Community based Residential Firefighting Strategy: A Case Study of Malang City

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Abstract

Fires that occur in residential areas have a negative impact on the community, from both social and economic perspectives. In urban areas, where the high density of buildings and people is evenly distributed, the chances of loss of life and property are considerably high. Those changes are even higher in residential areas or villages located far from fire brigade access. The occupants should not wait for the assistance of the city fire brigade but should act to terminate the flame themselves to save their properties and lives.

This study aimed to determine the awareness of fire safety measures in residential areas and fire safety behavior and the capability of residents to independently extinguish fires. A total of 122 participants participated in filling out an online questionnaire to find answers to possible strategies for handling fires in residential areas. Statistical analysis was carried out to see behavioral trends and some of the potential in the community to prevent fires in residential areas. This study discovered that the availability of water is mostly preferred for fighting fires in residential areas, that there is a lack of awareness of electrical as the primary source of fires and that a level of disbelief in the society's ability to fight fires on their own. This study includes both individual and communal self-extinguishing strategies.

Keywords: Building, fire, firefighter, residential, safety

Introduction

Fires that occur in buildings and residential areas will have a negative impact on the community, both socially and economically[4]. In many developing countries, urban communities are frequently associated with a concentration of poverty, inequality and neglect, all of which will be severely impacted by fire incidents. Rapid urbanization in cities causes residential buildings to catch fire with great velocity[20]. Residential fire hazards harm millions of people annually through death, serious injury and loss of property and means of subsistence.

Occupants of dense buildings with narrow pathways and limited fire services are at risk of fire. The fires in 34 developed countries kill an average of two people per 100,000 inhabitants and injure four people per 100,000 inhabitants annually[2,15]. High population and building densities increase the likelihood of fatalities, injuries and property loss. Fire reports from Jakarta, Indonesia, indicate that an average of 11 houses are consumed by fires each day[14].

In a city with high-density residential buildings, the spread of fire will be relatively easy and quick and the evacuation process will be more time-consuming and hazardous. The inability of the city's fire brigade to reach the area in a timely manner and the ineffectiveness of firefighting are due to a lack of nearby water sources. This situation requires a strategy to combat the risk of fire[10]. The residents should not rely exclusively on fire services to extinguish fires.

Fire causes have been investigated worldwide. They are extremely important for developing a tactic or strategy to improve life safety and minimize property losses. Federal Emergency Management Agency in the United States indicated that cooking activities were the primary causes of fires in residential areas. These activities were reported to be over 38% of the annual fires from 2017 to 2019[16]. Fires caused by uncontrollable trash and garbage fires accounted for an average of 5.6% of all recorder incidents, followed by the mechanical failure of heating machines at 3.8%. Fire outbreaks due to refrigerator machine failure were also reported to be relatively high in the United States; in Britain, this fire cause was reported to be approximately 300 times each year[1].

The report also identified that fires caused by a mechanical or electrical failure in a refrigerator have a higher impact than those caused by other (household) electrical devices such as dishwashers, washing machines and drying machines. In Finland, refrigeration machines are also known to be the primary causes of fires in residential areas[6]. Contrary to Europe and the United States, in China, many fires in residential areas were generally triggered by electrical failure and careless behaviors toward the fire source[17]. The fire situation in China is almost similar to that in Indonesia.

It is the general knowledge for homeowners to evacuate at the first sign of a fire in order to save their lives, this study investigates the possibility that homeowners will fight fire at first instance by themselves. This research examines a community-based firefighting strategy that can be implemented for a residential environment in a city. This study was done based on the awareness of the residents about fires. The implementation of this strategy should be beneficial to terminate the fire in the first place and reduce

the dependency level on city fire services attendance. Malang city was used as the case study site because of population development, residential building trend and fire incidents improvement reasons.

Material and Methods

The study was conducted by disseminating an online questionnaire. A set of questions has been constructed, developed and tested continuously in the building science laboratory of the architecture department of Brawijaya University. Using Google forms, the questionnaire was broadly uploaded within 2 months, inviting the local community of Malang city to participate.

Preliminary research on the questionnaire has been conducted multiple times to avoid misinterpretation of questions and the proper way to fill up the answer. Five-point Likert scale was used to identify options that satisfied respondents' opinions. Data were collected and statistically analyzed using a statistical package software; simple frequencies and cross-tabulation analyses were performed using 122 responses. The data were interpreted with caution.

The questionnaire was focused on three main topics: (1) occupants' awareness toward fire measures, (2) types of activities of occupants potentially causing fire outbreaks and (3) the level of residents' ability to extinguish a fire with their tools or equipment. Additionally, the background profile of the respondents was gathered to seek the validity of subjects filling the online survey, as their background may be associated with their responses[13].

Results

Both in terms of age and educational level, all respondents were deemed suitable for participation in the survey. All respondents are residents of Malang city. Thus, their attitudes and behavior reflected the socio-economic conditions and social norms. Therefore, the results of this study can be directly applied to communities in Malang. Of the respondents, 59% were females and 41% were males. This remarkably close ratio shows a representative gender opinion that is well-balanced. In terms of age, 66% of participants (81 people) are in the range of 12–25 years followed by 19% of the participants in the range of 46–65 years (23 people) and 15% of the participants in the range of 26–45 years (18 people). Most likely, the respondents in the age range of 12–25 years are undergraduate students, considering that almost 40% of the respondents have the latest high school education and the other 40% have bachelor's degrees.

Based on the composition from the type of residence, some respondents live in a housing/urban area (60%) and some (28%) live in a kampong house; only 10% of the respondents live in individual houses on the main road. The composition of the residence is consistently seen from the width of the road in front of the house, where most of the respondents were in an environment that can be accessed by four-wheeled vehicles with a 3–6-m-wide street; 12% were those who live in residential neighborhoods that have a road width of 6–8 m.

Awareness toward fire measures: The level of knowledge of building occupants on mitigation measures in the event of a fire is analyzed based on their responses to the four questions. Table 1 indicates that most of the respondents were aware of the causes of fires in residential areas as 68 people felt "certain" and 32 felt "very certain." The table also indicates that the society knew how to terminate fire (56 people) and what to do when they discover a fire in their homes (65 people). Table 1 also reveals that 37 participants felt "uncertain" when having no readily accessible tools or fire precautions in their homes whereas 17 felt "very uncertain" about the same.

Cross-tab analysis was carried out on each of the questions above with data on gender, educational level and experiences in extinguishing building fires. The results show that the majority of the residents in Malang city (both males and females who are at least high school level) confidently know what causes fires in their homes; however, the majority of them have no experience in extinguishing fires. In addition, more than half of the respondents (54.1%) did not know how to extinguish fires in their living environment and nearly half (46.7%) did not know what to do if their houses went on fire.

Table 1
Level of understanding of fire measures

S.N.	Question	Very uncertain	Uncertain	Neutral	Certain	Very certain
1	Do you have knowledge about residential fire causes?	1	5	16	68	32
2	Do you know how to terminate a residential fire?	2	15	49	38	18
3	Are there available fire measures/tools inside your house?	17	37	49	15	4
4	Do you know what to do in case you discover that your house is on fire?	1	15	41	48	17

The data also show that 84.4% of the respondents did not have equipment that could be used any time to extinguish a fire in case of a house fire; this was reported by 59 of 72 female respondents who spend most of the time at home.

Regarding fire prevention knowledge, this study identified more emergency-useful equipment and materials (Figure 1). The image demonstrates that the vast majority of people are familiar with the presence of water tanks, portable fire extinguishers, emergency exits, emergency generator sets, emergency lights, alarms, CCTV monitoring systems and evacuation signs. They lack experience with sprinklers, sandbox exit signs, hydrants and water pools. This is because these objects are rarely found in the residential environment.

Fire safety behaviors: Today, the activities of building inhabitants are widely believed to be the leading cause of fires[8] and Malang city is no exception[12]. Some of the questions in the questionnaire were designed to elucidate the usual fire-inciting behaviors of residents of a residential house. Data analysis revealed that many of the daily actions carried out by tenants of residential buildings have the potential to start a fire. These activities include the erroneous use of electrical extension cables, failure to inspect electrical cables/connections, stringing the electrical connection plugs themselves, using electrical branch connections, leaving mobile phone/laptop chargers plugged into the outlet, placing combustible materials near sources of fire, performing other activities while operating sources of fire and storing highly flammable materials in the house (Figure 2).

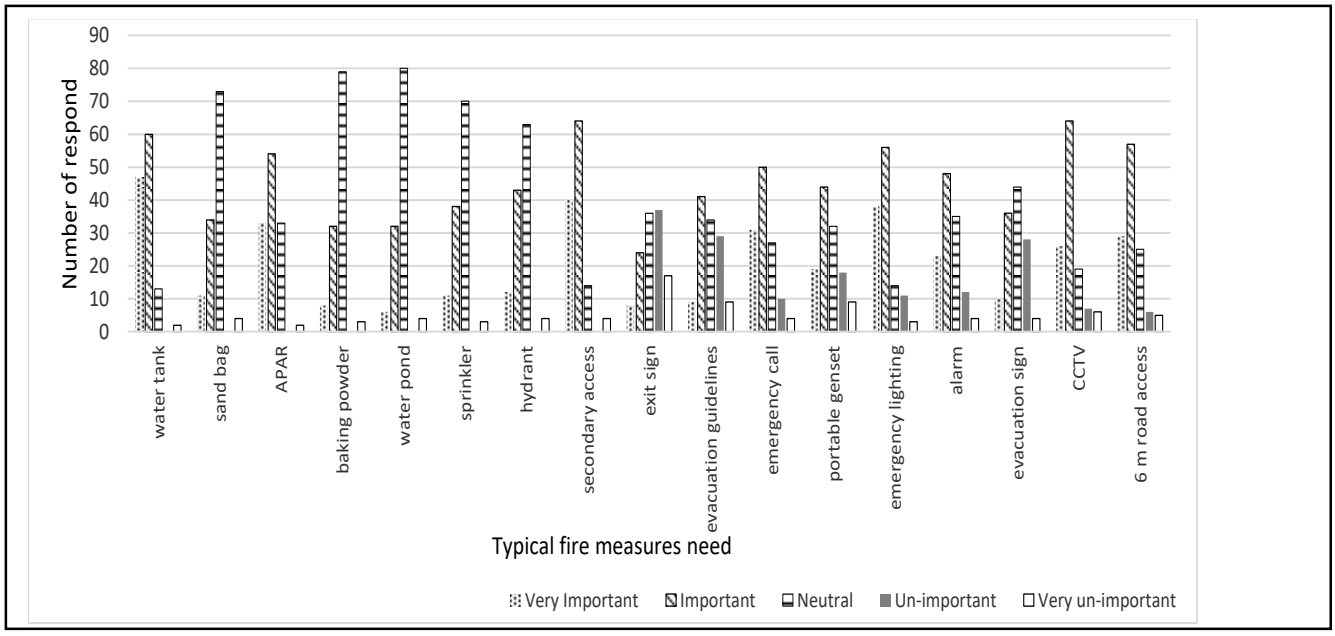


Figure 1: Level of need for the presence of objects and tools in the house

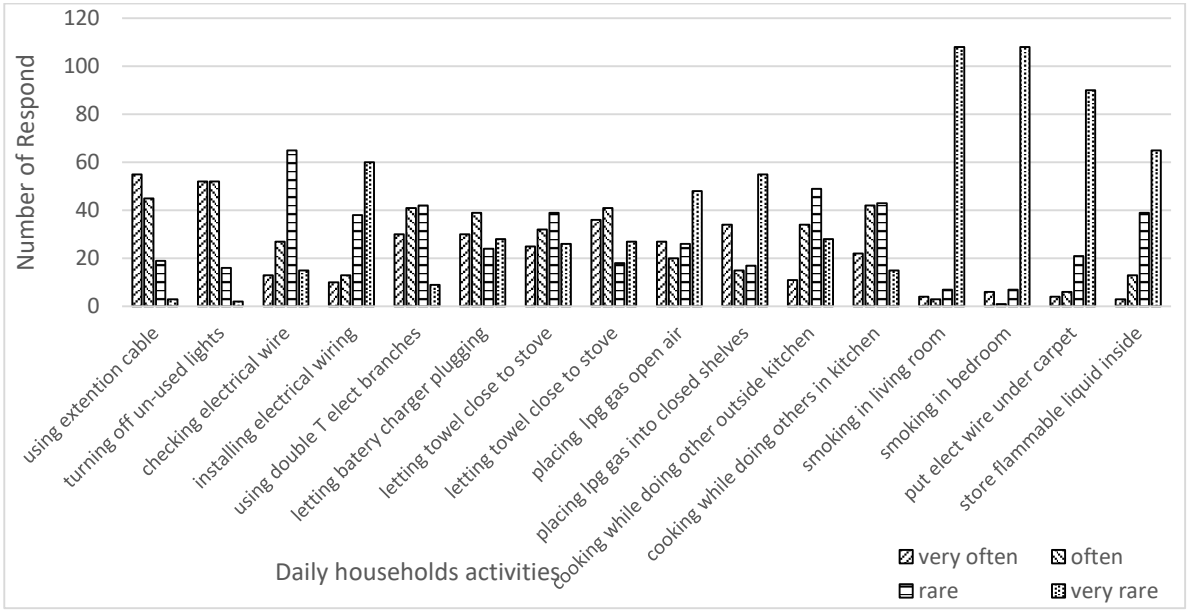


Figure 2: Typical daily household activities that may initiate fires

Figure 2 shows that the occupants of the house still have behaviors that can unconsciously be the causes of fires; 97.5% of the respondents stated that they used extension cables/electric roll cables; 92.6% reported that they used a T (electrical) connection; 76.2% stated that they allowed leaving cellphone charger cables plugged into a wall socket. Half of the respondents reported that they were usually assembling the power plug or connecting the power cable on their own. The behavior of turning off electricity when it is not used, has been carried out by the majority of the Malang residents, represented by 98.4% of the respondents. Most of the Malang residents also do not place electrical cables under a carpet, which is represented by 73.8% of the respondents.

Figure 2 also indicates several fire-safe behaviors, such as avoiding smoke in the living room and bedroom and never storing flammable liquids within the house. The data collected in figure 2 shows an irony: On one hand, the residents were confident in their knowledge of potential fire sources and on the other hand, they behave in a manner that could cause a fire. The majority of the respondents ignored or underestimated the danger of fire.

Fire extinguishing ability: The extent of community reliance on the existence of city fire brigades was assessed based on the inhabitants' abilities to independently extinguish fires. Anecdotally, the residents assume that the fire service is solely responsible for the successful firefighting of their buildings. Figure 3B reveals that the majority of residents are unsure (25%) and doubtful (36%) that they have the courage to extinguish a home fire whereas only 15% of the residents are confident and very confident in their capacity to do so. This was consistently evident from the residents' answers to other questions which suggested that most of them had doubts about their abilities to put out fires on their own (Figure 3A).

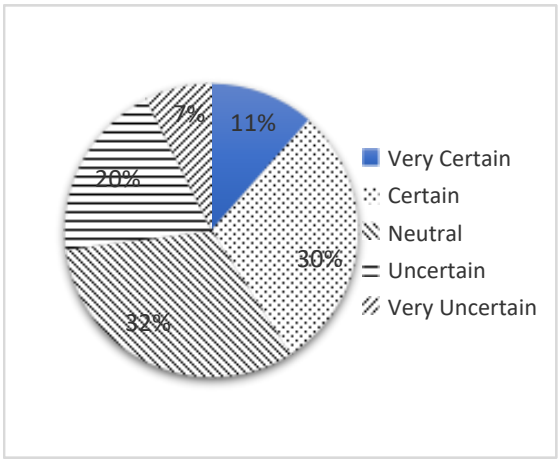
Figure 4 depicts three common techniques for putting out a fire: using a wet towel or cloth, spraying water and turning off the electrical. These strategies are useful in the early stages of fire growth. The selection of inhabitants was irrational, given that the leading cause of fire outbreaks. The ability of householders to extinguish fires is also based on their familiarity with firefighting methods or tools. Figure 4 shows that wet clothes/towels or water sprays are very well known among them. This was followed by cutting out the power lines of the buildings and then sand sprinkling. Closing doors and windows, which is effective in attempting to reduce the levels of oxygen in a room, was unpopular to some respondents.

Figure 5 indicates that water spraying is the preferred strategy for extinguishing fires. Fifty-four respondents ranked extinguishing fires with water as their first priority when a fire occurs, but 13 respondents ranked it as their fourth priority (Figure 5). Calling the police station/PMK, which has the highest votes, was the second priority followed by the fifth priority, which was chosen by 18 respondents. Contacting or visiting the RT to look for the tallest building when facing a fire is the seventh priority, which was chosen by 28 respondents.

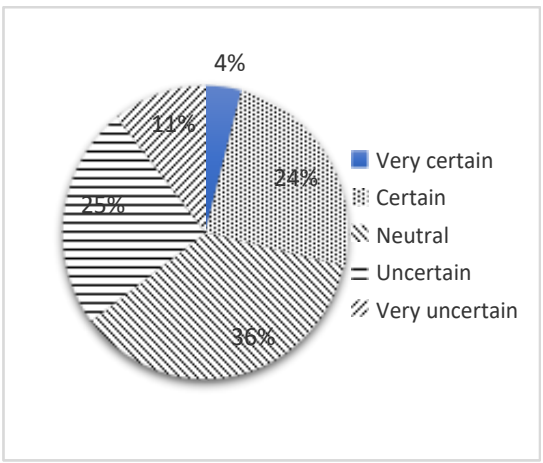
Bringing family/friends out of the house got the highest votes as the first and second priorities, which were equally chosen by 29 respondents. Rescue the most selected items on the 5th priority. Closing windows/doors was chosen as the last priority (36 respondents). Running out of the house in the event of a fire was chosen by 23 respondents as the fifth priority. Finally, shouting for help was chosen as the sixth priority.

Discussion

In this study, the level of fire safety awareness among the occupants was higher than their fire safety knowledge. The results of fire safety inspections indicated that all inspected buildings complied with local regulations and examinations of safety documents were satisfactory. The scores for fire safety measures in all selected colleges were also satisfactory and in good condition overall.



[A] Self-extinguishing efforts in case of a fire



[B] Level of courage in extinguishing a fire

Figure 3: Ability of residents to extinguish a fire

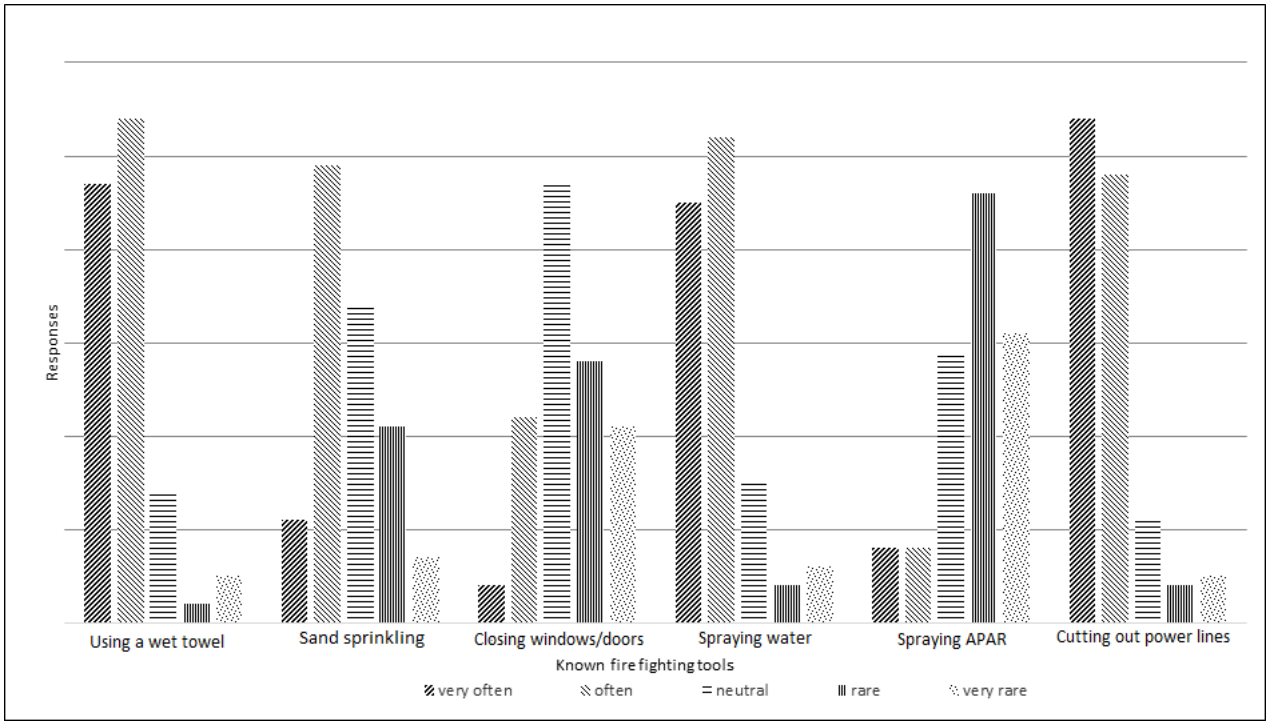


Figure 4: Typical fire extinguishing methods known by house residents

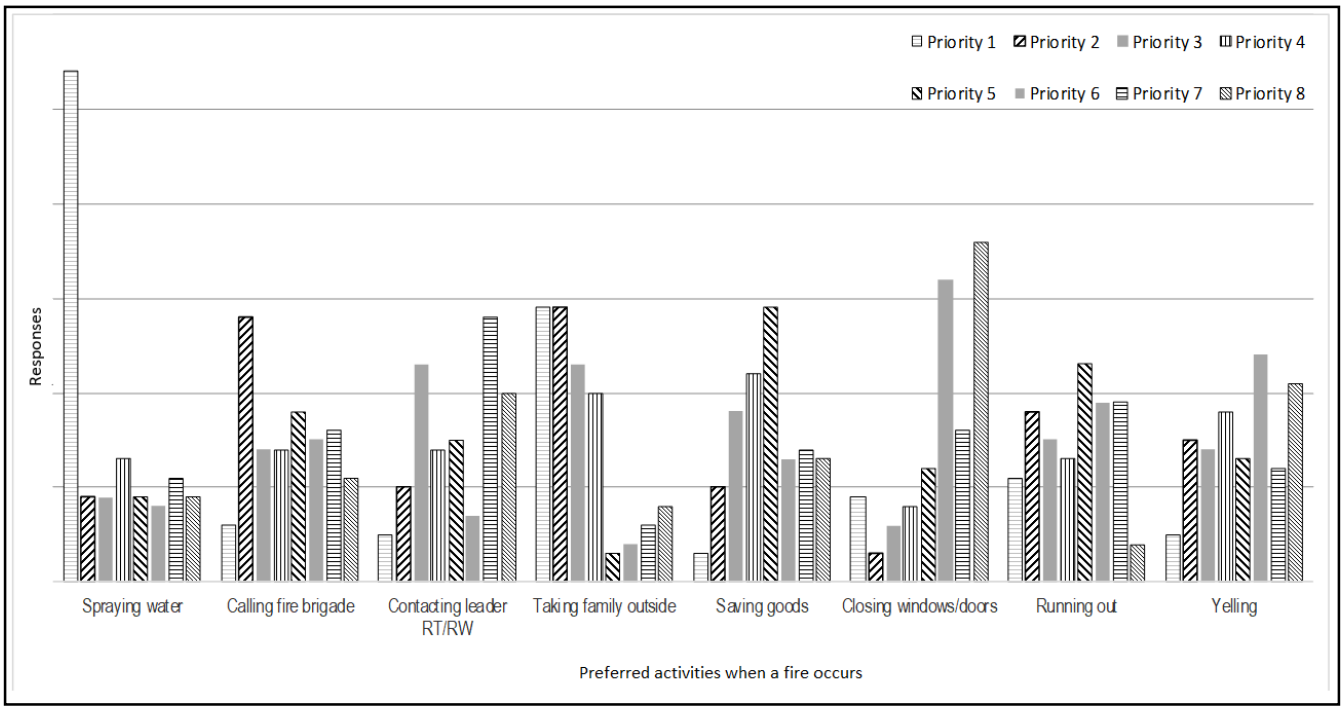


Figure 5: Typical priority of the respondent's activities in the event of a fire

This study is important for people in the field of safety and health practice related to fire safety engineering and regulations in order to plan for more effective fire hazard and risk assessment.

Some respondents did not comprehend how to prevent and extinguish fires in residential areas as seen in figure 1 which can be interpreted that the community must know more about fire prevention and suppression techniques. From the low degree of public attention to safeguarding their property/property from the risk of loss/damage due to fire, the status of this community appears precarious. This may be viewed as their fire safety awareness being lower than their fire safety knowledge, contrary to a Malaysian study[19]. Government and business organizations, as well as educational institutions at all levels, must raise society's understanding and concern for fire risk and fire prevention measures. Government regulations could be designed to incentivize the industrial sectors to reduce the cost of fire protection measures so that they are affordable for citizens.

Therefore, all levels of community organizations should consistently introduce fire risks. Unfortunately, they are frequently constrained by inadequate support[5]. Through mass media, social media and Government websites, it is also possible to increase public awareness of numerous fire safety issues. Despite their understanding of various fire prevention methods, Malang's population must strengthen their firefighting fundamentals.

This study found that respondents lack a comprehensive understanding of the risks associated with their daily actions. Fire-prone cultural practices include the use of extension electrical cables, T-branch electrical connectors and cables buried beneath the carpet. This is similar to a previous study[9], except the participants in this study do not have preventative measures such as alarms and escape plans.

Due to a lack of safety behavior, enhancing risk awareness in society may require intervention; this might be achieved through the use of modern information technology such as interactive computer games played by young children aimed at the elderly. This strategy has been found to be effective[11]. More programs and campaigns among the general public also improve risk behaviors[3]; this should be a feasible intervention if the population of Malang is receptive to any public gathering.

Despite their awareness and conduct against fire, the majority of participants appear to lack the confidence to fight fires on their own. This study identified three common techniques for extinguishing fires: using a wet towel or cloth, spraying water and cutting out power lines. These strategies are useful in the early stages of fire. The choice of the occupants was unreasonable given that electrical short circuits were frequently the leading cause of fire outbreaks.

Based on the responses, the residents have a poor understanding of the types of extinguishing agents required in common fires in residential areas—class A (dry matter). As most communities are experienced with using water to extinguish fires, having additional household facilities such as a water container, small water pond, or exterior water faucet appear to be a beneficial intervention.

Self-inspection of firefighting equipment may be helpful for maintaining their availability within the structure[7]. Nonetheless, portable fire extinguishers (APAR) are still necessary. They can be provided through mutual cooperation among community groups and they should be located in publicly accessible facilities such as security guardhouses, public places and halls. When the participants discovered a fire in their houses, they prioritized extinguishing the fire with water, calling the fire department and contacting the society's leader and then evacuating family members, running from the building and notifying neighbors by shouting. This behavior is similar to that of the Chinese, who upon discovering a fire, attempt to extinguish the fire before alerting others and evacuating[18].

Conclusion

This study suggests based on data analysis and interpretation that the residents of Malang are familiar with water as the primary firefighting method in their houses, despite their knowledge of defective power lines as the leading cause of fire incidents.

In addition, the Malang population lacks a comprehensive understanding of the fire risks associated with their daily activities, particularly when it comes to electrical appliances in their houses. There is widespread disbelief among the populace that they can fight fires on their own.

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References

1. Beasley M., Holborn P., Ingram J. and Maidment G., Causes, Consequences and Prevetion of Refrigeration Fires in Residential Dwellings, *Fire Saf. J*, **102**, 66–76 **(2018)**

2. Brushlinsky N., Ahrens M., Sokolove S. and Wagner P., World Fire Statistics. Bulletin Nº24, World Fire Stat. **(2019)**

3. Cvetković V. M., Dragašević A., Protić D., Janković B., Nikolić N. and Milošević P., Fire Safety Behavior Model for Residential Buildings: Implications for Disaster Risk Reduction, *SSRN Electron J.*, **2021**, https://doi.org/10.2139/ssrn.3974738 **(2021)**

4. Duncanson M., Woodward A. and Reid P., Socioeconomic Deprivation and Fatal Unintentional Domestic Fire Incidents in New Zealand 1993-1998, *Fire Saf. J.*, **37(2),** https://doi.org/10.1016/S0379-7112(01)00033-9 **(2002)**

5. Haristianti V., Linggasani M.A.W., Natali S. and Hartabela D., Proteksi Risiko Kebakaran Di Perumahan, Studi Kasus Perumahan Baru Di Kelurahan Cigadung, Bandung, *J. Arsit. ZONASI*, **2(1),** https://doi.org/10.17509/jaz.v2i1.15061 **(2019)**

6. Hietaniemi J., Mangs J. and Hakkarainen T., Burning of Electrical Household Appliances: An Experimental Study, *VTT Tied. - Valt. Tek. Tutkimuskeskus*, **2084**, 3–60 **(2001)**

7. Hyun-Hee Y., Kwang Bin B. and Gi-Geun Y., A Study on the Improvement Plan of the Self-Inspection System of Fire-Fighting Ffacilities: Focusing on Multi-Family Houses, *Korean J. Secur. Converg. Manag.*, **9(2),** https://doi.org/10.24826/kscs.9.2.14 **(2020)**

8. Jonsson A., Bonander C., Nilson F. and Huss F., The State of the Residential Fire Fatality Problem in Sweden: Epidemiology, Risk Factors and Event Typologies, *J. Safety Res.*, **62**, https://doi.org/10.1016/j.jsr.2017.06.008 **(2017)**

9. Karemaker M. et al, Elderly about Home Fire Safety: A Qualitative Study into Home Fire Safety Knowledge and Behaviour, *Fire Saf. J.*, **124**, https://doi.org/10.1016/j.firesaf.2021.103391 **(2021)**

10. Morrissey J. and Taylor A., Fire Risk in Informal Settlements: A South African Case Study, *Open House Int.*, **31(1),** https://doi.org/10.1108/ohi-01-2006-b0012 **(2006)**

11. Morrongiello B.A., Schwebel D.C., Bell M., Stewart J. and Davis A.L., An Evaluation of the Great Escape: Can an Interactive Computer Game Improve Young Children's Fire Safety Knowledge and Behaviors?, *Health Psychol.*, **31(4),** https://doi.org/10.1037/a0027779 **(2012)**

12. Radar, Human Error Picu Kasus Kebakaran Di Kota Malang, Radar Malang Online **(2021)**

13. Runefors M. and Nilson F., The Influence of Sociodemographic Factors on the Theoretical Effectiveness of Fire Prevention Interventions on Fatal Residential Fires, *Fire Technol.*, **57(5),** https://doi.org/10.1007/s10694-021-01125-x **(2021)**

14. Sufianto H. and Green A.R., Urban Fire Situation in Indonesia, *Fire Technol.,* **48(2),** https://doi.org/10.1007/s10694-011-0226-9 **(2012)**

15. Topical Fire Report Series FEMA, Residential Building Fires (2017-2019) **(2021)**

16. US Department of Homeland Security, Behavioural Mitigation of Cooking Fires, In Home Fitre Safety; Moretti Cornelio, Eds., New York, 1–72 **(2009)**

17. Xin J. and Huang C.F., Fire Risk Assessment of Residential Buildings Based on Fire Statistics from China, *Fire Technol.*, **50(5),** https://doi.org/10.1007/s10694-013-0327-8 **(2014)**

18. Yuan J., Fang Z., Tang Z. and Wang J., Study on Pre-Movement Behavior of Chinese People in Residential Buildings under Fire Situations, *J. Appl. Fire Sci.*, **23(4),** https://doi.org/10.2190/AF.23.4.b **(2013)**

19. Zakaria S., Ahmad D., Abdan K. and Rafee M., A Case Study of Fire Safety Measures at Malaysian University Residential Colleges, *J. Occup. Saf. Health*, **16(2),** 41-55 **(2019)**

20. Zhou B., Fire Situations and Prevention Measures of Residential Building, I*n MATEC Web of Conferences*, **100**, https://doi.org/10.1051/matecconf/201710002062 **(2017)**.

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