APPLICATION OF GEOGRAPHICAL INFORMATION SYSTEM (GIS) AND LOGISTIC REGRESSION ANALYSIS TO INVESTIGATE SPATIAL, TEMPORAL AND CLINICAL RISK FACTORS FOR ROAD TRAFFIC INJURY (RTI) WITHIN KOTA BHARU DISTRICT

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by

NIK HISAMUDDIN BIN NIK AB RAHMAN

Thesis submitted in fulfillment of the requirements for the degree of Doctor of Philosophy

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DEDICATION

This thesis is dedicated to my beloved parents, my siblings and my wife Hasliza binti Mohd Khalid. Thanks for their sincere love, patience and sacrifices.

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All praise and glory goes to Allah SWT, the almighty who alone enabled your humble servant to accomplish this thesis successfully. May Peace be upon his prophet and his family and his companions until the day of Judgement.

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Last but not least, I wish to dedicate my work to my utterly beloved wife, Hasliza Binti Mohd Khalid, who throughout my study, has relentlessly encouraged and motivated me until I have reached this point in my life. Her patience and perseverance has yielded string of colors in my life. Also to my family members, especially to my nephew and nieces, who have immensely supported me emotionally to progress in my career. To my late father, Nik Abdul Rahman Bin Nik Yusoff, you were truly my inspiration. May Allah bless his pure soul in Heaven….Ameen.

Nik Hisamuddin Nik Ab Rahman

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ACTH	Adenocorticotrophic hormone
AIS	Abbreviated injury scale
ART	Ambulance response time
AUC	Area under curve
BMI	Body mass index
BOR	Bed occupancy rate
CI	Confidence interval
CRP	C-reactive protein
DALY	Disability adjusted life years
DTM	Data tool management
ED	Emergency department
ERTIs	Electronic road traffic injury surveillance system
ESPARR	Etude et Suivi d'une Population d'Accidentés de la Route du Rhône
FSQ	Functional status questionnaire
GCS	Glasgow coma scale
GIS	Geographical Information System
GPS	Global positioning system
HDU	High dependency unit
HRPZ	Hospital Raja Perempuan Zainab
HUSM	Hospital Universiti Sains Malaysia
ICD	International classification of disease
ICU	Intensive care unit
IDW	Inverse distant weighting

ISS	Injury severity score
JKJR	Jabatan Keselamatan Jalanraya
JKR	Jabatan Kerja Raya
LOS	Length of stay
MIROS	Malaysian Institute of Research For Road Safety
MLR	Multiple logistic regression
MOH	Ministry of Health
MVC	Motor vehicle crash
NTRD	National trauma registry database
OR	Odd ratio
PDRM	Polis DiRaja Malaysia
ROC	Receiving operator curve
RR	Respiratory rate
RTA	Road traffic accident
RTI	Road traffic injury
RTS	Revised trauma score
SBP	Systolic blood pressure
SD	Standard deviation
TBI	Traumatic brain injury
TRISS	Trauma and Injury Severity Score
USM	Universiti sains Malaysia
WHO	World Health Organization

APLIKASI ANALISA SISTEM MAKLUMAT GEOGRAFI DAN REGRESI LOGISTIK UNTUK MENYELIDIK FAKTOR RUANG, MASA DAN KLINIKAL UNTUK KECEDERAAN JALANRAYA DI DAERAH KOTA BHARU

ABSTRAK

Kajian kohort prospektif telah dilakukan bermula Julai 2011 sehingga Jun 2013 melibatkan sampel populasi yang cedera akibat kemalangan jalanraya dalam daerah Kota Bharu. Sampel diambil daripada kes-kes yang didaftar di Jabatan Kecemasan Hospital USM dan Hospital Raja Perempuan Zainab (2) Kota Bharu, Kelantan. Data yang dikumpul telah dianalisa secara georuang dan regresi logistik pelbagai dengan menggunakan perisian ARCGIS versi 10.1 dan SPSS versi 22.0.

Keseluruhan sampel yang direkrut adalah sebanyak 439 kes. Purata umur mangsa ialah 26.04 years (s.d 15.26) dan lelaki merupakan kumpulan jantina yang paling biasa iaitu sebanyak 302 (71.7%) kes. Penunggang dan pembonceng motosikal merangkumi 351 (80.0%) kes dan lokasi panas kejadian secara amnya berlaku di jalan dan simpang di mukim Kenali dan Binjai. Kes trauma berbilang paling kerap berlaku di jalanraya kelajuan had maximum 60 km/jam.

Peningkatan skala ISS sebanyak satu akan meningkatkan keberangkalian kurangupaya semasa discaj sebanyak 37% (95% CI: 1.253, 1.499, p-value $<$ 0.001). Keberangkalian kurangupaya semasa discaj untuk golongan pediatrik berkurangan sebanyak 52.1% (95% CI: 0.258, 0.889, p-value $<$ 0.001) manakala keberangkalian kurangupaya semasa discaj untuk kes yang terlibat dengan pembedahan adalah 4.14

lebih tinggi (95% CI: 1.681, 10.218, p-value = 0.002). Peningkatan skala ISS sebanyak satu akan meningkatkan kebarangkalian untuk kemasukan ke wad sebanyak 50% (95% CI: 1.359, 1.650, p-value <0.001). Golongan lelaki dan kes yang menerima intervensi pelbagai akan meningkatkan keberangkalian untuk kemasukan ke wad sebanyak 3.1 (95% CI: 1.345, 7,138, p-value = 0.008) dan 6.1 (95% CI: 3.095, 12.121, p-value < 0.001) masing-masing.

Kajian ini melibatkan gabungan analisa georuang dan statistik bagi tujuan penilaian perhubungan antara kecederaan kemalangan jalanraya, ruang dan pembolehubah klinikal. Secara amnya gabungan georuang dan analisa tradisional statistik adalah teknik kajian yang berupaya tinggi dan berpotensi dalam bidang kecederaan membabitkan kemalangan jalanraya.

APPLICATION OF GEOGRAPHICAL INFORMATION SYSTEM (GIS) AND LOGISTIC REGRESSION ANALYSES TO INVESTIGATE SPATIAL, TEMPORAL AND CLINICAL RISK FACTORS FOR ROAD TRAFFIC INJURY WITHIN KOTA BHARU DISTRICT

ABSTRACT

This was a Prospective Cohort Study commencing from July 2011 until June 2013 involving all injuries related to motor vehicle crashes (MVC) attended Emergency Department (ED), Hospital Universiti Sains Malaysia and Hospital Raja Perempuan Zainab 2 (HRPZ 2) Kota Bharu Kelantan. Selected attributes were geospatially analysed by using ARCGIS (by ESRI) software version 10.1 licensed to the USM and Google Map free software and multiple logistic regression was performed by using SPSS version 22.0.

A total of 439 cases were recruited. The mean age (SD) of the MVC victims was 26.04 years (s.d 15.26). Male comprised of 302 (71.7%) of the cases. Motorcyclists were the commonest type of victims involved 351(80.0%). Hotspot MVC locations occurred at certain intersections and on roads within Mukim Kenali and Binjai. The number of severely injured and polytrauma are most on the road network within speed limit of 60 km/hour.

A person with an increase in ISS of one score had a 37 % higher odd to have disability at hospital discharge (95% CI: 1.253, 1.499, p-value < 0.001). Pediatric age group (less than 19 years of age) had 52.1% lesser odds to have disability at discharge from hospital (95% CI: 0.258, 0.889, p-value < 0.001) and patients who underwent operation for definitive management had 4.14 times odds to have disability at discharge from hospital (95% CI: 1.681, 10.218, p-value = 0.002). An increase in ISS of one score had a 50 % higher the odds to be admitted to hospital (95% CI: 1.359, 1.650, p-value <0.001). Men and those who received multi-intervention had 3.1 (95% CI: 1.345, 7,138, p-value = 0.008) and 6.1 times odds (95% CI: 3.095, 12.121, p-value < 0.001) respectively to be admitted to hospitals following MVC.

This study combined geospatial and traditional statistical analyses to evaluate the relationship between injury-related MVCs and clinical parameters and its outcomes. Overall this study has proven that GIS with a combination of traditional statistical analysis is a powerful tool in RTI related research.

CHAPTER 1

INTRODUCTION

1.1 Introduction

Road traffic injury (RTI) is a very common cause of admission to the hospital worldwide, in particular in the developing countries (Hyder and Vecino-Ortiz, 2014). It has been a long and agonizing disease that contributes to major cause of loss to life, long term suffering, disablement and psychological sequelae to both the victims and carer (Nhac-Vu, Hours, Chossegros, et al., 2014). Specifically, it is frequently related to high morbidity and mortality among the young age groups (Le and Blum, 2013). The most productive group of population has been mostly inflicted by injury. Lost of days of work, schooling and earning as a result of the injuries contribute to further socioecenomic deprivation in the society. According to WHO, RTI is ranked ninth among the leading causes of loss of disability-adjusted life years (DALYs) worldwide, and is anticipated to rise to become the third leading cause by 2020 (WHO Global Status Report on Road Safety, 2013). In Malaysia, it is the fourth common cause of death and admission to the hospital over the last 5 years (Health Facts MOH Malaysia, 2012). Considering the global burden of disease per 100,000 populations, Malaysia is at the 20th in the world ranking in terms of prevalence of RTI (34.5 injured per 100,000). It is an ever increasing problem and it is the leading cause of morbidity and mortality in the under 40s age group (Road Safety Annual Report, 2013).

Thus, the main challenge for public health in this century is to decrease the burden of injuries. RTI should be considered as a disease. It has a host (the patient), and it has a vector of transmission (e.g motor vehicle, fall etc.). To reduce morbidity and mortality related to RTI, trauma care planning, injury prevention and systems improvement is extremely important (Larson and Henning, 2013). In a developing nation such as Malaysia, there are currently multiple efforts aimed at strengthening disease burden surveillance as well as addressing issues which have been kept aside for far too long. Preventive programs have been taken with much enthusiasism by multi agencies such as Ministry of Transportation, Polis DiRaja Malaysia, Jabatan Keselamatan Jalanraya & Malaysian Institute of Road Safety Research (Ministry of Transport Malaysia, 2014).

1.2 Problem Statement

Much of the preventive programs and efforts on road safety in Malaysia are based solely on the non-clinical data. Certain aspect has been neglected such as integrated data gathering and keeping which can be the main pillar of future preventive program. Systematic integrated database and surveillance system are much required to enlighten the policy and law makers on the actual burden of the disease in particular in relation to the clinical outcome (Sabariah, Ramesh and Mahathar, 2008). The knowledge of the epidemiological and clinical characteristics of trauma related RTI is the backbone for trauma care planning, injury prevention and systems improvement. The integration between the pre hospital and in hospital data will assist the policymakers and the clinicians in promoting the preventive programs and hence enhance the road safety programs locally and nationwide. Specifically, very little information has been gathered pertaining to the relationship between the spatial information and the actual clinical outcome of the patients who sustain RTI.

Much of the studies in the past just identified clinical parameters of RTI but no correlation analysis has been done in relation to spatial factors (Zulkipli, Abdul Rahmat, Mohd Fauzi et al., 2012) It would be ideal and interesting for the policymakers to know this correlation so that effective preventive and sustainable surveillance programs can be implemented. It can also be a tool for certain agencies like PDRM and JKR to implement their safety program for the road users. Determination of causes will help to create concrete measures to reduce injury fatality. For example creating a proper zebra crossing or pedestrian bridge at very busy intersections will reduce pedestrain related RTI (Senserrick, Boufous, de Rome et al., 2014). The development of prevention strategies, such as education, environmental improvements (spatial parameters), and changes in vehicle design need to be correlated with the actual severity of the disease and clinical outcome of the patients.

However particularly, in Malaysia it is well known that there is lack of research into RTI epidemiology (Tran, Hyder, Kulanthayan et al.,2009 and Sabariah, Ramesh and Mahathar., 2008). Only few articles and work have been carried out mainly by non health sectors on this encumbering issue. No single local work has focussed on the predictors of clinical outcome such as disability and the hospital admission. Thus, the goal of this study is particularly to collect data on the epidemiology, pattern of injury and to relate with spatial data in the district of Kota Bharu. Admissions to the hospital due to injury on the roads in Kota Bharu district consist of approximately 5% of all emergency department admission. However the clinicians and the road safety enforcers constantly focus on the clinical management and traffic violations respectively without much of integration of data. In other words the clinicians are placed in the darkness about the environment where the motor vehicle crash (MVC) occurs and like wise the policymakers are left unaware about the nature of victims' injury and outcome.

This study planned to utilize the geographical information system (GIS) software and performed the spatial-temporo analysis in relation to clinical data for RTI cases attending the emergency department. The primary aim of this study is to document the demographic parameters, the predominant injury mechanisms and severity, geographical positioning data (i.e coordinates of the incidents locations), spatial data, mortality, length of hospital stay and finally the clinical outcome. The overall output is integrated spatial-temporal, pre-hospital and clinical data. This study provides additional reliable and integrated data that can be used for planning current and future trauma care related to RTI in Kota Bharu specifically and in Malaysia generally.

1.3 Research Questions

Based on the problems raised above, this study questioned few pertinent issues:

i. Would the clinical and geographical data integration on motor vehicle crashes ilicit a much clearer picture of the injury demography and outcome pattern of the road traffic injury (RTI) victims?

ii. Would the geospatial analysis assist the investigators in identifying hot spot and high risk areas for motor vehicle crashes (MVC) in Kota Bharu District?

iii. What were geographical pattern and land use within the vicinity of the MVC victims within the Kota Bharu District?

iv. What were the predictive factors of hospital admission among MVC victims in Kota Bharu district?

v. What were the predictive factors of disability at discharge from hospital among MVC victims in Kota Bharu district?

1.4 Objectives

General aim:

To perform geospatial and logistic regression analyses for road traffic injuries (RTI) cases among vulnerable road users within the district of Kota Bharu to investigate the factors correlating with hotspot for MVC and clinical outcomes. The identification of the factors will be the key points for further preventive measures and enhancing clinical care of injured patients both prehospital and inhospital settings.

Objectives:

1. To analyze the general demographic pattern of cases related to motor vehicle crash among the vulnerable road users (motorcyclists and pediatric age) attending the EDs of HUSM & HRPZ II
2. To perform general spatial analysis for the vulnerable road users (motorcyclists, and pediatric age group) involve in RTI based on injury, prehospital, clinical and geographical data
3. To determine the common geographical factors within 100 meters of buffer analysis for vulnerable road users (motorcyclists and pediatric) and severely injured RTI cases
4. To determine the predictive factors for hospital admission post RTI in the District of Kota Bharu
5. To determine the predictive factors for the disability at discharge post RTI in the District of Kota Bharu

1.5 Hypothesis

Hypothesis

i. There will be differences in the demographic pattern of road traffic related injuries among vulnerable road users within the District of Kota Bharu.

ii. There will be differences in the geospatial pattern of RTI among the vulnerable road users based on injury, prehospital, geographical and clinical data within the District of Kota Bharu

iii. There will be differences in the geographical factors presence within the 100-meter buffer among the vulnerable and severly injured motorvehicle crash victims within the District of Kota Bharu

iv. There are various factors that predict the risk hospital admission post RTI in the District of Kota Bharu

v. There are various factors that predict the risk for disability at discharge post RTI in the District of Kota Bharu

1.6 Structure of Thesis

The thesis structure followed the general guide for the thesis writing up set by the Institute of Postgraduate Study of the Universiti Sains Malaysia (USM) (Figure 1.1).

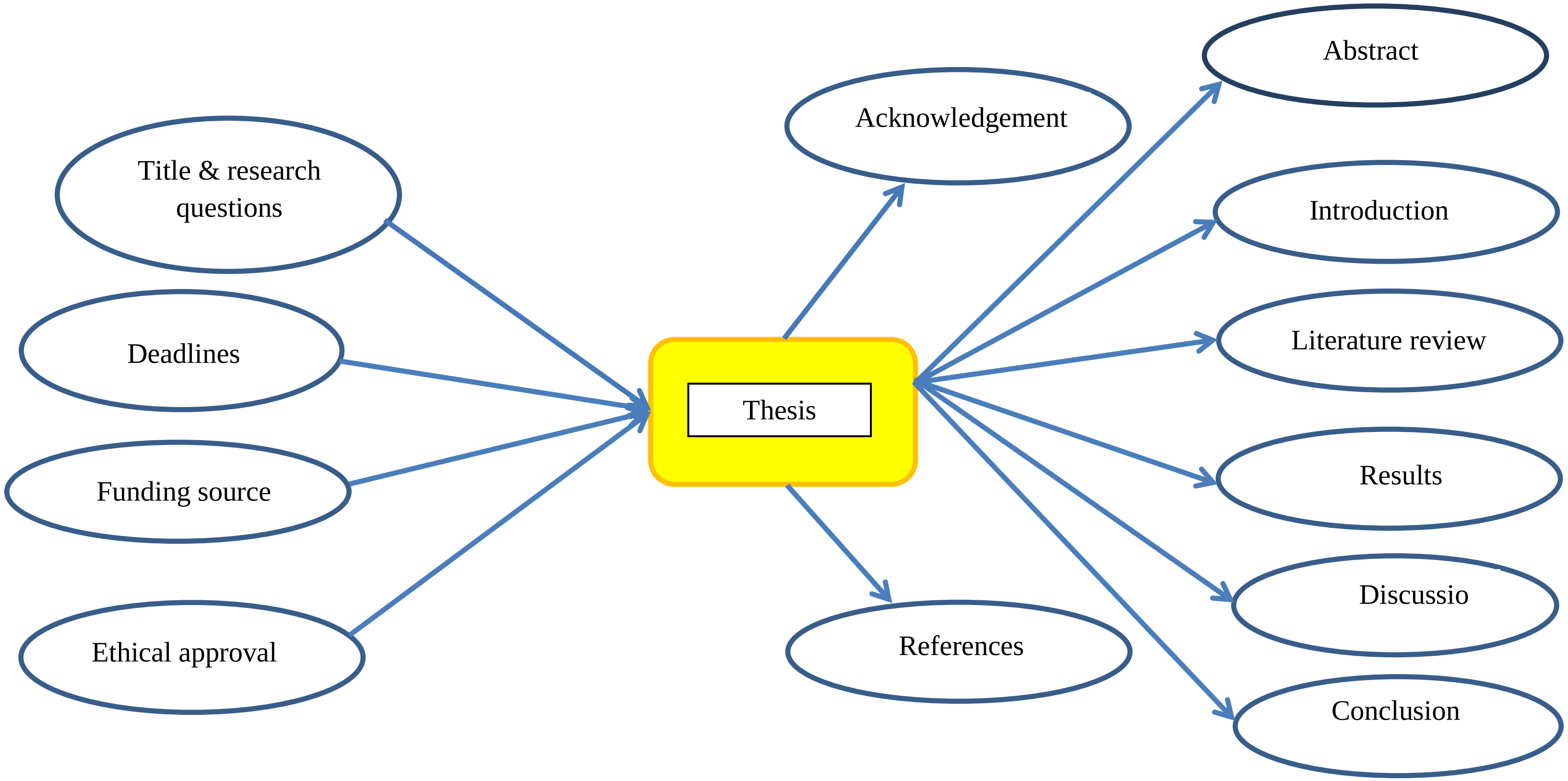

Figure 1.1: Structure of thesis

The ethical approval was granted by the Universiti Sains Malaysia and Ministry of Health Malaysia ethical committee for human research and was registered under National Malaysian Research Registry (NMRR) in 2011. (APPENDIX A)

1.7 Keywords

There are eight main keywords that created the foundation of this study. Those are:

i. Road safety

   It refers to methods and measures for reducing the risk of a person using the road network for being killed or seriously injured. This include for all types of road users either pedestrian or vehicle occupants. The measure for safety includes the prevention of serious injuries and deaths crashes inspite of human fallibility. Safe road program involves the pre, peri and post events. Specifically the programs include the modifications of human, mechanical, social and environmental factors.

ii. Road traffic injury

   It is defined as fatal or non-fatal bodily harm caused by external factors as a result of collision on a public road involving at least one moving vehicle. The vulnerable group of road user includes pedestrian, children, two wheeler users and elderly. The injury data is also related to clinical outcomes such as deaths, hospital admission, disability and complications.

iii. Geographical information system

   It is a system designed to capture, store, manipulate, analyze, manage, and present all types of spatial or geographical data. GIS is a broad term that can refer to a number of different technologies, processes, and methods. It is attached to many operations and has many applications related to engineering, planning, management, transport/logistics, insurance, telecommunications, business and health.

iv. Geospatial analysis

   It is an approach to applying statistical analysis and other informational techniques to data that has a geographical or geospatial aspect. Such analysis would typically employ software (i.e ARCGIS) capable of geospatial representation and processing, and apply analytical methods to geographical datasets.

v. Spatial factors

The entity that related to the size, shape, and position of things, and the relation of objects to each other in space. In this study, it involved mainly the geographical variables that located in the vicinity of the motor vehicle crash locations.

vi. Temporal factors

This was the variables related to time such as hours of the day, day of the week, week of the month and month of the year. It could also be a categorical in nature such as peak hour or non peak hour or seasonal in nature such as school holiday versus non school holiday or weekend versus weekdays.

vii. Buffer analysis

Buffer analysis is a GIS technique use to identify areas surrounding geographic features. The process involves generating a buffer around existing geographic features and then identifying or selecting features based on whether they fall inside or outside the boundary of the buffer.

viii. Logistic regression

Logistic regression is a statistical method for analyzing a dataset in which there are one or more independent variables that determine an outcome. The outcome is measured with a dichotomous variable (in which there are only two possible outcomes).

1.8 Summary

The overall intention of this study was to answer certain problem questions arising from road safety issues. In particular, the study attempted to prove that the consolidation of prehospital, clinical and geographical data would enhance the knowledge that could be utilized further for road safety programs by multi agencies. The study provided an excellent opportunity and platform in providing reliable and integrated data could be used for planning current and future trauma care related to RTI in Kota Bharu specifically and in Malaysia generally.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Trauma or injury is a disease of significant proportions and it is an important health problem worldwide, it may be seen as a neglected disease. Injuries are one of the top 10 causes of death and disability in most developed countries and developing countries including Malaysia, and their importance has been predicted to increase (Rahman, Allen and Hyder, 2014). Road traffic injuries (RTI) were the ninth leading cause of death in 1990 but are predicted to become the third most common cause of disability worldwide by 2020 (Ramli, Oxley, Hillard et al., 2014). About 3000 deaths were recorded worldwide on the road (Chekijian, Paul, Kohl et al., 2014). Reported mortality rates for severely injured patients remain substantial, ranging from 7% to 45%. For every death attributable to trauma, 3 persons are permanently disabled (Littleton, Hughes, Poustie et al., 2012).

World health organization (WHO) has estimated that about 1.2 million people die each year from road traffic accidents, and 20 to 50 million suffer minor injuries. High-income countries has an estimated mortality rate of 10.3 per 100 000 population while the low and middle-income groups have higher mortality rate 21.5 and 19.5 per 100 000 population respectively. It is estimated that in year 2004 the road traffic accidents is ranked 9^{th} (2.2%) in ten list of causes of death worldwide. This however is projected to increase in year 2030 to 4^{th} (3.6%) ranked of death globally (Toroyan, Peden and Laych, 2013). In the middle income country it is estimated that road traffic accidents cause life of 0.94 deaths in millions and ranked 7^{th} out of 10^{th} cause of deaths (Herman, Ameratunga and Jackson, 2012). Internationally the World Health Organization (WHO) has taken an initiative in year 2008 to cope with road traffic accidents by releasing a report to make the government and agencies in all country worldwide to understand that it is a global health issues (Chandran, Hyder and Peek-Asa, 2010).

2.2 Road Traffic Injuries: Burden of Disease in Malaysia

Malaysia is a middle-income country and is typical of countries that have seen a decline in infectious disease but an increase in death and disability from injuries over the past few decades. Health fact published by Ministry of Health, Malaysia showed that accidents were fourth out of ten principal causes of hospitalization in Ministry of Health hospital which accounts 8.03% of total admission in 2012 (Ministry of Health Malaysia, 2012). The accidents admission fall shorts by normal Obstetric deliveries, complication of pregnancies, and diseases of respiratory systems admission. The number of deaths caused by road traffic accidents was seventh (4.89%) out of tenth principal causes of death in ministry of health hospitals. Accidents is a cause of death followed shortly by heart diseases 16.09%, septicaemia 13.82%, malignant neoplasm 10.85%, pneumonia 10.38% cerebral vascular accidents 8.43% and disease of digestive systems 4.98% (Lee and Indralingam, 2012).

Road traffic deaths and injuries today place an enormous strain on our country's health care system and national economy. In our nation, it has never been a day without reported cases of trauma in the newspapers. Sometime it hits the major headlines but most of the times due to the large number of road traffic accidents that the news are not reported in national news or just being mentioned in a small column of newspapers. Malaysia suffers an annual loss of approximately RM 9.0 billion based on estimated value of RM1.2 million for each life lost. In Malaysia, more than 6,200 Malaysians are killed annually on our roads and many more are seriously injured. In the year 2009, about 397,194 accidents in the road of Malaysian and these resulted in 6,745 deaths which was 3.55% deaths in 10,000 vehicles, 8,849 serious injury and 15,823 minor injury (Hosseinpour, Yahaya and Sadullah, 2014). However, there has been some improvement in terms of fatality rate. The fatality index per 10,000 registered vehicles dropped from 8.2 in 1996 to 3.6 in 2009. More importantly, injury related RTI has declined from 54,088 in 2004 to 31,417 in 2009, but these figures are still a far cry from the international benchmarks. Undoubtedly, the large numbers of road traffic injuries relates directly to the ever increasing number of road users. In the year 1990 the number of registered cars were 1,811,141 and motorcycles were 3,035,930. Ten year later in the year 2001 the number of registered cars increased substantially to 4,557,992 and motorcycles were 5,609,351. Furthermore, in the year 2007 the number had increased markedly to 7,419,643 for cars and 7,943,364 for motorcycles (Tran, Hyder, Kulanthayan et al., 2009).

The increasing number of vehicles may affect the number of vehicle per road and thus the number of mishap at a particular area. At the same time, there was steady increase in number of road traffic accidents from the year 2002, 279,711 cases to 414,421 cases in the year 2011. Similarly, the statistic of accidents between January and May 2011 showed there were 170,048 cases of accidents without injuries, and another 8,650 accidents with injuries. The number 8,650 accidents with injuries were further divided to 2,500 deaths, 2,029 with severe injuries, 4,121 with minor injuries (Transport Statistics Malaysia, 2012). The index of road traffic accidents to 100 thousand of population was 24.20 and index of road traffic accidents to every 10 thousands of registered vehicle is 3.40 in 2010 (Mohamed, Mohd Yusoff, Isah et al., 2011)**.** In 2008, 428,475 cars and 111,958 motorcycles were reported to involve in accidents. In another statistic in the similar publication stated that the number of death according to type of vehicle involved from September 1st to 12th September 2008 showed that number of death due to motorcycle riders were 42 (50%), pillion riders 4 (5%), driver of car 9 (11%) and passenger of car 12 (14%) and other constitute 14 (20%) respectively (PDRM, 2014; JKJR, 2014). (Figure 2.1, Figure 2.2 & Figure 2.3) The number of lower reported cases of motorcycles can be due to cheap repair cost that does not involved insurance claims and not involving other third party vehicle, which may be the cases, causes under reported cases.

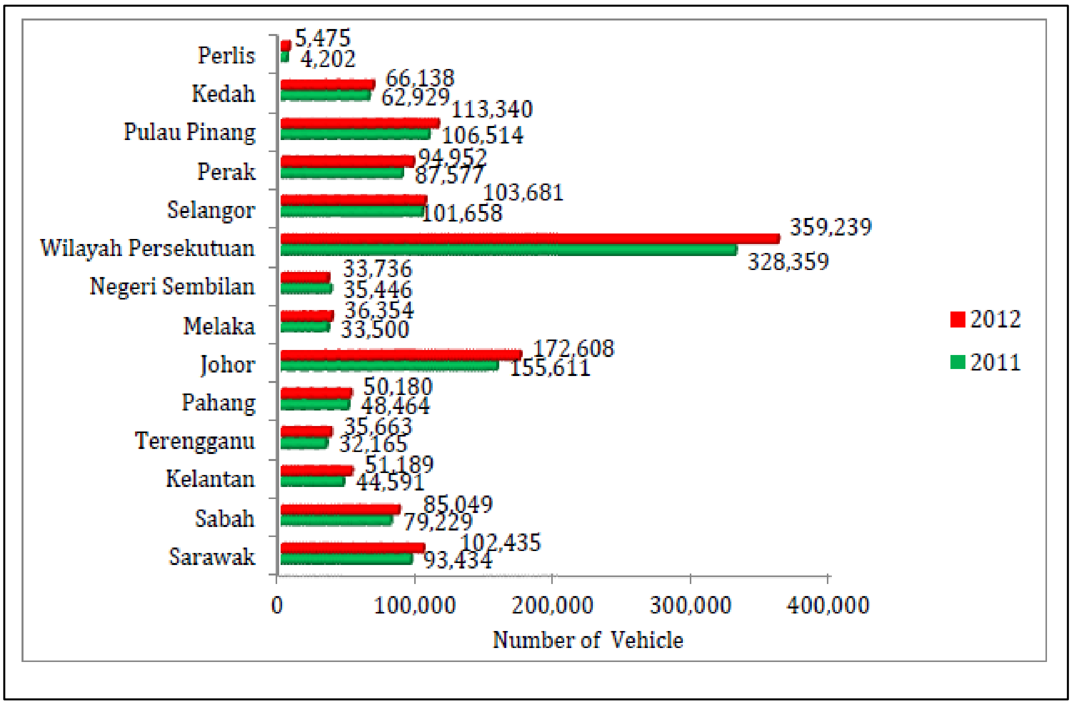

Figure 2.1: Transport statistics Malaysia (2014)

(http://www.mot.gov.my/en/Statistik%20Tahunan%20Pengangkutan/Transport%20Statistics%20Malaysia%202014.pdf)

State	2008		2009		2010		2011		2012	
	Active	Non-Active	Active	Non-Active	Active	Non-Active	Active	Non-Active	Active	Non-Active
PERLIS	56,557	15,171	59,831	16,492	63,743	18,045	66,618	19,373	68,853	22,593
KEDAH	605,125	290,892	635,959	309,587	671,989	330,155	717,393	347,955	745,237	385,710
PULAU PINANG	1,478,826	418,812	1,540,529	453,974	1,614,307	492,924	1,686,521	527,226	1,735,367	590,849
PERAK	1,207,765	439,055	1,255,105	470,867	1,305,640	505,529	1,361,606	537,163	1,390,851	601,404
SELANGOR	1,482,326	582,648	1,527,221	628,523	1,582,587	679,296	1,636,011	727,322	1,663,026	803,089
WILAYAH PERSEKUTUAN	3,331,539	709,747	3,546,433	774,901	3,785,566	849,646	4,041,587	922,059	4,290,989	1,029,573
NEGERI SEMBILAN	490,407	220,585	507,097	235,400	525,097	251,757	544,534	266,055	553,716	292,089
MELAKA	445,282	161,471	465,696	172,778	487,240	185,188	509,414	196,547	524,690	217,297
JOHOR	1,831,776	654,559	1,912,894	707,096	2,003,475	764,791	2,105,420	818,478	2,185,121	909,835
PAHANG	516,322	204,230	542,982	219,763	570,653	237,155	603,906	252,373	619,965	285,966
TERENGGANU	303,785	99,317	326,866	106,844	351,839	115,242	376,449	122,952	394,851	139,758
KELANTAN	409,294	166,776	440,088	177,637	473,470	190,382	505,713	203,021	526,996	232,451
SABAH	553,765	180,184	598,291	195,463	649,911	213,270	712,093	230,344	770,272	256,595
SARAWAK	865,688	248,393	912,578	274,193	968,255	301,413	1,039,390	323,746	1,100,360	364,718
MALAYSIA	13,578,457	4,391,840	14,271,570	4,743,518	15,053,772	5,134,793	15,906,655	5,494,614	16,570,294	6,131,927

Figure 2.2: The number of vehicles on the road in Malaysia 2008-2012 (http://www.mot.gov.my/en/Pages/darat0317-4283.aspx?RootFolder=%2Fen%2FStatistik%20Darat%2F2014%204%20%2D%20SUKU%20IV%202014&FolderCTID=0x0120008DD397591B2E4D4D9E70C4547CA18822&View={DF91B57F-1E20-48BC-9D01-58D8502C6CFB})

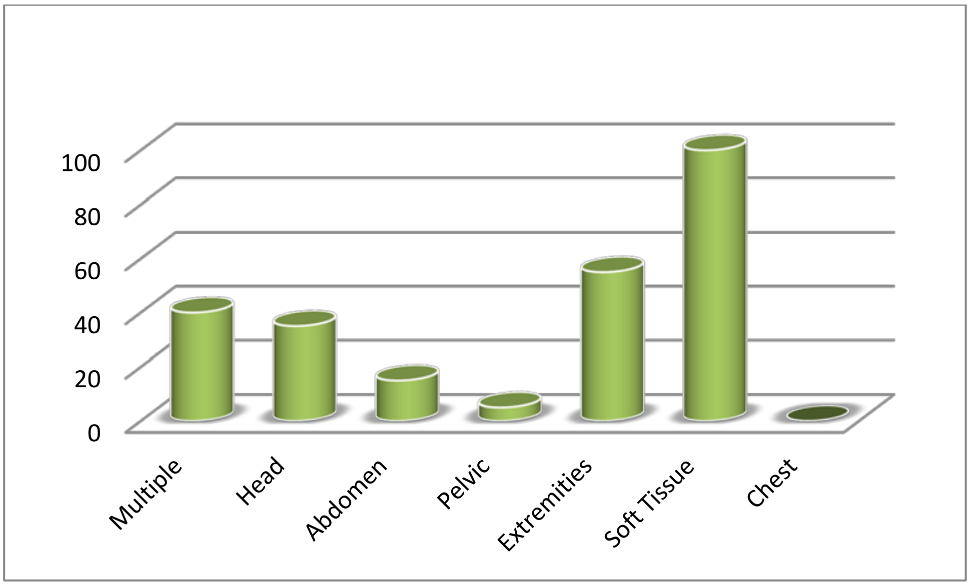

Figure 2.3: Type of injuries sustained by motorcyclist and pillion riders

(Unpublished dissertation by Dr Aetosham, USM, 2012)

The yearly average patients' attendance to the ED HUSM is 56,000 and that of HRPZ is approximately 68,000. From our data, the prevalence of MVC cases directly attending the ED from the crash sites during the study period is at 0.83% of all injury cases. (Page 93) This figure may be under represented due to cases referred from other hospitals and poor documentation of cases during the data collection that were not included. Estimated referred MVC cases from district hospitals in Kelantan to HUSM are at the average of 1800 annually based on data from Medical Record Unit in HUSM. This would have made the total prevalence of MVC cases attending to the ED HUSM at 3.7%. Even though the prevalence is not as high as those with medical conditions, the morbidity and mortality have contributed to significant adverse clinical outcome for both short and long-term duration (Ahmad, Rahmat, Hisamuddin et al., 2009; Radin Umar, 2006).

Malaysian National Trauma Database Registry (NTRD) was established for a short trial from 2007 till 2009. The registry system that was based and managed by ED specialist based in Hospital Sungai Buloh involved in data collection for all major trauma cases from five major hospitals throughout the nation. According to the NTRD, the total prevalence of major trauma due to MVC attending the ED in 2007 was at 19% (Sabariah, Ramesh & Mahathar, 2008). This figure is much higher than the study figure mainly because the NTRD include all trauma cases both with direct admission and the referred cases from other hospitals that did not involve in NTRD project. Another obvious reason was due to the three hospitals out of nine that involved in NTRD are located in Klang Valley which have a much bigger catchment population (4 times more than that in Kota Bharu). The initial data has shown that MVC has contributed to 72% of major trauma cases of which 84% was blunt in nature.

In general low income and middle-income countries on an average have higher MVC related death rate than the more developed highly income countries (21.5 per 100 000 vs 10.3 per 100 000 population) (Esperato, Bishai and Hyder 2012; Hyder, Allen, Peter et al., 2013). Half of those injured and died involve the most vulnerable road users such as children, pedestrian and two wheeler users (Mehmood, Khan, Mir et al., 2015; Edirisinghe, Kitulwatte & Senarathne, 2014). It is almost impossible to create a uniform and comparable data collection throughout the Asia region due to un-uniformity of data collection system and non-availability of certain variables. Though many countries may provide data, the reliability of the data can be challenged. In addition many injury statistics related to MVC are under reported (Slesak, Inthalath, Wilder-Smith et al., 2015).

An attempt was made by a group of physicians from the Ministry of Health Malaysia (MOH) to develop a comprehensive data base system for the severe trauma cases attending ED of major hospitals in Malaysia. The initial data collection involved six major hospitals and included only major trauma cases of all causes. The project was initially developed and managed by private sector that required significant amount funding to sustain its system. Few major hurdles were faced by the NTRD administrators such as manpower compliance, accuracy of data and sustainable funding. However, unfortunately the system came to halt in 2010 due to money constraint. Only few publications on the projects have been published

(National Trauma Database, 2015). The study has shown similar trend in the pre hospital and clinical parameters of the MVC victims to the nationwide and international data in particular data originating from the developing countries (Chekijian, Paul, Kohl et al., 2014; Chalya, Mabula, Dass et al., 2012). The victims commonly involved the young age group (40% at between 20 to 40 years of age), the age at which the general population is very productive socioeconomically. Sadly quite significant amount of the victims were among the school aged population ranging from primary schools to the late adolescent (28%). Male group contributed significantly to the MVC victims compared to the female counterpart. The young age and being a male, both are common denominators in any MVC cases worldwide. The two factors are strongly related to psychosocial contributions towards involving in challenging and risky behaviors on the road. This risky behavior such as speeding, showing off stunt actions, illicit drug influence and driving without safety equipment commonly result in disastrous outcome on the road (Summala, Rajalin and Radun, 2014 and Constantinou, Panayiotou, Konstantinou et al., 2011). Similar trend of young age and male preponderance was found in Singapore data on road fatalities from year 2000 to 2004 (Wong, Chong, Tai et. al. 2009).

According to world wide data from WHO, the MVC mostly affected young people between the ages of 15 to 39 years; and the traffic injuries is the number one killer of children under the age of 15 years. (WHO, 2008) Numerous other data and reports in other parts of the world also support the similar trending in male and young age preponderance in road related injuries (Solagberu, Osuoji, Ibrahim et al, 2014 and Moudon, Lin, Jiao et al., 2011). Comparison of numerical variables (age, ambulance response time, ISS, SBP, respiratory rate, GCS, RTS, hospital stay, body systems and parts injured) between male and female groups in our study did not show any significant differences between the two groups apart from the ambulance response time (ART) which showed significant shorter ART among the female group (Refer to Page 110). However the researcher could not explain this finding based on any literature, evidence based reasons and logical explanation. A study carried in Singapore and published in 2015 looked at factors affecting ART for injury cases. The investigators did not find any increase risk for delayed ART among the gender groups. However they concluded that the density of traffic on the road and weather played important roles in predicting the ART (Silverman, Galea, Blaney et al, 2007). In this study, the mean difference of ART for both groups was merely below two minutes and might be just co-accidental finding. The same numerical variables comparison was made on the age groupings.

2.3 Clinical Impact of Road Traffic Injuries

2.3.1 Overview

RTI causes a significant impact not only to human being but also to the economy of any one country and the social wellbeing of affected victims and family members. Almost 16 000 people die every day around the world from all types of injuries. (WHO) Injuries represent 12% of the global burden of disease, the third most important cause of overall mortality and the main cause of death among victims 1 to 40 years of age. The category of injuries worldwide is dominated by those incurred in road crashes. According to WHO data, deaths from road traffic injuries account for around 25% of all deaths from injury. Specifically when the mortality and morbidity for road traffic injuries are viewed alongside other causes of death and disability, it can be considered a public health crisis, particularly in low income and middle-income countries (Razzak, Shamin, Mehmood et al., 2012). One of the crude methods of measuring clinical impact of RTI is disability adjusted life years (DALY). It is a measure that combines information on the number of years lost from premature death with the loss of health from disability due to any specific disease or injuries. Around 85% of all global road deaths, 90% of the disability-adjusted life years lost due to RTI and 96% of all children killed worldwide as a result of road traffic injuries occur in low-income and middle-income countries (Goonewardene, Baloch, Porter et al., 2010).

Worldwide rank order of DALYs in 1990 for the 10 leading causes of the global burden of disease showed that RTI was at the ninth place but the projection in the year 2020, RTI will be at the third place behind the psychiatric disorders and ischemic heart disease. In many low-income and middle-income countries, the burden of traffic-related injuries is such that they represent between 30% and 86% of all trauma admissions (Zirkle, 2008). Recent data in 2011 on the world wide ranking for the top most numbers per 100,000 population affected by the RTI, the top 20 countries are from the low income and developing countries. Majority of the countries in the top 10 in the list are the countries from the African Continent. Malaysia is placed at 20th rank in the list. Many studies had supported this finding. For example in Benin City in Nigeria, car crash is very common and it accounted for the most common cause of RTI related mortality and morbidity. Chest and facial injuries are very common and fatality is mostly related to the traumatic brain injury (Joshi, Joshi, Singh et al., 2014; Parker, Ear, Roehler et al., 2014; Chalya, Mabula, Dass et al., 2012). Motorcycle related road accident is perhaps the commonest cause of RTI being reported in Malaysia. In 2010 alone, the average number of death monthly due to motorcycle riders were 42 (50%), pillion riders 4 (5%), driver of car 9 (11%) and passenger of car 12 (14%) and other constitute 14 (20%) respectively (Hashim & Iqbal, 2011; Yuen, Karim and Saifizul, 2014). Therefore, the preventive measures and clinical care should be focusing on this group or road users in order to reduce the overall burden of RTI in Malaysia. Similarly the enforcement of road safety and law on the road should also look at how to reduce impacts of RTI among these vulnerable road users.

2.3.2 Impact on Morbidity

Most of the literatures mentioned about well-established factors that determine the clinical outcome such as (Zambon and Hasselberg, 2006 & Moini, Rezaishi and Zafarghandi, 2000):

i. inadequate in-vehicle crash protection;
ii. inadequate roadside protection;
iii. the non-use of protective devices in vehicles;
iv. the non-use of protective crash helmets;
v. excessive and inappropriate speed;
vi. the presence of alcohol.

Many studies have indicated that most MVC occur on the roads in urban areas but the morbidities and fatalities are more in the rural areas. This is due to many similar strong reasons as we mentioned above for our study such as the speeding on rural roads, lack of intersection and prolonged ART resulting in an increase in morbidity and mortality (Gururaj, Uthkarsh, Rao et al., 2014).

RTI frequently causes major trauma that can be defined as simultaneous injuries to different body regions or organ systems, which together can result in systemic dysfunction that might cause death (Ardolino, Sleat and Willett 2012; Boyle, Smith and Archer 2008). (Figure 2.4) As described in the advanced trauma life support, predictions of severe trauma based on physiological, anatomical and mechanisms of injury parameter are crucial in identifying potential life and limb threatening among injured victims of any cause. The identifications of major trauma cases should be carried out as early as possible in the phase of trauma management beginning at pre hospital setting so that the appropriate victims should be managed accordingly at the right time and at the right place.

The concept of golden hour in trauma management focuses on timely management in order to avoid irreversible major organ damage and hence complications due to late onset of trauma resuscitation. Major trauma victims related to RTI are at a high risk of development of multiple organ dysfunction or death (Stiell, Nesbitt, Pickett et al., 2008). Early assessment of injury severity is important in major trauma at the Emergency Department (ED) level. Patient treatment and disposition (ward versus Intensive Care Unit) is influenced by these initial assessments and the ability to predict the burden of a particular injury should lead to improved patient care as well as outcome later. Similar injuries lead to remarkably different outcomes in similar populations and specific individuals seem to respond to the stressful situation of trauma differently. Outcome of major trauma can be defived into long and short-term outcomes. The long-term outcome usually refers to morbidity of the patients including extent of the disability and functional recovery, length of stay in hospital and cost incurred (Rainer et al., 2014 & Newnam et al., 2014)**.** Variations in trauma outcomes might be a result of a number of factors, including patient injury severity and co-morbidities, individual practitioner management of trauma, and center specific systems management of trauma**.** It has been shown that demographic factors (age and gender), injury-related factors (localization, severity, number of injuries), socio-demographic, psychological factors, patients' co-morbidities and body mass index (BMI) as well as genetic variation could be important in predicting survival rates of RTI patients (Huber, Biberthaler, Delhey et al., 2014; Gautschi, Huser, Smoll et al., 2013; Dinh, Bein, Byrne et al., 2014; Curtis, Mitchell, Chong et al., 2012).

VITAL SIGNS (major trauma if any one of the following present)

	ADULT	CHILD (<16yrs)
❖ RESPIRATORY	< 10 OR > 30 /min	< 15 OR > 40 / min
❖ CYANOSIS	Present	Present
❖ CONSCIOUS STATE	GCS < 13	GCS < 15

OR

INJURIES (major trauma if any one of the following present)

- ❖ ALL PENETRATING INJURIES : head/neck/chest/abdo/pelvis/axilla/groin
- ❖ BLUNT INJURIES
  - Patients with a significant injury to a single region : head/neck/chest/abdo/axilla/groin
  - Patients with lesser injuries involving two or more of the above body regions
- ❖ SPECIFIC INJURIES
  - Limb amputations/limb threatening injuries
  - Suspected spinal injury
  - Burns > 20% (adults or children)or suspected respiratory tract
  - Serious crush injury
  - Major compound fracture
  - Fracture to two or more of the following femur/tibia/humerus
  - Fractured pelvis

IF ANY OF THE ABOVE ARE PRESENT → MAJOR TRAUMA

IF NONE OF THE ABOVE ARE PRESENT ↓

THESE PATIENTS ARE AT HIGH RISK OF HAVING MAJOR TRAUMA

- Ejection from vehicle
- Motor/cyclist impact (<30 kmh)
- Fall from height (>5m)
- Vehicle rollover
- Fatality in the same vehicle
- Explosion
- Pedestrian impact (> 30kmh)
- Prolonged extrication (>30 min)

↓

CONSIDER CO-MORBIDITY

- Age < 10 or > 55
- Pregnancy
- Significant underlying medical condition

↓

AT RISK OF HAVING MAJOR TRAUMA → MAJOR TRAUMA

Figure 2.4 : Criteria for major trauma

(Advanced Trauma Life Support Manual 2014, American College of Surgeon)

2.3.3 Impact on Mortality

Death from RTI is not uncommon and perhaps the most devastating clinical outcome not only to the healthcare providers but also to the relatives of the victims. Death from trauma has been classically described as occurring during three peaks: immediately, early, and late. The immediate deaths are usually due to apnea, severe brain or high spinal cord injury, and rupture of the heart or large blood vessels. The early deaths occur within minutes to hours and are often due to an epidural hematoma, subdural hematoma, pneumothorax, hemothorax, ruptured spleen, liver laceration, or pelvic fractures. This is known as the golden hour. The late deaths occur days or weeks after the injury (Tyson, Varela, Cairns et al., 2014)**.** This classical distribution however may no longer be occurring in the United States due to improvements in trauma care.

Malaysia suffers an annual loss of approximately RM 9.0 billion based on estimated value of RM1.2 million for each life lost. In Malaysia, more than 6,200 Malaysians are killed annually on our roads and many more are seriously injured. In the year 2009, about 397,194 accidents in the road of Malaysian and these resulted in 6,745 deaths which was 3.55% deaths in 10,000 vehicles (Transport Statistics Malaysia, 2012; PDRM, 2013). In 2009 alone, there were 75 deaths caused by the RTI in Hospital USM (HUSM). Majority of them were less than 55 years of age and caused by traumatic brain injuries. 50% of them succumbed to their illness within the first 45 hours after the incident (Rahman and DeSilva, 2012)**. (**Figure 2.5) In this study, the dominant mechanism in fatal trauma was due to blunt injuries 73(97.33%). This result showed that the result near similar to study done in Canadian Trauma Center in 2007 which found that blunt trauma represented 87% of all cases (Tien, Nascimento, Callum et al., 2007). The impact of fatal TBI in this region remains significant, and further in-depth analysis to define potential protective and preventive areas appears the key to reducing mortality. Secondary brain injuries contributed to a weak, but identifiable, first peak of trauma death. Identification of possible pre-hospital and in-hospital weaknesses in the