

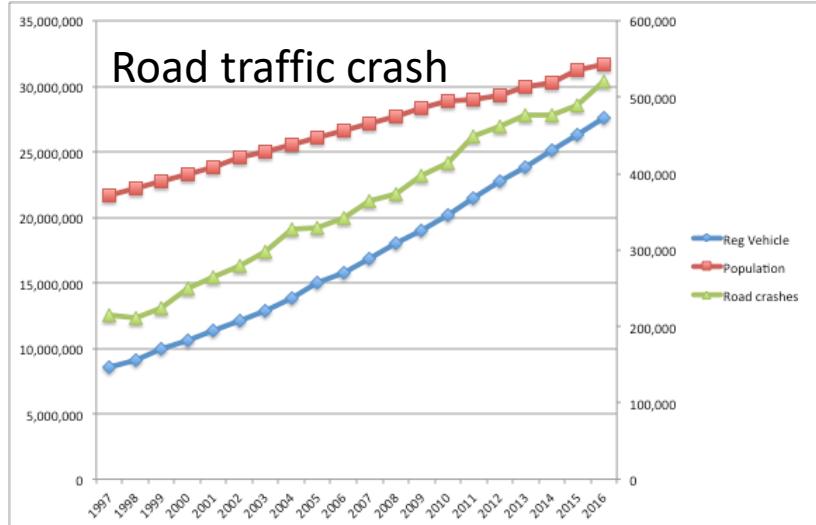
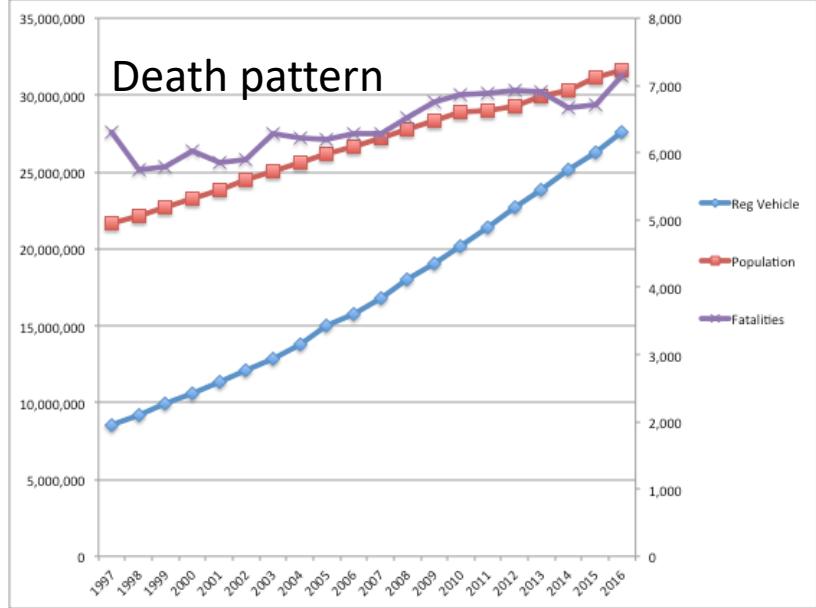
# APPLICATION OF GEOGRAPHICAL INFORMATION SYSTEM (GIS) TO IDENTIFY SPATIAL & CLINICAL PATTERNS FOR ROAD TRAFFIC INJURY (RTI) WITHIN A DISTRICT IN NORTHEAST OF PENINSULAR OF MALAYSIA

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# RTI in MALAYSIA

MALAYSIAN ROAD SAFETY TREND

	Reg Vehicle	Population	Road crashes	Fatalities
1997	8,550,469	21,665,600	215,632	6,302
1998	9,141,357	22,179,500	211,037	5,740
1999	9,929,951	22,711,900	223,166	5,794
2000	10,598,804	23,263,600	250,429	6,035
2001	11,302,545	23,795,300	265,175	5,849
2002	12,068,144	24,526,500	279,711	5,891
2003	12,819,248	25,048,300	298,653	6,286
2004	13,828,889	25,580,000	326,815	6,228
2005	15,026,660	26,130,000	328,264	6,200
2006	15,790,732	26,640,000	341,252	6,287
2007	16,813,943	27,170,000	363,319	6,282
2008	17,971,901	27,730,000	373,071	6,527
2009	19,016,782	28,310,000	397,330	6,745
2010	20,188,565	28,910,000	414,421	6,872
2011	21,401,269	29,000,000	449,040	6,877
2012	22,702,221	29,300,000	462,423	6,917
2013	23,819,256	29,947,600	477,204	6,915
2014	25,101,192	30,300,000	476,196	6,674
2015	26,301,952	31,186,000	489,606	6,706
2016	27,613,125	31,660,700	521,466	7,152



1. Injury on the road in Malaysia has not shown any improvement
2. Need new approach

# What caused the failure

- Intervention based...not outcome based
- Poor target indicators
- Nation wide strategy
- Poor data integration
- Multichampions

# NATIONAL BLUE OCEAN STRATEGY OF MOT MALAYSIA FOR ROAD SAFETY

- Localising road safety
  - Localized strategy at high risk area
- Outcome-based approach
  - Set measurable outcomes

Multi agency involvement at district level

## ROAD TRAFFIC INJURY FOR THE STATE OF KELANTAN TAHUN 2015

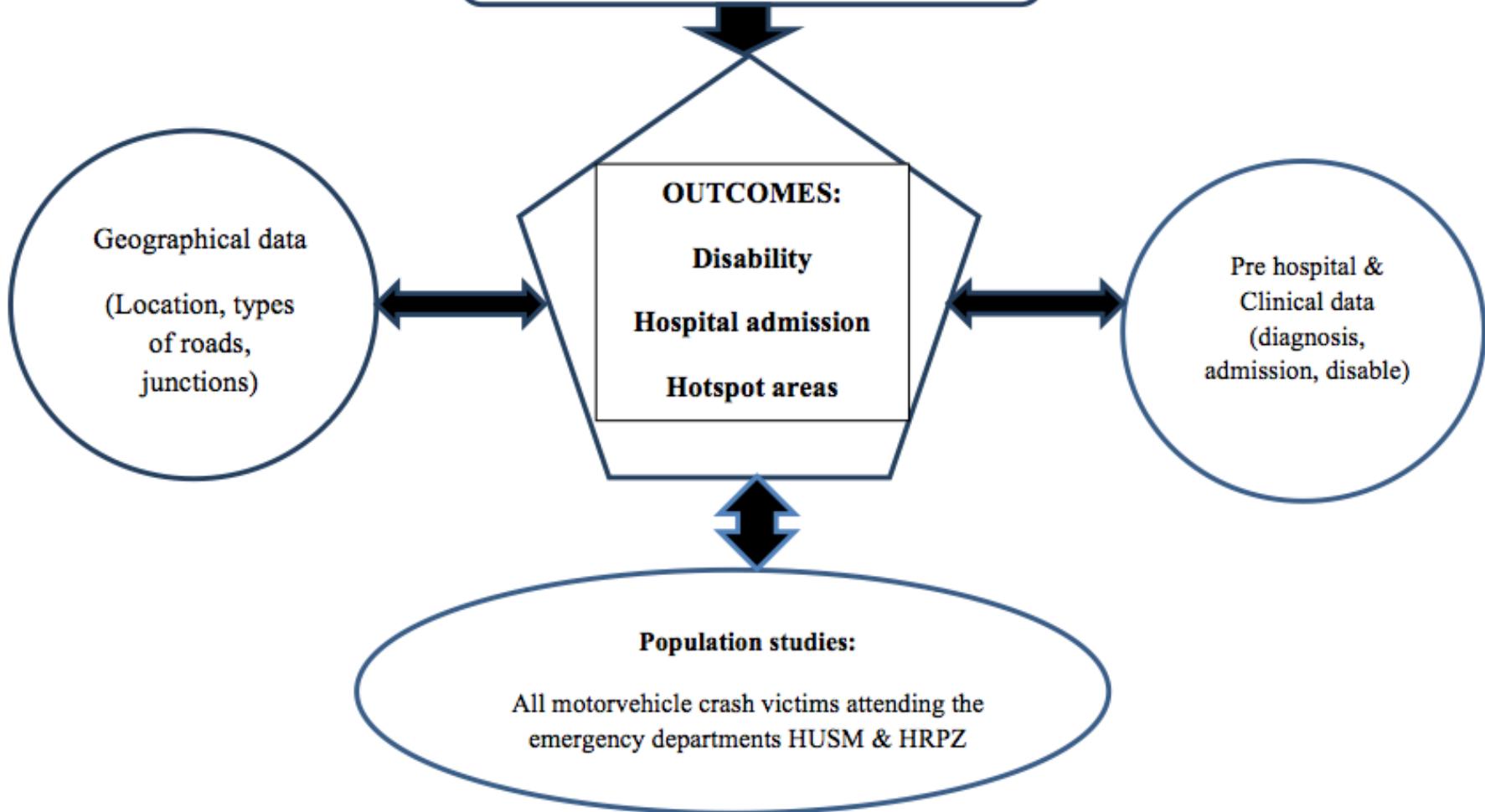
District	Number of RTIs cases	Deaths	Serious injuries	Minor injuries	% of RTI cases	% of deaths
<b>Kota Bharu</b>	<b>3,623</b>	<b>98</b>	<b>5</b>	<b>113</b>	<b>36.38</b>	<b>23.00</b>
Kuala Krai	642	32	76	99	6.45	7.51
Pasir Mas	1,030	34	31	132	10.34	7.98
Pasir Puteh	603	35	32	103	6.05	8.22
Tanah Merah	814	48	50	53	8.17	11.27
Tumpat	651	33	20	146	6.54	7.75
Machang	714	42	31	146	7.17	9.86
Gua Musang	801	39	34	18	8.04	9.15
Bachok	666	40	10	227	6.69	9.39
Jeli	416	25	19	22	4.18	5.87
<b>Jumlah</b>	<b>9,960</b>	<b>426</b>	<b>308</b>	<b>1,059</b>	<b>100.00</b>	<b>100.00</b>

Source: Traffic Department Royal Malaysian Police Force

# Challenge

- Would the geospatial analysis assist the taskforce in identifying hot spot and high risk areas for motor vehicle crashes (MVC) in Kota Bharu District (Among vulnerable road users)?
- Would the geospatial analysis identify hotspot locations of certain injury demography?

**Enhancing Road Safety program by  
integrating GIS & clinical data**



## GIS in RTI Project Framework

# Cases Selection

- All patients who presented to emergency departments in HUSM and HRPZ 2 with road traffic injuries within the district of Kota Bharu.(Referral & direct admission)
- Patient who died in emergency departments/hospital secondary to road traffic injuries.
- Cases with confirm exact location of incidence. (x,y coordinates)



**Patient Enrollment**

**Hospital**:

**Section 1: Patient Demography**

- Patient Registration**
  - Patient's IC:  Eg:8809230354
  - Patient's Passport Number:
  - R/N No:
- Race**:
- Sex**:
- Date of Birth**:  (dd/mm/yyyy)
- Age (auto calculate)**:  years

**Section 2: Police & Prehospital Data**

- Date of crash (dd/mm/yyyy)**:
- Time of crash (24-hour format)**:  Eg: 1220
- Location of crash**:
- If Others, specify**:

**4. Global Positioning System (GPS)**  
(If GPS is available, please use GPS to get approximate location of a crash)

Example: +34 40 50.12 for 34N 40E

**Patient Record**

No	Date Crash	Patient's IC	R/N	Passport Number	Hospital	Details
1	25-09-2013	700412035427	B145951		(1) Hospital Universiti Sains Malaysia	<a href="#">Report</a>   <a href="#">Edit</a>   <a href="#">Delete</a>
2	24-09-2013	931118035141	B481155		(1) Hospital Universiti Sains Malaysia	<a href="#">Report</a>   <a href="#">Edit</a>   <a href="#">Delete</a>
3	22-09-2013	920324035907	A156630		(1) Hospital Universiti Sains Malaysia	<a href="#">Report</a>   <a href="#">Edit</a>   <a href="#">Delete</a>
4	21-07-2013	800102116748	33997		(2) Hospital Raja Perempuan Zainab II	<a href="#">Report</a>   <a href="#">Edit</a>   <a href="#">Delete</a>
5	21-07-2013	950901035565	E19270		(2) Hospital Raja Perempuan Zainab II	<a href="#">Report</a>   <a href="#">Edit</a>   <a href="#">Delete</a>
6	21-07-2013	950922115031	E19271		(2) Hospital Raja Perempuan Zainab II	<a href="#">Report</a>   <a href="#">Edit</a>   <a href="#">Delete</a>
7	20-07-2013	950312035712	33973		(1) Hospital Universiti Sains Malaysia	<a href="#">Report</a>   <a href="#">Edit</a>   <a href="#">Delete</a>
8	30-05-2013	860926295063	B521930		(1) Hospital Universiti Sains Malaysia	<a href="#">Report</a>   <a href="#">Edit</a>   <a href="#">Delete</a>
9	28-05-2013	941109036301	A202871		(1) Hospital Universiti Sains Malaysia	<a href="#">Report</a>   <a href="#">Edit</a>   <a href="#">Delete</a>
10	28-05-2013	850324035631	B249724		(1) Hospital Universiti Sains Malaysia	<a href="#">Report</a>   <a href="#">Edit</a>   <a href="#">Delete</a>
11	21-05-2013	000527030020	B521086		(1) Hospital Universiti Sains Malaysia	<a href="#">Report</a>   <a href="#">Edit</a>   <a href="#">Delete</a>
12	21-05-2013	910414035056	B521087		(1) Hospital Universiti Sains Malaysia	<a href="#">Report</a>   <a href="#">Edit</a>   <a href="#">Delete</a>
13	21-05-2013		B521183		(1) Hospital Universiti Sains Malaysia	<a href="#">Report</a>   <a href="#">Edit</a>   <a href="#">Delete</a>
14	21-05-2013		B435009		(1) Hospital Universiti Sains Malaysia	<a href="#">Report</a>   <a href="#">Edit</a>   <a href="#">Delete</a>
15	20-05-2013	820927035924	B163005		(1) Hospital Universiti Sains Malaysia	<a href="#">Report</a>   <a href="#">Edit</a>   <a href="#">Delete</a>
16	19-05-2013	720909035439	B520995		(1) Hospital Universiti Sains Malaysia	<a href="#">Report</a>   <a href="#">Edit</a>   <a href="#">Delete</a>
17	19-05-2013	700611035411	B231867		(1) Hospital Universiti Sains Malaysia	<a href="#">Report</a>   <a href="#">Edit</a>   <a href="#">Delete</a>
18	18-05-2013	990200631695	B484940		(1) Hospital Universiti Sains Malaysia	<a href="#">Report</a>   <a href="#">Edit</a>   <a href="#">Delete</a>
19	18-05-2013	931213036396	B367622		(1) Hospital Universiti Sains Malaysia	<a href="#">Report</a>   <a href="#">Edit</a>   <a href="#">Delete</a>
20	18-05-2013	990200631695	B484940		(1) Hospital Universiti Sains Malaysia	<a href="#">Report</a>   <a href="#">Edit</a>   <a href="#">Delete</a>
21	17-05-2013	720903035083	B325141		(1) Hospital Universiti Sains Malaysia	<a href="#">Report</a>   <a href="#">Edit</a>   <a href="#">Delete</a>
22	17-05-2013	730206075038	A177108		(1) Hospital Universiti Sains Malaysia	<a href="#">Report</a>   <a href="#">Edit</a>   <a href="#">Delete</a>
23	17-05-2013	921209035607	B047089		(1) Hospital Universiti Sains Malaysia	<a href="#">Report</a>   <a href="#">Edit</a>   <a href="#">Delete</a>
24	14-05-2013	871201035079	B423064		(1) Hospital Universiti Sains Malaysia	<a href="#">Report</a>   <a href="#">Edit</a>   <a href="#">Delete</a>
25	11-05-2013	900728115673	B520337		(1) Hospital Universiti Sains Malaysia	<a href="#">Report</a>   <a href="#">Edit</a>   <a href="#">Delete</a>
26	10-05-2013	940818035147	B502269		(1) Hospital Universiti Sains Malaysia	<a href="#">Report</a>   <a href="#">Edit</a>   <a href="#">Delete</a>
27	07-05-2013	980721038035	B069435		(1) Hospital Universiti Sains Malaysia	<a href="#">Report</a>   <a href="#">Edit</a>   <a href="#">Delete</a>
28	07-05-2013	560710035415	B520079		(1) Hospital Universiti Sains Malaysia	<a href="#">Report</a>   <a href="#">Edit</a>   <a href="#">Delete</a>
29	06-05-2013	970820295041	B519911		(1) Hospital Universiti Sains Malaysia	<a href="#">Report</a>   <a href="#">Edit</a>   <a href="#">Delete</a>
30	05-05-2013	931017035775	B519843		(1) Hospital Universiti Sains Malaysia	<a href="#">Report</a>   <a href="#">Edit</a>   <a href="#">Delete</a>
31	05-05-2013	600103035759	B519881		(1) Hospital Universiti Sains Malaysia	<a href="#">Report</a>   <a href="#">Edit</a>   <a href="#">Delete</a>

## Variables:

- General demography
- Prehospital & Police
- Injury
- Geographical data
- Emergency care
- Clinical outcome

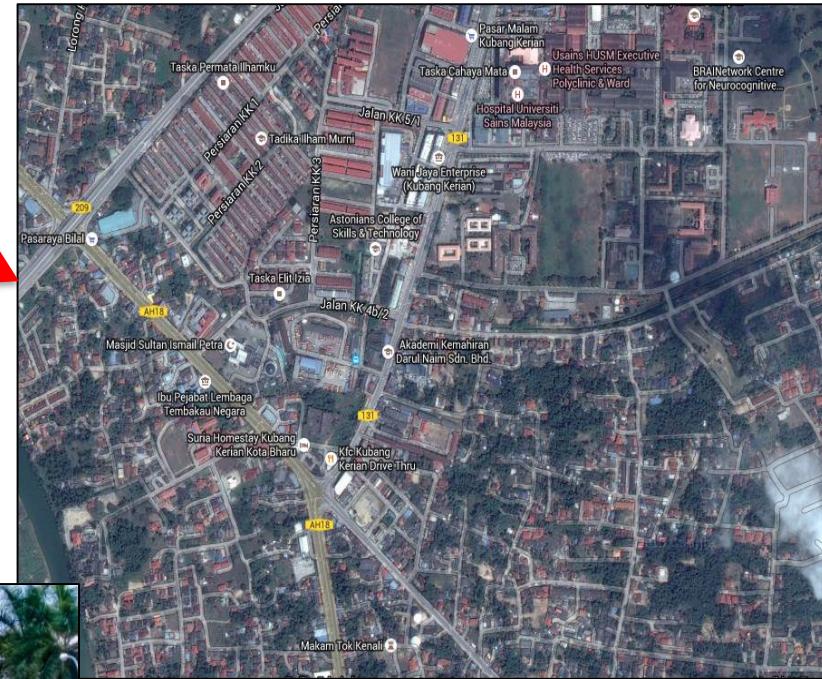
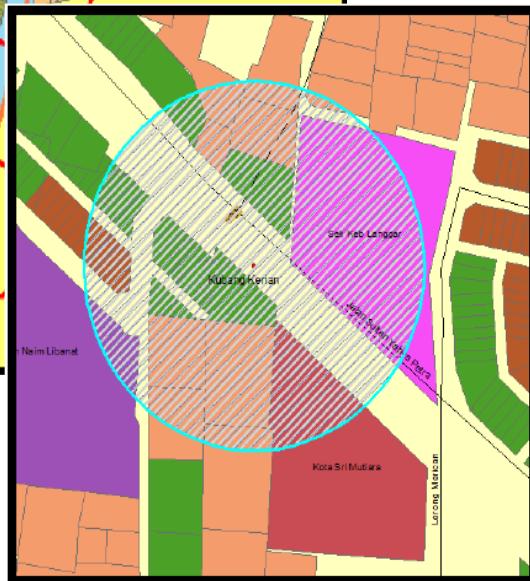
# Tool



Coordinates in WGS 84 format (Longitude, Latitude)  
Converted into Cassini format

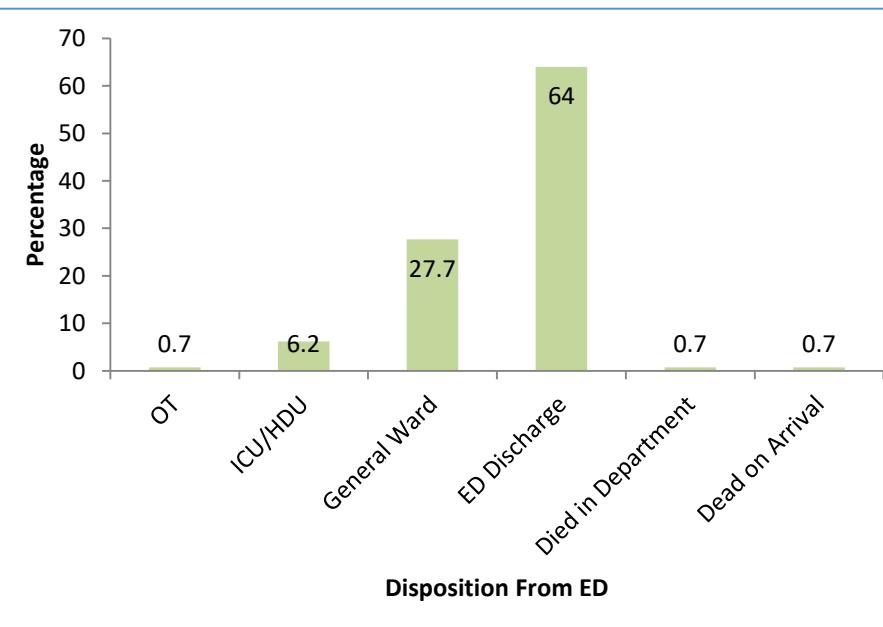
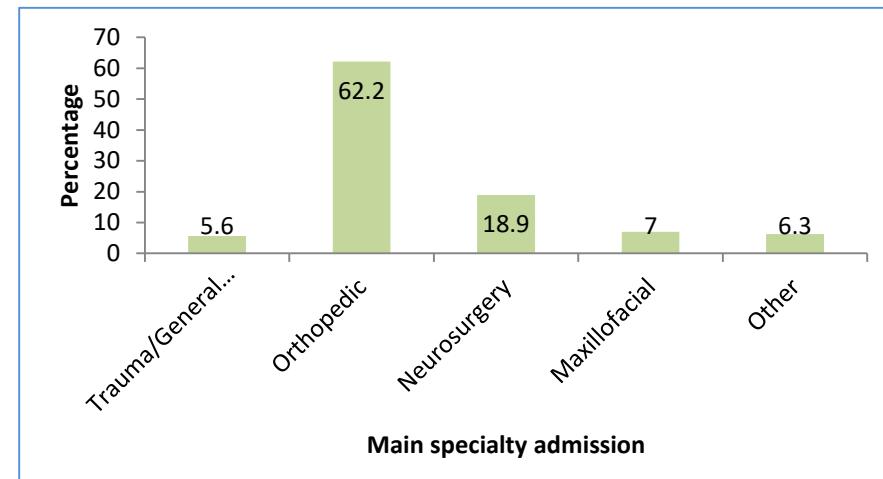
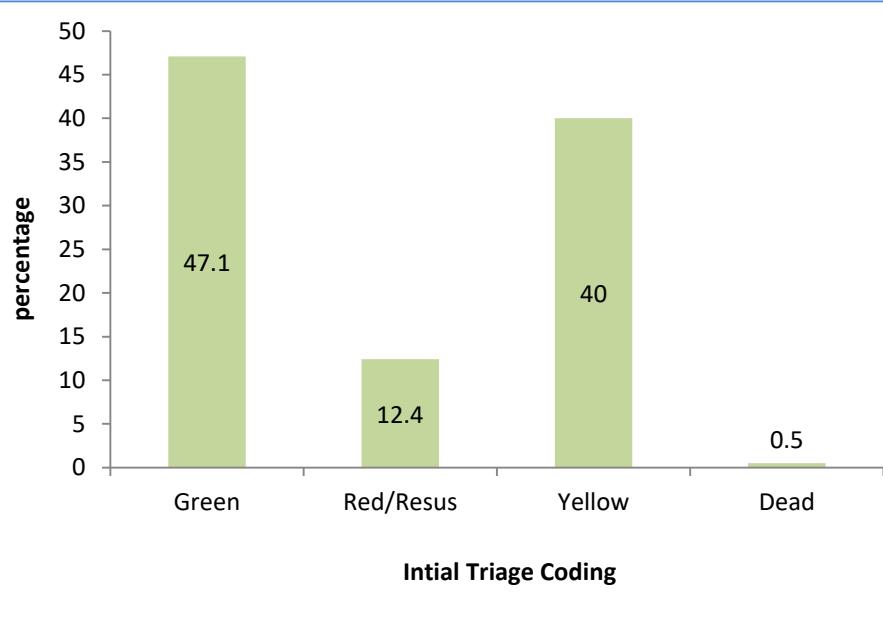
# Geospatial & Statistical Analyses

- Geospatial analysis by using ARCGIs version 10.0 (mapping, inverse distance weighting, 50 meter buffer)
- Digital Map obtained from town planning dept. (Data and map converted to digital and shapefile: Landuse, road network, borough boundaries)
- Analyses: inverse distance weighting (IDW), hotspot, buffer, road network
- Multiple logistic regression analysis for predictive factors

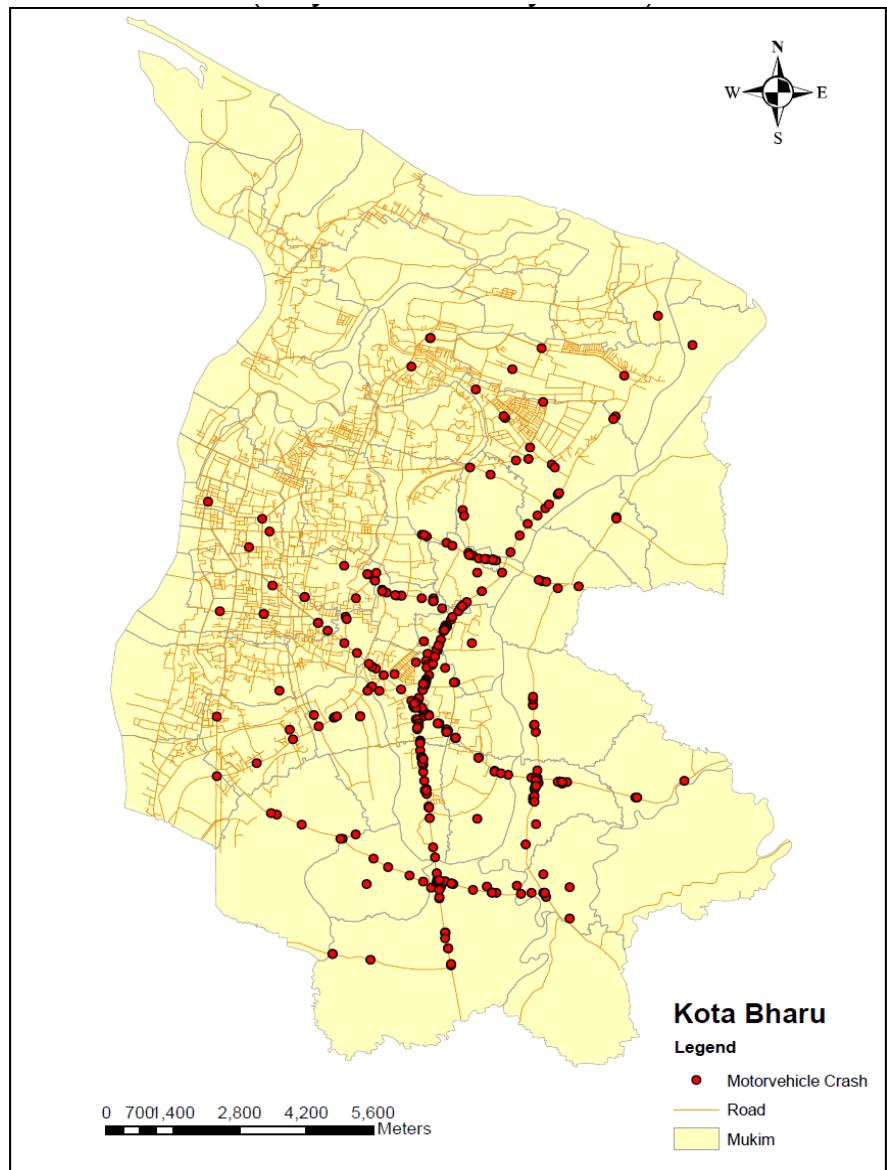
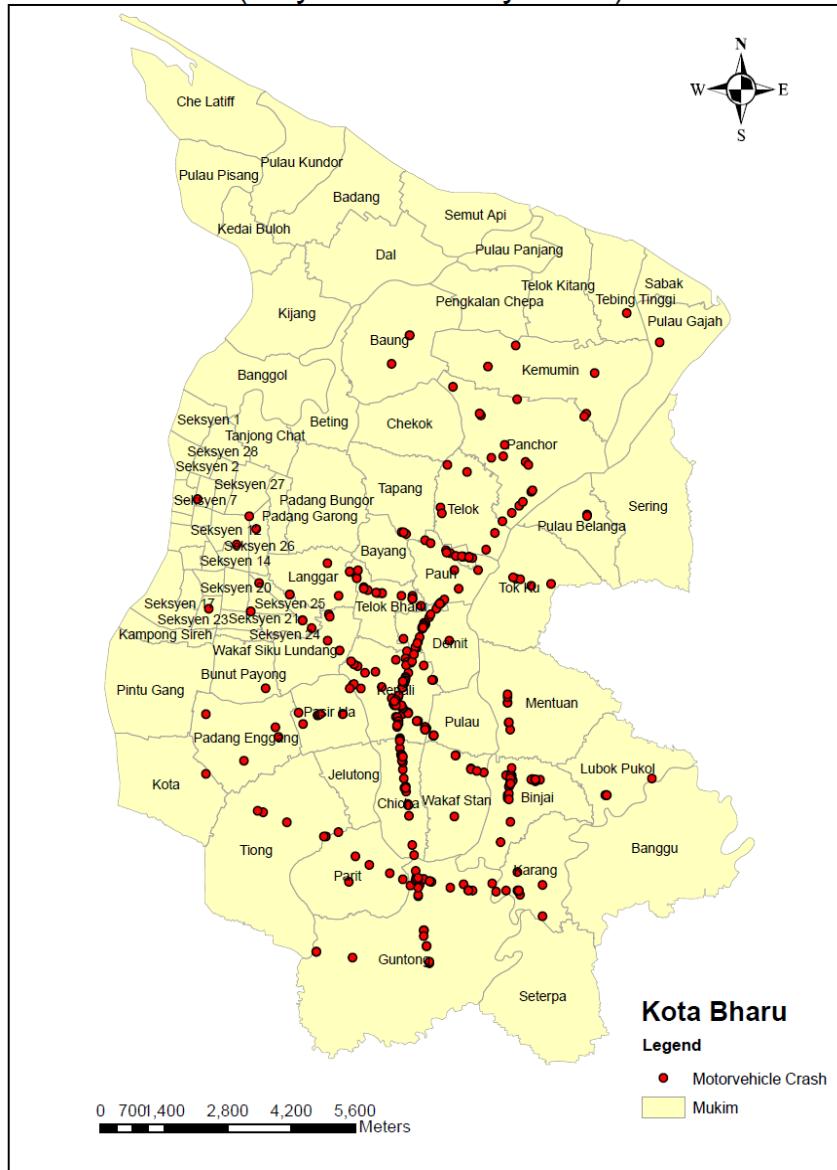


# Findings:

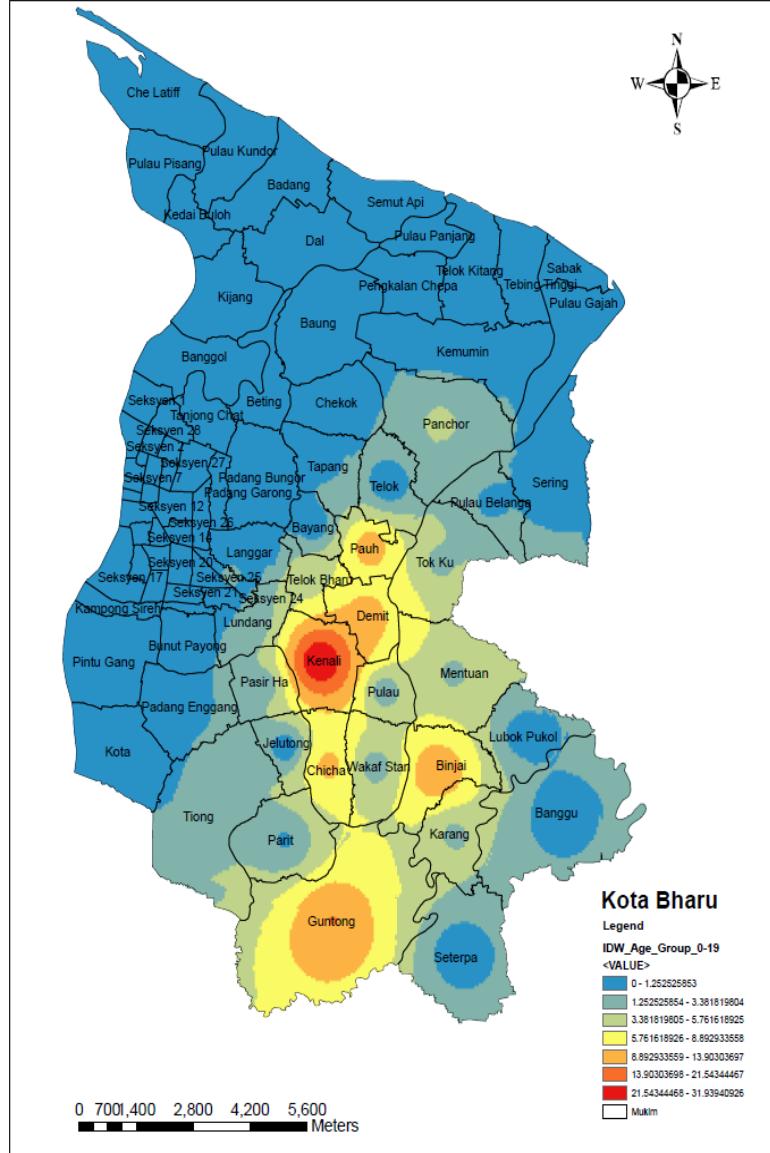
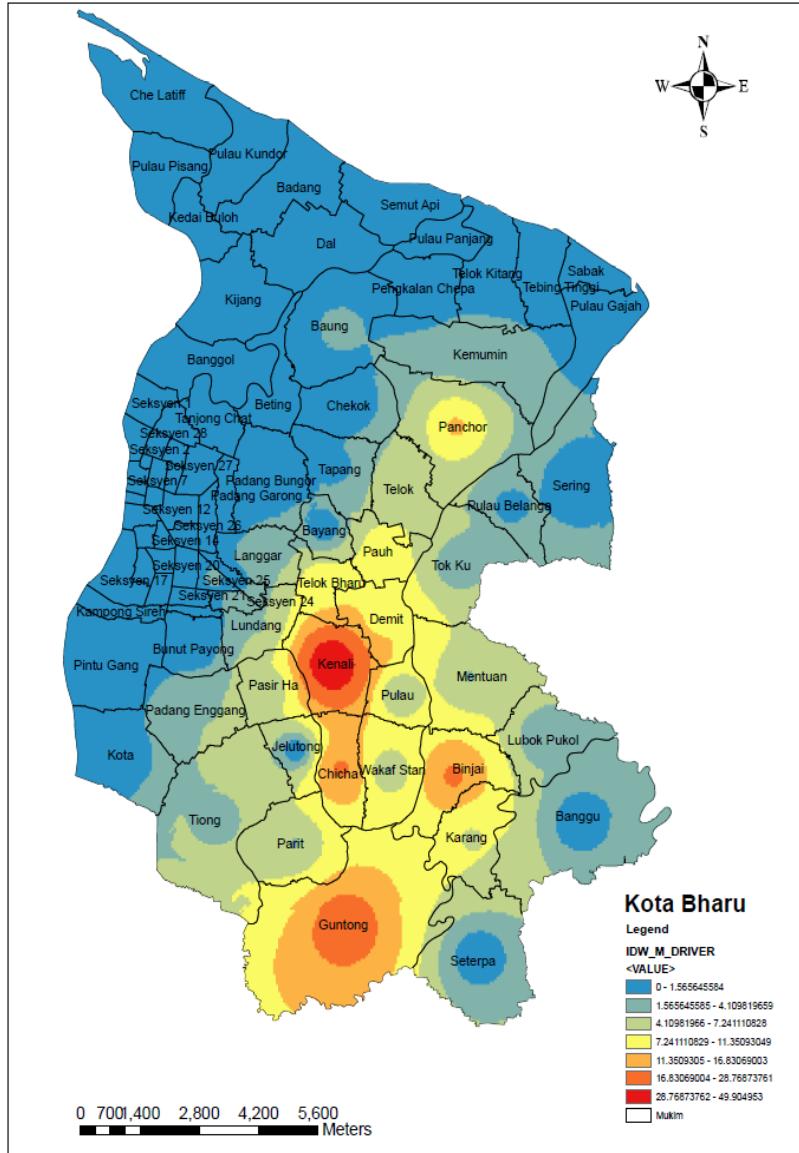
- A total of 439 cases were included over 6 months.
- The mean age of RTI victims 26.9 (s.d $\pm$ 14.5)
- Male comprised of 302 (71.7%) of the cases.
- 176 (41%) of the victims were between the age of 20 to 40 years. Majority of the victims were also among the adult group (i.e above 18 years of age) [320 (72.9%)].
- Motorcyclists were the commonest type of victims involve [351(80.0%)] followed by car occupants [55 (12.5%)].



The median (IQR) length of hospital stays was 5.0 days (6.0), ranging from one to fifty one days.

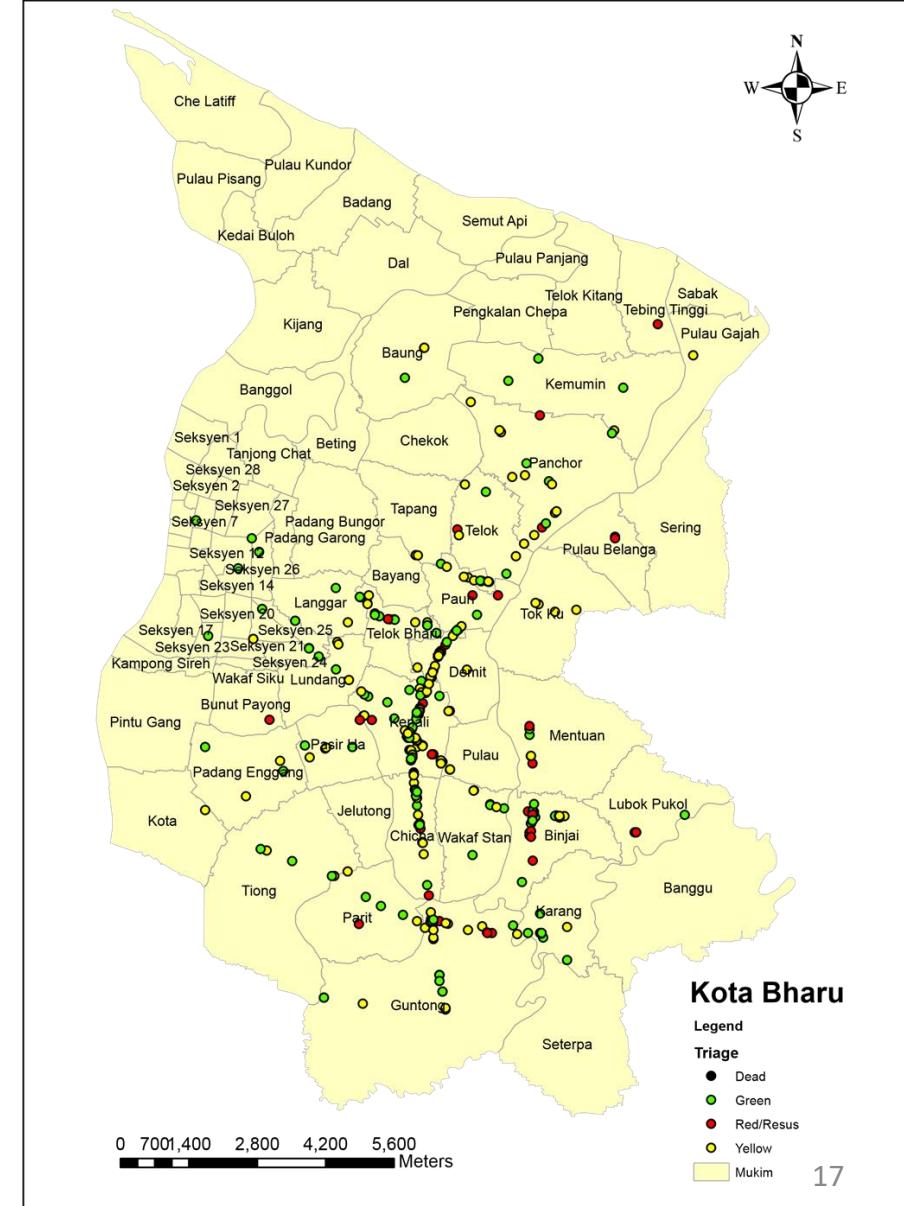
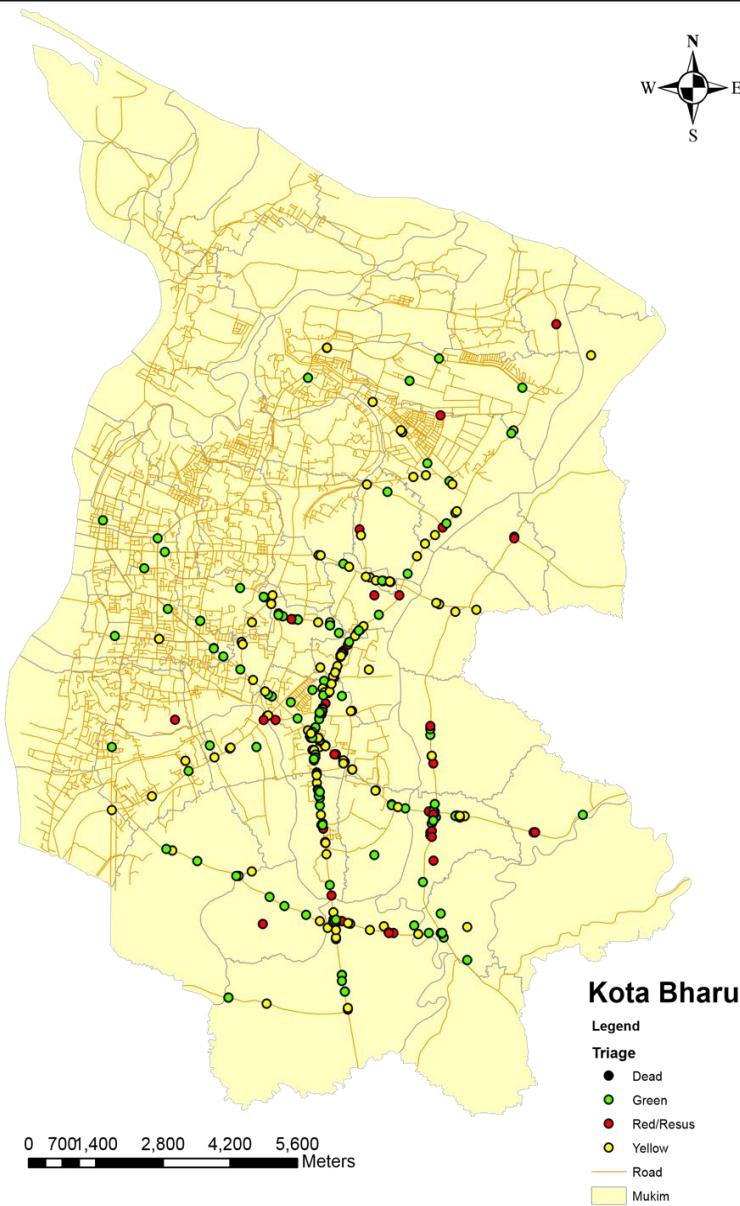


Locations of all MVC that occurred from December 2015 till May 2016 based on  
borough & road network

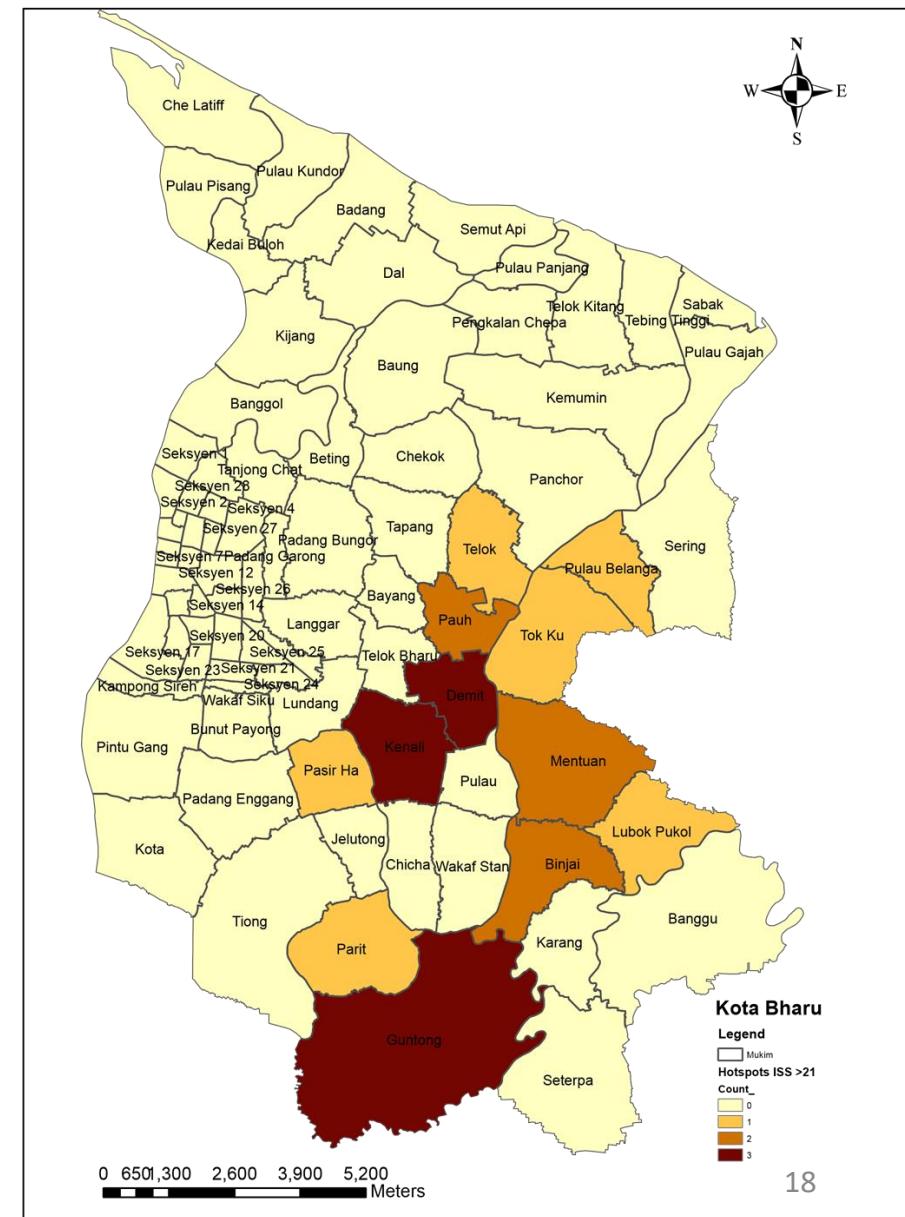
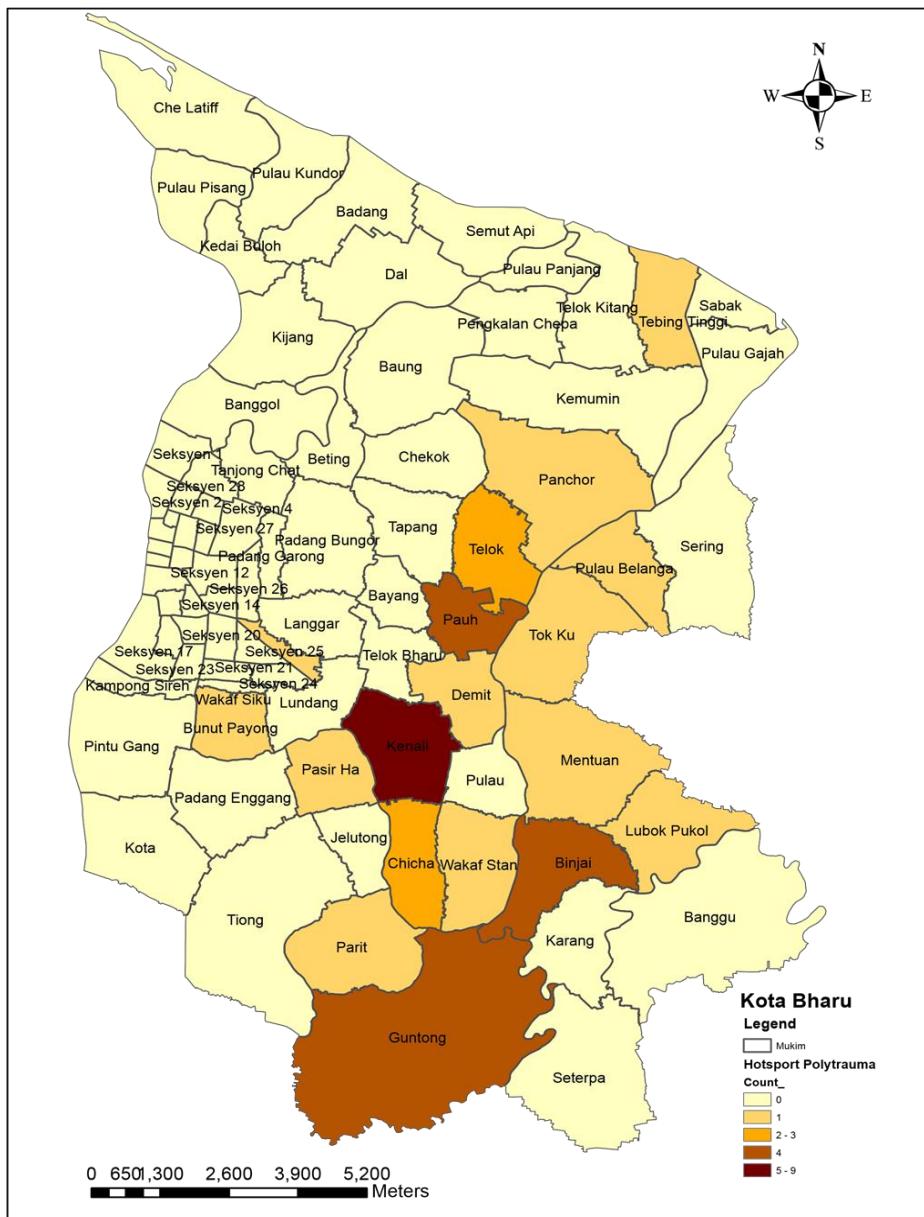


Map of motorcycle crash (driver) and pediatric victims based on inverse distance weighting analysis

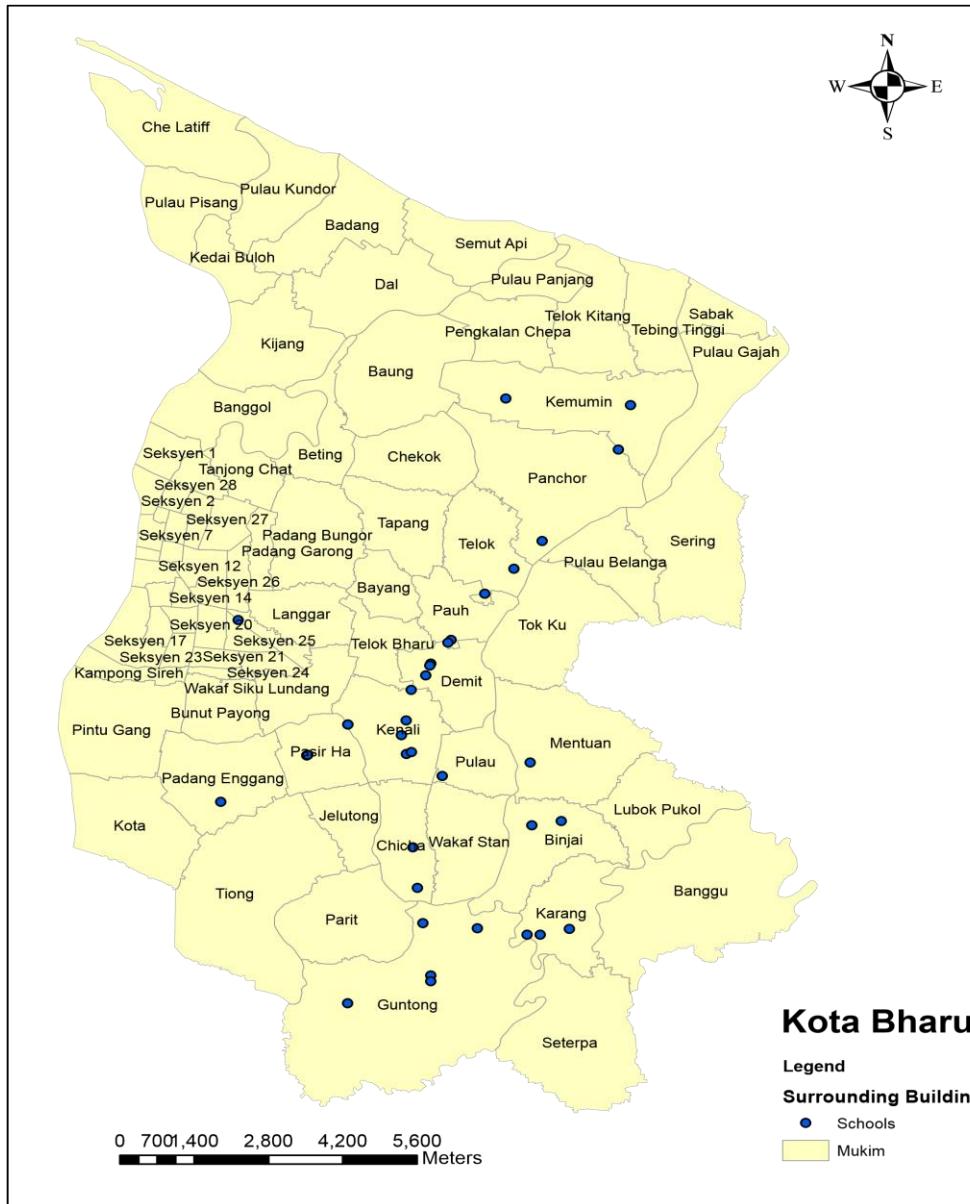
# Map of Motorvehicle Crash Locations Based on Triage Categories (Road & BoroughLayers)



# Map of Motorvehicle Crash with Polytrauma and severe ISS Based on Hotspot Analysis



# Map of Motorvehicle Crash Locations Based on School Area (Borough Layer)





## Map of Network of Ambulance Response Towards Road Traffic Injury Case (Case 4)

- Measure shortest route to nearest tertiary center
- Able to calculate total distance in kilometers
- Further analysis can be done by direct visualization on number of junctions, traffic lights, high risk areas, road lightings, hump & bump, road conditions

# 50 meter buffer analysis for cases involving motorcycles

Types of Road	Frequency	Percentage (%)
State Road	50	23.0
Municipal Road	160	73.7
Jalan Kampung	4	1.8
Other	3	1.4
<b>Total</b>	<b>217</b>	

Junction	Frequency	Percentage (%)
Junction/Curve	59	2.7
Straight	158	72.8
<b>Total</b>	<b>217</b>	

Types of Housing	Frequency	Percentage (%)
Village	171	63.1
Terrace	72	26.6
Flat	25	9.2
Istana	3	1.1
Perumahan Kakitangan	1	0.4
<b>Total</b>	<b>271</b>	

Institution	Frequency	Percentage (%)
Kindergarten	10	25.0
Primary School	14	35.0
Secondary School	6	15.0
Sekolah Agama	5	12.5
IPT	5	12.5
<b>Total</b>	<b>40</b>	

# 50 meter buffer analysis for cases involving pediatric

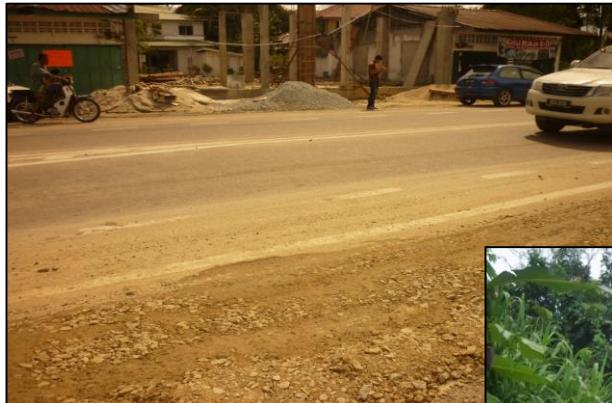
Types of Road	Frequency	Percentage (%)
State Road	11	15.1
Municipal Road	59	80.8
Jalan Kampung	1	1.4
Other	2	2.7
<b>Total</b>	<b>73</b>	

Junction	Frequency	Percentage (%)
Junction/Curve	19	26.0
Straight	54	74.0
<b>Total</b>	<b>73</b>	

Types of Housing	Frequency	Percentage (%)
Village	60	51.3
Terrace	30	25.6
Flat	20	17.1
Istana	5	4.3
Perumahan Kakitangan	2	1.7
<b>Total</b>	<b>117</b>	

Institution	Frequency	Percentage (%)
IPT	3	11.1
Secondary School	3	11.1
Primary School	14	51.9
Kindergarten	1	3.7
Sekolah Agama	6	22.2
<b>Total</b>	<b>27</b>	

# Direct Visualization of Injury Site



# Analysis based on speed limit area

**Table 4.11:** Type MVC outcomes in relation to speed limit at the sites

SPEED LIMIT	ISS 16 OR MORE	POLYTRAUMA n (%)	CRITICAL AT ARRIVAL n (%)	DISABLE AT DISCHARGE n (%)	OPERATED n(%)
35 km/hr or less	4 (7.7)	5.(11.9)	3 (6.1)	21 (10.3)	10 (9.6)
60 km/hr or less	38 (73)	28 (66.7)	34 (69.4)	145 (71.4)	75 (72.1)
90 km/hr or less	10 (19.2)	9 (21.4)	12 (24.5)	37 (18.2)	19 (18.3)

ISS: Injury severity score (The sum of three squared highest Abbreviated Injury Score)

*Maximum ISS is 75*

*Less than 9 = mild*

*9 – 15 = moderate*

*16 – 24 = severe*

*> 24 = Very severe*

# Predictive Factors of Disable at Discharge

Variable	Simple Logistic Regression			Multiple Logistic Regression		
	b	Crude OR (95% CI)	p	b	Adjusted OR (95% CI)	p
Injury Severity Score (ISS)	0.384	1.47 (1.35,1.59)	0.000	0.315	1.37 (1.25, 1.50)	<0.001
Age Group						
Adult	0	1				
Pediatric	-0.513	0.60 (0.39,0.94)	0.027	-0.735	0.48 (0.26, 0.89)	0.020
Operative						
No	0	1				
Yes	3.020	20.50 (9.61,43.72)	0.000	1.422	4.14 (1.68, 10.21)	0.002

Forward & Backward LR Multiple Logistic Regression model were applied

Multicollinearity and interaction term were checked and not found

Hosmer-Lemershow test, ( $p=0.104$ ), classification table (overall correctly classified percentage=81.2%) and Area under the ROC curve (88.3%) were applied to check the model fitness

# Lesson learnt ....

- We were able to identify hotspot cases for RTI in particular for vulnerable groups (2-wheeler & children)
- Able to plan for focus road safety program
- Able to plan for better PHC care for trauma
- Able to do trending analysis of hotspot
- Geographical and clinical data would provide clearer view of injury epidemiology

# Limitations

- Difficulty in getting accurate but yet vital data information for MVC cases. The very obvious inaccuracy arose from data such as:
  - speed limit
  - helmet wearing
  - illicit drug use
  - accurate location
- inability to obtain mechanical variables (conditions of vehicles)

# GIS in Health Interest Group

- Mapping of stroke related cases
- Mapping of malnourished children
- Mapping of PHC provisions among geriatric cases
- Mapping of Dengue & Leptospirosis cases
- 2<sup>nd</sup> Phase of mapping of RTI cases

# Acknowledgement

- Thank you to the USM for granted the RUI grant (1001/PPSP/812099)
- Thank you to the staff of Emergency Dept and ambulance paramedic HUSM & HRPZ
- Thank you to the BA students in Geomatics UITM Perlis
- Thank you to the MIROS & Malaysian Royal Police Force