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Initial Assessment of Fire Response Time Between Different Category of Fire Station

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Abstract

Response time is an important indicator in fire operations. A continuous assessment of the response time is crucial for monitoring the firefighter's performance level. An initial assessment of fire response time was conducted on selected category A–D fire stations throughout Malaysia from 2018 until 2020. In this study, the mean response time and distance travelled for the selected fire stations were calculated. To measure the fire station's performance, a 10-min standard response time was used as a benchmark. A one-way ANOVA is also applied to determine statistically any significant differences between the mean response time and mean distance travelled. Category C and D fire stations recorded high mean distances travelled and mean response times within the four categories. Most of the fire stations in this category travelled approximately 14 km with a mean response time of 18 mins. A new risk profiling for minimising fire risk stemming from constant development in these areas might be necessary for future improvement

1. Introduction

Fire departments are constantly working with numerous measurements to improve their performance and effectiveness. An essential indicator in the management of any emergency call is the response time. A prompt response by the fire department to the fire scene is crucial for minimising the damage a fire can cause to a structure and public safety. Suppressing a fire before the flashover will reduce the ability of the fire to grow and spread to adjacent areas. A large amount of heat and smoke is generated during flashover, reducing the chances of saving occupants.

The total response time calculation is the period calculated from the receipt of the alarm until the arrival of the first responder team at the scene to initiate action or control the incident. Nonetheless, response times are frequently determined with different measures by firefighters and reported to the public using different approaches (NFPA 1710,2010).

Claridge and Spearpoint (2013) studied the New Zealand Fire Service response time. The response time analysis was established based on topographic conditions and divided into urban and rural area approaches. The response time for the permanent fire station was 90% achievement at 7 min 30 sec while that for volunteer-based fire stations was 90% at 10 min. The United Kingdom regulations for fire are divided into four risk categories (A, B, C, and D), with response times of 5, 8, 10, and 20 min, respectively (Institution, 2019).

Several studies have investigated the response time for monitoring the service performance and capability of fire organisations. Nonetheless, the response requirements vary greatly between countries. The standard response time of the Fire and Rescue Department of Malaysia (FRDM) is 10 min without any classification of demand zone. There have been limited studies on FRDM response times in recent years, but only focused on specific districts or states (Sardi & Razak, 2019; Subramaniam et al., 2012; Tamat et al., 2014). This study

conducted an initial assessment of the response time across different fire station categories and states in Malaysia. In addition, the distribution of Malaysian fire station categories was identified and the mean response times compared using analysis of variance (ANOVA).

2. Methodology

2.1. Data Collection

The fire response time data from 2018 to 2020 were obtained from FRDM. The data were based on fire stations under four categories in five states (Johor, Kedah, Pahang, Selangor and Sarawak). Each state represents a specific Malaysian geographical region, namely East Coast, Northern, Southern, and West Coast Peninsular Malaysia, and East Malaysia. Each state represents a specific Malaysian geographical region. The initial data comprised of fire and rescue incidents, including special tasks assigned such as support to other government agencies on natural disaster relief and handling wildlife. For this study, only fire incidents data recorded from 2018 to 2020 are selected for further analysis.

The State Operations Management Centre or fire station control room involved in the fire incident logs the response time data in the Malaysian Emergency Response Services (MERS) 999 system. The control room duty officer records the interval directly in the MERS 999 system.

The FDRM emergency response time was calculated as follows:

Response time = time of arrival at the scene – time of the alarm is acknowledged at fire station control room

2.2. One-way Analysis of Variance (ANOVA)

Several organisations publish a considerable quantity of statistical data on fires via annual reports on fires and fire departments. Unfortunately, the actual firefighter performance or the relationship between firefighting operations are not included in most statistics (Sardqvist & Holmstedt, 2000).

This study used one-way ANOVA to determine statistically significant differences between the mean response time and mean distance travelled. The first stage of the ANOVA involved constructing a hypothesis statement set consisting of a null hypothesis (H0, all means are equal) and an alternative hypothesis (at least one mean is not equal).

3. Results and Discussion

3.1. Data Description

Currently, there are 324 fire stations in Malaysia and are categorised under A, B, C, D, and E. Nationwide, 52.8% (n = 171) of fire stations fall under category C, indicating moderate-fire risk locations, 25.3% (n = 82) of fire stations are category B, indicating high-risk locations, followed by 11.7% (38) under category A for very high-risk areas. Category E fire stations were excluded from this study as the category encompassed very few fire stations. Figure 1 illustrates the distribution of fire stations in Malaysia according to category.

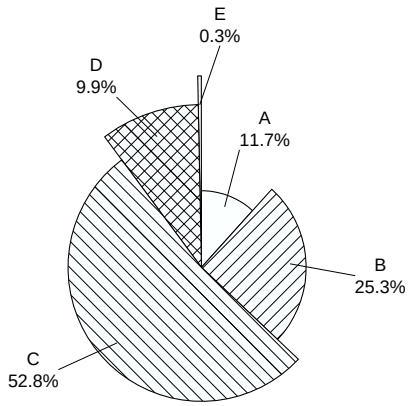

Figure 1. Fire station category in Malaysia

3.2. Fire Incidents of the Selected Stations

Total of 20 fire stations included in this study as listed in Table 1 with 10 233 fire incidents were recorded. Some of the recorded data yielded a negative value due to system error and were excluded from the analysis.

State	Fire Stations			
Johor	Larkin	Kota Tinggi	Pekan Nenas	Yong Peng
Kedah	Alor Setar	Kulim	Pokok Sena	Sungai Petani
Pahang	Bukit Angin	Kuantan	Ringlet	Taman Tas
Sarawak	Kanowit	Limbang	Petra Jaya	Tanjung Manis
Kuala Lumpur	Seputeh	Jalan Hang Tuah	Setapak	Sungai Besi

Table 1. The fire stations included in this study

Figure 2 illustrates the mean fire incidents for 2018–2020 according to category. The mean fire incidents were highest in category A locations, which recorded 50% more fire incidents compared to the other categories. In 2020, there were 15 393 reported fire incidents nationwide from March 18 to August 31. During the same period in 2018 and 2019, 19 165 and 23 094 fire incidents were reported, respectively (Mohammad, 2020). Similar trends were observed for the data from the selected fire stations, where reported cases decreased in 2020. This finding could be related to the issuance of the first Movement Control Order (MCO) beginning 18 March 2020 in response to the COVID-19 pandemic in the country. Over the three consecutive years, the fire incidents reported for all categories was highest for 2019. In the next section, fire station comparisons within a similar category yielded an excellent basis for assessing the response time.

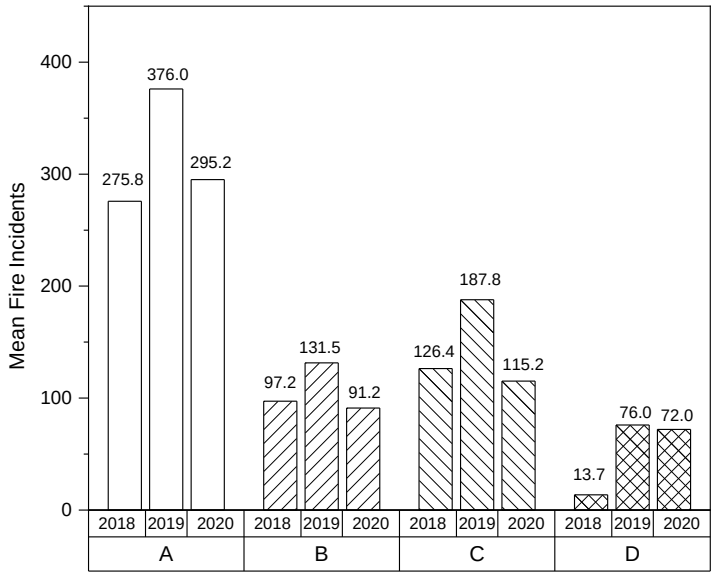

Figure 2. Mean fire incidents reported from 2018 to 2020 for selected fire station for all category

3.3. Mean Response Time from 2018 to 2020

Figure 3 demonstrates that most of the selected fire stations recorded a mean response time of > 10 min between 2018 and 2020. It is worth noting that the mean response time for category A, C, and D fire stations improved, while category B fire stations maintained the same mean response time of 14 min. In 2020, category A and D fire stations met the 10-min standard response time with mean response times of 7.96 and 8.90 min, respectively. The MCO had reduced traffic density significantly, which aided the reduction of the rescue team's delay in arriving at fire incidents as compared to that in 2019, as supported by Chen et al. (2021).

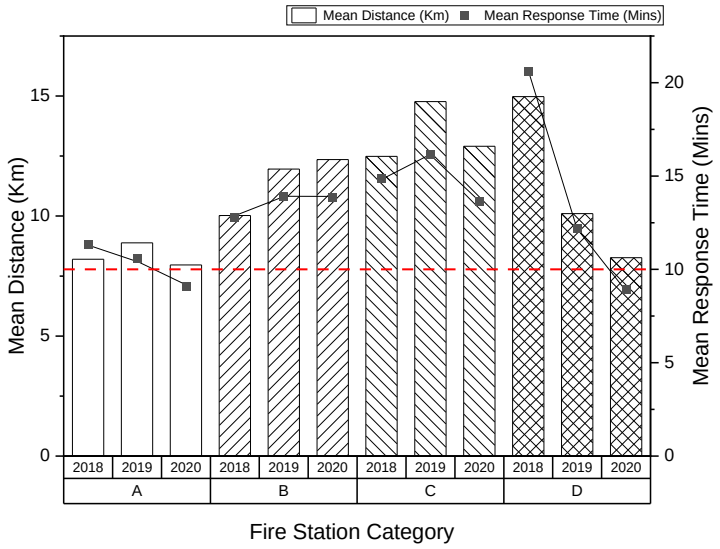

Figure 3. Mean distances travelled against mean response times by fire stations category

The shorter mean distance travelled for category D fire stations could be an important factor for the significant reduction in response time in 2020. Yung (2008), Tómasson et al. (2008), and Claridge and Spearpoint (2013) reported that one of the main factors influencing the response time was the distance travelled, where the city centre recorded average speeds of approximately 20 km/h for a short distance compared to 70 km/h on state highways for longer distances.

This main factor was proven with Pearson's correlation value between response time and distance travelled based on fire station category.

Table 2. Summary of Pearson's correlation analysis

Station category	**A**	**B**	**C**	**D**
Pearson correlation	0.39	0.89	0.76	0.86

Table 2 demonstrates exhibits a strong positive correlation between response time and distance travelled for category B, C, and D fire stations where the values lies between 0.5 and 1. The highest Pearson correlation value was for category B with 0.899, followed by 0.859 and 0.764 for category D and C. This positive value indicates that the response time may increase with distance. Category A fire stations recorded a medium positive correlation (0.387), as the value was < 0.5.

Figure 4 depicts the mean distances travelled and mean response times of the category A fire stations. The highest mean distance travelled and mean response time was recorded for the fire station in Kuantan, a city on the Peninsular Malaysia east coast. East Coast cities are moderately less dense than cities in west or south Peninsular Malaysia. In 2019, Kuantan firefighters travelled a mean 11.76 km to fire incident locations. Meanwhile, from 2018 to 2020, the Kuantan fire station recorded a mean distance travelled of 10.72 km with a mean response time of 13.9 min. The Larkin fire station recorded improved mean response times each year, with a response time of 7.45 min in 2020. The clearer traffic in 2020 could be one of the primary factors for the better response time by the category A fire stations.

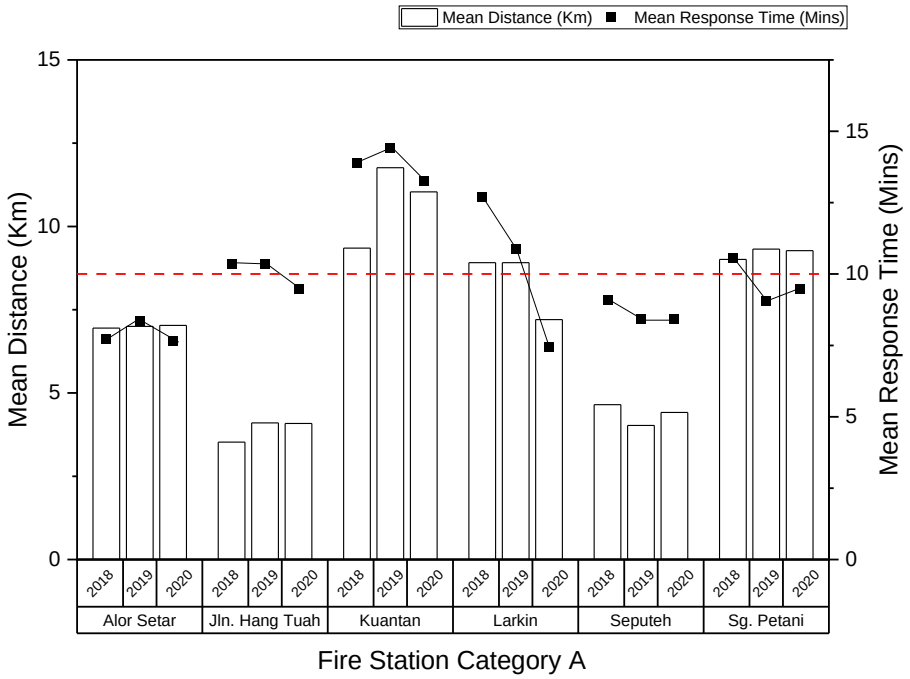

Figure 4. The mean distance and mean response time for category A fire stations

The high response time of the Kuantan fire station might be due to its bigger coverage, as the overall mean distance travelled was 10.88 km. The population and industry distribution in this area are quite distant from each other. A New York study reported that travel time increased linearly with the square root of the distance travelled for short distances and proportionally with the distance travelled for long distances (Kolesar & Walker, 1974).

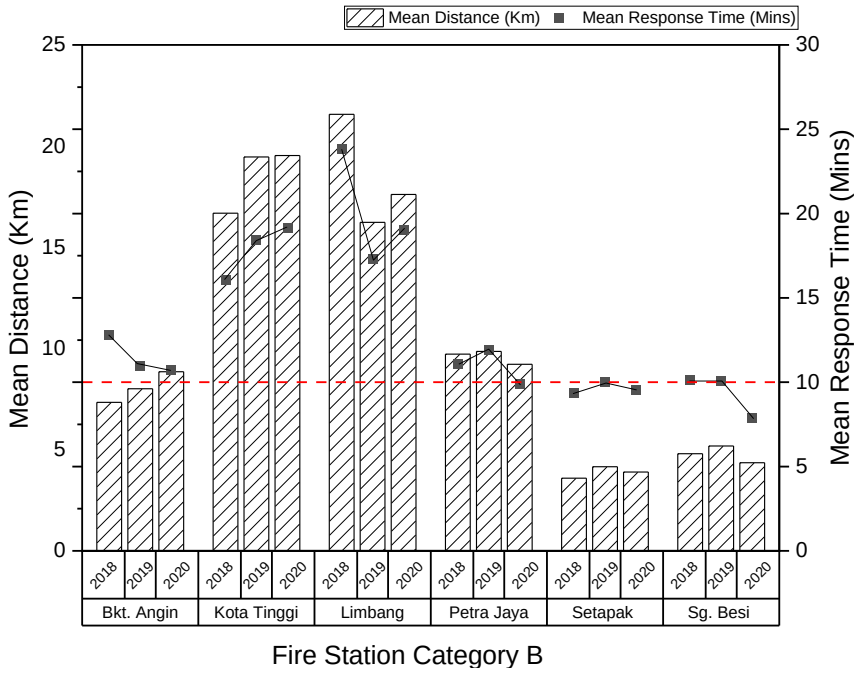

Figure 5. Mean distances travelled and mean response times recorded by category B fire stations

Figure 5 demonstrates that under category B, the Kota Tinggi and Limbang fire stations recorded the highest mean distances travelled and mean response times from 2018 to 2020. The mean distance travelled and mean response times of the Kota Tinggi and Limbang fire stations were 18.6 km and 17.9 mins and 18.5 km and 20.0 mins, respectively. The two fire stations also recorded a slight increment in mean response times for 2019 and

2020. The Setapak and Sungai Besi fire stations recorded consistent mean response times. These two stations experience slower traffic movement during peak hours (to and from the office).

Category C is the largest category of Malaysian fire stations. Figure 6 demonstrates that all fire station except for Kulim fire station did not meet the standard response times in 2019 and 2020. Kulim is a district in Kedah, a northern Peninsular Malaysian state known for its growing industrial area. Kulim firefighters travelled a mean distance of only 8.6 km for three years compared to the 20.1 km by Kanowit firefighters. Kanowit is a Sarawak district with a less dense population and development than other fire stations. This could contribute to larger coverage of Kanowit fire station compare to other areas. The Taman Tas, Yong Peng, and Pekan Nenas fire stations recorded mean distances travelled of < 17 km and decreased mean response times in 2020. The lower traffic density during the MCO could be the main reason for the reduced response times.

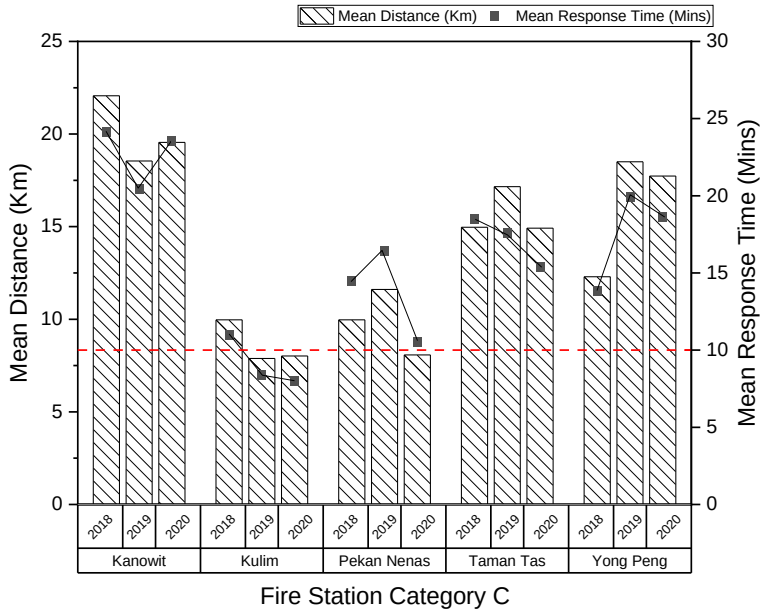

Figure 6. Mean distances travelled and mean response times recorded by category C fire stations

The areas in which category D fire stations are located are considered semi-rural. The low density of these areas results in the fire stations servicing a greater coverage area, as illustrated in Figure 7 for the Ringlet and Tanjung Manis fire stations. Both fire stations recorded a mean distance travelled of approximately 14 km and a mean response time of 18 min.

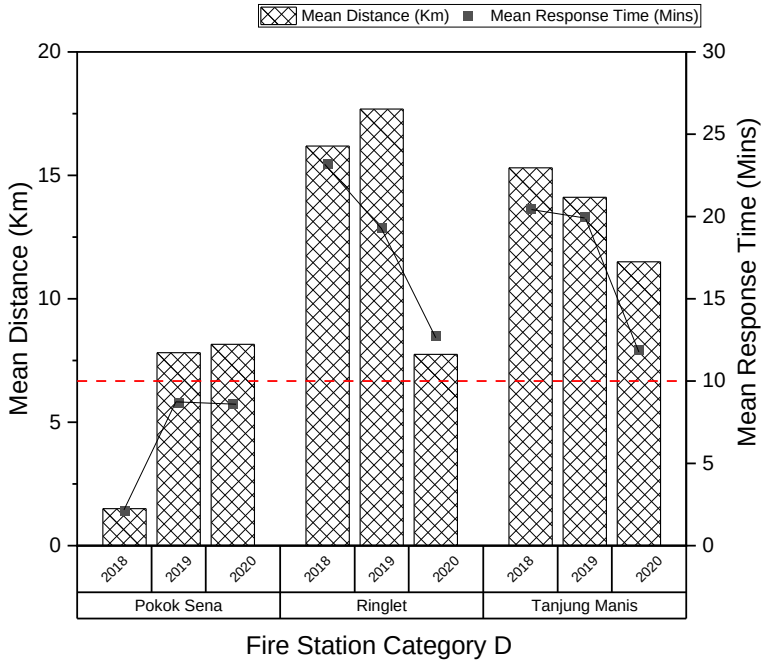

Figure 7. Mean distances travelled and mean response times recorded by category D fire stations

Based on the study conducted by (Tharima, 2010), most fire incidents that happened in semi-rural or rural areas are mainly on houses made of wood. This flammable building material is possible to create a flashover of less than 10 mins. As reported by Zikmund (2001), the flashover can occur from three to eight minutes while Wrack (2010) claims that flashover incidents happen from four to six minutes.

4. Conclusion

The initial assessment demonstrated that, regardless of category, most of the fire station response times recorded an improvement trend from 2018 to 2020. Besides, more than half of the category C and D fire stations recorded shorter mean response times in 2019, whereas fire stations in the other categories demonstrated no significant changes.

The distance travelled demonstrated a directly proportional relationship with the response time, as illustrated by the graphs that supported the Pearson correlations of > 0.7 for category B, C, and D. The findings indicated that new fire station developments are inevitable for reducing the fire incident response time in Malaysia. Developing new fire stations in strategic locations based on the risk profiling schedule and analysing urban planning, particularly in semi-urban areas, would ensure a fast response from firefighters.

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