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An Analysis of Variation of Turn out Time and Response Time in Penang State Fire and Rescue Department

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ABSTRACT

Every year, fire takes thousands of lives and destroys property worth billions of dollars. Firefighters are one of the more well-rounded and versatile emergency task forces in the world. Firefighters are called to serve a civic duty which is to protect citizens in time of crisis. But sometimes they cannot reach their ultimate goals because of some barriers such as the distance from a fire station to the incident location is far, insufficient fire-fighting equipment or traffic jam to the location of fire. Taking the cue from here, this study provides an analysis of turn out time and response time of the Penang State Fire and Rescue Department. During two year study, the researchers identify Perai (16.12%) and Jalan Perak (16.72%) stations as having the most number of rescue cases. Fire occurrences in the months of January, February and March are the highest while December has the lowest. In tandem, the percentage of house fireis higher than the other two categories (forest fire and machinery fire). Most of the stations are able to perform their duties on time, however, Kepala Batas, Tasek Gelugor and Teluk Bahang stations could not meet turn out time on due time. Bandar Perda, Balik Pulau and Bukit Mertajam stations show lower percentage of response time on due time for joint analysis. The analysis shows that 65.15% of the cases occur during day time rather than night time. There exists a positive relationship between turnout time and response time for the year 2010 and 2011 jointly. Also there are significant differences among the mean response times for the reference year.

Key words: Turnout time, response time, Mean response time, Penang fire stations

INTRODUCTION

Fire is the visible effect of the process of combustion-a special type of chemical reaction. It occurs between oxygen in the air and some sort of fuel. Fire is a continuous threat to life and property. Every year, it takes thousands of lives and destroys properties worth billions of dollars. The human cost is financially incalculable. The direct costs from loss of property, the cost of fighting fire and treating those injured can be measured. In the early 1990s, the costs ran to some 450 million pounds per annum with indirect costs estimated at adding a further 190 million pounds to the bill in UK GDP (Wilmot, 1989). Unlike natural disasters that invite national and international attention (for examples tsunami, earthquake, etc.), fires area common tragedy that goes unnoticed.

Fires are not a natural disaster since their occurrence can be predicted and a scientific method can be applied to reduce the risk. In order to improve public safety, reduce fatalities in society, increase the quality of life and reduce property loss, research is required to understand common failings within the current system with the aim of improving and the use of fire protection technology as a means of reducing fire risk.

Literature review: The field of emergency services response time performance measurement seems to be a relatively young field, given the age of the fire service. Stout (1987) characterized the situation as, "There is no standard basis for the calculation of response times." Vadnais (1990) also echoed this sentiment and expressed response time as "Response time plays a critical role in firefighter safety, as well as public safety." According to Keller (1995), "Right or wrong, the most critical measure of an emergency service's performance is its response times." Mason (1996) defined response time as "The elapsed time between the radio-dispatched notification of an incident requiring a response time and the arrival of the first engine company on the scene."

However, over the past fifteen years, the field of response time performance measurement has expanded dramatically. Sardqvist and Holmstedt (2000) found little support for the hypothesis that short arrival time result in smaller fires. Lawrence (2001) focuses on post arrival fire management but acknowledges that even with longer response times the flashover incident rate is relatively low. As articulated by Castillo (2002). "There is little doubt that the more rapidly well-equipped, highly trained people reach the scene of an emergency and began to mitigate the said emergency, the better the likelihood of a positive outcome will be." So, improving the response time performance of the fire department is important. AFAC (2005) study analyzed the demographics of fatalities and injuries from fires and found that low socio-economic status, high levels of smoking and alcohol consumption amongst individuals and areas with higher than average proportions of children, the elderly, disabled and individuals of non-white background were associated with increased fire risk. There is very little research into the actual utility of quick response by fire services. Challands (2010) found that response time of fire services has a clear correlation with the amount of structural damage.

Background of the study area: Penang is one of the 13 states in Malaysia. It is located in the North-western coast of Peninsular Malaysia. It is bordered by Kedah in the north and east and Perak in the south. Penang State consists of two parts, Penang Island and mainland Seberang Perai. Highly urbanized and industrialized Penang is one of the most developed and economically important states in the country, as well as a thriving tourist destination (http://www.penang.gov.my/?lang=en). The state has the highest population density in Malaysia. The whole of Penang State has a density of 1,450.5 people km^{-2} (Jabatan Perangkaan Malaysia, 2010). Jabatan Perangkaan Malaysia. p. 27 and has a population of 1,520,143 as of 2010 (Jabatan Perangkaan Malaysia, 2010). Jabatan Perangkaan Malaysia. p. iv. There are sixteen fire stations in Penang. Among them, seven fire stations are in Penang Island and 9 fire stations are in mainland Seberang Perai. This number is not sufficient for a large population.

The main component that is affected by fire service activities is the response time. When the call is critical, speed is essential and response time often serves as a surrogate for more basic performance measures such as lives saved. As such, response time is an appropriate statistic. The shortest response time will lead to lives being saved and damages to properties reduced. In this study, the researchers will only focus on the turnout time and response time.

MATERIALS AND METHODS

Data set: Information on turnout time and response time were gathered from the Penang State and Fire Department in Prai. Panel data has been considered for two years, 2010 and 2011, worth of data and uses time as a proxy for climatic conditions.

Fire is categorized into three types, fire from residential, machinery equipment and forest. There are many subsections under these three categories. Residential fire happened from kitchen fire, electric fire and shop fire. Some subsections of machinery fire are car fire and truck fire. While forest fire is categorized by hill, woods and grass fire. Some fire incidents remain unrecorded because they are too small or they are extinguished by the others without notifying the fire service. Checks across both sets were made for consistency and sense before being analyzed by the SPSS (Statistical Package for the Social Sciences).

Pearson's correlation: Correlation is a technique for investigating the relationship between two quantitative, continuous variables; here considerable variable is turnout time and response time. Pearson's correlation coefficient (r) is a measure of the strength of the association between the two variables.

The hypothesis used for linear correlation is:

$$H_0: r = 0$$
$$H_1: r \neq 1$$

Test statistics: Pearson's correlation has a distribution with degrees of freedom and the test statistics is:

$$t = \frac{r - p}{\sqrt{\frac{1 - r^2}{n - 2}}}$$

Pearson's correlation coefficient (r) for continuous (interval level) data ranges from -1 to +1.

ANOVA test: The one-way ANOVA test is always right-tailed with the rejection region in the right tail of the F-distribution curve. The value of the test statistic is calculated as:

$$F = \frac{\text{Variance between samples}}{\text{Variance within samples}} = \frac{MSB}{MSW}$$

Software: SPSS 17 is used for the above analysis.

RESULTS AND DISCUSSION

In this section results are divided into two main streams. First, results and discussion of fire incidents in Penang city which focus on frequency of fire incidents according to fire station, the time of incident, causes, estimates the emergency Response Time (RT) and Turnout Time (TT) for year 2010 and 2011. Second, the most suitable statistical analysis of correlation, ANOVA, has been carried out.

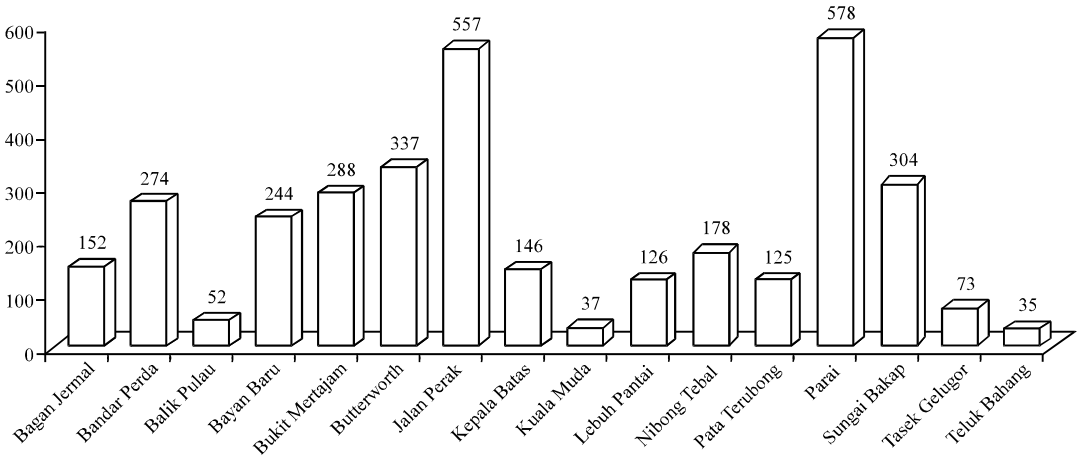

Fig. 1: Frequency of cases according to station

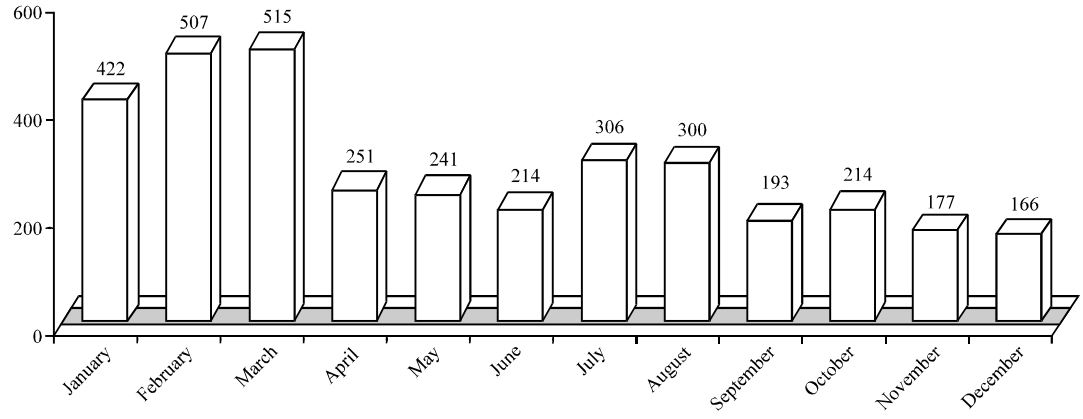

Fig. 2: Frequency of cases according to month of a year

Station-wise cases: From Fig. 1, Jalan Perak and Perai stations are involved in 16.72% cases and 16.12% cases. Butterworth, Sungai Bakap, Bukit Mertajam, Bandar Perda carry out their services with average cases of 9.61, 8.67, 8.33 and 7.82%. The rest of the stations accomplished their duties with lower percentage of cases. Perai, Jalan Perak, Butterworth and Sungai Bakap stations rescued more cases in 2010 and 2011. Because of the above reasons, these stations need more manpower, equipment and fire engines to give better services in standard time.

Month-wise cases: Most of the cases occur in the months of January, February and March. Event occurs on an average for the rest of the month. December has the lowest rate. According to a seven year analysis of fire data by Sufianto and Green (2012). the months of August, September and October recorded the highest fire incidents while January to April are the lowest. These results are in contradictory from the researchers' results. The dry spell lasts from December to March. In December, the coldest temperature is 6°C, average daily temperature is 27°C and rain is 230 mm. September to November may be considered the wettest months. A clear idea will be available from Fig. 2. Based on the study of fire pattern in Queensland, Australia shows that high fire incidents

Table 1: Frequency of cases according to category

Type of fire	Frequency of cases	Percent
Forest fire	453	13.11
House fire	2041	59.06
Machinery fire	962	27.84
Total	3456	100.00

Table 2: Turn out time is taken by firefighters assuming standard time is 1:30 min

Station name	Total cases	Cases on due time (≤1.30 min)	Cases out of due time (>1.30 min)	Percentage of turn out on due time
Bagan Jarmal	152	150	2	98.68
Bandar Perda	269	266	3	98.87
Balik Pulau	52	50	2	96.15
Bayan Baru	236	233	3	98.73
Bukit Mertajam	288	283	5	98.26
Butterworth	320	307	13	95.94
Jalan Perak	557	523	34	93.90
Kepala Batas	140	126	14	90.00
Kuala Muda	37	36	1	97.30
Lebuh Pantai	122	118	4	96.72
Nibongtebal	178	165	13	92.70
Paya Terubung	125	112	13	89.60
Perai	578	556	22	96.19
Sungai Bakap	294	274	20	93.20
Tasek Gelugor	73	66	7	90.41
Teluk Bahang	35	32	3	91.43
Total	3456	3297	159	94.88

correlates with the impact of high temperatures in locations around Queensland (Corcoran *et al.*, 2011). In these months, the fire stations need to increase their manpower, equipment and fire engine to meet the extra workload.

Category-wise cases: From Table 1, forest fires and smoke-haze are dangerous occurrences. The problems seem to be increasing in intensity and recurring periodically. Within two years 2010 and 2011, Penang faces 13.11% cases. House fire is also increasing to 60%. Based on fire experience, it has been found that the worst fires occur when many failures take place simultaneously (Bukowski, 1996). These types of occurrences happen due to human mistakes, electrical or mechanical faults, as well as extreme weather conditions. The percentage of fire from house is higher than the other two categories. The Penang State Fire and Rescue Department needs to take initiatives such as putting up advertisements in the local newspapers and conducting seminars, workshops and conferences for the general public so that the general public are informed and alerted of the latest fire situation in the state. The public will be aware of the department's ongoing activities.

Turnout time: From Table 2, most of the stations performed their duties on time. They went out on due time for 3347 cases but unable to meet the standard time for 159 cases. Bagan Jarmal, Bandar Perda, Bagan Jarmal and Bukit Mertajam stations turn out on time for 99% of the cases while Kepala Batas, Tasek Gelugor and Teluk Bahang stations could not meet

Table 3: Response time is taken by firefighters assuming standard time is 7:00 min

Station name	Total cases	Cases on due time (≤7.00 min)	Cases out of due time (>7.00 min)	Percentage of response on due time
Bagan Jarmal	152	107	45	70.39
Bandar Perda	269	93	176	34.72
Balik Pulau	52	21	31	40.38
Bayan Baru	236	135	101	57.20
Bukit Mertajam	288	77	211	26.74
Butterworth	320	171	149	53.44
Jalan Perak	557	389	168	69.84
Kepala Batas	140	77	63	55.00
Kuala Muda	37	32	5	86.49
Lebuh Pantai	122	113	9	92.62
Nibongtebal	178	105	73	58.99
Paya Terubung	125	105	20	84.00
Perai	578	305	273	52.77
Sungai Bakap	294	173	121	58.84
Tasek Gelugor	73	35	38	47.95
Teluk Bahang	35	19	16	54.29
Total	3456	1957	1499	58.98

their goals of turning out on due time. It is suggested that more fire stations in these areas need to be built in order to increase efficiency in service. As can be seen these stations cover wider areas.

From the analysis, it can be deduced that Paya Terubung and Jalan Perakfire stations need public cooperation to pave the way for firefighters who are attending to fire call. Special unitsare required at the stations to help ease traffic obstacles because the roads in these areas are narrow and traffic is heavy during the day.

Response time: Emergency response is affected by many influencing factors on any given day. This analysis confirms the results. Although the fire stations are serving the public and community and turning out on due time in most of cases but they cannot maintain response time according to turnout time. From Table 3, Percentage of total response on due time is 58.98%. Sardqvist and Holmstedt (2000) found small support for the hypothesis that short arrival times result in fewer fires. The target of achieving 100% is not viable because of failure to response to balance 43.35% cases. Bandar Perda, Balik Pulau, Bukit Mertajam stations show less percentage of response on due time for joint analysis. Thus the firefighters must take the most efficient travel routes to reach the scene to response effectively and also these fire stations need faster vehicles to reach within the stipulated standard time.

Events according to day and night: Here, the researchers have categorized events as day and night only. Calendar events have been relatively well researched by Corcoran *et al.* (2011). They made a list of all major calendar events during the period under study. Frequency of cases on the basis of day time and night time has been presented. Day time starts from 7:00 am until 6:59 pm and night time starts from 7:00 pm until 6:59 am. From Table 4, it depicts a clearer picture, 65.15% are day time cases and 34.85% are night time cases. Kuala Muda station provides service for a total of 37 cases (26 events occur during day time and only 11 events at night time). The analysis shows that 65.15% of the cases occur during day time rather than night time. So, some stations' activities have to be routinely conducted during daytime. Firefighters need to be alert all the time and placed on standby during day time.

Table 4: Station wise-frequency distribution according to day and night time

Station name	Frequency of cases	Cases on day time (7:00 am-6:59 pm)	Cases on Night time (7:00 pm-6:59 am)	Percentage of firing in day time
Bagan Jarmal	152	84	68	55.26
Bandar Parda	269	171	98	64.15
Balik Pulau	52	31	21	59.62
Bayan Baru	236	150	86	63.56
Bukit Mertajam	288	195	93	67.71
Butterworth	320	221	99	69.06
Jalan Perak	557	363	194	65.17
Kepala Batas	140	86	54	61.43
Kuala Muda	37	26	11	70.27
Lebuh Pantai	122	78	44	63.93
Nibongtebal	178	123	55	69.10
Paya Terubung	125	82	43	65.60
Perai	578	386	192	66.78
Sungai Bakap	294	198	96	67.35
Tasek Gelugor	73	47	26	64.38
Teluk Bahang	35	19	16	54.29
Total	3456	2260	1196	65.39

Table 5: ANOVA of mean response time

Source of variation	Sum of squares	df	Mean square	F-statistics	Significant
Between groups	30982182.476	16	1936386.405	15.141	0.000
Within groups	439808304.858	3439	127888.428		
Total	470790487.333	3455			

Correlation between turnout time and response time: Correlation between turnout time and response time is being done for 2010 and 2011 jointly. Several types of relationship have been checked through correlation test. Correlation between weather and fire incident is shown by Sufianto and Green (2012).

The null hypothesis is rejected at 1% level of significance. Turn out time is positively related with response time. If firefighters are to delay in taking action obviously they will miss their goals and ultimately their response to the fire scene will be late. In these cases, fire damage will be higher than normal time. So, firefighters need to adopt and adapt new methods to turnout on due time and make response on due time.

Test of mean response time according to fire station: To check the validity of response time, the researchers have done test of mean response according to fire stations. Every area covers a fire station which is very important for reducing damage. A common application of a null hypothesis test is to determine whether two samples have different means or not. The following hypothesis is to be tested:

H_0: There is no difference among the mean of response time
H_1: There is difference among the mean of response time

In this case observed values of F are greater than the critical value of F; thus the means of response time are significantly different at 16, 3489 degrees of freedom. From Table 5, the

researchers conclude that there are significant differences among the mean response times for the joint analysis. So, the Penang State Fire and Rescue Department must maintain the same mean of response time for all stations.

CONCLUSION

The sources of fire are mostly human-caused. Increasing public awareness is very important to overcome this issue. Fire station location is another important factor to reduce damages to properties, lost of lives and livelihood in cases of fire and to provide emergency services to the community. Determining fire location depends on standard response time; it should be divided into specific time intervals for each of the components that make up total reflex time: Dispatch time, turnout time, response time and setup time. From this analysis it can be concluded the station that services more cases but is unable to response in due time, delay in its response time, will cause greater danger because properties and lives cannot be saved during crucial time. More fire stations need to be built where the percentage of fire is high. Automatic fire alarm systems should be implemented to keep the premises and their occupants safe by installing an early warning system. This system will enable the occupants to evacuate their premises in time. If every house installs an automatic switch on system, house fire can be prevented.

Appendix

Dispatch time: Amount of time that it takes to receive and process an emergency call. This includes, (1) Receiving the call, (2) Determining what the emergency is, (3) Verifying where the emergency is located, (4) Determining what resources are required to handle the call and (5) Notifying the units that are to respond.

Turn out time: Turn out time is the time from when units acknowledge notification of the emergency. When the fire station acknowledges it is enroute. In this analysis, the standard time turn out is 1.30 min (90 sec) based on the mean of turn out time.

Response time: Amount of time required for the firefighters to move from where the apparatus stops to where the emergency exists. This can include moving to the interior or upper stories of a large building and dealing with any barriers in the access to that area. In this analysis, the standard time of response is 7 min (420 sec) based on the international standard time of response.

Set up time: The amount of time required for fire department units to set up connect hose lines, position ladders and so on and prepare to extinguish the fire.

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