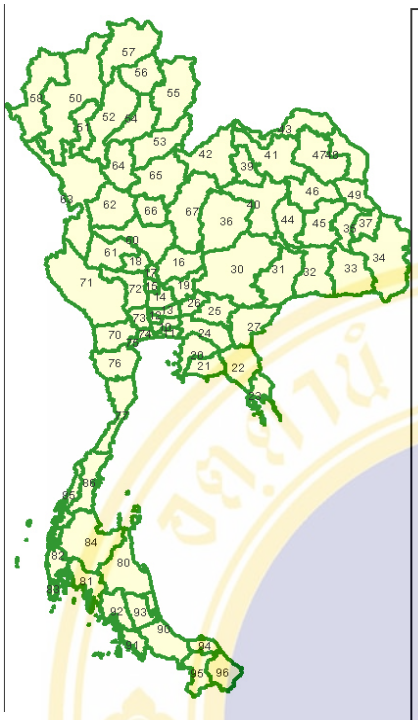
Table 5. Number of fatalities, injuries and registered vehicles in Thailand during the year 1995-2002.

Year	1995	1996	1997	1998	1999	2000	2001	2002
Fatalities	14,404	13,077	12,680	10,966	10,916	11,079	10,825	12,228
Injuries	45,073	45,998	45,005	42,839	44,186	49,613	50,672	65,865
Registered Vehicles.	14,081,719	16,099,046	17,669,240	18,878,503	20,026,536	20,835,684	22,589,185	24,517,250

Table 6. Trend in number of accidents, total death rates and injury rates per 10,000 vehicles in Thailand, 1995-2002

Year	1995	1996	1997	1998	1999	2000	2001	2002
Death rate	10.2	8.1	7.2	5.8	5.5	5.3	4.8	5.0
Injury rate	32.0	28.6	25.5	22.7	22.1	23.8	22.4	26.9
Number of accidents	94362	88556	82336	73725	67786	73737	77616	91623

Thailand map labeled with 76 provincial codes in figure 5. was shown in order to illustrate trend of death and injury rate. Trends of death rate and injury rate per 10,000 vehicles from the period 1995-2002 were shown in figure 6 and 7 and table 6.



Bangkok	10	Lamphun	51
Samut Prakan	11	Lampang	52
Nonthaburi	12	Uttaradit	53
Pathumthani	13	Phrae	54
Ayutthaya	14	Nan	55
Angthong	15	Phayao	56
Lopburi	16	Chiangrai	57
Singburi	17	Maehongson	58
Chainat	18	Nakhonsawan	60
Saraburi	19	Uthaithani	61
Chonburi	20	Kamphaengphet	62
Rayong	21	Tak	63
Chanthaburi	22	Sukhothai	64
Trat	23	Phitsanulok	65
Chachoengsao	24	Phichit	66
Prachinburi	25	Phetchabun	67
Nakhonnayok	26	Ratchaburi	70
Sakaeo	27	Kanchanaburi	71
Nakhonratchasima	30	Suphanburi	72
Buriram	31	Nakhonpathom	73
Surin	32	Samutsakhon	74
Sisaket	33	Samutsongkhram	75
Ubonratchathani	34	Phetchaburi	76
Yasothon	35	Prachuapkhirikhan	77
Chaiyaphum	36	Nakhonsithammarat	80
Amnatcharoen	37	Krabi	81
Nongbualamphu	39	Phangnga	82
Khonkaen	40	Phuket	83
Udonthani	41	Suratthani	84
Loei	42	Ranong	85
Nongkhai	43	Chumphon	86
Mahasarakham	44	Songkhla	90
Roi-et	45	Satun	91
Kalasin	46	Trang	92
Sakonnakhon	47	Phatthalung	93
Nakhonphanom	48	Pattani	94
Mukdahan	49	Yala	95
Chiangmai	50	Narathiwat	96

Figure 5. Thailand map labeled with 76 provincial codes

Reference code: Department of Local Administration (DOLA), Ministry of Interior

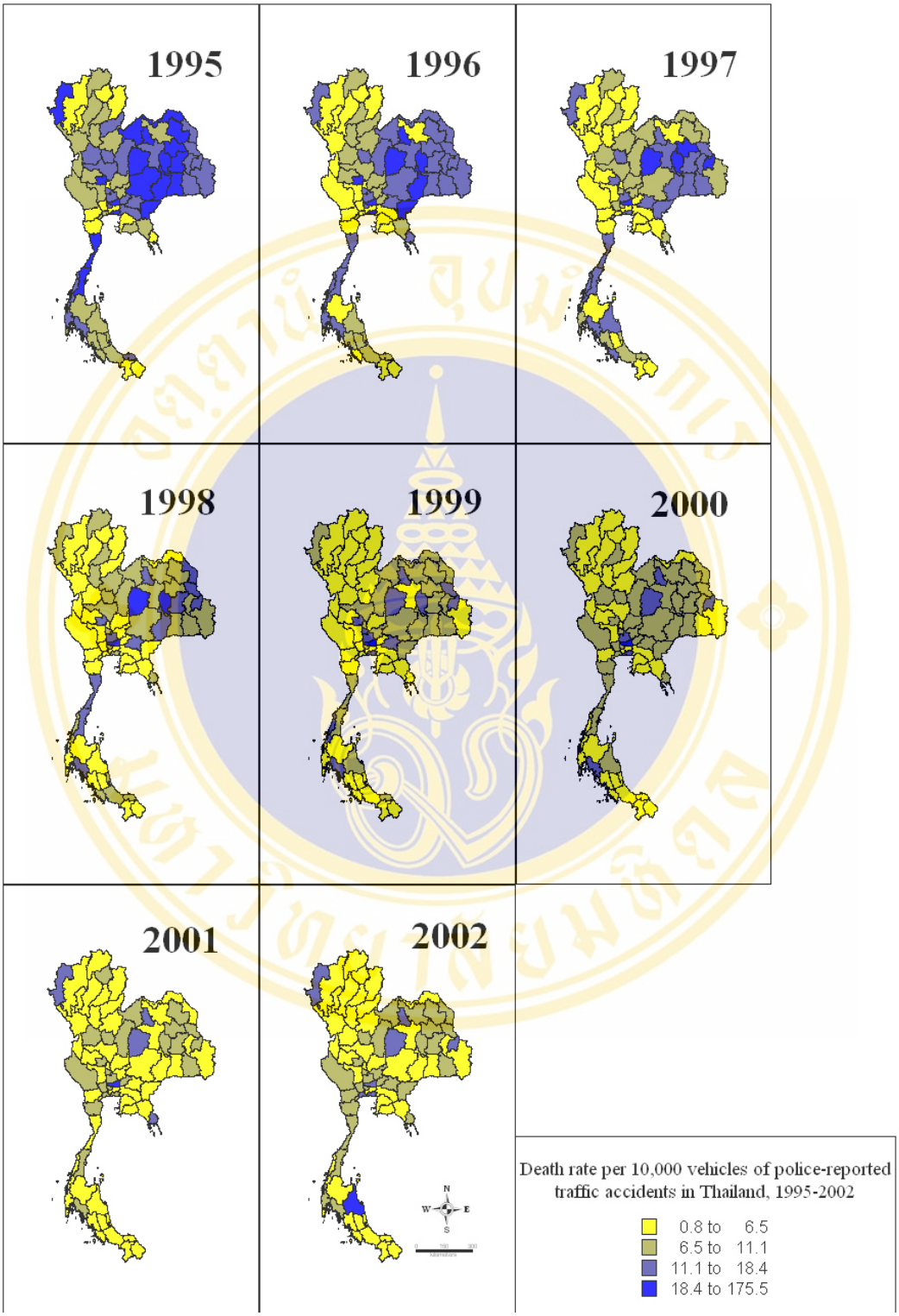


Figure 6. Trend of death rate per 10,000 vehicles in Thailand, 1995-2002

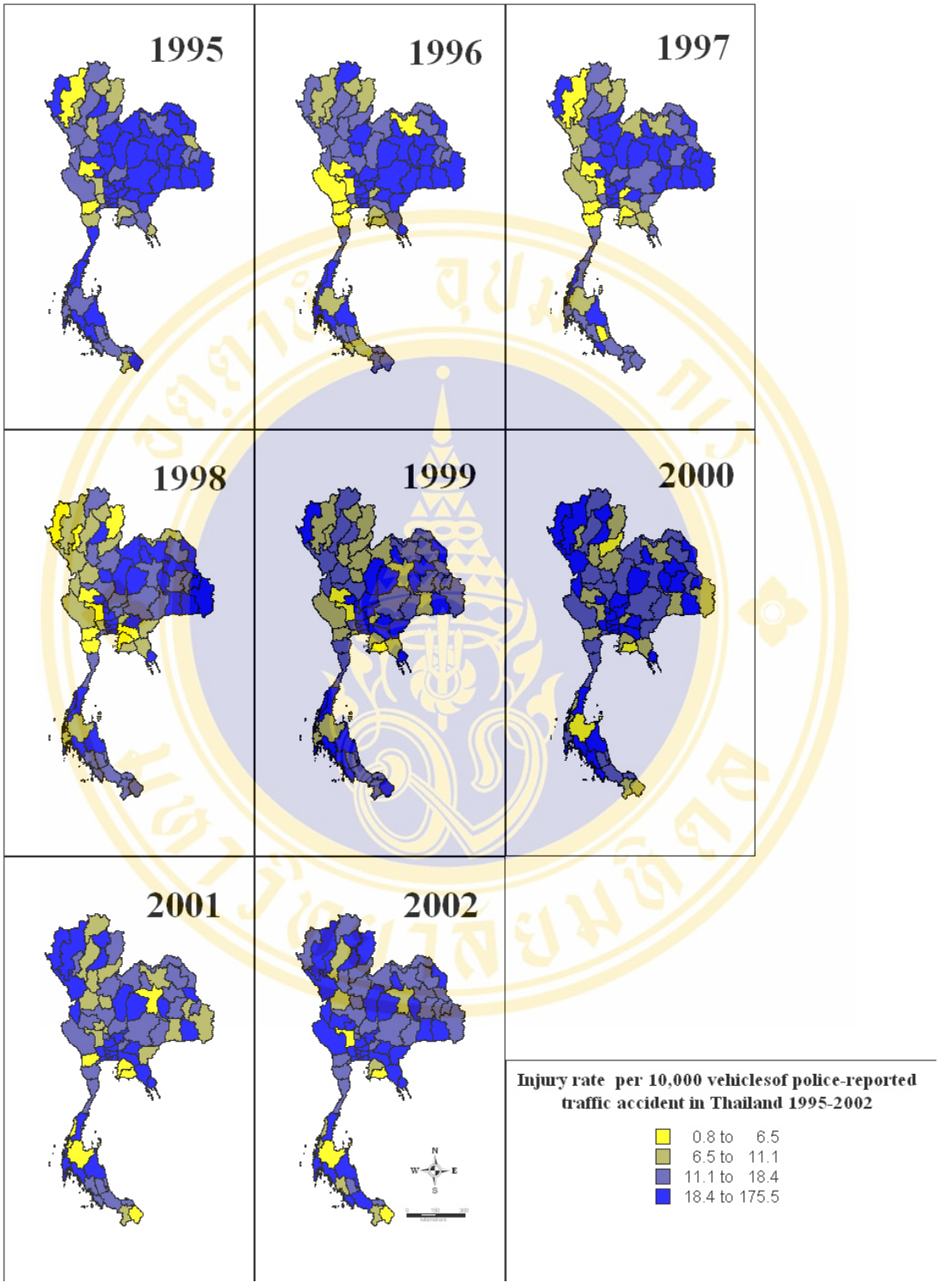


Figure 7.Trend of injury rate per 10,000 vehicles in Thailand, 1995-2002

Figure 8. showed that number of accidents, the death and injury rates had declined whereas the end of the financial bubble and the economic crisis happened during the year 1995-2000 and number of accidents and injury rate increased during the economic recovery during the year 2000-2002. While death rate would rather keep constant during the year 2000-2002.

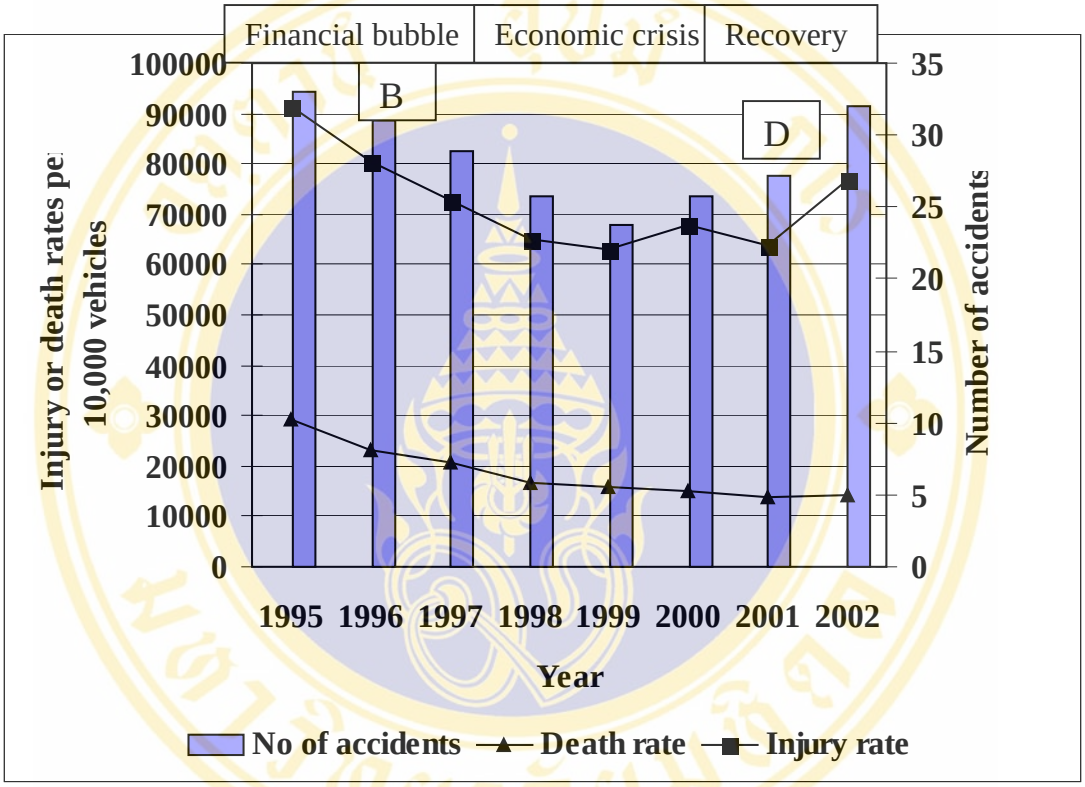


Figure 8. Trends of police-reported road traffic accidents in Thailand, 1995-2002
Enforcement: B = seat belt; D = drunk driving
Source: Police Information System Center

Regarding Gender, during the period 1995-2002, it revealed that number of deaths among female accounted for an average of around 20 % of total victims and there was a minor trends of increased in female who died. Male accounted for an average of around 80 %. There was a minor trend of decreased in male who died. as shown in Figure 9. For severe injuries, male accounted for an average of around 74 % there were minor trends of decreased in male who severely injured. Female accounted for an average of around 26 %. There was a minor trend of increased in female who severely injured as shown in Figure 10.

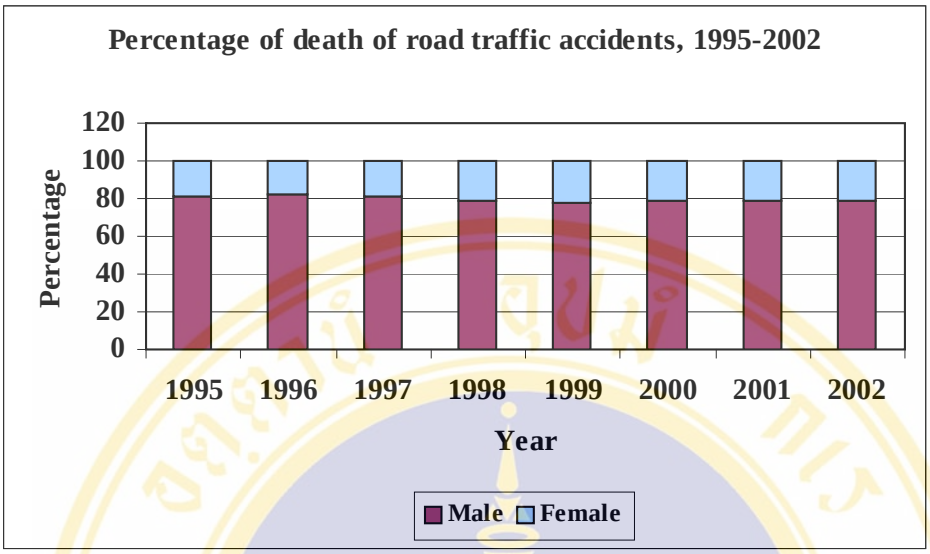


Figure 9. Percentage of death of road traffic accidents by gender, 1995-2002

Source: Police Information System center

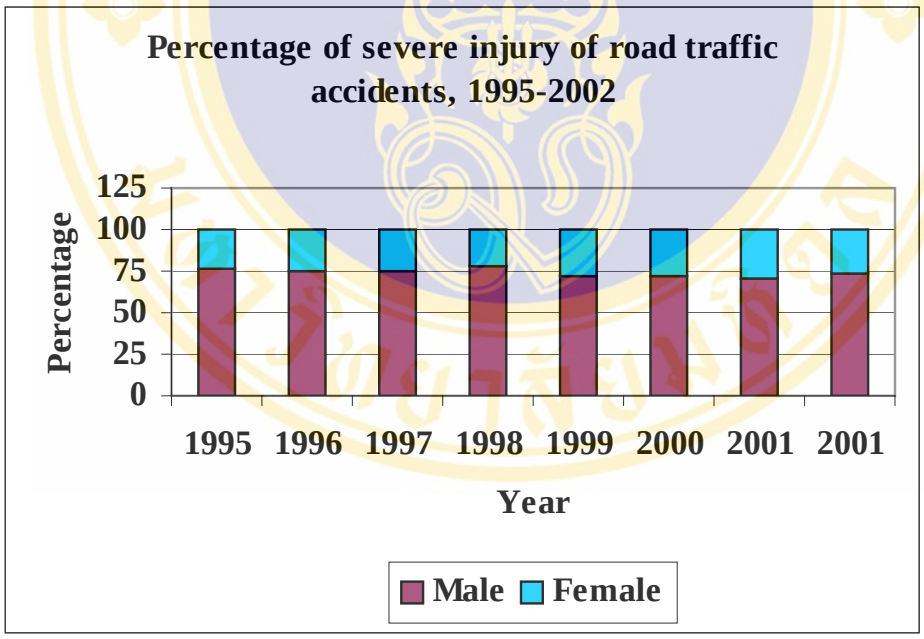


Figure 10. Percentage of severe injuries of road traffic accidents by gender, 1995-2002

Source: Police Information System center

Male constituted around 75% of the people mildly injured in 1995 before decreasing slightly to around 70% in 2002. There was a minor trend of decreased in male. Female accounted for 25% of the people mildly injured in 1995 before increasing to around 30% from 1998 until 2002 and there was a minor trend of increased in female who mild injured. as shown in Figure 11. Number of severity injuries during the period 1995-2002 were shown in table 7.

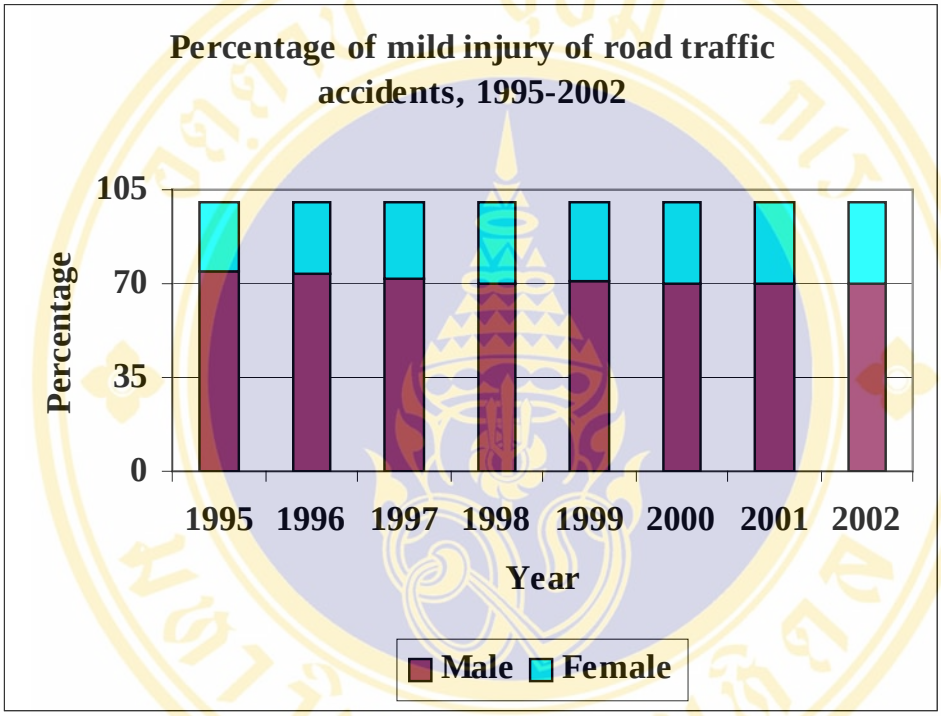


Figure 11. Percentage of mild injuries of road traffic accidents by gender, 1995-2002
Source: Police Information System center

Table 7. Number of severity injuries by gender during the period 1995-2002

Year	Male			Female		
	Death	Severe	Mild	Death	Severe	Mild
1995	13553	11222	26863	3174	3589	9044
1996	11827	9538	27574	2578	3100	9832
1997	11225	8857	26545	2611	3053	10256
1998	9703	11717	26208	2531	3294	11319
1999	9385	8612	25235	2655	3442	10474
2000	9415	8920	28532	2573	3582	12077
2001	9256	8553	29362	2396	3481	12564
2002	10405	12316	36747	2711	4490	15760

With regard to cause of accident, Over speeding driving was found to be the largest contributing factor of road traffic accident during the period 1995-2002 followed by drunk driving and drowsy driving. The percentage of over speeding driving increased from 23.5% of total crashes in 1995 to 28.4% in 1997 before decreasing slightly to around 22.8% in 2002.The percentage of drunk driving slightly increased from 2.0 in 1995 to 3.08 in 2002. And drowsy driving accounted for an average of 0.5 % as shown in Figure 12 and Number of major causes of accident occurring during the period 1995-2002 were shown in table 8.

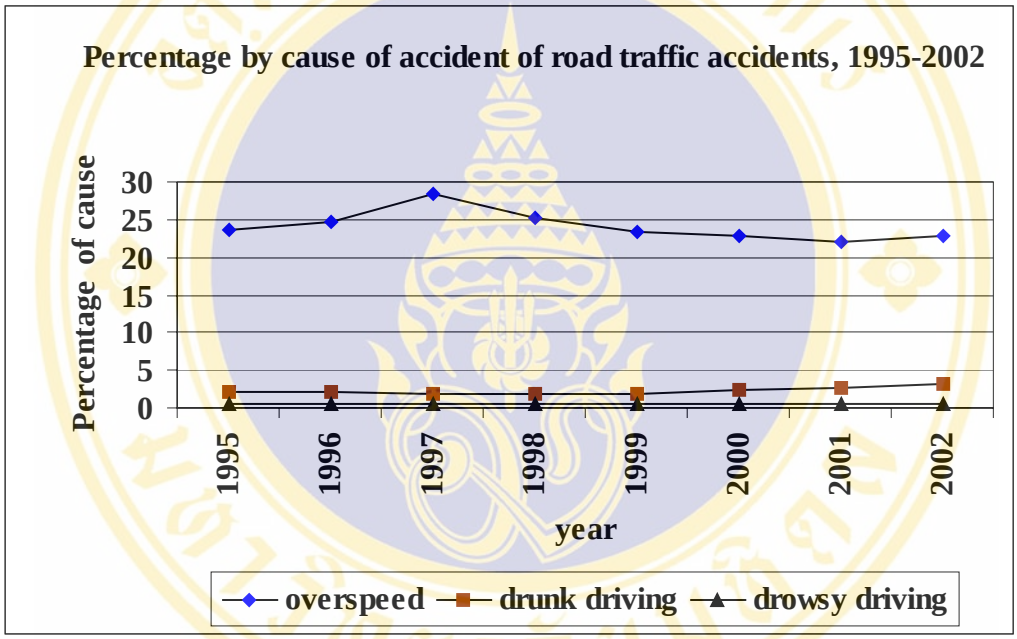


Figure 12. Percentage by major causes of accident of road traffic accidents, 1995-2002
Source: Police Information System center

Table 8. Number of major causes of accident occurring during the period 1995-2002

Year	Over speeding	Drunk driving	Drowsy driving
1995	22173	1868	505
1996	21783	1775	420
1997	23408	1438	354
1998	18589	1431	416
1999	15830	1346	320
2000	16777	1811	344
2001	17156	2089	395
2002	20896	2823	448

Source: Police Information System center

According to vehicle type of road traffic accident, the percentage of motorcycle involving road traffic accident accounted for 29.4% of total vehicles in 1995 and had increased gradually into 36.8% in 2002. In contrast, The percentage of car and truck involving road traffic accident decreased from 30.8% and 8.7% to 26.9% and 5.3% respectively. The other accounted for an average of 32%.as shown in figure 13 and Number of vehicle involving road traffic accident during the period 1995-2002 were shown in table 9.

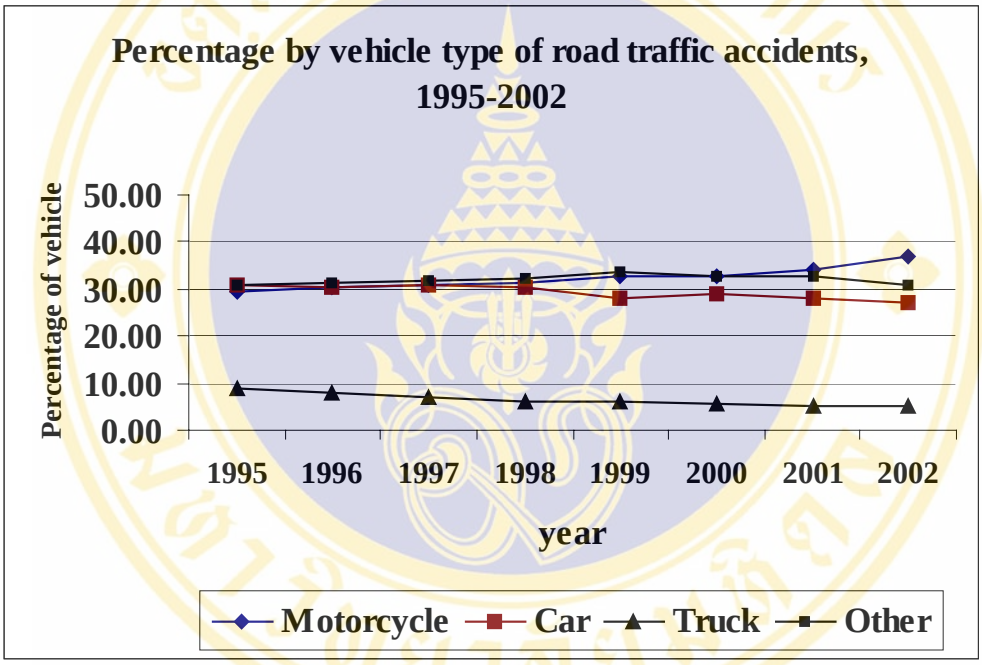


Figure 13. Percentage by vehicle type of road traffic accidents, 1995-2002

Source: Police Information System center

Table 9. Number of vehicle involving road traffic accident during the period 1995-2002

Year	Motorcycle	Car	Truck	Other	Total
1995	45707	47893	13542	48171	155313
1996	43989	44228	11772	45646	145635
1997	41969	42103	9502	43118	136692
1998	37414	36538	7259	38866	120077
1999	34936	29860	6435	36154	107385
2000	37498	33392	6404	37192	114486

(continued.)

Year	Motorcycle	Car	Truck	Other	Total
2001	41215	33907	6364	39811	121297
2002	53732	39279	7743	45254	146008

Source: Police Information System center

4.2 Result for the specific objective 2; To develop map of accident-prone areas on motorways during the year 2002.

In 2002, number of people killed in road traffic crashes in Thailand using police reports was 13,116 compared to 29 persons (0.2%) killed in crashes on motorways. The fatal-nonfatal crash ratio on motorways for 2002 was 1 to 2.6. There were a total of 205 reported road traffic accidents, of which 72 events involved road traffic casualties. Figure 14. showed that the injury crashes were concentrated on three clusters on motorway route 7 and three clusters on motorway route 9. More than 4%(3 of 72) of crashes were equally distributed in 3 provinces; Bangkok, Chachengsao, Chonburi in kilometer 3rd, 43rd, 78th of motorway route 7; nearly 3%(2of 72) of crashes took place in kilometer 33rd, 45th, 64th of motorway route 9 lied on Bangkok, Samutprakan and in kilometer 1st, 7th, 8th, 16th,18th ,42nd and 49th of motorway route 7 which mostly located on Bangkok; and the remaining 1.39%(1 of 72) of crashes occurred on motorway route 7 which equally distributed on 4 provinces; Bangkok, Samutprakan, Chachoengsao and Chonburi, and motorway route 9 which predominantly located on Bangkok.

For total crashes occurred on motorways during the year 2002, it was reported that the total crashes were concentrated on two clusters on motorway route 7 and one cluster on motorway route 9. More than 11% (23 of 205) of crashes which consisted of 22 property-damage crashes and 1 injury crash, occurred on Pravet, Bangkok at kilometer 4th of motorway route 7 and more than 4% (10 of 205) of crashes which were all property-damage crashes, took place on Lat Krabang, Bangkok at kilometer 12th of motorway route 7 as well.

According to route 9, It was found that more than 1% (3 of 205) of crashes which consisted of 1 property-damage crash and 2 injury crashes occurred on Klong Samva, Bangkok at kilometer 33rd of motorway route 9. All were shown in figure 15.

All clusters of high concentration of injury crashes and total crashes occurring on motorway route 7 and 9 in the year 2002 were shown in table 10.

Table 10.The areas of high concentration of injury crashes and total crashes occurring on motorway route 7 and 9 in the year 2002.

	Route7	Route 9
Injury crashes	Km. 3^{rd}, 43^{rd}, 78^{th}	Km. 33^{rd}, 45^{th}, 64^{th}
Total crashes	Km. 4^{th}, 12^{th}	Km. 33^{rd}

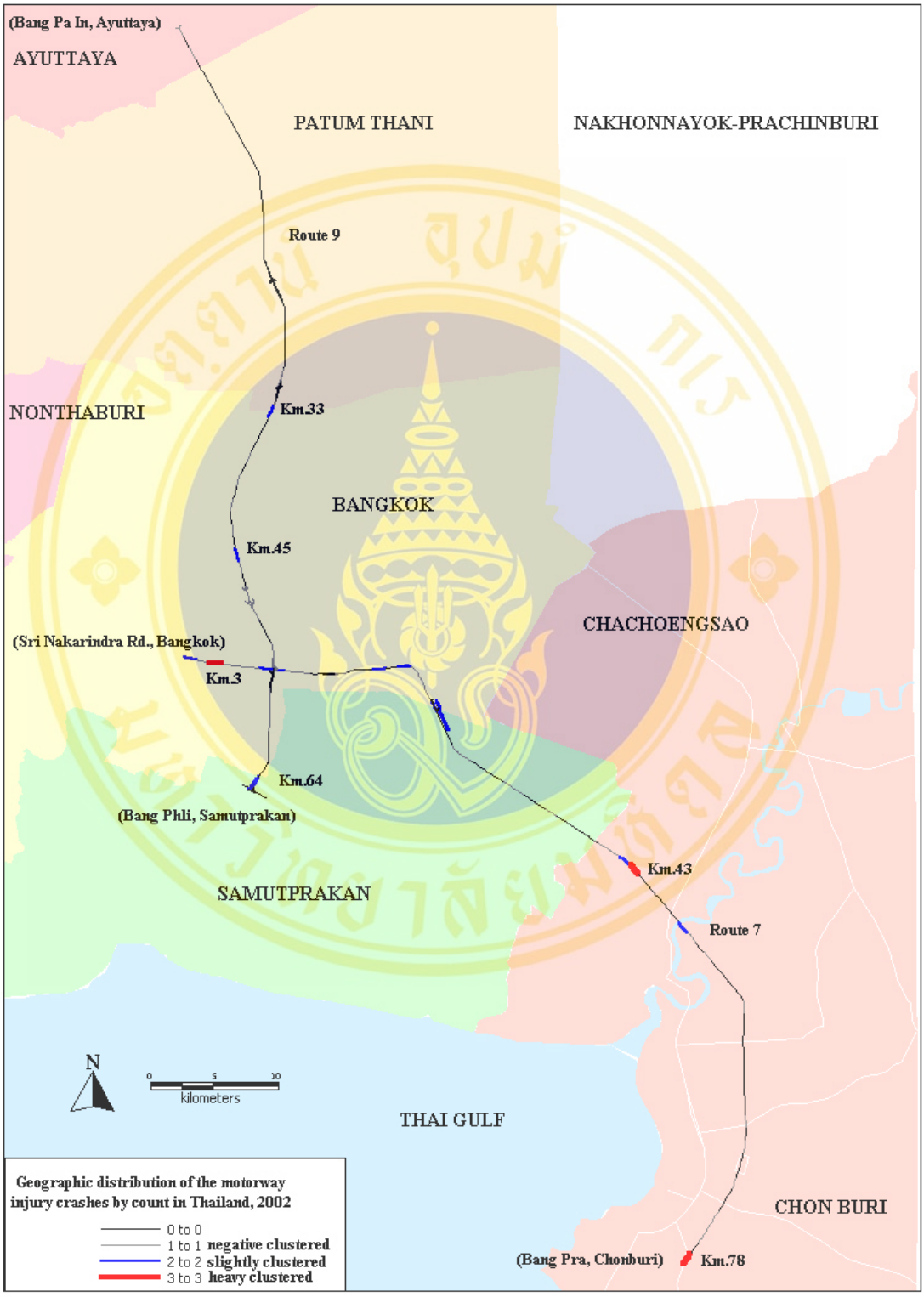


Figure 14. Geographic distribution of Motorway injury crashes, 2002

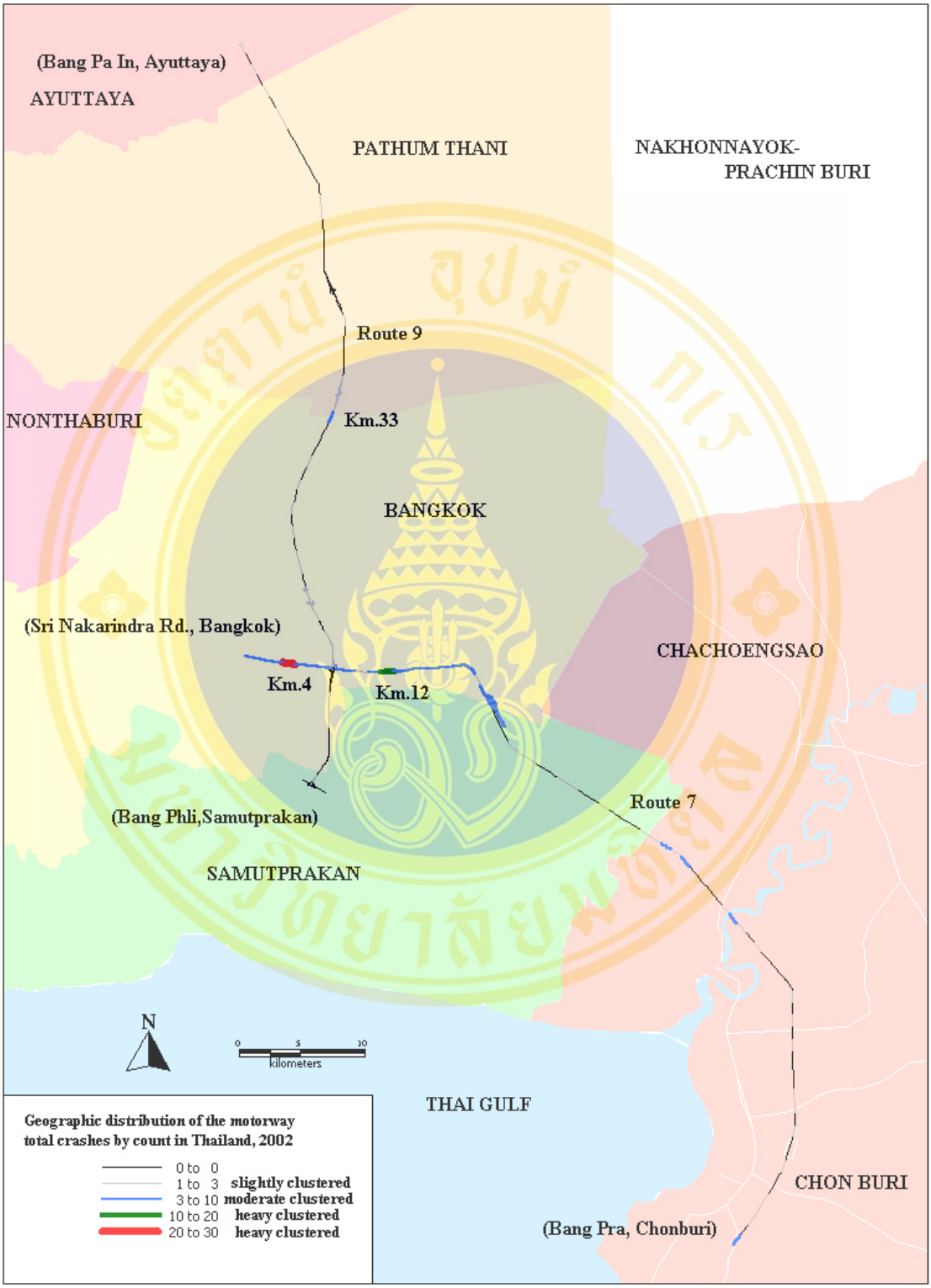


Figure 15. Geographic distribution of Motorway total crashes, 2002

4.3 Result for the specific objective 3; To investigate the distribution of accidents involving casualties on motorways during the year 2002 at different times of the day.

The association between the number of road traffic accidents involving casualties by month and different time of accident on motorways during the year 2002 was shown in table 11. It was found that the percentages of number of the injury crash at different time of the day were 36.1% in 24.00-07.59, 19.4% in 20.00-23.59, 18.1% in 12.00-15.59, 13.9% in 16.00-19.59, 12.5% in 08.00-11.59 respectively.

Measures of central tendency and variability in number of the injury crashes per month at different time of the day showed that mean was 1.08 (SD $\pm$ 1.56) in 12.00-15.59, 0.83 (SD $\pm$ 1.19) in 16.00-19.59, 1.17 (SD $\pm$ 1.40) in 20.00-23.59, 2.17 (SD $\pm$ 1.40) in 24.00-07.59, 0.75 (SD $\pm$ 0.75) in 08.00-11.59.

When Repeated Measures analysis was performed to assess the effect of different time of day on the injury crash. It was found that the difference among of different time of the day on the injury crash do approach statistical significance (Multivariate Test: Hotelling's Test, p-value = 0.036). And after plotting graph as shown in figure 16 between means of injury crashes per month and each different time of day, It showed that 24.00-07.59 appeared to be the time mostly affecting on the crashes followed by 20.00-23.59, 12.00-15.59, 16.00-19.59 and 08.00-11.59 respectively.

Table 11. Frequency distribution of number of injury crashes at different time of day

Time	N	%	Mean	SD	P-value: Hotelling's Test
12.00-15.59(1)	13	18.1	1.08	1.56	0.036
16.00-19.59(2)	10	13.9	0.83	1.19	
20.00-23.59(3)	14	19.4	1.17	1.40	
24.00-07.59(4)	26	36.1	2.17	1.40	
08.00-11.59(5)	9	12.5	0.75	0.75	

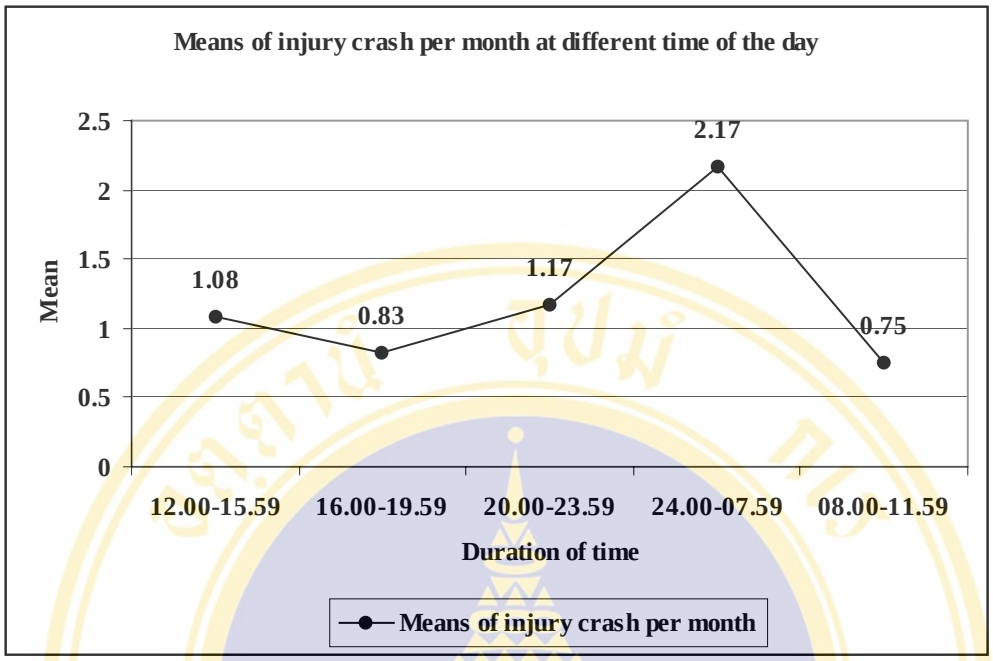


Figure 16. The association between means of injury crash per month and duration of time of the day

4.4 Result for the specific objective 4; To compare number of accidents involving casualties per day occurring on weekdays and weekends on motorways during the year 2002.

The association between the day of week and number of accidents involving casualties per day on motorways during the year 2002 was shown in table 12. It was found that there was slightly difference in percentage of number of the accidents per day between weekday (48.6%) and weekend (51.4%).

Measures of central tendency and variability in number of the accidents per day per month showed that mean was .206 (SD± .179) in weekday and mean was .201 (SD± .151) in weekend. When paired t test was used to assess the association between the day of week and number of the accidents. It was found that there was a statistically non-significant difference of number of the accidents between weekday and weekend (P-value = 0.825, 95%CI = -1.79-1.46).

Table 12. Frequency distribution of number of accidents per day per month on day of week

Number of crash per day on	N	percentage	mean	SD	P value	95%CI Lower	Upper
weekday	35	48.6	.206	.179	0.825	-1.79	1.46
weekend	37	51.4	.201	.151			

4.5 Result for the specific objective 5; To identify factors associated fatal crashes on motorways during the year 2002.

The result of this objective is based on 72 records from police database which involving road traffic casualties on motorways during the year 2002.

Tabular presentations of the different factors involving road traffic casualties were presented into four groups.

1. Descriptive presentation for Personal factor.
2. Descriptive presentation for Road and Environmental factors.
3. Descriptive presentation for Vehicular factor.
4. Association between dependent variable (injury crash) and independent variables (Personal, Road and Environmental, Vehicular factors) using cross-tabulation.
5. Association between dependent variable (fatal crash) and independent variables (Personal, Road and Environmental, Vehicular factors) using binary logistic regression.

4.5.1 Descriptive presentation for Personal factor

4.5.1.1 Table 13 showed that among 72 episodes, regarding major cause of accident, the majority (61.1%) was over speeding driving followed by careless driving (8.3%), drowsy driving (6.9%), driving with machinery deterioration (6.9%), closer following driving (5.6%), cut across driving (4.2%), heavy rainy driving (2.8%), driving with non-respect road traffic sign and signal (2.8%) and overload driving (1.4%) respectively.

Table 13. Frequency distribution of Personal factor

Personal factor	Number (n=72)	Percentage (%)
Major cause of accident		
• over speeding driving	44	61.1
• careless driving	6	8.3
• drowsy driving	5	6.9
• driving with machinery deterioration	5	6.9
• closer following driving	4	5.6
• cut across driving	3	4.2
• heavy rainy driving	2	2.8
• driving with non-respect road traffic sign and signal	2	2.8
• overload driving	1	1.4

4.5.2 Descriptive presentation for Road and Environmental factor

4.5.2.1 Table 14 showed that regarding time of accident, the highest number of accidents (36.1%) occurred on 24.00-07.59 followed by the moderate number of accidents (19.4% and 18.1%) occurred on 20.00-23.59 and 12.00-15.59 respectively, and the rest were accidents (13.9% and 12.5%) occurred on 16.00-19.59 and 08.00-11.59 respectively.

Regarding day of week, the percentage of number of accidents occurred on weekday and weekend were 51.4% and 48.6% respectively.

Regarding month of accident, the highest number of accidents (20.8%) occurred on April followed by the high number of accidents occurred on January (13.9%), September (11.1%) and February (11.1%). The moderate number of accidents occurred on May (8.3%), December (8.3%), August (6.9%) and July (5.6%). The rare number of accidents occurred on October (4.2%), November (4.2%), March (2.8%) and June (2.8%).

Regarding day of accident, the percentage would rather be not different. The high percentages were Friday (16.7%) and 15.3% were found on Monday, Tuesday and Wednesday as well. The rest were Thursday (13.9%), Sunday (12.5%) and Saturday (11.1%).

Regarding the route, 68.1% and 31.9% of number of the accidents were found in route 7 and 9 respectively.

Regarding nature of crash site, the accidents occurred on the straight road (81.9%) and less than one-fourth occurred on the curve road.

Regarding intersection and bridge, the accidents predominantly took place on where have no intersections (94.4%) and no bridges (93.1%). The rest occurred at intersection(5.6%) and bridge (6.9%).

Table 14. Frequency distribution of Road and Environmental factor

Road and Environmental factors	Number (n=72)	Percentage (%)
Time of accident		
• 24.00-07.59	26	36.1
• 08.00-11.59	9	12.5
• 12.00-15.59	13	18.1
• 16.00-19.59	10	13.9
• 20.00-23.59	14	19.4
Day of week		
• Weekday	37	51.4
• Weekend	35	48.6
Month of accident		
• January	10	13.9
• February	8	11.1
• March	2	2.8
• April	15	20.8
• May	6	8.3
• June	2	2.8
• July	4	5.6

(continued.)

Road and Environmental factors	Number (n=72)	Percentage (%)
• August	5	6.9
• September	8	11.1
• October	3	4.2
• November	3	4.2
• December	6	8.3
Day of accident		
• Sunday	8	11.1
• Monday	11	15.3
• Tuesday	11	15.3
• Wednesday	11	15.3
• Thursday	10	13.9
• Friday	12	16.7
• Saturday	9	12.5
Route		
• 7	49	68.1
• 9	23	31.9
Nature of crash site		
• Straight	59	81.9
• Curve	13	18.1
Bridge		
• No	67	93.1
• Yes	5	6.9
Intersection		
• No	68	94.4
• Yes	4	5.6

4.5.3 Descriptive Presentation for Vehicular factors.

4.5.3.1 Table 15 showed that regarding type of vehicle involved. Two-third (66.7%) of the accidents came from vehicles which were not involved heavy vehicle. About one-third (33.3%) involved heavy vehicle.

Regarding number of vehicle involved, the majorities were the accidents involved one vehicle (47.2%) and two vehicles (40.3%). The rest were the accidents involved three vehicle (9.7%), four vehicles (1.4%) and nine vehicles (1.4%).

Table 15. Frequency distribution of Vehicular factor

Vehicular factor	Number (n=72)	Percentage (%)
Type of vehicle involved		
• Heavy vehicle involved	24	33.3
• No heavy vehicle involved	48	66.7
Number of vehicle involved		
• 1 vehicle	34	47.2
• 2 vehicles	29	40.3
• 3 vehicles	7	9.7
• 4 vehicles	1	1.4
• 9 vehicles	1	1.4

4.5.4 Association between dependent and independent variables by using cross tabulation

4.5.4.1 Association between injury crash and Personal factor.

4.5.4.2 Association between injury crash and Road and Environmental factors.

4.5.4.3 Association between injury crash and Vehicular factors.

4.5.4.1 Association between injury crash and Personal factor.

In table 16. Major cause of accident had been statistically analyzed for association with fatal crash. Over speeding (61.1%) was the highest major cause of the accidents. Among this cause, 16.7% of injury crashes contributed to fatal crash. Second cause was drowsy driving (6.9%) which 5.6% of injury crashes led to fatal

crash. Major cause of accident was found to be significantly associated with injury crash at P value, (P = 0.049).

Table 16. Percentage of injury crash, in association with Personal factor. (n=72)

Personal factor	Injury crash				Total	Statistical analysis
	Non-fatal		Fatal crash			
	n=52	%	n=20	%	72	
Major cause of accident						
• over speeding driving	32	44.4	12	16.7	44	χ^2 =15.577
• careless driving	5	6.9	1	1.4	6	P = 0.049
• drowsy driving	1	1.4	4	5.6	5	
• driving with machinery deterioration	5	6.9	-	-	5	
• closer following driving	4	5.6	-	-	4	
• cut across driving	2	2.8	1	1.4	3	
• heavy rainy driving	-	-	2	2.8	2	
• driving with non-respect road traffic sign and signal	2	2.8	-	-	2	
• overload driving	1	1.4	-	-	1	

4.5.4.2 Association between injury crash and Road and Environmental factors

Table 17. showed that eight groups; time of accident, day of week, month of accident, day of accident, route, nature of crash site, intersection and bridge had been statistically analyzed for association with Injury crash.

For time of accident, the highest number of the accidents (36.1%) appeared to be occurred on 24.00-07.59 and 12.5% of injury crashes was fatal crash. Second duration time (18.1%) appeared to be occurred on 12.00-15.59 and 5.6% of injury crashes was fatal crash. There was non-significant association between time of accident and injury crash at P-value, (P= 0.313).

Regarding day of week, it was interesting that there was not only slightly different among number of accidents between weekday and weekend (51.4% and 48.6% respectively) but the fatal crash was equally distributed (13.9%) between them

as well. Day of week was not found to be significantly associated with injury crash at P-value, (P= 0.884).

According to month of accident, the majority of accidents (20.8%) occurred on April and 6.9% of injury crashes was fatal crash and it showed that this factor had a significant association with injury crash at P-value, (P= 0.029). And the frequency distribution of number of fatal crash and non-fatal crash by month was shown in figure 17.

With regard to day of accident, it was surprising that there was slightly difference among the number of accident among day of accident (11.1-15.3%) and the percentage of fatal crash (4.2%) on each day was equally distributed. It was found that a non-significant association with injury crash at P-value, (P= 0.982).

According to route, the majority of accidents (68.1%) appeared to be occurred on route 7 and 19.4% of injury crashes was fatal crash. It showed that this factor had a non- significant association with injury crash at P-value, (P= 0.826). And travelling on route 7 appeared to have 1.13 times (95% CI 0.33-4.02) greater chance of fatal crash occurrence than route 9.

Regarding nature of crash site, it was interesting that the majority of accidents (81.9%) appeared to be occurred on straight road and 20.8% of injury crashes was fatal crash. With the help of chi-square test, it was proved that nature of crash site was non-significant related to injury crash at P-value, (P= 0.342).

Regarding intersection, the majority of accidents (94.4%) appeared to be occurred on the location where had no intersection and 25% of injury crashes was fatal crash. There was non-significant association between intersection and injury crash at P-value, (P= 0.307).

Regarding bridge, the majority of accidents (93.1%) appeared to be occurred on the place where had no bridge and 25% of injury crashes was fatal crash. There was non-significant association between bridge and injury crash at P-value, (P= 0.427).

Table 17. Percentage of injury crash, in association with Road and Environmental factors. (n=72)

Road and Environmental factors	Injury crash				Total	Statistical analysis
	Non-fatal		Fatal crash			
	n=52	%	n=20	%	72	
Time of accident						
• 24.00-07.59	17	23.6	9	12.5	26	$\chi^2 = 4.756$
• 08.00-11.59	5	6.9	4	5.6	9	P = 0.313
• 12.00-15.59	9	12.5	4	5.6	13	
• 16.00-19.59	9	12.5	1	1.4	10	
• 20.00-23.59	12	16.7	2	2.8	14	
Day of week						
• Weekday	27	37.5	10	13.9	37	$\chi^2 = 0.021$
• Weekend	25	34.7	10	13.9	35	P = 0.884
Month of accident						
• January	9	12.5	1	1.4	10	$\chi^2 = 21.448$
• February	6	8.3	2	2.8	8	P = 0.029
• March	-	-	2	2.8	2	
• April	10	13.9	5	6.9	15	
• May	6	8.3	-	-	6	
• June	2	2.8	-	-	2	
• July	4	5.6	-	-	4	
• August	3	4.2	2	2.8	5	
• September	5	6.9	3	4.2	8	
• October	-	-	3	4.2	3	
• November	3	4.2	-	-	3	
• December	4	5.6	2	2.8	6	
Day of accident						
• Sunday	5	6.9	3	4.2	8	$\chi^2 = 1.855$
• Monday	8	11.1	3	4.2	11	P = 0.933
• Tuesday	9	12.5	2	2.8	11	

(continued.)

Road and Environmental factors	Injury crash				Total	Statistical analysis
	Non-fatal		Fatal crash			
	n=52	%	n=20	%	72	
• Wednesday	8	11.1	3	4.2	11	
• Thursday	7	9.7	3	4.2	10	
• Friday	9	12.5	3	4.2	12	
• Saturday	6	8.3	3	4.2	9	
Route						
• 7	35	48.6	14	19.4	49	$\chi^2 = 0.48$
• 9	17	23.6	6	8.3	23	P = 0.826
Nature of crash site						
• Straight	44	61.1	15	20.8	59	$\chi^2 = 0.903$
• Curve	8	11.1	5	6.9	13	P = 0.342
Bridge						
• Yes	3	4.2	2	2.8	5	$\chi^2 = 0.400$
• No	49	68.1	18	25.0	67	P = 0.527
Intersection						
• Yes	2	2.8	2	2.8	4	$\chi^2 = 1.403$
• No	50	69.4	18	25.0	68	P = 0.307

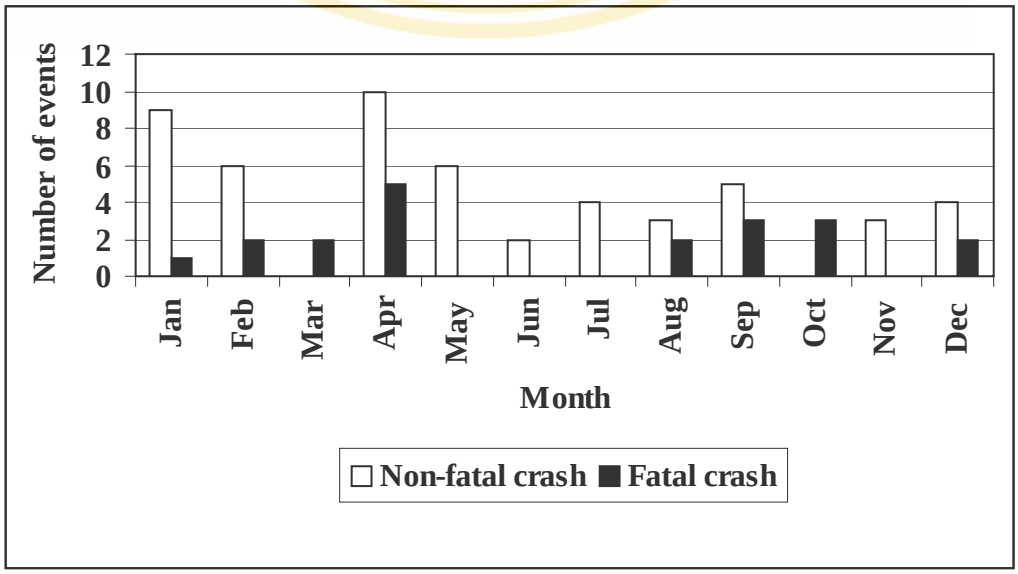


Figure 17. The frequency distribution of number of fatal crashes and non-fatal crashes by month

4.5.4.3 Association between injury crash and Vehicle factors.

Table 18.showed that two groups; type of vehicle involved and number of vehicle involved had been statistically analyzed for association with injury crash.

Regarding type of vehicle involved, the injury crashes involving heavy vehicle accounted for 33.3% and 11.1% of injury crashes was fatal crash. The other factor that was studied for its association with injury crash was number of vehicle involved, and it was found that two of majority (47.2% and 40.3%) occurred with episodes which had only one vehicle and two vehicles involved respectively. 15.3% and 11.1% of injury crashes were fatal crash relating one vehicle and two vehicles involved respectively. Both factors were not found to be significantly associated with injury crash at P-value, (P= 0.457 and P= 0.780 respectively).

Table 18. Percentage of injury crash, in association with Vehicular factors. (n=72)

Vehicular factor	Injury crash				Total	Statistical analysis
	Non-fatal		Fatal crash			
	n=52	%	n=20	%	72	
Type of vehicle involved						
• Heavy vehicle involved	16	22.2	8	11.1	24	$\chi^2 = 0.554$
• No heavy vehicle involved	36	50.0	12	16.7	48	P = 0.457
Number of vehicle involved						
• 1 vehicle	23	31.9	11	15.3	34	$\chi^2 = 1.760$
• 2 vehicles	21	29.2	8	11.1	29	P = 0.780
• 3 vehicles	6	8.3	1	1.4	7	
• 4 vehicles	1	1.4	-	-	1	
• 9 vehicles	1	1.4	-	-	1	

4.5.5 Association between dependent variable (fatal crash) and independent variables (Personal, Road and Environmental, Vehicular factors) using binary logistic regression.

It was found that number of fatal crashes and non-fatal crashes were too few to compute odds ratio, which was used to assess magnitude of the association between fatal crash and relating factors.

CHAPTER V
DISCUSSION

5.1 Discussion

Road traffic accidents are second most fatal non-infectious cause of death and disability within Thai population. Road traffic accidents account for 35% of the total accidents. The economic losses are over 100 billion bahts. Moreover the country is loosing productive year of life in these road traffic mishaps (Pattanothai, 2001). Medical Division of Public Health Ministry reported in 1999 that mortality trend of road traffic is rapidly increasing-21.2 (1993), 22.8(1994), 24.4(1995), and 27.2(1996) per 100,000 (Medical Division of Public Health Ministry, 1999). Actually police is the first authority who faced the origin of the crash.

This descriptive study used the secondary data from Police Information System center during the period 1995-2002 to identify trends overtime of death rate, injury rate and other factors involving road traffic accidents such as gender, cause of accident and type of vehicles involved. It was found that death rate per 10,000 vehicles among province had decreased from the period 1995 to 1998 and would rather keep constant until 2002. And, injury rate per 10,000 vehicles among province had decreased from the period 1995 to 1999 and then increased until the year 2002. In Thailand, It was known that the period of the financial bubble was 1993-1997 after that the country faced economic crisis during 1997-2000 and then the economy has just recovered until now. It showed that both rates had declined whereas the end of the financial bubble and the economic crisis happened during the year 1995-2000 and injury rate increased during the economic recovery during the year 2000-2002. But death rate would rather keep constant during the year 2000-2002. It might reflect good supporting from Government about law enforcement of many campaigns such as “drunk don’t drive”, helmet use, seat belt use while the economy recovered. It could reduce injury severity and control death rate.

In this study, there was pattern of trends close to a report by Suriyawongpaisal et al. in 2003 reported that from the period 1984 to 2000, the number and rate of traffic injury in Thailand swung from a record low during the economic recovery in the 1980s to a high record during the period of bubble economy, and then a decline as the country approached the latest period of economic crisis in 1997 (Suriyawongpaisal *et al.*, 2003). This study used death and injury per 10,000 registered vehicles but they used death and injury per 100,000 populations. Owing to having several denominators such as number of population at risk, number of vehicles involving at defined area or the distance which that vehicle had been driven before crash (Mercer, 1987) used in identification of death and injury rate, there was the difference in the value of outcome. Suriyawongpaisal *et al*. in 2003 also reported that when rate per 10.000 vehicles was considered, from 1998-2000, the Central region ranked first among regions by death rate and injury rate. This data was documented by the Highway Department of Thailand whose responsibility accounted for 23% of the national highway network (Suriyawongpaisal *et al.*, 2003). As compared with the study about trends of road traffic crashes and associated injury and fatality in the People's Republic of China were studied by Wang *et al*. in 2003. It was reported that the crash, fatality and injury rates also increased after 1985 until 1999, due to increase motorization spurred by rapid economic growth (Wang *et al*., 2003). As this study, the economic status affected on death rate and injury rate. Regional difference occurring within death and injury rate in this study might reflect different law enforcement, a gap of appropriateness of vehicle registration, socio-economic characteristic of each province, risk behavior of drivers, different status of travelling promoting province and underreporting of police data.

Regarding Gender, during the period 1995-2002, it revealed that number of deaths among female accounted for an average of around 20 % of total victims and male accounted for an average of around 80 %. For severe injuries, male accounted for an average of around 74 %. And female accounted for an average of around 26 %. Male constituted around 75% of the people mildly injured in 1995 before decreasing slightly to around 70% in 2002. The same results were reported in China, Colombia, Ghana, Kenya, Mexico, Mozambique, the Republic of Korea, Trinidad and Tobago, Vietnam and Zambia that all indicate greater rates of male as opposed to female

involvement in road traffic collisions (Nantulya VM *et al.,* 2003). And in Columbia (Rodriquez *et al*., 2003) and Singapore (Wong *et al.,* 2002) also showed the same result of percentage of fatal accidents as this study. Male drivers usually exhibit a higher probability to become involved in serious or fatal accidents. This finding was found in Holubowycz et.al. in 1994, Massie et.al. in 1995, Zhang et.al. in 2000, Hayakawa et.al. in 2000 and Valent et.al. in 2002. It may reflect that females may excluded as drivers or passengers, and in general may face less exposure to road traffic crash risk for cultural or economic reasons.

With regard to cause of accident, The percentage of over speeding driving increased from 23.5% in 1995 to 28.4% in 1997 before decreasing slightly to around 22.8% of total road traffic accidents in 2002. Whereas in Ghana (Afukaar, 2003) and South African (Ministry of Transport, 2001) reported that 50% of such crashes are related to speed. It may reflect that speed was identified as the main contributory factor of road crashes but the proportion of speed in Thailand was lower than the other. It may come from aggressive driving in term of police definition was divided into several causes such as over speeding, running lights, improper lane changes, failing to yield the right of way and etc. Another reason could be police reports about speeding involving accidents based on observations by police and/or statements by the drivers or witnesses.

The percentage of drunk driving slightly increased from 2.0% of total crashes in 1995 to 3.1% of total road traffic accidents in 2002. In similarity, The result was reported in Utah, USA (Smith *et al.,* 2004) found that almost 2% of all crashes involved drunk driving. Information on alcohol involvement and driver fatigue may also less reliable since it is obtained by the investigating police officers. However, a study by Grossman et al. (1996) suggested that in the case of alcohol intoxication under-reporting by police officers is not a significant problem. It might reflect that drivers involving drunk driving were likely to be speeding or aggressive driving apparently based on police reports, which were likely to be less accurate. The other reason, drunk driving may be under-reported in particularly where those involved were severely injured and taken to hospital.

And drowsy driving accounted for an average of 0.5 % of total road traffic accidents. The result was reported in Utah, USA (Smith *et al.,* 2004) found that

approximately 1% of crashes was distributed to driver fatigued. Fatigue is known to be under-reported as a contributory crash factor because there is generally little evidence to prove that a crash-involved driver was drowsy or felt asleep (McCartt *et al.*, 2000). But fatigue was reported as a contributing factor in the injury crash as well especially fatal crashes involving heavy commercial transport or work unduly long hours. Therefore, it is possible that only the most severe cases of fatigue-related crashes are reported.

According to vehicle type of road traffic accident, the percentage of motorcycle involving road traffic accident accounted for 29.4% of total vehicles in 1995 and had increased gradually into 36.8% in 2002. It was the same report as the study of Ichikawa *et al.*in 2003 that motorcycle crashes account for the majority of traffic injuries in Thailand, motorcyclist are a highest risk group of road users. In contrast, The percentage of car and truck involving road traffic accident decreased from 30.8% and 8.7% to 26.9% and 5.3% respectively. As compared to report of Health Statistic Yearbook of Vietnam in 1999 showed that vehicles involved in road traffic accidents as follows: 62.3% were motorcycles and 27.2% were cars. It may reflect that the level of education affected income, which in turn influences the choice of transport and the associated road traffic risks. So the poor population groups the affordable transport mode would be passenger bus or motorcycle. The other accounted for an average of 32%.

Another data in this study was secondary data from motorway police stations in the year 2002, which had 205 accident episodes.72 out of 205 was injury crash.It was studied in term of the concentration of crashes and factors related to fatal crash. Motorways consist of special highway route 7 and 9. Average traffic flow is between 1,207 and 2,055 vehicles per day and 9-13% of which was trucks, respectively. Special highway route 7 started from Sri Nakarindra road, Bangkok- Samutprakan-Chachoengsao - the Chonburi - Pattaya Highway (Sai Mai). Special highway route 9 started from Bang Pa In, Ayuttaya - Lam Looka, Patumtanee - Ram Indra, Bangkok - Bang Phli, Samutprakan.

For road map of motorway. Regarding route 7, the high concentration of crash involving casualties were located within three crash clusters on kilometer 3rd, 43rd,

78th. It was found that two crashes clusters on kilometer 3rd (Pravej, Bangkok) and 43rd (Bangsamak, Chachoengsao), there was under renovation on some part of the road surface. Even having traffic sign to inform location which was still on remedy but that signalization could not resist the excessive speed or other cause of the vehicle which was running fast. The other probable cause was the driver would drive across the bridge from kilometer 1st to 2nd, the curve portion of road on kilometer, might make the driver loss his control and face easily the crash on kilometer 3rd. And regarding kilometer 43rd, there was Bang Khwaj interchange at kilometer 40th, which connected between Bang Na Trat and motorway route 7. It made the connecting portion at kilometer 42nd for the way to chonburi. Drivers who came from Bang Na Trat road and attempted to slip into the traffic stream of motorway route 7, which took them to pattaya or chonburi, might face injury crash if they drove carelessly with high speed. On the last cluster kilometer 78th (Chonburi), there was an interchange which could lead the drivers to 3 different ways; Pattaya, Chonburi and U-turn to the opposite lane. Wrong decision of driver might cause accident involving casualties any time.

Regarding route 9, the high concentration of crashes involving casualties were located within three crash clusters on kilometer 33rd, 45th, 64th. It was found that on the first cluster kilometer 33rd was straight portion of road which lead driver to Klong Ra Hang bridge. Driving with high speed on slippery road could cause injury crash any time. On kilometer 45th, there was Seri-Thai interchange which led to the byroad that could go to Ramkamhaeng road. It needed careful driving and good decision of drivers. On the third cluster kilometer 64th (Bangphli, Samutprakan), it was Wat Salut interchange which took drivers to Bangphli highway. It was the terminal of motorway route 9. Sharing lanes properly and lowering driving speed were needed for drivers there.

For high concentration of total crashes in 2002. Regarding route 7, it was located within two clusters on kilometer 4th and kilometer 12th. On kilometer 4th, it consisted of 22 property-damage crashes and 1 injury crash. As mentioned above about the characteristic of road from kilometer 1st, 2nd and 3rd which was bridge and curve and straight portion of road. High speed of driving with carelessness might lead to loss of control and encounter accident. The latter one, kilometer 12th(10 property-damage crashes), which was Rom Klao interchange which could lead drivers to other roads;

Onnut road and the opposite way, Meen buri, It also needed careful driving and good decision of drivers. Owing to route 9, high concentration of total crashes occurred on kilometer 33rd, which consisted of 1 property-damage crash and 2 injury crashes. It was the same portion of road as high injury crash in the same year. It showed that driving with high speed on straight road might affect crash occurrence.

The findings reflected that negative road engineering owing to road renovation including careless driving aimed to crash involving casualties. Another finding was lowering driving speed, careful driving and good decision of drivers can reduce crash occurrence at any interchange, nearby junction and crossroad. As compared to findings of Ogden in 1996, poor engineering can contribute to crashes. The road network has an effect on crash risk because it determines how road user perceive their environment and provides instruction for road users, through signs and traffic controls, on what they should be doing. The same result, negative road engineering factors include those where a road environment misleads a road user and thereby creates error, was found in study in European Transport Safety Council in 1996.

In the year 2003, Intercity Motorways office improved both motorways, which made the characteristic of some portion of road change. More data collection and addition analysis was conducted and shown in Appendix C by using two data sources of motorway, highway and police data. The secondary data from pooled sources, motorway police data and highway data, in the fiscal year 2004, which had 638 accident episodes. 80 accident episodes were injury crash. The result showed that in 2004, regarding route 7, high concentration of injury crashes occurred on kilometer 50th. There was the service area of motorway, those traffic would rather be congested. Attempting to slip into the traffic stream of motorway at the exit of service area might cause accident especially facing with high-speed motor vehicle.

For route 9, there were three clusters of high injury crash, kilometer 44th, 53rd and 62nd. On kilometer 44th which was straight road before reaching Seri-Thai interchange. High speed of driving with wrong decision might cause accident. On kilometer 53rd, there was Thub Chaeng interchange which driver could go to motorway route 7(Chonburi-Bangkok). High speed of driving with wrong decision might cause accident as well. On kilometer 62nd, which was the straight portion before reaching Wat Salut interchange. High speed of driving with wrong decision might also cause

accident. Comparing with injury crash in 2002, it was found that on route 7, the area of high injury crash was changed. It might reflect the impact of improvement of traffic engineering in 2003. On route 9, the areas that still have problem were kilometer 44th-45th and 62nd-64th. All of those were interchanges. Prior warning by striking sign or signal before reaching interchange about destination and reducing speed might be importance for drivers.

For total crashes on motorways in 2004, Regarding route 7, there were three clusters of high concentration of total crash, kilometer 1st, 12th and 53rd. On kilometer 1st (18 property-damage crashes) that was bridge portion. It might reflect attempting to slip into the traffic stream of motorway with high speed driving could cause easily crash. On kilometer 12th, Rom Klao interchange, it consisted of 10 property-damage crashes and 1 injury crash. It was the same portion of total crash in 2002. That meant the actual need for solving this problem. Prior warning by striking sign or signal before approaching accident-prone interchange about destination and reducing speed might be used for drivers as well. On kilometer 53rd (11 property-damage crashes) which was straight road before entering the service area of motorway. Reducing speed and careful driving was good for drivers to decide the way to go. Besides, it was found in 2004 that the awareness of injury and property-damage crashes should focus on the straight road before entrance and exit of the service area (between kilometer 50th-53rd).

Owing to route 9, there were four clusters of high concentration of total crash, kilometer 26th, 45th, 52nd and 62nd. On kilometer 26th (Thanyaburi temporary toll area) and 52nd (Thub Chaeng temporary toll area) consisted of 13 property-damage crashes and 2 injury crashes, and 15 property-damage crashes respectively. As it was known that number of truck involved on route 9 was higher than those involved on route 7. This study showed that crash occurrence at temporary toll area on route 9 was more than those on route 7. Attempting of truck driver to pass temporary toll as soon as possible by forcing themselves into the traffic stream in order to meet their delivery schedules might cause accident. Accidents might be caused by single or multiple-vehicle crashes. On the other hand, truck drivers almost were shift-worker and had long working. Fatigue-truck drivers might cause easily accident at both temporary toll areas.

For kilometer 45th and 62nd, there were Seri-Thai interchange and straight road before approaching Wat Salut interchange. 15 property-damage crashes occurred on kilometer 45th and 5 injury crashes and 13 property-damage crashes occurred on kilometer 62nd. High speed driving with wrong decision might cause accident especially kilometer 62nd, wrong decision driving by sudden lane changing driver might cause the car fell into the ditch between lane and cause easily injury crash including fatal crash. Comparing with total crashes in 2002, it was found that road improvement can change the accident-prone area. Comparing with injury crash in 2004 about risk area, it was found that the same portions (kilometer 44th-45th, 52nd-53rd and 62nd) affected both injury and property-damage crash simultaneously.

From additional study, it was summarized about the differences between highway and police data which shown in table 19.

Table 19. Comparison between highway and police data in the fiscal year 2004

Highway data	Police data
-Focus on events causing property of highway damage which led to sue offender and claim for money.	-Focus on events causing injury crash by referring to criminal law which led to sue and take offender to the court.
-Events which did not cause property of highway damage were not recorded.	-Such property-damage events were missing and not recorded.
-Lack of notification of degree of injury severity of victims in record	-Lack of mildly injured events which the parties arrive at some consensus about responsibility for the crash.
-Brief detail of accident location and no cause of accident was shown in record.	-Detail of location and cause of accident were shown in record.
-Details of offender were recorded	-Only name and gender of offender were recorded.

From additional study; secondary data from pooled sources (highway and police data) in the fiscal year 2004, which had 278 accident episodes on route 7 and 360 accident episodes on route 9. 31 and 49 injury crashes were reported on route 7 and 9

respectively. But there were only 107 and 179 accident reports recorded by special highway police route 7 and 9 respectively. It might reflect underreporting of police data when comparing with pooled data as follows: 61.51% in police station route 7 and 50.28% in police station route 9.

The incidence of road traffic accidents also varies with such environmental factors as time of the day, day of the week and type of road design (Wongsuwan *et al.*, 1991). Regarding day of week, It was found that its distinction does not appear to influence the injury crash on motorways occurring in the year 2002. In contrast, the findings of Martin JL. in 2002 about day of week showed that in heavy traffic level, the number of crashes was higher on weekdays than weekends because of the restriction of truck traffic on weekends in France. It is different from Thailand where truck traffic is available anytime. This is not surprising because most drivers of goods vehicles drive aggressively during normal working days in order to meet their delivery schedules. On the other hand, the private vehicles mainly drive during weekends and some of them may become involved in risky driving practices.

Regarding the different time of the day, there was significantly increasing of number of injury crashes on after midnight to 7.59am. (P=0.036). As compared to findings of Yau KK.W. in 2004, Accident taking place after midnight (from 00.00-07.59) have a higher risk of the involvement of fatal and serious injuries (OR= 2.557, 90% CI=1.431-4.568). or while for private vehicles severe accidents usually occur from midnight to early morning (00.00-07.59).This is probably due to this duration of time, drivers characteristically indulge in risky driving and illegal car racing.

Regarding factors related to injury crashes analyzed by cross-tabulation, Personal factor (Major cause of accident), Road and Environmental factors (Day, Time and Month of accident, Day of week, Route, Nature of crash site) and Vehicular factors (type and number of vehicle involved) were discussed as follows.

5.1.1 Personal factor

Major cause of accident was significantly related to injury crash (P= 0.049). About one-sixth (16.7%) of injury crashes appeared to be fatal crash caused by over speeding. As the report from a Speed Fact Sheet (2002) in United States indicated that speed was a factor in 12% of all 2,000 fatal crashes on Iowa and speed played a part in

a number of serious injuries in speed-related crashes during 2000. Especially, speeding was also a major contributor to road crashes involving young drivers. It reflects that over speeding is directly related to the occurrence of fatal crash, because of fast driving, driver could not control the vehicle and causes accident.

5.1.2 Road and Environmental factors

Day of accident was not significantly related to injury crash (P= 0.933). It appeared to have no difference of fatal crash among day. In contrast with the findings of Janjua KA. in 2002, the accidents mostly occurred on Sunday. It might be no restriction of truck traffic on holiday.

Time of accident was not significantly related to injury crash (P= 0.313). About one-eighth (12.5%) of injury crashes appeared to be fatal crash occurred on 24.00-07.59. It is similar to the findings of Yau KK.W. in 2004, Accident taking place after midnight (from 00.00-07.59) have a higher risk of the involvement of fatal crashes. It might reflect on crash involving drowsy driving, which was found that nearly three-quarters of those occurred on 24.00-07.00 (Horne *et al.*, 1995). Fast and monotonous driving on motorways could cause driver felt asleep. From this study showed that 5.6% (4 of 72) of injury crashes appeared to be fatal crash involving drowsy driving. So drowsy driving ranked second cause of accidents.

Month of accident was significantly related to injury crash (P= 0.029). About almost one-fourteenth (6.9%) of injury crashes was fatal crash occurred on April. It is similar to the findings of Khon Kaen Regional Hospital in 1992 that April is the month of the maximum accidents. It might reflect on long-weekend, Songkran festival. Passengers like to drink alcohol and pour the water to other car while are on high-speed vehicle. From this study, it was found that during Songkran (long weekend festival; 13rd-16th April 2002) there were 13 property damage crashes and 2 non-fatal (injury) crashes. Majority (11 of 13 or 84.6%) of property damage crashes occurred on 08.00-15.59 am. One third of fatal crashes were equally distributed among 12.00-15.59, 16.00-19.59 and 20.00-23.59. For another long weekend festival in Thailand, New year festival (31st December-1st January 2002),), there was only 1 fatal crash which occurred on 24.00-07.59 am. And no injury and property damage crash. And Chinese New Year on February, there was no road traffic crash occurred.

Day of week was not significantly related to injury crash (P= 0.884). It appeared to have no difference of fatal crash among day of week. In contrast with the findings of Mao *et al.*in 1997, Qayed in 1998, It was found that number of crashes was higher on weekend. So the reason might be most drivers of goods vehicles drive aggressively during normal working days in order to meet their delivery schedules, and the private vehicles mainly drive during weekends and some of them may become involved in risky driving practices.

Regarding route, It was found that in about nearly one fifth (19.4%) of injury crashes appeared to be fatal crash occurred on route 7 whereas one twelfth (8.3%) of those appeared to be fatal crash occurred on route 9. Route was not significantly related to injury crash (P= 0.826). As compared to the findings of Martin JL. in 2002, It was found that the victim of a crash is higher when traffic was light. According to route 7, hourly traffic flow is lighter than route 9. So these caused fatal crash appeared to occur on route 7 more than route 9.

Nature of crash site, Bridge and intersection were not significantly related to injury crash (P= 0.342), (P=0.527) and (P= 0.307) respectively. About one fifth (20.8%) of injury crashes appeared to be fatal crash occurred on straight road whereas one fourth (25%) of injury crashes appeared to be fatal crash occurred on the location which have no bridge and intersection respectively. It is similar to the findings of Marie-France in 1991, Kumjuddussakorn in 1986, Methaluck in 1991, Geamgool in 1994 and Kangkakate in 1979, those were found that the most accidents occurred at straight road and 90% of fatal crashes happened on the straight portion of the roads (Marie-France, 1991). It could reflect that on the straight roads especially with good lighting, well structure road as motorway and good traffic flow, the driver may be careless and drove day long with fast speed than the usual one.

5.1.3 Vehicular factors

Type of vehicle involved was not significantly related to injury crash (P= 0.457). It was found that in about one sixth (16.7%) of injury crashes appeared to be fatal crash without heavy vehicle involved. It is similar to the findings of Rodriques *et al.* in 2003 that in large cities such as Bogota', Medellin, Cali, 63% of all vehicles involved in crashes were private vehicles (automobiles, light trucks, sports utility, off-road vehicle, etc.), 7% were commercial vehicles (trucks with two or more axles). The

probable reason could be that with the different speed limit assigned on motorways, It made the private vehicle was driven carefully in order to stay away from heavy vehicles.

Number of vehicle involved was not significantly related to injury crash (P= 0.780). It was found that in about nearly one sixth (15.3%) of injury crashes appeared to be fatal crash involving one single vehicle. In contrast, the findings of Martin JL. in 2002 reported that crashes involving one single vehicle decrease as traffic flow increases. The probable reason could be that careless driving with high-speed may loss of control and cause accident without collision with other car.

According to factors related to fatal crash, It was reported that number of fatal crashes and non-fatal crashes are too few to compute odds ratio or magnitude of effect of relating factors.

However, on the motorways observed, hourly flow rates were always showing saturated traffic. It seemed likely to be found that when the traffic flow increased, the traffic density increased. In the same way, not only the average all-vehicle speed decreased at the same time but also it made the severity of crash decreased. The same result was reported in France (J-L Martin, 2002), it showed that for 2-lane motorways, the lighter hourly traffic flow was, the higher number of crashes were. Numbers of crashes were highest when hourly traffic flow was 500 vehicles per hours. This study concerned only motorways, which means, compared to the rest of the network, a better visibility at night, well-structure road, and less problems with alcohol during journeys. The proportion of injury crashes was 72 out of 205 (35.1%). It was N= 20 for fatal crash and 52 for non-fatal crash. It made number of fatal crashes and non-fatal crashes to be too few to compute odds ratio or magnitude of effect of relating factors and decreases the statistical power to identify important risk factors.

For this study, there were multiple groups, Police Information System Center, Department of Land Transport, Special highway police station Route 7 and 9, involved in managing and collecting data, gap existed thus decreasing data reliability. About police data, the reason of underreporting of police data might come from the number of crash not resulting in injury or death was approximate, due to cases in which reconciliation between those involved was reached and the crash was not reported to authorities. Another possible explanation was that the socio-economic and cultural

context in Thailand might imply that people were less willing to call the police than other country. The collection and analysis of data on the cause of vehicle crashes was at the discretion of a traffic police officer, who determined the 'most likely cause' in situ and registered it on a road traffic crash report. The technically deduced cause afterward was not entered in the report. Under current data collection schemes, the logbook is not specifically designed to record traffic crash data, the recording protocol being used among various police station was not uniform. Police officers might realize about management of criminal case more than recording accident form because of complicate process in taking offender to the court. Police officers responsible for the recording are not trained for the job. The frequent transfers in the police force create additional variation in recording. Moreover the data are not edited and cleaned at all steps. Regarding motorway data, it was found that the percentage of incompleteness of data in 2002 was shown in table 20.

Table 20. The incompleteness of data of motorway police stations, 2002

Factor	Route 7(n)	Route 9(n)	percentage (N=205)
1. Location of crash site	1	-	0.5(1)
2. Accident day and time	3	2	2.4(5)
3. Road surface	80	20	48.8(100)
4. Nature of crash site	9	16	12.2(25)
5. Detail and severity of casualties	5	21	12.7(26)
6. Cost of property damage	5	18	11.2(23)
7. Detail of vehicle	5	30	17.1(35)
8. Probable cause	9	13	10.7(22)

Source: Special highway police station route 7 and 9

Another data was the number of registered vehicles in Thailand recorded by Department of Land Transport. It should be aware of the vehicles that were discharged (destroyed, obsolete, stolen, etc.) in order to be the correct up-to-date records.

5.2 Limitation of the study

1. Cross-sectional study was applied to use in this study which the weaknesses consist of
    - Susceptible to selection bias
    - Susceptible to misclassification
    - Information on all factors is collected simultaneously, so it can be difficult to establish a putative cause antedated the effect.
2. Police databases only were studied.
3. Minor crashes, which the parties arrive at some consensus about responsibility for the crash, were not reported.
4. Only deaths on spot and injury, which were defined by Criminal Law section 297, were recorded.
5. Deaths after hospitalization of road accident victims were recorded as injuries.
6. For motorway data, this sample size, one-year data, is too small.
   So the number of non-fatal and fatal crash was not enough to compute odds ratio.

CHAPTER VI
CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The study about trends was conducted by using data from Police Information System center. The secondary data during the year 1995 and 2002 were studied in term of death rate, injury rate, type of vehicle involving road traffic accidents and cause of accidents. Descriptive studies showed that the death and injury rates had declined when the end of financial bubble and the economic crisis happened (1995-2000) and had increased during the economic recovery (2000-2002). Regarding gender affected injury severity of crash, minor trends of decrease were found for males who died, were severely and mildly injured. There were minor trends of increase in all three indicators for females. For all indicators of injury severity of males were as opposed to female. For cause of accident, there was a minor trend of decrease for speeding. Speed was still the main contributory factor of road traffic accident followed by drunk driving. It was found that there was a minor trend of increased drunk driving. It was one of cause of accidents that Thai Government has campaigned since 2001 and start using law enforcement on March 2001. And drowsy driving, It was showed that there was no trend for police-reported drowsy driving-related crash. Although drowsy driving would account for low percentage (0.5%) but fatigue was reported as a contributing factor in the injury crash as well especially fatal crashes involving heavy commercial transport or work unduly long hours. Moreover, motorcycle was the most outstanding contributing factor in road traffic accidents. There was a minor trend of increased motorcycle whereas private car and truck involvement in road traffic accidents had minor trends of decline.

Another data studied in term of accident-prone area and factor related to fatal

crashes was motorway data, data from special highway police station route 7 and 9, in the year 2002. Owing to motorway, it showed higher standard of design, particularly with respect to access to the carriageway and control of roadside activity and development (Suriyawongpaisal *et al*., 2003). These motorways make road travel convenient and quick, reducing the driving time but continuity, monotonous and high-speed condition. In the year 2002 and 2004, Data from 2 sources, highway and police data were used to study about accident-prone area. By crash plotting on digital motorway map, crash clusters were found on road-surface-improved area, temporary toll area, the nearby junction area and the interchange area.

The first problem, traffic engineering and high speed driving without careless contributed to injury crash easily. The second problem came from threatening attempt to the traffic stream in order to approach tollgate with careless driving, which could easily encounter crash. And the last one, the interchange or the nearby junction area where drivers could choose the way to go, poor decision driving with high speed including poor engineering always caused crash as well. Besides, there were some portions of motorway route 7 and 9 that were both high injury and property-damage crashes during the year 2004. It were kilometer 50^{th}-53^{rd} on route 7 and kilometer 44^{th}, $53^{rd}$and 62^{nd} on route 9.

Regarding number of injury crashes by day of week and the different of time within a day, it was found that there was no significant difference of number of injury crashes between weekday and weekend (P=0.825, 95%CI = -1.79-1.46) but in the different of time, there was significantly increasing of number of injury crashes after midnight to 07.59am. (P=0.036).

Regarding the factor relating injury crashes, it appeared to be found that the speeding driver in the period midnight to 07.59hr on motorway route 7, in the straight portion with no intersection or bridge in April, was more prone to a fatal crash without several and heavy vehicle involvement than the other groups. From this result, two factors, cause and month of accident, were significantly related to injury crash (P = 0.049, 0.029). Owing to low number of fatal and non-fatal crash, it could not compute the odds ratio in order to see the magnitude of effect of the factors.

6.2 Recommendations

1. Police data.

1.1 Non-uniformity handwritten notes of police clerk in certain station should be changed into inputting accurately data into report form, which was set up in computer software.

1.2 Increasing such potential variables of offender that leads to prevention and reducing of road traffic accident. The variables are age, presence of driving license, and seat belt use.

1.3 Police officers who are responsible for recording should be trained for the same standard.

1.4 Problem of transferring in the police force, which created additional variation in recording, should be solved.

1.5 Definition of variables, which was edited, should be understood by police officers who are responsible clearly.

2. Motorway data

2.1 Prior warning by striking sign or signal before reaching interchange about destination and reducing speed should be conducted.

2.2 Prior warning by striking sign or signal before reaching the entrance and exit of the service area about destination and reducing speed should be conducted.

2.3 In law enforcement, there is a need to strengthen mobile police patrol units so that it can achieve its full daily patrol schedule and targets. This includes improvement in the overall maintenance of the resource required to increase the effectiveness of the police who presence on the roadway.

2.4 Owing to overlapping between highway and police data, increasing collaboration of both sources are importance to further improve traffic accident prevention on motorways.

3. Factors related to fatal crashes on motorways

3.1 Data collection more than one year would be better to analyze relating factors and compute odds ratio.

4. Owing to starting to increase number of lanes from 2 to 4 of motorway route 7 since 2004 and followed by route 9 in the end of this year, it should be studied for number of crashes while number of lane increases. As the findings of Martin JL. in

2002 in France, it was reported that in light traffic (1000-1500 vehicles per hour), the number of crashes is higher on 3-lanes than 2 lanes motorways.

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APPENDIX

APPENDIX A

Summarized road traffic accident report occurring in area.....

Month.....Year..... Total number of accident.....case

Number of road user or of vehicle involved accident		Cause of accident		Total loss	
1.pedestrian	.....	1.excessive speed	.....cases	1.death	male..... female.....total.....
2.bicycle	.....	2.sudden cut across driving	.....cases	2.severe injury	male..... female.....total.....
3.tricycle	.....	3.illegal passing of driving	.....cases	3.mild injury	male..... female.....total.....
4.motorcycle	.....	4.turn the light off-driving	.....cases	4.property dama	total.....Baht
5.motor-tricycle	.....	5.no signal given when want to park or slow down or turn the direction	.....cases	Alleged offender	
6.private car	.....	6.non-respect of stop signal	.....cases	1.arrested	male..... female.....total.....
7.van	.....	7.non-respect of traffic light	.....cases	2.escaped	male..... female.....total.....
8.pick-up	.....	8.no driving in left lane	.....cases	3.unknown	total.....persons
9.passenger bus	.....	9.no showing signal of out of order	.....cases		
10.light truck	.....	10.non-respect of authorized weight	.....cases		
11.large truck	.....	11.less experience driving	.....cases		
12.farmer's equipm	.....	12.machanical breakdown	.....cases		
13.taxi	.....	13.drunk driving	.....cases		
14.others	.....	14.drowsy driving	.....cases		
		15.abuse drug consumption	.....cases		
		16.sudden animal's cut across	.....cases		
		17.wrong lane driving	.....cases		
		18.closer following	.....cases		
		19.no allowance for priority	.....cases		
		20.others	.....cases		
		21.no denoted	.....cases		

Appendix B

Basic Accident record form

Dear Commander (Highway Police Division),

Special Highway route … would report traffic accident case that occurring on responsible area as follows.

1. Accuser name ……
2. Number of accused person ……..person.
   2.1 ……. The first accused person's name.
   2.2 …….. The second accused person's name.

3. Accusation.
   3.1 The first accused person……
   3.2 The second accused person ……

4. Accident site on special highway route… at number of kilometer ……
   Subdistrict ……District ……..Province ……
   Date ……Month …….. Year ……Time(estimated)……

5. Nature of Crash site ( )straight ( )curve ( )slope / steep ( )bridge ( )block U-turn of street isle ( )junction ( )crossroad ( )pedestrian crossing ( )spur track ( )same direction … lane ( )opposite direction ( )dry / wet ( )road surface……..

6. Number of casualties.
   6.1 Died ….person. Male…..person. Female….person. Child.….person
   6.2 Severely injured.…person. Male…..person. Female….person. Child.….person
   6.3 Mildly injured ….person. Male…..person. Female….person. Child.….person

7. The estimated cost of property damage……..bahts.
8. The detail of involved vehicle on crash site.
   8.1 Vehicle type …….Brand……Color……..Number-plate…….
   8.2 Vehicle type …….Brand……Color……..Number-plate…….
   8.3 Vehicle type …….Brand……Color……..Number-plate…….
9. Probable causes ( ) Over speeding ( ) Cut across driving ( ) Drunk driving ( ) illegally passing of driving ( ) Wrong lane driving ( ) Closer following of driving ( ) Drowsy driving ( ) Non-respect of traffic signal driving ( )Others…

10. Accept petition of traffic case number…./year……,Evidence number…./year……

Signature …….
Deputy Superintendent of service section
of special highway route ….
Report to Highway Police Division by radio call number…./year…/on date…/…/….
Signature ……. radio messenger
Date…./……/……

Appendix C: Additional data source and analysis

For better visualization about the overall of the accident-prone area on motorways, more secondary data were collected from special highway police station route 7 and 9, and Intercity Motorways office, Department of Highways, Ministry of Transport and communication (MOTC) during the fiscal year 2004 for analysis.

Data source

Inclusion criteria

All road accident episodes occurring on motorway route 7 and 9 were recorded by special highway police stations route 7 and 9 and Intercity Motorways office during the fiscal year 2004(1st October 2003 to 31st September 2004).

Exclusion criteria

Road accident episodes occurring outside motorway route 7 were recorded by special highway police stations route 7 during the fiscal year 2004(1st October 2003 to 31st September 2004).

Data flow

Police data

The pattern of data flow was mentioned in figure. 4 of Chapter III Research Methodology

Highway data

Investigation team from motorway rescue unit obtained crash notifications from several sources such as the parties of the accident, the accident encounter, Narenthorn center; Ministry of Public Health, accident–report radio program, Highway police information center or member of charity foundations of accident by telephone communication or monitoring police radio communication. After notification, the team reached to the crash scene. Once on-scene, the team collected and recorded on-scene measurements in Highway Accident Report. Data were extracted and put into excel format. The data were compiled at statistical unit of Intercity Motorways office.

Data Analysis

Maps of accident-prone areas consisted of

1. Map of all road traffic crashes of pooled data between police and highway data without repeated events recorded by both sources. The excessive data of those were excluded.

2. Injury crashes of police data

The maps were developed and presented by using MapInfo version 6.0 software. The address of the site where each road traffic crash occurred. Each kilometer has a specific ID code, which serves as the link between attributable data and corresponding spatial area. The crash site presented by number of crashes by count was displayed simultaneously on one single map. The percentage was used to present number of road crashes on that scene in order to see the concentration of the crashes.

Result

In 2004, there were a total of 638 reported road traffic accidents, of which 80 injury crashes. As shown in figure 18, It was found that nearly than 4% (3 of 80) of injury crashes were occurred at Bang Pakong, Chachoengsao on kilometer 50th of motorway route 7. And regarding route 9, It was found that more than 6% (5 of 80) of injury crashes were occurred at Bang Phli, Samutprakan on kilometer 62nd of motorway route 9 and nearly than 4% (3 of 80) of injury crashes were equally distributed at Bangkok on kilometer 44th and 53rd of motorway route 9 as well.

For total crashes, 2004. As shown in figure 19, It was found that nearly 3% (18 of 638) of crashes which were all property-damage crashes occurred at Pravet, Bangkok on kilometer 1st of motorway route 7 and nearly 2% (11 of 638) of crashes were equally distributed at Lat Krabang, Bangkok and Bang Pakong, Chachoengsao on kilometer 12th and 53rd of motorway route 7 respectively. On kilometer 12th which consisted of 10 property-damage crashes and only one injury crash. And on kilometer 53rd which were all property-damage crashes. According to route 9, It was found that nearly 3% (18 of 638) of crashes which consisted of 13 property-damage crashes and 5 injury crashes were occurred at Bang Phli, Samutprakan on kilometer 62nd. More than 2% (15 of 638) of crashes were equally distributed at Lam Lukka, Pratumthani on at kilometer 26th, which consisted of 13 property-damage crashes and 2 injury crashes, and at Buengkum, Bangkok on at kilometer 45th which were all property-damage crashes. More than 2% (17 of 638) of crashes which consisted of 15 property-damage crashes and 2 injury crashes were occurred at Pravet, Bangkok on kilometer 52nd.

All clusters of high concentration of injury crashes and total crashes occurring on motorway route 7 and 9 in the fiscal year 2004 were shown in table 21.

Table 21. The areas of high concentration of injury crashes and total crashes occurring on motorway route 7 and 9 in the fiscal year 2004.

	Route7	Route 9
Injury crashes	Km. 50th	Km. 45th, 53rd, 62nd
Total crashes	Km. 1st, 12th, 53rd	Km. 26th, 45th, 52nd, 62nd

Figure 18. Geographic distribution of Motorway injury crashes, 2004

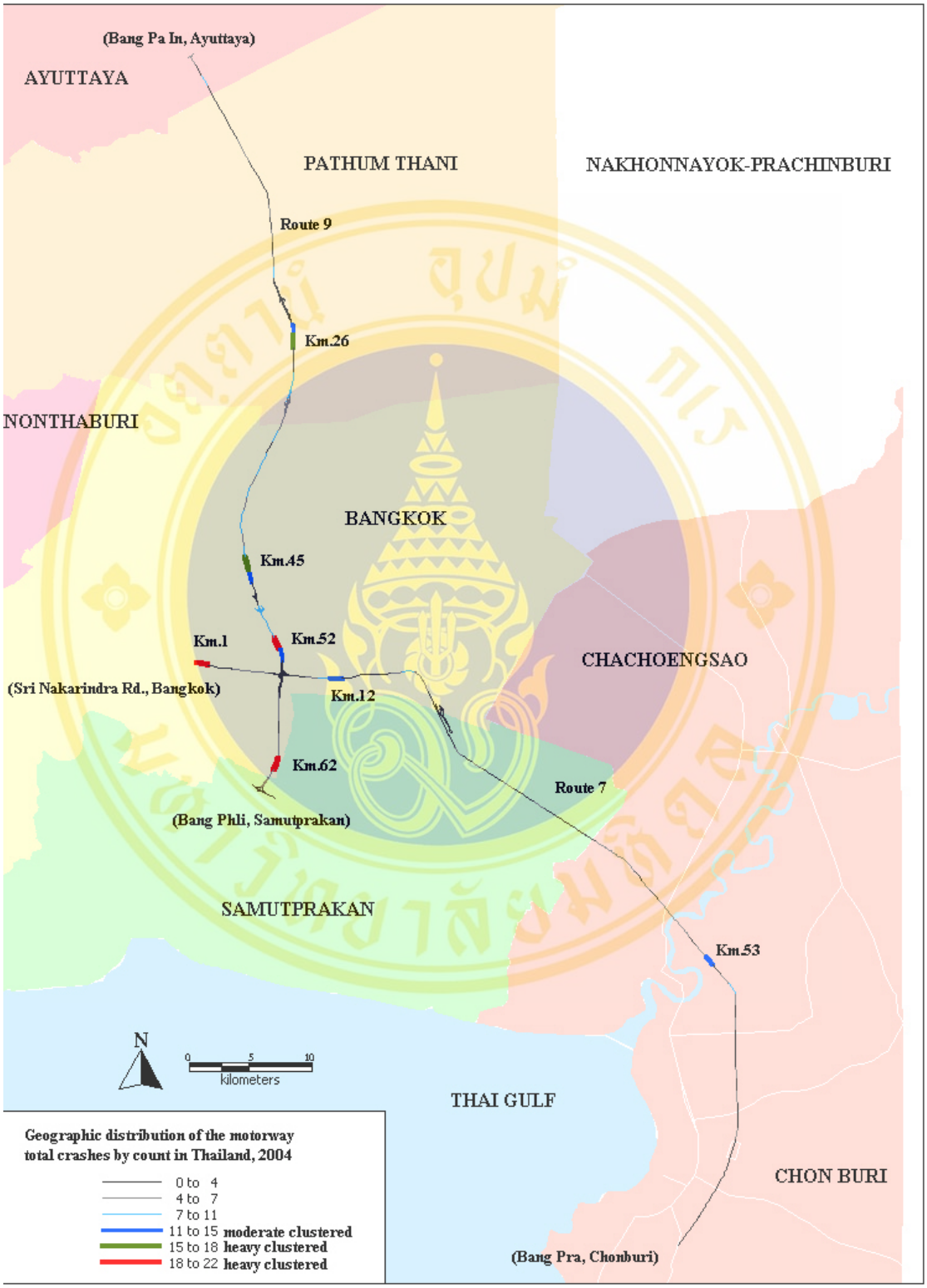
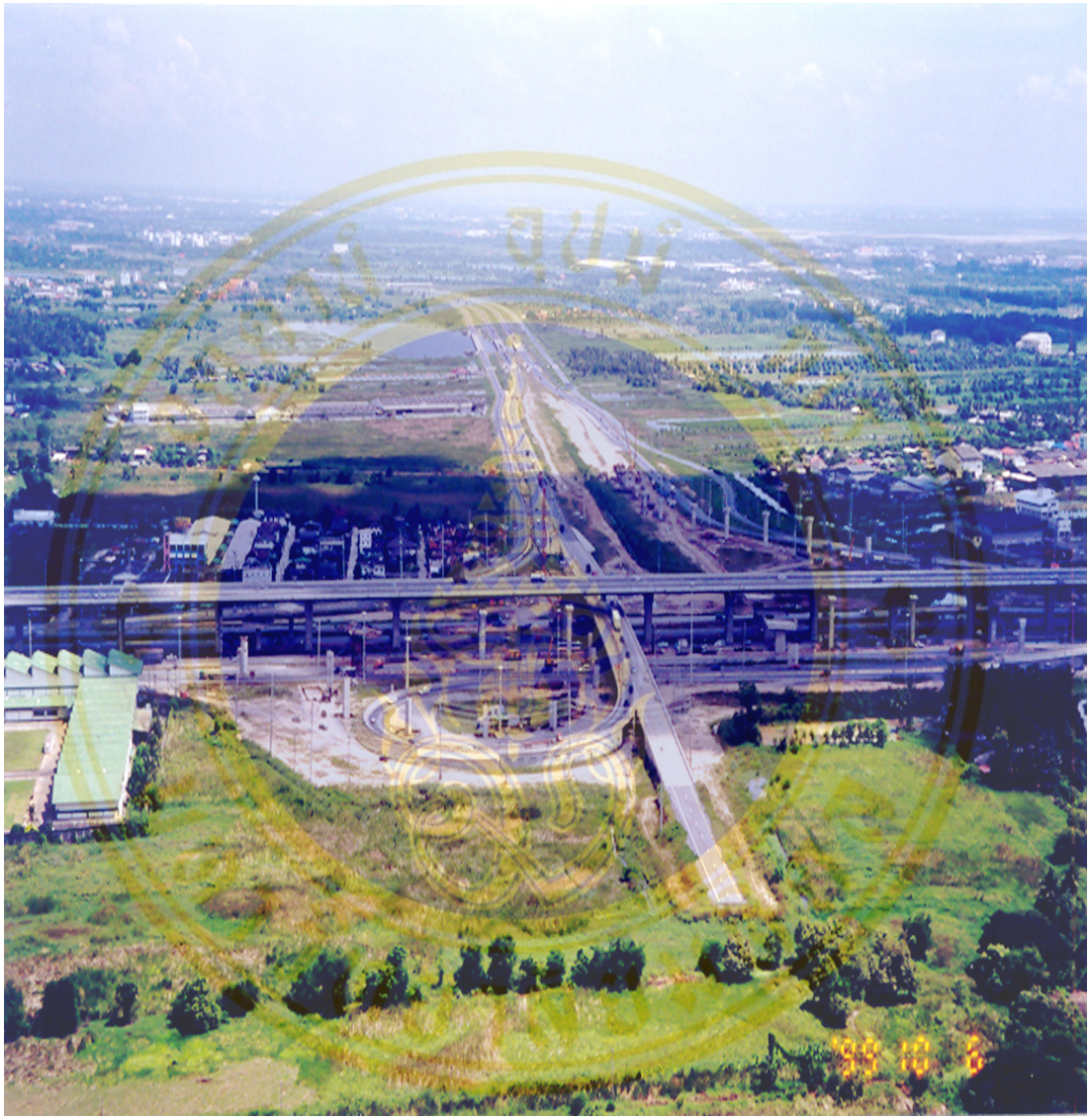


Figure 19. Geographic distribution of Motorway total crashes, 2004

Appendix D: The pictures of accident-prone area on motorways in 2002 and 2004

Picture 1. Bang Pra interchange: motorway route 7; Km.78

Picture 2. Seri-Thai interchange: motorway route 9; Km.45th



<u>Picture 3.</u> Wat Salut interchange: motorway route 9; Km.64th

<u>Picture 4.</u> Bang Khwaj interchange: motorway route 7; Km.40th

Picture 5. Rom Klao interchange: motorway route 7; Km.12th

<u>Picture 6.</u> Service area: motorway route 7; Km.49th-50th

Picture 7. **Thanyaburi temporary toll area**: **motorway route** 9**; Km**.25th

Picture 8. **Thub Chaeng temporary toll area: motorway route** 9**; Km**.51st –52nd

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