

A COMBINATION OF GEOSPATIAL AND CLINICAL ANALYSIS IN PREDICTING DISABILITY OUTCOME AFTER ROAD TRAFFIC INJURY (RTI) IN A DISTRICT IN MALAYSIA

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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 Departments (ED) of two tertiary centers in a district in Malaysia. Selected attributes were geospatially analyzed by using ARCGIS (by ESRI) software version 10.1 licensed to the institution 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 borough of Kenali and Binjai. The number of severely injured and polytrauma are mostly 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). Overall this study has proven that GIS with a combination of traditional statistical analysis is still a powerful tool in road traffic injury (RTI) related research.

1. INTRODUCTION

This study utilizes the geographical information system (GIS) software and performs the temporo-spatial analysis in relation to clinical data for road traffic injury (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) and finally to predict factors that caused the disability by RTI prior to discharge from hospitals.

2. METHODS

This study was planned for prospective cohort study commencing from July 2011 until June 2013. The study sample included all patients with road-related injuries within the district of Kota Bharu in Malaysia who attended emergency departments of two tertiary hospitals within the district. Consent was taken from each patient or relatives by using standard consent form approved by Ethical Committee of the main study center. By using a two proportion sampling; alpha value of 0.05, power of study 80% and 20% drop out, the required sample of road traffic accident victims were 415.

The exclusion criteria included missing or unable to detect the exact location and coordinate (Latitude and Longitude) of RTI,

injury treated in hospitals other than the two study hospitals, injury caused by other events i.e domestic violence or assault and no clinical outcome data available. The clinical variables and outcome were documented prospectively and retrospectively based on the ED clerking sheet and medical record. In addition to injury, pre hospital care and outcome data, the coordinate of the locations were obtained by the ambulance paramedics by using portable handheld GPS unit brand Garmin® model GPS 72H with Serial number 1T7071348 (Manufactured in Taiwan by Garmin® Corporation in 2010) which was accurate to 5 meters of the location.

The disability outcome was considered either at discharge from the ED and/or from the ward. Disability at discharge was defined as a physical or mental condition that limits a person's movements, senses, or activities as a consequence of RTI. The data was transferred into the excel format which in turn underwent GIS analysis by using ARCGIS® (by ESRI) software version 10.1 licensed to the study institution. The GIS analysis included general borough and road network RTI layer mapping and Buffer analysis (Within 100 meters) of accident locations (Figure 1 & Figure 2).

The variables for geographical build up area within the vicinity of each RTI cases were also obtained by direct visualization (photo) and by using Google Earth™ free software version 7.1.2.2041 operating system Microsoft Windows® (5.1.2600.3) with maximum texture size set at 4096x4096 and image date taken on

the 19th August 2013. (Figure 3) Geographical attributes identified were analyzed together with other clinical parameters by using multivariate analysis to identify the predictive factors for hotspot and clinical outcome. The univariate analysis included independent t-test and chi-square test. In addition, the multivariate analysis would answer the predictive and confirmatory objectives by using multiple logistic regression (MLR) set in SPSS version 22 licensed to the study center.



Figure 1. 100-meter buffer analysis using ARCGIS® software version 10.1

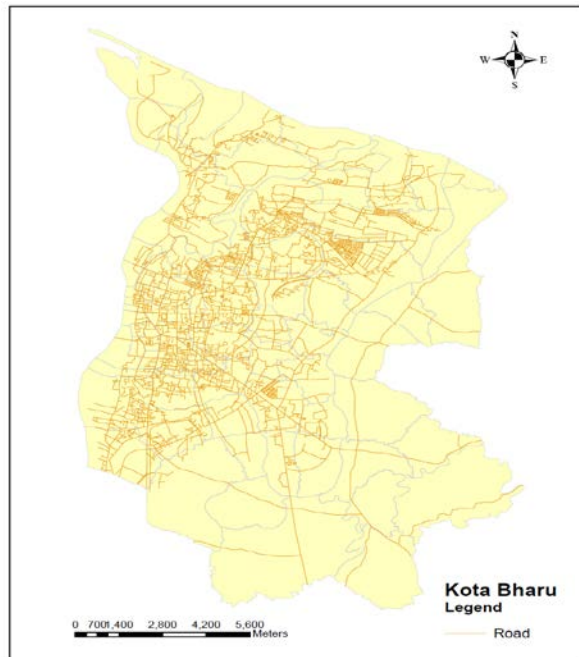


Figure 2. Digital road network within the study location

3. RESULTS

A total of 459 cases were recruited over the ten-month data collection period. However there were 27 cases with missing data

that needed to be excluded from the epidemiological analysis. The mean age (SD) of the RTI victims was 26.04 years (s.d 15.26). The range of age was between 2 to 81 years of age. Male comprised of 302 (71.7%) of the cases. Majority of the victims were the drivers of the vehicles involved in the MVC [320 (72.9%)]. Motorcyclists were the commonest type of victims involve [351(80.0%)] followed by car occupants [55 (12.5%)]. One hundred and seventy six (40%) of the motorcyclists admitted wearing the safety helmets either from the history taking or from the witness. However, 120 (27.3%) of the victims do not disclose whether they wore the helmets during the incidents.

A total of 145 (33.3%) victims were admitted to the wards. 117 (26.7%) and 28 (6.4%) of the victims were admitted to the general wards and critical care units respectively for further management. The mean (SD) length of hospital stays was 7.19 days (6.94), ranging from one to fifty one days. Majority of the patients 205 (49.4%) were discharged well whereas 201 (48.4%) and 9 (2.2%) were disabled and died upon discharged from the ED respectively. Majority of the MVC 310 (73.3%) occurred on the municipal roads within the District of which were under the maintenance of the Municipal Office. Urban area was the most common location 247 (58.8%). Figure 4 show the geographical locations of all the RTI cases that attended the two EDs. Most of the RTI occurred on municipal and straight roads. (77% and 71% of cases respectively)

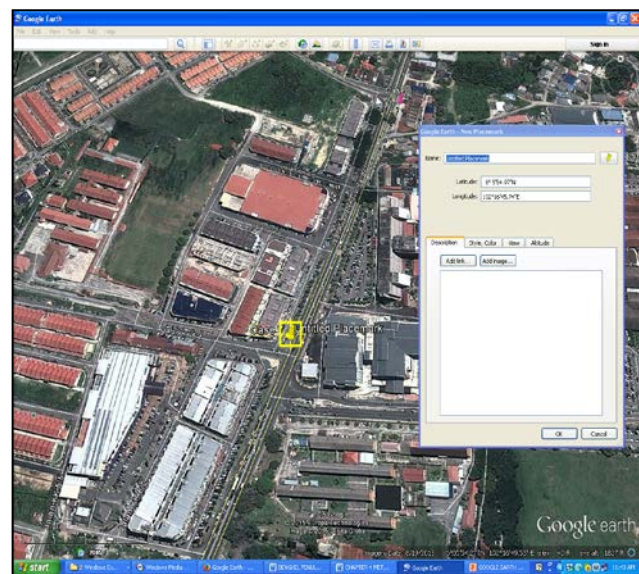


Figure 3. Mapping of RTI case by using Google earth free software version 7.1.2.2041 operating system Microsoft Windows

A person with an increase in ISS of one score had 37 % higher odds to have disability at hospital discharge (95% CI: 1.253, 1.499, p-value < 0.001) when adjusted for age group and operative procedure. Pediatric age group (less than 19 years of age) had 52.1% lesser odds compared to the adults to have disability at discharge from hospital (95% CI: 0.258, 0.889, p-value < 0.001) when adjusted for ISS and operative procedure. Thus being a child was a protective factor against the disability. Patients who underwent operation for definitive management had 4.14 times odds compared to the non-operative group to have disability at discharge from hospital (95% CI: 1.681, 10.218; p-

value = 0.002) when adjusted for ISS and age group. (Table 1)
The model predicted probability by assessment the goodness of fit (AUC) was 88.3% (95% CI: 0.850, 0.915; p-value = 0.000).

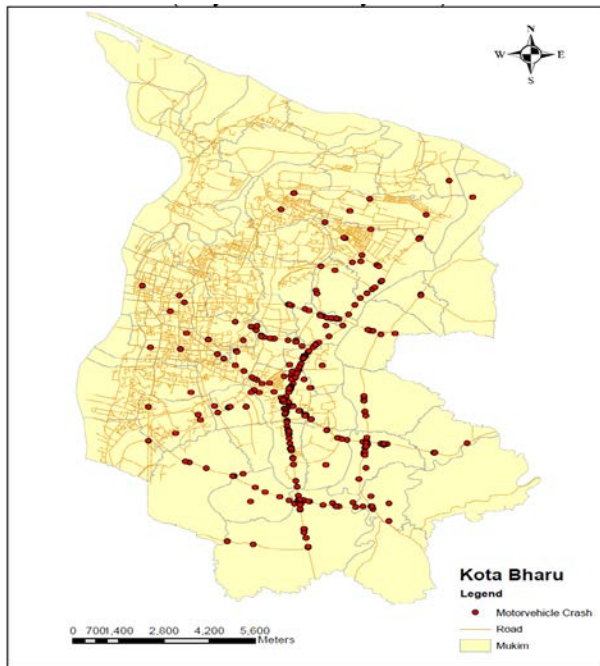


Figure 4: Geomapping of all road traffic injury cases by using ARCGIS® software version 10.

Variables	b^a	Adjusted OR ^b (95% CI)	p-value
Injury severity score (ISS)	0.315	1.37 (1.25, 1.50)	< 0.001
Age grouping		1	
Adult (18 years and more)	-0.735	0.48 (0.26, 0.89)	0.020
Pediatric (Less than 18 years)			
Operative procedure		1	
No	1.422	4.14 (1.68, 10.21)	0.002
Yes			

Table 1: Multiple logistic regression analysis for disability outcome

^aRegression coefficient

^bAdjusted regression coefficient

Forward and backward multiple linear regression selection was applied.

Model assumptions were met (Hosmer Lemshow test, classification table & AUC).

There were no interactions between independent variables.

No multicollinearity problem detected.

4. DISCUSSION

Injury is one of the common causes of attendance to ED in any parts of the world, in particular in developing countries.(Hyder, 2014)(Nhac-Vu, 2014) WHO has published the most recent report on global road safety in 2013 and stated that 1.24 million people were killed on the world's roads in 2010. (Toroyan, 2013)(Dalal, 2013) Road traffic injuries are the eighth leading cause of death globally, and the leading cause of death for young people aged 15–29.

Current trends suggest that by 2030 road traffic deaths will become the fifth leading cause of death unless urgent action is taken. Even though the injury prevalence secondary to RTI 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, 2009)(Radin, 2006)

This study has shown similar trend in the pre hospital and clinical parameters of the RTI victims to the nationwide and international data in particular data originating from the developing countries. (Chekijian, 2014)(Chalya, 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. Male group contributed significantly to the motor vehicle crash (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 (Constantinou, 2011;Blackman, 2013).

As in other middle and low-income countries, the most common type of vehicle involved was two wheelers (motorcycles) and cars (80% and 12% respectively). Numerous other similar findings were published on the risk factors of a two-wheeler involvement in the MVC resulting either in severe injuries or deaths worldwide. (Albalate, 2010; Munivenkatappa, 2013; MIROS, 2014) Malaysian Institute on Road Safety Research (MIROS) reported that over the 10 year period (2000-2010), an estimated 1.2-1.5% of the registered motorcycles in Malaysia involved in accidents. In 2010 alone, out of the 120,156 motorcycle accidents, 3,614 riders and 422 pillion riders were fatal. (15) This gives the fatality index (i.e. no. of fatalities per road accidents) of 0.03 and 0.003 for riders and pillions respectively. (JRamlil, 2014)

Majority of the MVC occurred on the municipal roads that are under the maintenance of the Municipal Office of Kota Bharu District (MPKB). This is not surprising as the vehicular density and the total number of motorcyclist are expected to be much higher within the urban area. The increased road users at a particular point of time will certainly increase the chances of the MVC to occur. (Abdul Manan, 2012) Strikingly, approximately 70% of MVC cases occurred on the straight road. This study has postulated that most MVC tends to occur at the busy intersections and at the curved road due to architectural reason that leads to some barriers in any vehicle movements. The common occurrence of MVC on the straight road can be attributed to the increased

tendency by the road users to speed due to minimal barriers presence on the road. (Hours, 2013)

The geospatial distribution shows that most of the MVC related to the motorcycles are focused on the main municipal roads on the central and southern parts of the town. The most plausible explanation is due to the areas that contain extensive major road network with high density of road users. The roads within these areas are the main feeder road network connecting the suburban and the urban areas. The road network and infrastructure development within the town area expanded as the population of the study area increased. There is a shift of the center of business and offices towards these areas to accommodate the population expansion and hence the density of road users will also increase. As the density of road users increased, so does the risk of motor vehicle crash and hence injury cases.

This study has purposely chosen disability at discharge as the final outcome for all MVC cases. It shows that 48% of all injured victims were disabled at discharge from hospital. This is comparable with many other studies in other countries. The Etude et Suivi d'une Population d'Accidentés de la Route du Rhône (ESPARR) cohort study from France reported that only 45% of the participants with mild-to-moderate injury in road traffic crash reported to have fully recovered from the injury (Berecki-Gisolf, 2013). In Victoria, Australia, cohort studies following up orthopedic and trauma patients have reported worse short term and long-term health, vocational and functional outcomes, among people claiming compensation through Transport Accident Commission (TAC) (Heron-Delaney, 2013). The restoration of disabled individuals to their highest level of physical, mental, social, and vocational function and the prevention of disability are important treatment goals for clinicians, therapists and victims themselves. The longer the victims suffer from disability, the more adverse effects it is on socioeconomic and general health of the MVC victims (Pieracci, 2007).

The data variables selected into the analysis to predict the presence of the disability at discharge include gender, geographical locations, helmet wearing, presence of valid driving license, operative procedure, ISS, age and number of body parts injured. The injury severity score (ISS) has been shown to be a strong predictor of disability at discharge by approximately 40% chances for every increase in one unit score of ISS. Obviously ISS is the outcome of individual body part injured namely abbreviated injury score (AIS) and hence the increment in ISS suggests that the AIS scoring would be higher too. This implies the person is injured more and hence longer process of recovery is required and chances to be disabled at discharge is more. In this study, the common injuries such as musculoskeletal fractures and dislocation resulted in at least four to eight weeks of recovery and hence during this recuperation period the victims would be disabled resulting in time loss for work and schooling; and compromised physical ability to perform daily task. In addition, the suffering and pain due to injuries will cause emotional stress that might interrupt the daily activity physically and spiritually.

Interestingly this study has found that being a pediatric victim has a much less odd (50% less) to be disabled compared to the adult victims. Even though the children group have less mature anatomical structure development, their body responses towards injury are much more intense when compare to those adult group.

The adults and elderly group tend to have co-morbidities such as diabetes mellitus and heart condition making them more susceptible to delayed healing and more protracted recovery. Medications such as anticoagulants can easily make them bleed and prone to bruises and internal bleeding hence more serious conditions and outcome (Simsek, 2014). Children on the other hand possess excellent physiological ability to respond to injuries such as intense cell growth and regeneration. Their healing ability is more superior to that in adults.

Another factor that strongly predicts the disability outcome is the operative procedures received by patients in hospital. This study has shown that those who receive operative procedure have a four time higher risk to develop disability later. Obviously one would expect that the more severe and multiple injured cases would have received the more invasive and multiple procedures carried out on them. Patients subjected to operative procedures will face with marked upsurge in major metabolic stress responses primarily due to the injury (Ahmadi, 2010). This implies longer recuperation period and hence either temporary or long term disability. For example patients who underwent surgery (craniotomy) were 0.29 times as likely to be mobile on discharge ($p < 0.001$) compared to those patients that had no surgery and no medication. Finally the injured patients face with protracted healing and recovery and hence prolonged disability. In general, the magnitude and duration of the response are proportional to the surgical injury and the development of complications such as sepsis.

4.1 Limitations of the study

This study is also subjected to few limitations. The fundamental of this thesis work required the exact location of the MVC occurrence for the hotspot analysis. Majority of the latitude and longitude readings were taken by the paramedics who attended the cases with 5 to 10-metre accuracy but however there were small proportion of the self-attended cases which we had to rely on the graphical drawing of the exact location by the victims or relatives and retrieval of the coordinates was done retrospectively by the researcher. The confirmation of these locations was made by asking the witness at the site and by locating the traces of the MVC such as broken glasses and vehicle parts at the sites.

One of the striking findings but yet causing the limitation of this study was the involvement of motorcyclists in the majority of MVC cases. We were hoping the analysis would have covered for all types of the road users but unfortunately it was skewed mainly for two-wheeler users. This is un-avoidable as the same pattern of MVC involvements throughout developing countries especially within the urban and suburban areas has been reported in journals and government websites. However this would not alter the ultimate objectives of the study as one of the main objectives was to look at the hotspot analysis and clinical outcome rather than the mechanism of injury.

5. CONCLUSION

This study has successfully achieved the combination of geographical, pre hospital and clinical data; and the use of GIS analysis in addition to the multiple logistic regression analysis which has created a robust and reliable study outcome. We hope that this study can be an impetus to a bigger study in future in

particular in enhancing the importance of GIS in medical research in general.

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