

Perception of Firefighters on Risk of Exposure to Respiratory Health Hazard: A Qualitative Analysis in Malaysia

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ABSTRAK

Anggota bomba terdedah kepada pelbagai bahan berbahaya disebabkan oleh pekerjaannya. Salah satu bahaya yang dihadapi adalah bahan kimia yang boleh mempengaruhi sistem pernafasan. Namun, hanya sedikit yang diketahui mengenai persepsi anggota bomba mengenai sumber pendedahan kepada bahan berbahaya kepada pernafasan terutama di Malaysia. Objektif kajian ini adalah untuk meneroka perspektif anggota bomba mengenai pendedahan bahan berbahaya pernafasan dan mengkaji kepatuhan terhadap penggunaan peralatan pelindung diri (PPE). Temubual mendalam dilakukan dikalangan 12 anggota bomba di Jabatan Bomba dan Penyelamat Malaysia pada bulan September 2020. Rakaman temu bual ditranskripsikan secara verbatim dan dianalisis secara tematik oleh penyelidik menggunakan perisian NVIVO 12. Kesemua peserta terdiri daripada bangsa Melayu, lelaki dan berkahwin. Pendedahan kepada bahan berbahaya pernafasan dari perspektif anggota bomba dapat dibahagikan kepada pekerjaan (ppededahan kepada asap akibat pemadam kebakaran, latihan kebakaran, demonstrasi pemadam kebakaran, ulang-alik ke tempat kerja, jentera bomba, bahan kimia dan debu) dan bukan pekerjaan (merokok). Anggota bomba menyedari kepentingan

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untuk memakai PPE, dan hakikat bahawa mereka tidak patuh kepada pemakaian PPE. Mereka juga mempunyai persepsi bahawa pemakaian PPE membebankan dan mereka tidak mempunyai cukup bekalan PPE. Pendidikan dan latihan perlu diperkukuhkan untuk memperkuat persepsi risiko, pengenalanpastian bahaya dan penilaian risiko pendedahan bahan berbahaya. Prosedur operasi standard dan pemantauan yang ketat semasa tugas anggota bomba adalah penting untuk mengurangkan pendedahan kepada bahan berbahaya dan meningkatkan pematuhan pemakaian PPE. Pengurusan inventori secara sistematik dan teliti penting untuk memastikan bekalan PPE mencukupi. Daripada analisa kualitatif, persepsi anggota bomba mengenai pendedahan bahan berbahaya pernafasan telah diperoleh, dan ia kini siap untuk kajian lebih lanjut.

Kata kunci: anggota bomba, pendedahan pekerjaan, penyakit paru-paru

ABSTRACT

Firefighters are exposed to multiple occupational hazards, where one of the hazards is chemical hazard that can affect the respiratory system. However, little is known regarding the perception of firefighters on the source of exposure to respiratory hazards, particularly in Malaysia. This work aims to explore the firefighter's perspective on respiratory hazard exposure and to examine the compliance of the use of personal protective equipment (PPE). In-depth interviews were employed among 12 firefighters at Fire and Rescue Department of Malaysia in September 2020. The interview recordings were transcribed verbatim and of thematic analysis done via the NVIVO 12 programme. All participants were Malay, male, and married. The respiratory hazard exposure perceived can be divided into occupational source (e.g. exposure to smoke from firefighting, fire training, firefight demonstration, commuting, firefight vehicles: chemicals and dust) and non-occupational source (e.g. smoking). Firefighter recognised both the importance of wearing PPE and the fact they are still not compliant in wearing it. They also perceived wearing PPE as burden and having only a limited stock of PPE. Education and training need to be reinforced to strengthen firefighters' risk perception, hazard identification, and risk assessment of hazards exposure. Strict standard operating procedure (SOP) and supervision during firefighters' task is crucial to reduce hazard exposure and increase PPE compliance. Systematic and thorough inventory management is needed to ensure adequate PPE supply. Post qualitative analysis, the firefighters' perception on respiratory hazard exposure was obtained, demonstrating that the analysis is ready for further study.

Keywords: exposure, firefighter, respiratory hazard

INTRODUCTION

Globally, it is estimated that mortality accounted from occupational lung disease is 17.6%, the third-highest occupational mortality after circulatory disease and malignancy (Hämäläinen et al. 2017). Exposure to occupational airborne particulate attributed to an estimate of 386,000 deaths and nearly 6.6 million disability-adjusted life years (DALYs) (Driscoll et al. 2005). A report shows that the global exposure for several occupational hazard between 1990 and 2015 had increased by more than 25% (GBD 2015 Risk Factors Collaborators 2016).

Firefighters are exposed to multiple occupational hazards; one of the hazards is a chemical hazard from combustion during firefighting. The chemical hazard exposure can occur through inhalation, ingestion, and skin absorption. Through inhalation, chemical causes respiratory hazard and is among the most prevalent hazards, according to Schermer et al. (2014), to up to 10% of firefighters experiencing chronic respiratory problems. Additionally, occupational exposure is one of the major risk factors for chronic lung diseases (Management of Chronic Obstructive Pulmonary Disease 2009). Whole-body exposure was demonstrated by Fernando et al. (2016), whereby smoke chemicals were detected in skin wipe samples acquired from multiple body sites of firefighter involved in training exercises held in burn houses, which can cause the risks of inhalation and skin absorption.

For protection against the various

hazards, firefighters are required to wear their personal protective equipment (PPE). However, a recent pilot survey in United States (US) showed that majority of firefighters do not comply to their wearing of protective gear (Kahn et al. 2020) and in an analysis of 50 video recordings of firefighting, 28% of firefighters had failed to comply to Self-Contained Breathing Apparatus (SCBA) (Kahn et al. 2014). There is yet a study on PPE compliance among Malaysian firefighters, but other sector such as construction has shown low PPE compliance, whereby only 37.5% had complied with PPE use (Tanko et al. 2020) and for agricultural sector, only 26.3% workers had worn full PPE (Sulaiman et al. 2019). Goal seduction (firefighters prioritise the need to rescue others over their own safety) (Maglio et al. 2016) and burnout negatively influenced personal protective equipment compliance (Smith et al. 2018), while safety motivation and safety-specific leadership had a direct relationship with personal protective equipment use (Smith et al. 2020).

Little is known regarding the perception of firefighters on risk of exposure to respiratory hazard and how they are mitigating that risk through activities such as wearing PPE, particularly in Malaysia. Thus, the objective of this study is to explore and establish the perceived exposure to respiratory hazards among firefighters and their compliance towards PPE use. The information gained can provide basic data for future assessment of firefighters through empirical assessment into the respiratory hazard of firefighters in Malaysia. Subsequently, stakeholders

are better able to develop interventions aimed at firefighters' attitudes and behaviours toward respiratory hazards upon acquiring an understanding of how firefighters make sense of hazards within their organisational context and therefore, stakeholders are able to identify measurable variables.

MATERIALS AND METHODS

This study was carried out among firefighters at Fire and Rescue Department of Malaysia owned by Ministry of Urban Wellbeing, Housing and Local Government of Malaysia. This department provides fire prevention and extinguishing services, enforcing laws related to safety and firefighting aspects, as well as providing efficient and effective humanitarian services (Fire and Rescue Department of Malaysia 2020). Fire stations from two states in Malaysia, namely Selangor and Kuala Lumpur, were involved in this study. Both of the above mentioned states have the highest building fire cases in the country, whereby Selangor has the highest fire cases in Malaysia (Fire and Rescue Department of Malaysia 2018). This study was undertaken with received written consents from participants involved.

The sampling procedure in this study was purposeful sampling involving 12 participants from three different fire stations, namely Tun Razak, Shah Alam and Rawang fire stations. Participants of this study ranged from regular firefighters, supervisors, to high-ranking officers. Interviewing people in different roles and ranks provided

triangulation of the data collected, as each person provided their own descriptions and interpretations of experience; this ensured rigour in data analysis.

This work adopted individual semi-structured interview protocol for the study to elicit responses that would address the research questions. The interview was conducted in September 2020; during the interview, the researcher collected the participants' demographic information and concurrently develop an ice-breaking session and rapport with the participants. Additionally, the researcher presented questions such as, "Based on your experience working as a firefighter, please tell me something about the exposure to respiratory hazards," to stimulate participants into telling their story as they see it, feel it, and experience it. The researcher had also ventured further into participants' job scope, PPE compliance, and availability of training.

Upon the firemen's agreement to participate, face-to-face interviews were conducted in Bahasa Malaysia at the fire stations and each interview lasted for approximately 30 minutes. During the interviews, the researcher made field notes of ideas and audio-recording in order not to miss out on any details of the interview. The follow-up from the interview was done via phone call to clarify information from the first interview. The recordings were transcribed verbatim and analysed by the researcher. Triangulation, member checking, and expert checking were applied for validity and reliability of the data. Further triangulation was

done from the obtained data of annual reports from Fire Department, high-ranking officers, and data available at fire stations. The transcripts were then imported and analysed using NVIVO 12 programme, which facilitated data organisation and retrieval.

This study was approved by the Research Ethics Committee of National University of Malaysia (UKM PPI/111/8/JEP-2020-686) and Fire and Rescue Department of Malaysia.

RESULTS

Table 1 shows the sociodemographic characteristic of participants. A number of 12 participants were recruited, all of which were Malay, male and married. Their age ranged from 25 to 58 years, with a median of 38 years old. Total years of service of personnel in the fire department ranged from 5 to 36 years, with a median of 15 years. We divided

the age into two categories; below 40 years and 40 years and above in Table 1 to portray the number of participants at risk as previous study (Douglas et al. 1985) stated that lung function fell more rapidly than predicted in firefighters in the latter group. The participants comprised firemen from normal operational unit, supervisor, to head of the fire station department. Special forces unit included were from Hazardous Material Unit Team (HAZMAT), Special Tactical Operation and Rescue Team of Malaysia (STORM) and Emergency Medical Rescue Services (EMRS). Training on proper PPE use during firefighting and exposure to hazards had been provided to all respondents.

The focus of this work then shifted on respiratory hazards during the interview. Firefighters were asked what respiratory hazard exposure meant to them in general, in which

Table 1: Sociodemographic characteristic of participants

Variables	Mean (±SD)	Number	Percentage, %
Age (N=12)	39.83 (±12.03)		
Below 40 years old		7	58.3
40 years old and above		5	41.7
Gender (N=12)			
Male		12	100.0
Female		0	0.0
Ethnicity (N=12)			
Malay		12	100.0
Non-Malay		0	0.0
Education (N=12)			
Low		0	0.0
Moderate		8	66.7
High		4	33.3
Marital status (N=12)			
Married		12	100.0
Single/Divorced		0	0.0
Work Duration (N=12)			
20 years and less		9	75.0
More than 20 years		3	25.0

their answers can be divided into two themes; occupational hazard and non-occupational hazard. For occupational hazard, overwhelming answers from participant indicate exposure to smoke from product of combustion. The smoke can be from firefighting, fire training among firefighters, firefight demonstration to publics, while commuting and firefight vehicles. The firefights involved were vehicle fire, building fire, wildfire, agricultural fire, and landfill fire. Respondents informed that stopping fire in buildings or vehicles is much quicker than stopping wildfire and landfill fire. The magnitude of wildfire and landfill fire may take a few days to combat and require helps from other fire stations.

Firefighters perceived they exposed to traffic-related smoke while commuting to and from workplace. A firefighter simple quotation, “[...] go to work riding motorcycle and exposed to smoke”.

The respondents indicate that firefight vehicles and machineries, such as fire appliances and fuel-powered equipment, for inspection and testing were done daily and there were opportunities for exhaust smoke to enter their workstation.

“Occupational safety committee decided we put outside the machinery. However, the smoke still exposed to us and enters (into workstation). In 10-15 minutes daily”.

“Surrounding factors such as fire engine. Personnel had to be exposed to smoke from pump testing, vehicle testing, equipment inspection [...] we have changed the concept of this fire engine must start outside. Can't

be in the bay. It means there is a ventilation, meaning, firefighter started the engine without sitting in confined compartment [...] The fire engines are all open”.

Other occupational respiratory hazards perceived by firefighters were from chemicals particularly exposed to HAZMAT team. To identify chemical hazard, HAZMAT team can either inquire the person in-charge of premise, refer to hazard label on tanker in vehicle spillage or refer to labelled raw material container at the facility. If no information on hazard identity can be gained, field-testing such as personal dosimeter and gas meter or sending samples for laboratory analyses are other alternatives. HAZMAT team will perform risk assessment and analyse each chemical hazard properties from guidebook and safety data sheet (SDS). Among chemical names that are frequently mentioned by respondents is ammonia.

“Like recently I was exposed to ammonia leaks. We sat outside on the premises, but at the same time the wind pushed the smell to us. We wear regular masks. Face mask. So, when the wind blows, we inhale a little taste here (points with index finger at his nose)”.

Only a few respondents mentioned about dust from collapsed building as respiratory hazard, but it was claimed that dust will not affect them directly, as dust is only present when the building is collapsing. During rescue, they are no longer exposed to dust, as the building would have had already collapsed. Their only concern was the safety issues such as injury, fall, and

crash from the collapsed structure.

The next theme was non-occupational respiratory hazard. Smoking is a non-occupational respiratory hazard mentioned frequently by the respondents. Hobbies and other non-work activities were not mentioned by respondents.

When explored on PPE use among firefighters, among the types of PPE mentioned were bunker gear including glove, hood and boot, and respirator including self-contained breathing apparatus and filter mask.

The majority of the participants agreed that respiratory hazard exposure could be prevented by using PPE. Majority of the respondents claimed that they received yearly training on PPE use. They are also made compulsory to wear PPE during every firefight. Respondents were confident with the current PPE supplied in terms of its safety and durability, compared with the older version of PPE. However, some of the respondents complained of PPE shortage due to short supply and loss from wear and tear.

Even though they were required to wear PPE during firefight, they are unable to adhere to it at all times during certain circumstances. For example, during firefight at wildfire, they need to walk uphill and downhill to cover large operational area, which required a lot of time, thus, they perceived the condition to be unsuitable for wearing proper PPE. Some of the respondents also perceived it is safe not to wear PPE at an open area. Occasionally, they remove the PPE to take a rest.

“Let say if open-air like forest fires, we do not use PPE, maybe we will

use hoods or filter masks supplied for our forest fires that are not suitable for breathing apparatus.”

“[...] BA (breathing apparatus), but when go inside (the wildfire) they use 30 minutes to 40 minutes, but the work to be done may take up to 2 hours. So, the first 45 minutes they used BA, when it was over, they did not have time to refill because to refill they had to turn back. When asked about why some of the staffs not compliant to PPE, the participants responded with variety of answers ranged from attitude problem, only focus on finishing the task, lack of situational awareness, tired of wear prolonged PPE, burden to wear, not comfortable, poor fit and shortage of PPE. Some of the participants indicated that when faced with other life-threatening circumstances of firefighting and rescue missions, they often prioritise to get job done rather than considering the effect of hazard to self. One of the respondents said, “If we see smoke during overhaul, we wear (PPE)”.

DISCUSSION

From this study, we determined that the respiratory hazard exposure perceived by the firefighters can be divided into occupational and non-occupational sources. As expected, most of the respondents indicated smoke as the respiratory hazard, as this was the obvious element that they can see, feel, and smell. According to Dave (2016), hazard is recognised from visual or sensory input, which tallied with the findings of this work. However, this recognition must be followed by risk

perception on their understanding of the hazard, which, in turn, depends on their experience and knowledge.

From the result, firefighters demonstrate landfill and wildlife fire is among a significant exposure, as it usually involves large fires. Exposure to landfill and wildfire have more exposure rating due to longer duration, degree of release or presence. as well as degree of possible inhalation. Previous studies (Toro & Morales 2018; Weichenthal et al. 2015) and a review (Vaverková 2019) only reported a focused research on the environmental impacts of landfill fire. Firefighter Occupational Exposures (FOX) Project Exposure Questionnaire from California (Dobraca et al. 2015) also did not include landfill fire in the questionnaire. This shows that landfill fire exposure may be important in Malaysia context, which requires further investigation in future study. The landfill fire is included in open air fire, as well as other fires such as wildland fire, farm fire, and bush fire. Open air fire occurs the most frequently, where it was reported to have involved 16,566 outdoor fires as compared to 3,061 building fires in Malaysia (Annual Report of Fire and Rescue Department of Malaysia 2018).

Training and demonstration using fire will produce smoke that is exposed to the firefighters involved. This is congruent with the empirical evidence from a study by Fent et al. (2019), which illustrated the exposure to polycyclic aromatic hydrocarbons and benzene from training of firefight exercises involved with simulated smoke. The benefit of training is to

brush up the firefighters' skills, their competency, firefighting techniques and endurance, while demonstration to public is to educate the community, thus there is need to balance between training and demonstration to smoke exposure reduction.

Commuting to and from workplace can expose a person to traffic-related air pollution from the exhaust gas of one's own vehicle and of other vehicles. Sample taken from police traffic by (Muhammad et al. 2012) revealed they were exposed to traffic-related air pollution, such as PM_{2.5}, which affected their lung function. Many recent studies also revealed respiratory changes due to traffic-related air pollution (Gaffney et al. 2016; Golan et al. 2018; Muhammad et al. 2012). However, these studies did not involve firefighter, thus, this type of exposure needs to be taken into account in further study.

Diesel exhaust emission were among the concerns expressed by participants. This is in agreement with a qualitative study from South Florida which showed that majority of the firefighters also expressed concern on their daily exposure to diesel exhaust emission (Anderson et al. 2017). Studies have shown respiratory hazard also present at the fire station itself (Bott et al. 2017; Froines et al. 1987; Michalak 2004). Even though improvements have been made to test vehicles and machineries in an open area and not in a truck bay, firefighters are still exposed to diesel smoke as direct operator and people inside nearby compound, thereby affecting the quality of indoor air. Further improvements need to be

done, such as operators wearing PPE, taking away nearby compound from the possible routes of exhaust smoke entry, proper ventilation of testing area, and shifting of operator from doing the same task.

Chemical exposure is especially handled by HAZMAT team and fortunately, complete PPE are normally worn. The most dangerous scenario is when regular firefighter is unable to detect and anticipate the presence of chemical hazard. The findings of ammonia exposure symptoms mentioned were correlated with ammonia properties of irritant to upper and lower respiratory tracts (Fabian et al. 2014).

The exposure to dust from collapsed building maybe not be perceived as significant in Malaysia context due to its small magnitude as compared to that in US with significant exposure, particularly on catastrophic event such as terrorist attack on World Trade Centre. Participants perceived the dust to have already settled down during their collapsed building operation, which is contradict with the fact that New York firefighters have a significant intensity-response relationship between dose intensity (indicated by those arrived earliest on site) and decline in lung function (Aldrich et al. 2010; Aldrich et al. 2016; Banauch et al. 2006).

Interestingly, participants did not mention personal hobbies, habits, or social activities as exposure to respiratory hazard. This may be since Malaysians rarely indulge in hobbies exposed to respiratory hazards, such as barbeque parties. Wood stove

that gives off emission of product of combustion is also not a usual situation in Malaysia, as this is a tropical country. Firefighters need to be educated on exposure to respiratory hazard while undertaking certain hobbies.

From the interview, motivation to wear PPE was perceived as important, as well as for the fear of danger, confidence with protection by PPE, frequent training, and compulsory to wear. This is contradictory with a research by Barker et al. (2012) which indicated concern about specific firefighter clothing features that did not function well, therefore, questioning the durability of the materials used in PPE. This contradiction may be attributable to different subject perception from two different countries, which are developing and developed countries.

Despite the motivations, the level of compliance is poor due to shortage of supply, not fit, perceived condition not suitable to wear, perceived condition safe not to wear, burden of PPE, restricted mobility, personal attitude problem and goal seduction. Burden of PPE can be due to the physical demand of firefighter tasks on top of the heavy PPE, as indicated by Burgess et al. (2001) who reported that the weight of SCBA is normally more than 10 kg. An example of perceived condition that is safe not to wear PPE is during overhaul, in which there is often no visible smoke, whereas firefighters generally only wear SCBA during periods of visible smoke exposure (Burgess et al. 2001). The findings of this work is similar to previous qualitative studies among US firefighter by Maglio et al. (2016), whereby wearing PPE is influenced by

goal seduction.

This study is pioneer to exploring the firefighters' perceived respiratory hazard exposure in Malaysia context and further objective study can be done based on the findings obtained. This study has revealed some important exposures among firefighter that never touched by previous firefighters respiratory-related studies such as exposure to landfill fire, traffic-related smoke from commuting activity and fire-demonstration smoke. This study also shows the insight of the firefighter such as good insight for smoke exposure but low insight for dust and non-occupational exposure, however this finding needs further objective evaluation. We are also able to elicit that firefighter perceived it is important to wear PPE, yet they still not comply of wearing it.

The strength of this study is we are able to interview people in different roles and ranks that provided triangulation of the data collected, as each person provided their own descriptions and interpretations of experience; this ensured rigour in data analysis.

Limitation of this study is the in-depth interview that was performed only once, however, researcher conducted a follow-up via phone call to clarify any information from the participants.

CONCLUSION

Firefighters' perceived exposure to respiratory hazard from occupational source (exposure to smoke from firefighting, fire training among

firefighters, firefight demonstration to publics, commuting, firefight vehicles: chemicals and dust) and non-occupational source (smoking). Firefighter perceived it is important to wear PPE, but compliance is low. Education and training need to be reinforced to provide a better insight to firefighters in terms of actual sources of hazard, risk perception, hazard identification, and risk assessment to increase PPE compliance. Implementation of strict standard operating procedure as well as strict supervising during firefights and other task is crucial to reduce risk of exposure and increase PPE compliance. Systematic and thorough inventory management also important for adequate PPE supply. Further study needs to examine the content of firefighter training and improvise if necessary. Post qualitative analysis, the firefighters' perception on respiratory hazard exposure was obtained, indicating its readiness for further objective study.

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