

# The analysis of fire losses and characteristics of residential fires based on investigation data in Selangor, 2012-2014

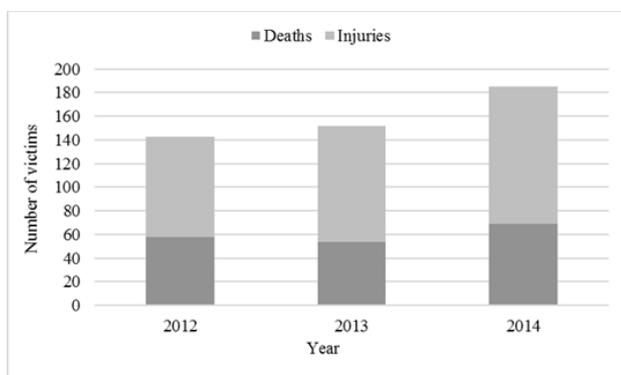
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**Abstract.** This is a research in progress where authors seek to investigate the factors of residential fires. As part of the research, this paper aims to analyse the fire problems faced by the community of Malaysia. Data regarding residential fires between 2012 and 2014 was collected from fire investigation reports prepared by the Selangor Fire and Rescue Department. Descriptive analysis is conducted to summarize the data collected and describe the common phenomenon of residential fires. The distributions of the fire characteristics suggested that residential fires are commonly occurred during daytime, confined within the room of fire origin, caused by electrical failure and cooking negligence, started from kitchen, and occurred in multi-units housing. Further analysis will be conducted in order to investigate the relationships between the characteristics and residential fires.

## 1 Introduction

Overall, Malaysia has an average rate of fire incidents at around 1024.67 fires per million populations per year in 9 year-period from 2006 through 2014. The rate of fire victims is 7.53 per million populations per year, with 3.07 deaths per million populations per year. Each year, there are approximately 90 residential fires per million populations per year. Accounting for fire casualties, the total number of victims in residential fires has increased about 30% in the three year-period as shown in Figure 1. Although residential fires comprised less than 10% of the overall fires in the past three years, they took about 61% of the overall fire deaths per year and 48% of the overall fire injuries per year.



**Figure 1.** Number of victims in residential fires (Source: Department of Operation, Fire and Rescue Department of Malaysia)

In order to reduce the rate of residential fires and the fire casualties, an ongoing research is conducted in order to examine the factors affecting the residential fires in Malaysia. Over the decades, various studies were conducted to investigate the relationships of fire characteristics, occupant characteristics (i.e. personal or demographics), and housing characteristics with the residential fire incidence. Socio-economic characteristics are important in predicting the residential fire risk in urban areas [1, 2]. Using statistical models, Hasofer and Thomas [3] found that the most significant fire factors that contributed to the risk of casualties and fatalities in apartment fires are the extent of fire damage, area of fire origin, type of material ignited, and ignition factor. They also found that the condition preventing escape, condition before injuries, activity at time of injury, location at ignition and cause of injury to be the significant personal factors. Analysis by Holborn et al. [4] highlighted the common risk factors of unintentional dwelling fire deaths which comprised of smoking, alcohol intake, elderly, disability, illness, living alone, social deprived, and without having a functioning smoke alarm. Epidemiology study, such as Runyan et al. [5], also proved that mobile home and absence of smoke detectors will result in the risk of fire death.

This paper is part of the ongoing research aimed to investigate the fire problem by descriptive analysis of the characteristics from fire investigation data. Although annual reports regarding fire statistics have been published by Fire and Rescue Department of Malaysia (FRDM) every year [6, 7, 8], there are lack of detail information such as room or area of fire originated and

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the extent of fire spread. The outcome of the paper intends to understand the phenomenon of residential fires based on the following questions.

- When is the fire usually occurred?
- How the fire ignited?
- What is the source of fire?
- Where the fire started?
- To what extent the fire spread?
- How severe the fire cause to the losses and life safety?

## 2 Source of data

The data used in the research was abstracted from fire investigation reports prepared by Selangor Fire and Rescue Department. The fire investigation reports contained detailed information about the fire scenario including nature of fire, structural information and design of building, damage caused by fire, and victim's personalities. The overview of the data abstracted from the reports are described as below:

- Casualties – the consequences of fire incidents in terms of number of injuries and deaths.
- Fatalities – the number of deaths of fire incidents.
- Estimated properties losses – the fire loss in terms of financial or monetary, in ringgit Malaysia (RM), based on the properties and percentage of damages estimated by FRDM.
- Month of years – month of the years of the fire incidents.
- Day of weeks – day of the weeks of the fire incidents.
- Time of days – the estimated time of the fire ignition.
- Extent of fire spread – the spread of fire in terms of how far the fire damages reached.
- Cause of fire - The causes of the fire ignition, such as intentional or unintentional by human activities or natural phenomenon.
- Source of ignition - The sources that provide heat to starts the fire.
- Room of fire origin (RFO) – the area or room where the fire started.
- Types of dwelling – the types of houses based on the nature of housing units in the building.

The research refers to the years of residential fires occurred between 2012 and 2014. There were total 2423 residential fires being collected within the three years. However, the total number of fires cannot represent the total population of residential fire happened in the Selangor. This is because there are fires that were not reported to the fire department. Records from the fire department are only based on the incidents that were attended by or reported to them. In fact, a national survey in U.S. found that almost 97% of the residential fires were not reported or attended by the fire department [9]. Besides, there are also confidential cases that are not allow to be accessed.

Upon collecting the data, there are data that were not being recorded. This leads to missing data for certain variables in certain cases. Since the data are categorical, the fire problems will be described with percentage or frequency distributions. All valid data will be used in the analysis.

## 3 Results

### 3.1 Number of casualties

The number of casualties is the combination of injuries and fatalities. Table 1 shows the frequency distribution of the number of casualties per fires. Among 2423 residential fires, there are only 38 fire incidents result in at least one casualty. Over 98% of the fires did not have any injury or fatality. The proportions of the fires that have casualties were not more than 0.02 (2%) of the total number of fire incidents. This shows that the fires that will cause casualties are rare. As the number of fatalities increased, the events become rarer (Figure 2). However, this does not mean that the rare event should be ignored. The total number of casualties are 55 victims and 13 of them were died. There is one fatality occurred in every four injured victims.

**Table 1.** Frequency distribution of number of casualties per fires.

Number of casualties per fires	Frequency
0	2385
1	26
2	9
3	1
4	2
Total	2423



**Figure 2.** Number of fires with more than one fatality

### 3.2 Estimated properties losses

Fires damage properties and cause monetary losses. There are 2234 residential fires where the property losses are known. Based on these known samples, the property losses are ranged from no damage (i.e. RM 0) to damages that caused the loss of RM 3.5 million. The mean of property losses is approximately RM 27 thousand (Std. Dev. = RM 113,266.85). Most of the residential fires have property damages less than one thousand Ringgit Malaysia.

### 3.3 Time distribution

Although there are slightly less fire cases being observed at the end of the years, the overall frequencies are

distributed quite evenly throughout the year (Figure 3) with an average of about 202 cases each month. This result is not consistent with other countries [10, 11] because Malaysia is a tropical country without changing of season throughout the year. Those countries encountered that cold winter (i.e. December, January, and February) were among the seasons that has higher number of fire cases occurred.

For distribution by day of week, weekdays tend to have higher number of fire occurrence compared to weekends with the highest in Wednesday as shown in Figure 4. This is different to data in China, where weekends have the higher fire occurrence [11]. Other than that, U.S. has a rather even distribution with about 14% everyday [10].

According to Figure 5, residential fires are commonly occurred during day time between 8 a.m. to 6 p.m. The number of fires decreased after 6 p.m. and reached its minimum in the midnight periods. This has reached the agreement with both data in U.S and China [10, 11].

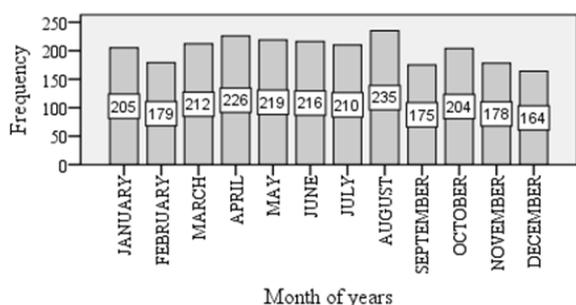


Figure 3. Frequency distribution by month of year

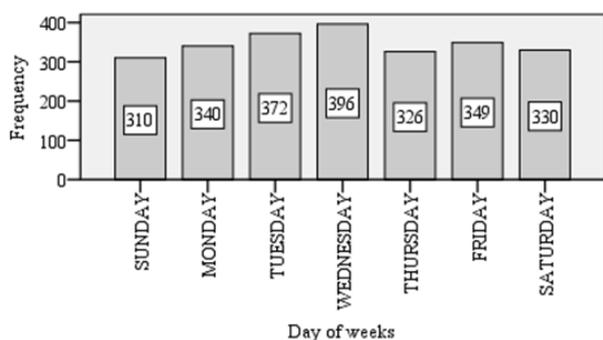


Figure 4. Frequency distribution by day of week

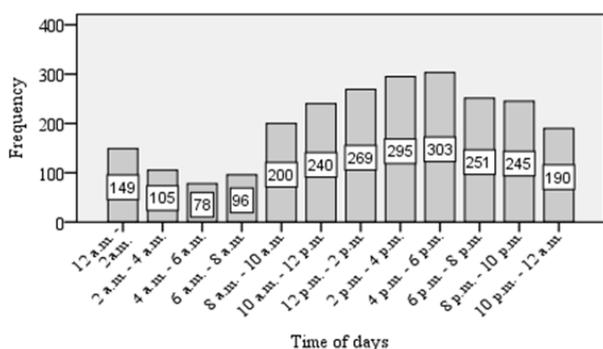


Figure 5. Frequency distribution by time of day

### 3.4 Fire damages

In relation to the estimated property losses, fire cases become rarer as percentage of fire damages (Figure 6) and extent of fire spread (Figure 7) reduced. In Figure 6, the number of fire with damage of more than 70% are higher than that of damage 10% - 20% and 20% - 70%. The percentage range of fire damages are depending on the size of the fire damages over the total size of the premise. Design of premise plays an important role determining the size of fires even though fire confined within the room of fire. Most of the studies used the extent of fire spread to interpret the fire damage. In Figure 7, residential fires are commonly confined within the room of fire origin (84.7%, including confined within the item of ignition) and most of them only confined within the items of ignition (44.2%).

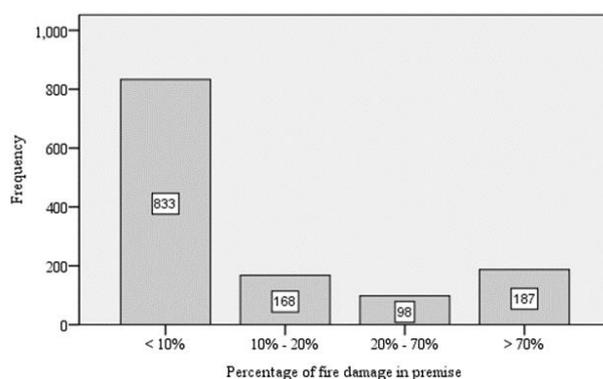


Figure 6. Percentage of fire damage in premise

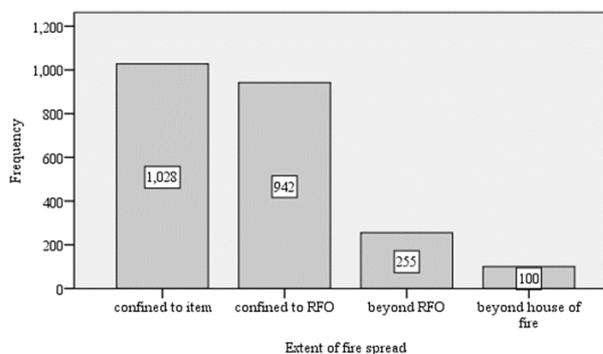


Figure 7. Extent of fire spread

### 3.5 Cause of fire

Based on Table 2, the most common cause of fire in residential fires are electrical failure (39.3%). Electrical failure included short circuit, resistance heating and overcurrent of electrical distribution and electrical appliances. There are almost 30% of the residential fires caused by careless or negligence during human activity such as cooking, followed by heat source close to combustible materials (8.7%) and leaking of gas (7.7%). There are minority of fires that are intentionally caused by irresponsible people including crime. They are incendiary fire with 4.2% and fires caused by unconscious person impaired by drugs, alcohol, or mental illness with only 0.1%. The percentages of intentional fires are relatively low compared to accidental fires.

**Table 2.** Frequency table of ignition factors

Ignition factors	Frequency
Electrical failure	852
Careless or negligence during human activity, e.g. cooking	611
Heat source close to combustible materials	189
Leaking of gas	167
Incendiary	92
Lightning strikes, including short circuit after the strikes	80
Others	76
Abandoned or discarded materials, e.g. cigarettes	47
Children playing with fire	47
Unknown, i.e. specified as unknown after the investigation	6
Drugs, alcohol impaired, mental illness	3
*Unspecified or missing data	253
Total	2423

\*Unspecified or missing data is not included in the analysis

### 3.6 Source of ignition

Frequencies ranking in Table 3 shows that the most common source of ignition in residential fires are electric (39.7%), followed by cooking appliances (34.9%). This could be explained from the cause of fire, where electrical failure caused the electrical sparks, arching or heating that burned the electrical wiring system or electrical appliances. Ranking in the second, cooking appliances are another common source of ignition which were caused by the careless or negligence during cooking or leaking of cooking gas. Categorized within the group of glowing fire with only 5.8%, cigarette is not a common source of ignition in our cases.

**Table 3.** Frequency table of ignition sources

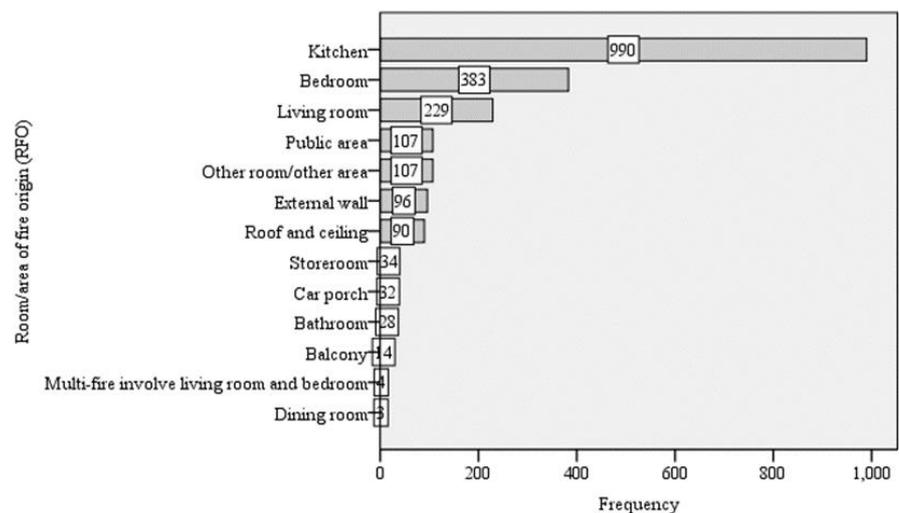
Sources of ignition	Frequency
Electric	949
Cooking appliances	834
Matches or lighter	194
Glowing fire, including cigarette, mosquito coil, and joss stick	138
Candle or torch	118
Lightning	80
Others	45
Hot object or surface	15
Fireworks or firecrackers	13
Friction	4
Unknown, i.e. specified as unknown after the investigation	3
*Unspecified or missing data	30
Total	2423

\*Unspecified or missing data is not included in the analysis

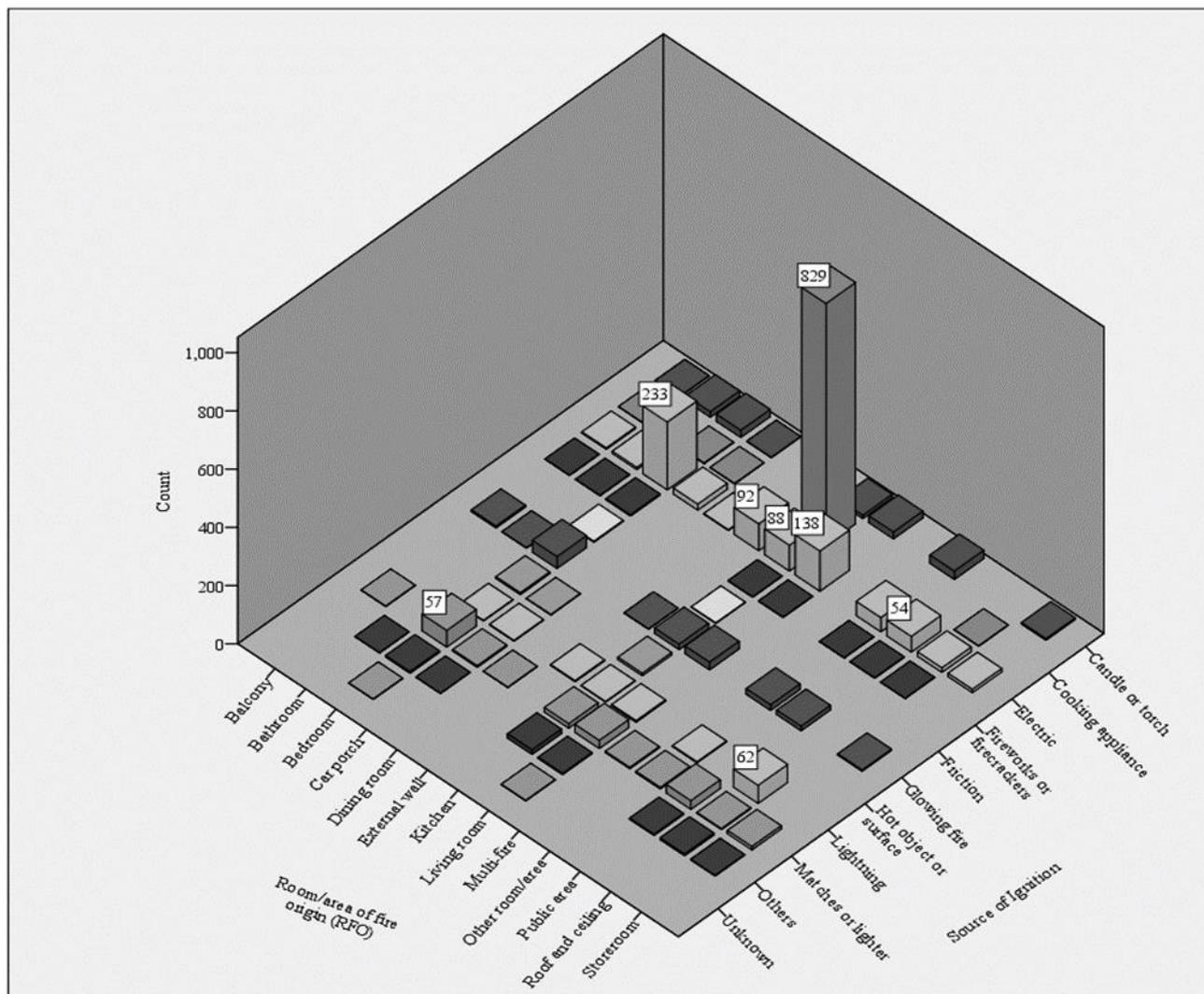
### 3.7 Room of Fire Origin (RFO)

Almost 50% of the residential fires started in kitchen as shown in Figure 8. Figure 8 also shows that the most common rooms or areas of fire origin followed after the kitchen are bedroom and living room with 18.1% and 10.8%, respectively.

Figure 9 shows the frequencies of residential fires by both the room or area of fire origin and source of ignition. The analysis suggested that there is a significant relationship between the two variables. In the figure, most of the kitchen fires have the cooking appliances as source of ignition. Electric sources also stand out in some of the room or area of fire origin, especially bedroom and living room.



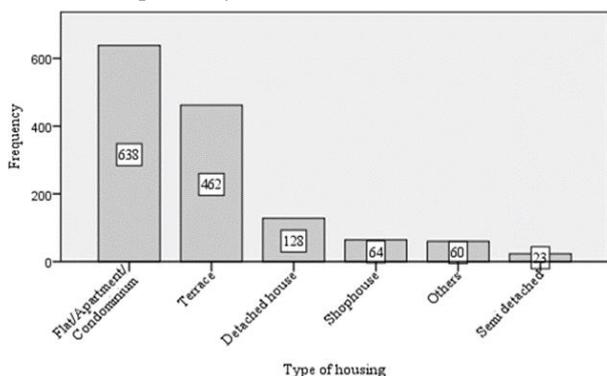
**Figure 8.** Room or area of fire origin



Fisher's Exact Test,  $p < 0.001$  (2-sided test)  
**Figure 9.** Relationship between RFO and Source of Ignition

### 3.8 Dwelling types

Figure 10 compared the numbers of fire frequencies between types of dwelling. Almost 40% of the fires occurred in multi-units housing, such as flat, apartment, or condominium. This is closely followed by terraced houses (33.6%). Other type of housing that were less likely to have fire occurrences are detached house, shop house, and semi-detached house which are 9.3%, 4.7% and 1.7%, respectively.



**Figure 10.** Type of dwelling

### 4 Conclusion

The results show the distribution of the fire losses and fire characteristics based on the investigation data in Selangor between 2012 and 2014. Based on the descriptive analysis, the fire problems faced in this community can be identified as highlighted as below.

- The fire frequency is distributed evenly throughout the years, unlike the other countries with four season where high frequency of fire was found to be happened during winter.
- Residential fires are commonly happened during daytime (8 a.m. – 6 p.m.) compared to night time (10 p.m. – 8 a.m.).
- Most of the residential fires did not spread beyond room of fire origin. They are either confined within the room or confined within the items of ignition.
- Two common source of ignition must be concerned, namely electricity and cooking appliances. This are closely related to the common cause of fire which are electrical failure and careless during cooking.
- Kitchen is the most likely room or area of fire origin due to the large amount of fire sources such as electrical

appliances and cooking appliances, including cooking gas.

• Comparing between dwelling types, multi-units housing such as flat, apartment, and condominium has the highest number of fire occurrences.

The conclusion based on the analysis of fire investigation data above provides the idea of how the scenarios of residential fires was and what is the issues that need to be concerned. After the initial analysis described in this paper, the data will be further analysed in order to investigate the factors that influence the residential fires.

## Acknowledgements

This work was supported by the Ministry of Higher Education, Malaysia through the FRGS Grant (Grant No.: FP046-2014B). Besides, the authors would like to express their gratitude to the Fire and Rescue Department of Malaysia (FRDM) for granting the permission to access fire investigation reports and to all the officers for their supports in the research. Finally, a special thanks to the Fire Research Centre of FRDM (PUSPEK) who made this research possible to carried out.

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