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ROAD CRASH DATA VISUALISATION AND ANALYTICS USING TABLEAU FOR MOUNTAINOUS ROADWAY AREAS IN CAMERON HIGHLANDS, MALAYSIA

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Abstract

Despite government efforts and enforcement, alarming statistics in road crashes with high fatality rates in mountainous roadways are a significant concern to the authorities and community. This research has aimed to produce road crash profiling of Cameron Highlands based on secondary data using Tableau software. Results show that 66 cases involving motorcycles less than 251cc are the most dominant type of vehicle involved in road crashes, followed by tour or excursion vehicles, lorry trailers, four-wheel drive, and cars. The most frequent crash locations in Cameron Highlands are at the boundary of Jalan Keramat Pulai (45 cases) and Jalan Ringlelet – Kg. Raja – Blue Valley (50 cases). These cases involved hitting pedestrians, sideswipe collisions, forced collisions, hitting the roadside animal, head-on collisions, vehicles out of control, and right-angle side, which lead to fatal injuries. These findings may assist in identifying intervention planning to control and manage road crashes in mountainous areas.

Keywords: Road Accident, Accident Profiling, Road Traffic Injury, Tourism City, Secondary Data

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INTRODUCTION

The aspiration, new plan, and vision of the United Nations Decade of Action on Road Safety in the year 2021-2030 is to cultivate road safety for the well-being of the nation and to focus on implementing zero death for each country in Malaysia (Idris et al., 2019; Ishak et al., 2020; UNCTAD, 2017). A vision zero of fatalities aspiration caused by road crashes was relatively not new as a global issue (Varhelyi, 2016). According to UNCTAD (2017), Sweden and Netherlands proclaimed that road safety is a safety system that originated in the 1980s and 1990s at the United Nations General Assembly. During that time the United Nations Decade of Action on Road Safety 2011-2020 was established in March 2010 by the United Nations General Assembly (UNGA). This initiative objectively stabilized and subsequently reduced the predicted numbers of road traffic fatalities worldwide by promoting road safety campaigns and awareness at the national, regional, and global levels (Ishak et al., 2020). The road safety strategy was mapped into TWO (2) Sustainable Development Goals (SDGs) targets, namely: SDG target 3.6 on halving the number of global deaths and injuries from road traffic crashes; and SDG target 11.2 on providing access to safe, affordable, accessible and sustainable transport systems as well as improve road safety for all.

Jain et al. (2020) and Shrestha & Kumar Shrestha (2018) reveal there are various reasons associated with frequent road crashes that happen in mountainous roadway areas. Factors such as transport demand and unsafe operation during unpredictable weather conditions can be the causes of road crashes in mountainous roadway areas road networks (Jawi et al., 2009). Other than that, road networks in mountainous roadway areas also faced problems such as difficulties in upgrading road networks and higher cost of road rehabilitation and maintenance (Hamednia et al., 2018; Zhang et al., 2020). Concerning road crash issues, few studies were conducted using secondary data focusing on the mountainous road network (e.g. Shaadan et al., 2021; Sunkpho & Wipulanusat, 2020). A study comparing mountainous and non-mountainous crash characteristics in Sabah, Malaysia found among factors that increase the odds of crashes along mountainous roads compared with non-mountainous roads including horizontal curve sections, single-vehicle crashes and weekend crashes (Rusdi et al., 2017). Past studies usually discuss qualitative factors, forecasting models, predictive models, cause, impact, and social influence of road crashes. However, limited studies examined specific area road crashes and crash characteristics. Therefore, user-friendly and efficient analysis techniques are essential for understanding big data and gaining meaningful insights regarding data structure, trends, causes, impact, and patterns (Sunkpho & Wipulanusat, 2020). Thus, this research uses data analytics and visualization technique to explore road crash data in Cameron Highlands compared to non-mountainous

areas to increase knowledge and understanding about road crash scenarios and patterns, particularly in rural and urban areas.

RESEARCH METHODOLOGY

Sources of Secondary Data

Cameron Highlands has been chosen as the research area for this study. It is located within the district of Pahang, Malaysia, and occupies a total area of 712.18 square kilometers. Cameron Highlands is one of the tourist cities to the North of Pahang and its boundaries touch Kelantan, and to the West, Cameron Highlands shares a part of its border with Perak in Peninsular Malaysia. This research obtained four years (2015 – 2018) crash data from the Malaysian Royal Police (PDRM) and the Malaysian Institute of Road Safety Research (MIROS) using the Road Accident Analysis and Database System (M-ROADS). This research exploits recorded crash data in four (4) roads, namely (i) Jalan Gua Musang – Lojing (rural and urban areas), (ii) Jalan Keramat Pulai (rural areas), (iii) Jalan Ringlet – Kampung Raja – Blue Valley (rural and urban areas) and (iv) Jalan Tapah (rural areas).

Framework for Data Analysis

This research followed a methodology framework from Shaadan et al. (2021) and the flow of the data analytics process are presented in Figure 1.

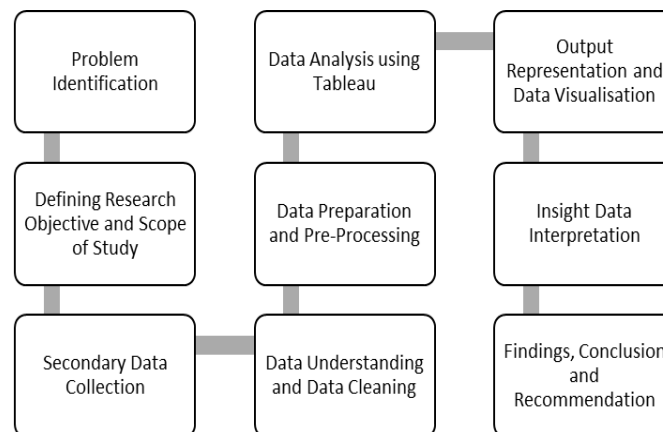


Figure 1: The Methodology Framework of the Data Analytics Process

The data analysis starts with the problem identification stage, followed by the definition of the research objective, and the scope of the research will be executed at the following stage. Next, the secondary or raw crash data gathered

in this research was filtered and arranged according to research categories in Table 1 using Microsoft Excel. The research categories and variables' names are compared to the standard POL27, a road traffic crash form used by the Malaysian Royal Police. Generally, POL27 form contains more than 63 variables of information, including a detailed road traffic crash report such as time of the crash, road information, environmental information, crash location, vehicle information, driver information, comments from the police officer in charge, the sketch of the crash incident with its location (Rusli et al., 2017). However, the variables of information filtered from the M-ROADS system may be subject to record and raw data available in the system at that particular time.

Table 1: Variables Name and Level of Measurements for Raw Data.

No.	Variable Name	Description	Level of Measurement
1	Crash Severity	The four types of crashes are fatal injury, serious injury, slight injury, and property damage only.	Nominal (category)
2	Crash Location	Road Type: The road type is divided into five categories: expressway, federal road, state road, municipal road, and others. Route No.: Each of the gazette roads in Malaysia has its unique route number.	Nominal (category)
3	Type of Collision by Year	There are thirteen collision types: head-on, rear-end, right angle side, angular, sideswipe, forced, hitting the animal, hitting an object off-road, hitting an object on the road, hitting pedestrian, overturned, out-of-control, and others.	Nominal (category)
4	Type of Collision (Urban or Rural Areas)	There are four categories of location types: city, urban, built-up area, and rural area.	Nominal (category)
5	Traffic System by Year	Four traffic systems categories are one-way, two-way, three-lane, and dual carriageways.	Nominal (category)
6	Road Geometry	There are seven categories of road geometry, including straight, bend, roundabout, cross-section, T/Y junction, staggered junction, and interchange.	Nominal (category)
7	Light Condition	There are four categories of lighting conditions: day, dawn/dusk, dark with street lighting, and dark without street lighting.	Nominal (category)
8	Type of Weather	Three categories of weather conditions are available: clear, foggy, and rain.	Nominal (category)

Note: Variables of information filtered from secondary data may be subject to raw data available. Some data is missing and incomplete. Therefore only consistent data for selected years were chosen to be analysed using Tableau software.

This research employs frequency and descriptive analysis by utilizing a data analytics methodology focusing on a data visualization tool using Tableau

software. In total, only eight (8) variables were identified for the selected study locations in this research, namely, (i) crash severity, (ii) crash location, (iii) type of collision by year, (iv) type of collision (urban or rural areas), (v) traffic system by year, (vi) road geometry, (vii) light condition and (viii) type of weather. The data was then transferred to Tableau software and arranged to the desired sequence and suitable visuals and figures. Tableau software allows the researcher to explore data preparation and to pre-process using limitless visuals such as spatial distribution patterns, graphical visuals, tables, bar charts, interactive histograms, and summary statistics. After that, data understanding and data cleaning can be done simultaneously using Tableau software to get a quick and interactive data visualisation presentation for research purposes. In addition, this value-added Tableau software will give the reader a better understanding and insight into data interpretation. Finally, the researcher discussed the research findings for each data presented in the conclusion and recommendation section.

ANALYSIS AND DISCUSSION

Research findings are presented in the following section for better insight and discussion. Sunkpho & Wipulanusat (2020) identified that many transport agencies adopt Tableau software as the visual analytics platform. The following indicate five (5) descriptive and frequency analysis types analysed in this research using Tableau software.

Descriptive and Frequency Analysis

Between years 2015 and 2018, there are 145 crashes occurred along the main road in Cameron Highlands, Pahang. Figure 2 shows the most dominant type of vehicle involved in road crashes in Cameron Highlands during data period.

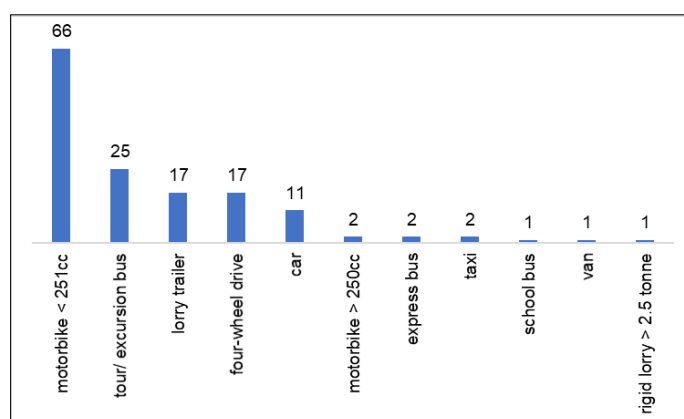


Figure 2: The Most Dominant Type of Vehicles involved in Road Crashes.

Results show that motorcycles less than 251cc are the most dominant type of vehicle involved in road crashes at the selected location with 66 cases. Then, it is followed by a tour or excursion vehicle (25 cases), lorry trailer (17 cases), four-wheel drive (17 cases), and car (11 cases). This finding is in line with finding from research by Idris et al. (2019), where 45.89% of motorcyclist and pillion fatalities crash cases occur in Malaysia. Most probably, the main factors that may cause fatality crash cases among motorcyclists and pillions are human behaviour; age; gender; anger and aggression; speeding; improper ways of wearing a helmet; poor road infrastructure and surrounding and vehicle (Abdul Manan et al., 2016; Idris et al., 2019; Rusli et al., 2017; Yusoff et al., 2022)

Category-by-Category Line Plot Chart

This research identified three (3) types of crash severity available in the secondary data, namely (i) fatal injuries, (ii) serious injuries, and (iii) slight injuries. In this research context, fatal injuries define as at least one person (driver or passenger) being killed (within 30 days) by injuries sustained in the crash (Elshamly et al., 2017; Peng et al., 2018). Serious injuries are defined as at least one person injured and admitted to hospital, but no fatalities and at least one person requiring medical care but no fatalities or injuries requiring hospitalisation, and slight injuries define as at least one person injured which having minor abrasion or bruises but no medical attention needed and no other more serious injuries (Elshamly et al., 2017; Peng et al., 2018). Crash severity cases concerning the collision type for the respective year in Cameron Highlands can be visualised and addressed in Figure 3.

Figure 3 visualises that that head-on collisions are the main factors contributed to all types of injury. The line plot chart pattern analysis shows the decreasing result of fatal injuries from 2015 to 2018. The most frequent fatal injuries collision is related to head-on collisions. The result indicates that in 2015, the line plot chart recorded a high number of fatal injuries involving head-on collisions (7.483%), out-of-control collisions (4.762%), hitting pedestrian collisions (0.680%), and sideswipes collisions (0.680%) respectively. Meanwhile, in 2016, the analysis shows that head-on collisions (6.803%), out-of-control collisions (5.442%), angular collisions (1.361%), forced crashes (0.680%), hitting objects on road collisions (0.680%), hitting pedestrian collisions (0.680%), rear-end collisions (0.680%) and sideswipes collision (0.680%) recorded as the reason of fatal injuries in that particular year. In 2017, the analysis revealed that head-on collisions (4.082%), out-of-control collisions (3.401%), rear collisions (1.361%), sideswipes collisions (1.361%), and angular collisions (0.680%) were recorded as fatal injuries. High cases involving serious injuries were recorded in 2016 compared to the remaining years. Analysis of the

line plot chart pattern shows the combination of hitting pedestrian collisions, right-angle side collisions, out-of-control collisions, rear collisions, and sideswipe collisions as the most frequent type of serious injuries in the year 2015, 2017, and 2018. Meanwhile, high cases of slight injuries occurred in 2015 and 2016 due to head-on collisions. The results reveal evidence that most road crashes that happen due to a head-on collision cause fatal injuries. This result aligns with findings from studies by Peng et al., (2018), where head-on collision is usually associated with fatal injuries under the mountainous roadway areas category.

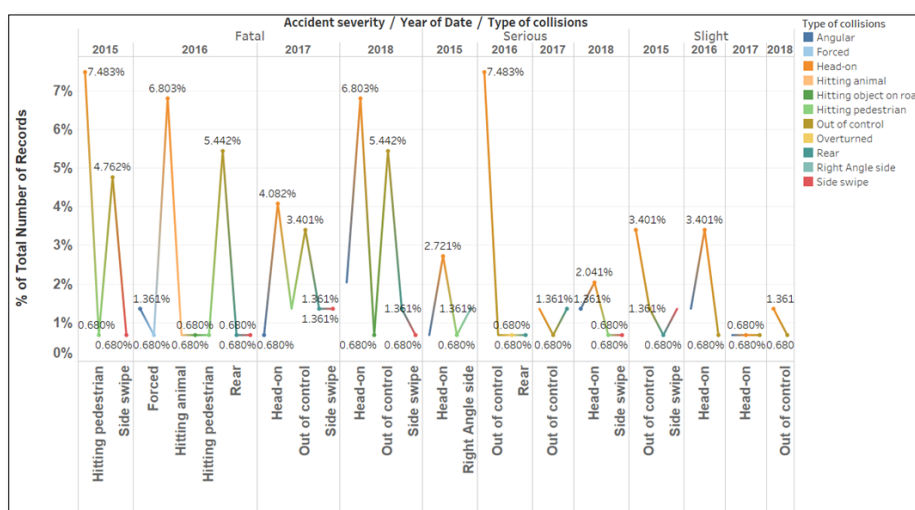


Figure 3: Crash Severity versus Type of Collision by Year (2015 – 2018)

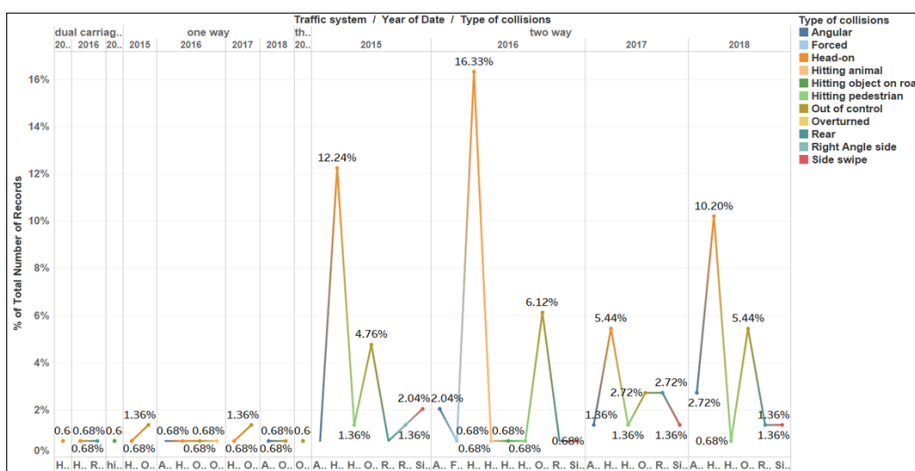


Figure 4: Traffic System versus Type of Collision by Year (2015 – 2018).

Figure 4 shows the area pattern chart with multiple categories that aim to visualize the traffic system according to the type of collision by year (2015 – 2018) in Cameron Highlands. There are four types of traffic systems in Cameron Highlands, namely (i) dual carriageway, (ii) one-way, (iii) three-lane, and (iv) two-way. From this table, the highest head-on collision cases occur in two-way rural road traffic systems where vehicles can travel in both directions. A study by Cáceres et al., (2021) and Maksid & Hamsa (2014) identified that head-on collisions are associated with geometric design factors where roads section of 7 meters or wider; road sections with curves; narrowing or drop changes; on wet or snowy roads surfaces; in twilight condition; incorrectly overtaking another vehicle and measurement of medians and paved shoulders not to the correct specification.

Area Pattern Chart with Multiple Categories

The area pattern chart with multiple categories in Figure 5 visualises the highest number of crash records (14 cases) in rural areas. A study by Shallam et al., (2022) has stated that safety criteria and geometric design consistency of undivided roadways in rural areas will give significant to high number of crashes.

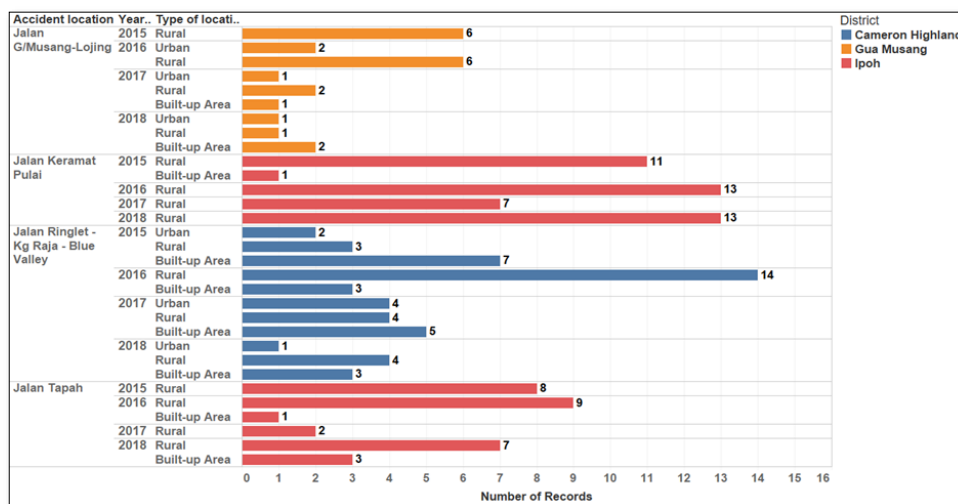


Figure 5: Crash Location and Type of Location (Urban and Rural Areas).

Figure 6 shows the ranking distribution of light conditions versus the type of weather. The most dominant vehicle crash happens during good light conditions and clear weather, with the highest record (31 cases) in 2016. Duddu et al., (2020) conducted a research in United States also found single-vehicle

crashes more likely to occur during clear weather compared to cloudy, rainy, and snowy weather. Driver behaviour was identified among the main factors of this scenario, where they give extra precaution during bad weather.

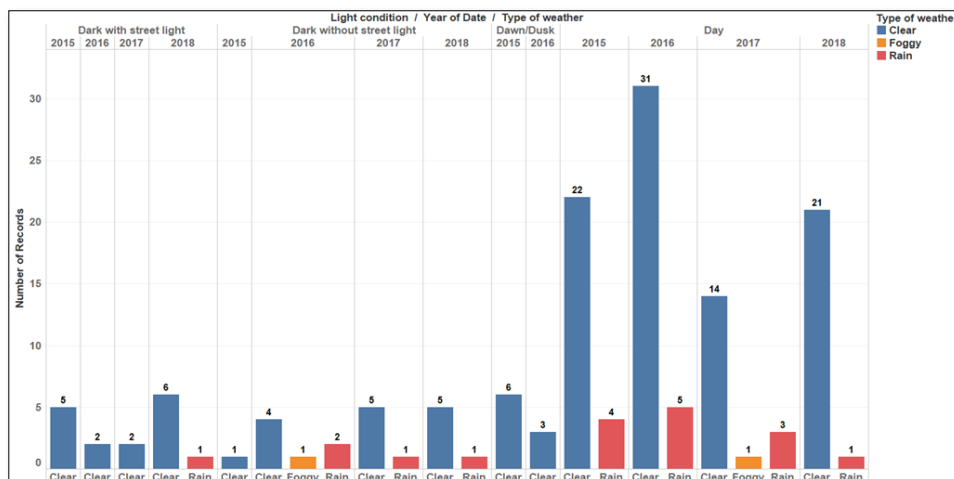


Figure 6: Light Condition versus Type of Weather.

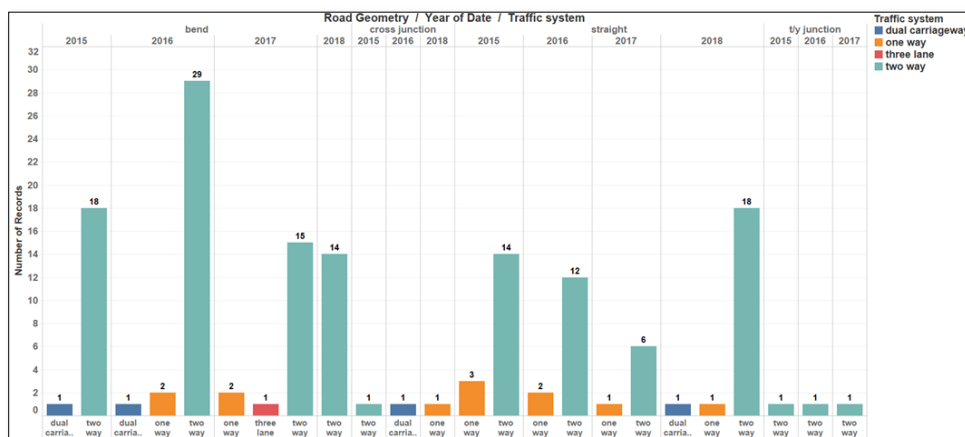


Figure 7: Road Geometry versus Traffic System by Yearly.

Regarding road geometry and traffic system, Figure 7 shows that high crash cases occurred in a two-way traffic system located at bend or curve (29 cases), T or Y junction (18 cases), and straight road (14 cases). This finding is consistent with previous research conducted by Ingle & Gates, (2023) and Joseph et al., (2023), where inconsistency in roadway geometry can lead to vehicle

crashes in rural areas with the two-way type of location. However, in this research data of curve combination, radius, gradient, sight distance, lane width and operating speed were missing valuable parameters to support research findings.

Spatial Distribution Pattern of Total Road Crash Cases

Based on the spatial map distribution pattern of total road crash cases in Figure 8, analysis shows that the most frequent crash locations in Cameron Highlands are located at the boundary of Jalan Keramat Pulai (45 cases) and Jalan Ringlet – Kg. Raja – Blue Valley (50 cases). Most cases involved hitting pedestrians, sideswipe collision, forced collision, hitting the roadside animal, head-on collision, vehicle out of control, and right angle side, which lead to fatal injuries.

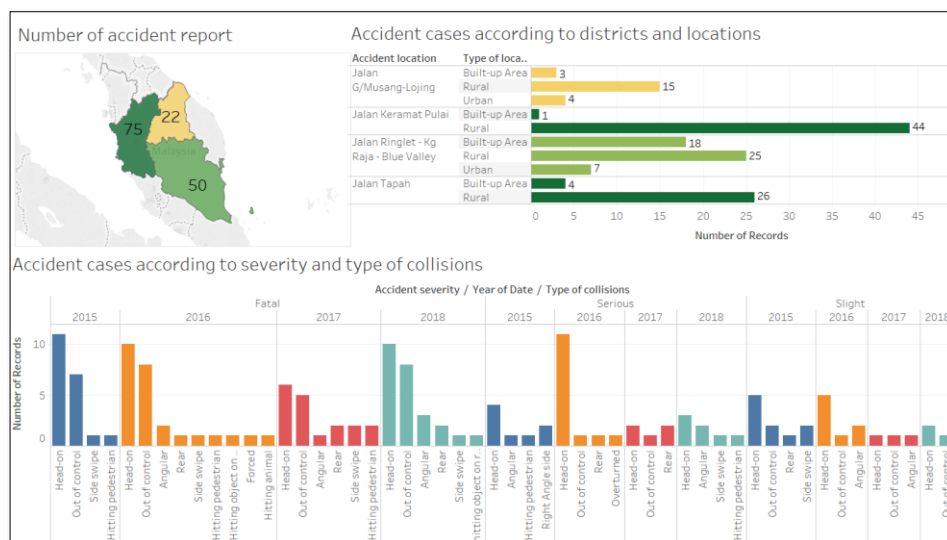


Figure 8: Spatial Distribution Pattern of Total Road Crash Cases.

CONCLUSION

This study has explored the visualisation and crash characteristics for Cameron Highlands roads between year 2015 and 2018. Result shows that head-on collisions contributed to all types of injuries. The highest head-on collision cases occur in two-way rural road traffic systems where vehicles can travel in both directions. High crash cases occurred during clear weather in a two-way traffic system located at bend or curve, T or Y junction, and straight road. The specific location approach may help gain insight as this initiative can improve road safety criteria and geometric design consistency roadways in mountainous terrain to reduce the injury severity significantly.

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