Preparedness towards Chemical, Biological, Radiological, Nuclear, and Explosive (CBRNE) threats among healthcare personnel in Pasir Gudang, Johor, Malaysia

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ABSTRACT

Chemical, Biological, Radiological, Nuclear, and Explosive (CBRNE) threats are one of the major concerns related to global security and threat. It is an unexceptional CBRNE crisis in the industrial area of Pasir Gudang, Johor Bahru, Malaysia, as the industrial sector keeps growing resulted to a crisis of toxic chemical exposure which affected 6000 lives in 2019. It is then had put more concern among healthcare personnel towards CBRNE disaster. It is of critical importance to assess the extent of preparedness in CBRNE hazards. Therefore, this article is primarily aimed to evaluate the level of preparedness among healthcare personnel toward CBRNE crises. 114 responses through questionnaire had been collected from healthcare personnel of four government agencies and was analyzed using SPSS Version 27. According to the results, progressive exposure to CBRNE knowledge with more than 5 years of working experience demonstrated an advanced level of preparedness towards CBRNE disaster. The impact of knowledge and resilience level proved to be strongly connected to CBRNE preparedness. Therefore, initiatives to improve CBRNE preparedness will provide endless CBRNE awareness. This study will enable the management to measure the readiness of other essential healthcare professionals or first responders while also assisting improving the quality of service among healthcare personnel towards disaster.

1. Introduction

A disaster is an unexpected, catastrophic occurrence that severely interferes with a population's or society's functioning and results in life, property, economic, or environmental losses that surpass the society's capacity to deal with its resources. As a result, chemical,

biological, radiological, nuclear, and explosive (CBRNE) disasters are often a potent threat and thus can create a large number of injured, fatalities, and significant damage to livelihood.

One of the eminent incidents is the 1995 sarin nerve agent attack in Tokyo Subway which had caused 245 healthcare workers tormented from secondary contamination [1]. Subsequently, Malaysia has increasingly dealt with CBRNE crises, with an annual total of 90 terror-related arrests [28]. It is an unexceptional crisis in the industrial area of Pasir Gudang district, Johor Bahru with urban development and possibility of continuous catastrophe as the industrial sector keeps growing. The recent numbers of factories currently reaching 2500 registered sectors with 250 chemical plants [8]. Two thoughtful crises of toxic chemical exposure had brought severe attention in 2019, which affected 6000 lives, including several healthcare personnel [2]. About 20 healthcare personnel (HCP) were affected and some of them admitted to the hospital [29].

Therefore, emergency planning and preparation is a crucial component to develop strategies, and reduce the effects of disasters. Hence, the HCP's alertness is a vital factor in dealing with CBRNE threats.

The main purpose of this study is to evaluate the level of preparation of HCP in Pasir Gudang, Johor Bahru. There are three key principles which affected the CBRNE's preparedness such as knowledge, training, and resilience factors. The HCP's knowledge and training level, including factors that influence readiness to deal with CBRNE threats could provide concrete strategies for effective readiness, planning, response, and recovery in disaster. This study's findings are valuable in maximising HCP potential with minimum health impact in CBRNE incidents, thus reducing the fatality and mortality rate.

2. Literature review

Disaster risk is extensively known as the significance of a combination between a threat, the exposure features of population and area, and vulnerability. There is clear evidence to reduce disaster risk by implementing disaster risk management comprised of actions linked with the prevention, mitigation, and preparedness [4]. Emergency response planning, preparedness, and communication are vital to develop effective response and 'Build Back Better' as stated in Sendai Framework in Disaster Risk Reduction (DRR).

CBRNE disasters are often a potent threat and can create a large number of injured, fatalities, and significant damage to livelihood. Presently, biological hazard of SARS-CoV2 (COVID-19) which spread via secretions, direct contact, and particles has caused much concern among community with around 223 million positive cases and killed more than 4.5 million people worldwide and badly affected healthcare facilities, economy and communities [30]. According to Amnesty International, Public Services International (PSI), there are about 17,000 HCP died due to COVID-19 infection [31]. Besides that, 50 persons suffered of radiation burns at the nuclear power plant at Fukushima and 573 died due to evacuation procedures and stress-related factors [5]. Also, the Chernobyl nuclear disaster in Ukraine in 1986 has been the most significant nuclear disaster in history. 237 HCP suffered acute radiation sickness of the Chernobyl disaster and claimed the lives of 31 individuals who died of blast consequences, while another 29 firefighters perished as a result of acute radiation exposure [6].

Nevertheless, Pasir Gudang in Johor Bahru had the same crisis with a frightening record of CBRNE incidents annually (Fig. 1). One of the enormous incidents were chemical spill in Kim Kim River in 2019 which had polluted the ecosystem and poisoned the population in that area. This in turn, affected several students and HCP with severe respiratory symptoms that need intensive critical treatment [7]. In total, 6000 livelihoods affected with respiratory and gastrointestinal problem [8]. Instituted on the Hospital Sultan Ismail's data, there are about 20 health care workers were affected with moderate to severe respiratory and gastrointestinal symptoms after exposed to the chemical pollution [29]. These issues had put more concern among emergency responders towards CBRNE disaster's preparedness.

In Pasir Gudang, the first responders, including emergency medical services, healthcare personnel, firefighters, emergency response team are accountable for managing the mass casualty incidents, including the CBRNE [7]. Pasir Gudang Emergency Mutual

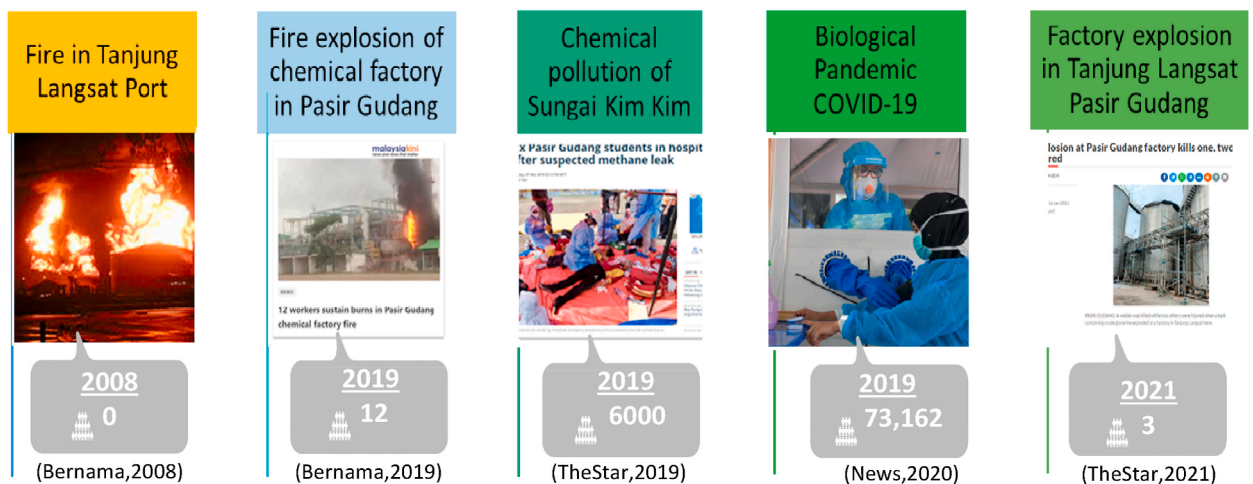| Fire in Tanjung Langsat Port	Fire explosion of chemical factory in Pasir Gudang	Chemical pollution of Sungai Kim Kim	Biological Pandemic COVID-19	Factory explosion in Tanjung Langsat Pasir Gudang
2008 0	**2019** 12	**2019** 6000	**2019** 73,162	**2021** 3
(Bernama,2008)	(Bernama,2019)	(TheStar,2019)	(News,2020)	(TheStar,2021)

Fig. 1. CBRNE's crises in Pasir Gudang.

Aid (PAGEMA) had attempted to lead an emergency in a large industrial area of Pasir Gudang. PAGEMA is actively supporting strategic collaboration efforts across 47 significant industries ranging from chemical, petroleum, and polymer manufacturing [9].

According to Centers for Disease Control and Prevention, any workers functioning in healthcare environments have the risk for direct or indirect contact to infectious materials are referred as HCP. Consequently, the HCP is the high-risk group for injuries, death, or infection, especially from the primary exposure of CBRNE crisis which could develop as a cause of spread [10]. It is because, even if they are HCPs, they will become community members after working hours. HCP readiness is critical since it influences the transmission of infection among frontline workers to the public.

Subsequently, all HCP who first arrived at the incident site will be holding a role as an incident commander. Thus, every HCP, including an Assistant Medical Officer (AMO), Staff Nurses (SN), and Medical Officers (MO) have a chance to lead the CBRNE disaster. The CBRNE preparedness in this study was concerning to the readiness among HCP towards CBRNE crisis. The HCP readiness which contributed from the level of knowledge, the level of training and drills, and the level of personal resilience towards the risk and death during CBRNE crisis. The risk of occupational injuries or death is high for HCP as a consequence of the high incidence of CBRNE (Yahya et al.,. 2021).

Therefore, incident factors should be identified to reduce the risk involved in the CBRNE crisis. The emergency responder-related factor is one aspect that needs to be explored as it is easier to control compared to the other factors. In addition, a review by Yahya et al. [10] found that several factors like knowledge, training, resilience, experience, and others contribute to CBRNE response preparedness. The indicator of preparedness among frontliners, especially HCP, is based on the level of awareness [11]. Education among staffs is essential, which affected alertness to respond efficiently to the disaster [12]. CBRNE attentiveness is gained through the significant roles of training and drill [13]. Regular exercise and drills could guide deliberate minds to realise preparedness and expand the quality of emergency services [14]. Continuous drill and training, which consist of theoretical and practical programs, are beneficial to generate long-standing CBRNE preparedness [10,11].

The important relevant professional characteristics such individual resiliency is related to greater responses to CBRNE crises. Therefore, the level of personal resilience in this study evaluated HCPs willingness to report duty during crisis and faith to bounce back after crisis. HCP believed that physical and psychological self-concern, particularly, reduces regular activity, psychological impact, depression due to the use of protective gear, affecting the ability to adapt in an austere setting [15]. The highest degree of risk, particularly from biological, chemical, and nuclear crises, could severely affect the responders and their families' safety and perceived lower preparedness for CBRNE [16,17].

There are three key principles which affected the CBRNE's preparedness such as knowledge, skills and training, and resilience factors (Fig. 2). The knowledge part covered the component of these measures:

1. Awareness of CBRNE threats.
2. Information level of CBRNE material.
3. Safety procedures.
4. Decontamination process.
5. Triaging principles.
6. Chain of command.
7. Frequency in receiving CBRNE knowledge.

The second part of the questionnaire entails training and drill levels among HCP. The training and drills consist of the following components:
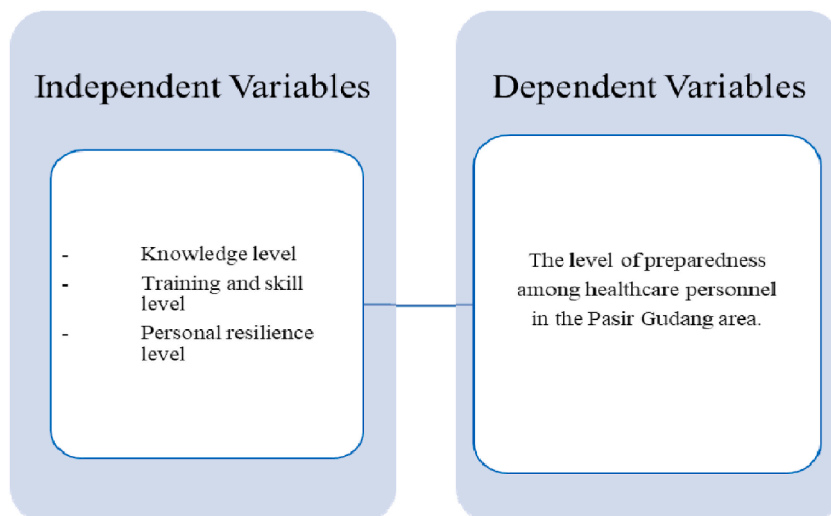

Fig. 2. The conceptual framework.

1. Emergency plan.
2. Method to identifying hazard.
3. Safety process.
4. Personal protective equipment.
5. Decontamination process.
6. Principle of quarantine and isolation.
7. Frequency of participating in CBRNE training or drill.

The third part of the questionnaire involves the personal resilience level among HCP. The personal resilience survey comprises of the following:

1. Ability to report to work when a CBRNE crisis occurs.
2. Ability to return to work after a period of CBRNE disaster.
3. Ability to go through stressful events during CBRNE occurrence.

The last part contains the evaluation of the CBRNE's preparedness. The questionnaire are as follows:

1. Readiness to manage CBRNE incidents.
2. Confidence level to manage CBRNE incident. The questionnaire had been evaluated by using 'the conceptual framework.'

At the time of this study, there was no Malaysian research available that focused specifically upon health care personnel readiness for CBRNE crises. However, there are several analyses which assessed bioterrorism response plan conducted by Vikneswaran [18] and Malaysian Armed Forces preparedness toward CBNRE threats carried out by Yusop [19]. Since the first-responder level of preparedness in Malaysia for CBRNE events has not extensively been examined, this study should be conducted to provide details on the first-response presentation of CBRNE management to recognise relevant factors that have affected preparedness and improve effective response, as outlined in Priority 4 of the Sendai Framework for Disaster Risk Reduction.

3. Methodology

This study was a cross-sectional survey. A five-part questionnaire of a five-point Likert scale was designed by the researcher from the factors which have been proved affected the level of preparedness from literature reviews. The generated questionnaire had been validated by Emergency Consultant, University Expertise and National Medical Research. The level of CBRNE preparedness among HCP had been evaluated based on the socio-demographic profile, knowledge, training, and personal resilience. The first part of questionnaire focused on the respondents' socio-demographic characteristics. The second part assesses HCP's knowledge of CBRNE emergencies which measures the element of awareness towards CBRNE threats, level of safety procedures, decontamination process, triaging principles, and chain of command. The third part of the questionnaire entails training and drill among HCP involving the components of emergency plan, safety process, personal protective equipment, decontamination process, and principle of quarantine and isolation. The fourth part of questionnaire involves the personal resilience among HCP. The last part evaluated the CBRNE preparedness, which includes respondents' readiness and confidence level in managing CBRNE incidents.

In this study, samples were selected from four government agencies that mandate to respond as immediate responders for any incidents in the Pasir Gudang area. The inclusion criteria including the Physician, MO, AMO and SN from the Emergency and Trauma Department of Hospital Sultan Ismail Johor Bahru (HSI), Pasir Gudang Health Clinic, Masai Health Clinic, and Ulu Tiram Health Clinic. The four institutions were situated around the Pasir Gudang district and were assigned by the Ministry of Health as immediate responders for any disaster in the Pasir Gudang area. The exclusion criteria included the practical doctor whose undergone houseman ship and contract staffs. The data collection precisely started on 13th June 2021 until 13th August 2021 (2 months period).

The reliability test is conducted to check the internal consistency of the items measuring the variables with subjective measures. The independent variables for this study are factors that affected CBRNE's level of preparedness. The Cronbach's Alpha for CBRNE's Preparedness is 0.794 (acceptable internal consistency). In contrast, Cronbach's Alpha for the independent variables is 0.902, indicating an excellent internal consistency level. Therefore, the items used to measure the variable were considered reliable.

The completed questionnaires that were collected from a total of four government hospitals and health clinics had been analyzed using Statistical Program for Social Sciences (SPSS) system version 27.

4. Data analysis

The sample size with a level of precision of 0.05 for the confident level of 95% is 114 respondents from the approximately 160 population size of HCP in government agencies in the Pasir Gudang area. Table 1 showed that the response rate from this study reach-

Table 1
Response rate.

Data Collection Period	Population Size	Sample Size	Government Agencies			
13th June 2021–13th August 2021	160	114	Hospital Sultan Ismail (HSI)	Pasir Gudang Health Clinic	Masai Health Clinic	Ulu Tiram Health Clinic
			73	18	22	3

ing 114 respondents resulted from 2 months period of data collection. This response rate achieves more than 100% of the sample size (114 sample size from Slovin's formula).

The study received a great response from three agencies. More than half of the responses come from the HSI, with 73 answers (62.9%). The least response derives from Ulu Tiram Health Clinic, which is three responses (2.6%). Overall, the AMO (n = 48; 42%), had a higher response rate than 45 SN which comprised 39%, or 17 MO (15%), and 4 physicians (4%) (Fig. 3). The response rate is excellent since it collected more than 60% response, even though this study took place during the surge of COVID-19 pandemic with daily more than 20,000 new positive COVID-19 cases in Malaysia.

5. Results

The descriptive analysis was used to describe the socio-demographic profile. Table 2 shows the distribution of the socio-demographic profile of HCP. The majority of the respondents were female (57.0%), whereas another 49 of the respondents were male (43.0%). 51 of the respondents were between the age of 26 years old until 30 years old (44.7%), followed by the 48 respondents within the range of age 31–40 years old (42.1%). More than three-fourths of the respondents were married (78.9%), whereas 23 of respondents were single (20.2%). Almost three-fourths of the respondents had more than 5 years of working experience in Pasir Gudang (n = 85, 74.6%), while the rest equally had less than 5 years and 3 years of working experience in Pasir Gudang. The majority of the respondents were HCPs who's having a duty in Hospital Sultan Ismail (HSI) (n = 71; 62.3%). 22 of the respondents were working in Masai Health Clinic (19.3%), whereas 18 of the respondents were working in Pasir Gudang Health Clinic (15.8%). On the other hand, only 2.6% of respondents were working in Ulu Tiram Health Clinic.

This study primarily aims to evaluate the level of preparation among HCP. On a five-point Likert scale, the majority of respondents rated themselves as moderately prepared for CBRNE. According to Table 3, the median for preparedness towards CBRNE threats is 3.00, whereas the interquartile range is 3.00. It was concluded that HCP's degree of readiness for CBRNE hazards was deemed adequate and the level of preparation was distributed widely across the respondents.

Fig. 4 shows that 59 respondents (51.8%) ranked themselves as having good preparedness to deal with CBRNE crises, compared to 36 respondents (31.6%) who entirely disagreed that they were prepared to deal with CBRNE circumstances. According to the findings, the majority of respondents believed they were ready to deal with a CBRNE incident. On the other hand, 52 of the respondents
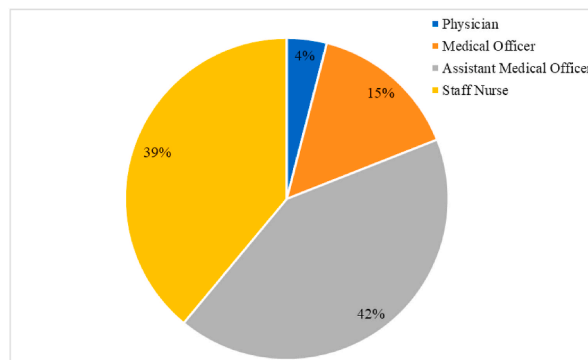

Fig. 3. The response rate of position distribution.

Table 2
Descriptive analysis for socio-demographic profile.

Items		Frequency (n)	Percentage (%)
Gender	Male	49	43.0%
	Female	65	57.0%
Age	<25	3	2.6%
	26–30	51	44.7%
	31–40	48	42.1%
	41–50	11	9.6%
	>51	1	0.9%
Marital Status	Single	23	20.2%
	Married	90	78.9%
	Divorcee	1	0.9%
Working Experience	>1 - <3 Years	14	12.3%
	>3 - <5 Years	15	13.2%
	>5 Years	85	74.6%
Workplace	Hospital Sultan Ismail (HSI)	71	62.3%
	Pasir Gudang Health Clinic	18	15.8%
	Masai Health Clinic	22	19.3%
	Ulu Tiram Health Clinic	3	2.6%

Table 3
Median and interquartile range of level of preparedness towards CBRNE.

	Level of Preparedness Towards CBRNE						
	Mean	Median	Variance	Std. Deviation	Minimum	Maximum	Interquartile Range
Statistic	2.82	3.00	1.88	1.371	1.00	5.00	3.00
Std. Error	0.128						
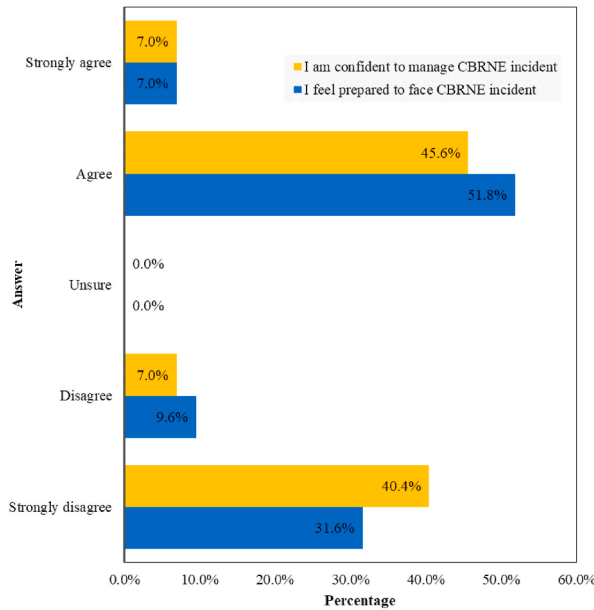
Fig. 4. Descriptive analysis of items in the level of preparedness towards CBRNE.

(45.6%) said they were confident in handling CBRNE occurrences, while 46 (40.4%) said they were not confident in their ability to control CBRNE crises.

It can be concluded that most of the HCP shows an adequate level of preparedness. However, we can see from the figure that about one-third of the HCP had a lower level of readiness towards CBRNE threats in the Pasir Gudang area. Overall, this figure representing the preparedness level among HCP in Pasir Gudang appears adequate, based on the median (3.00).

According to Fig. 5, the level of CBRNE preparedness was influenced by three types of factors (independent variables). The result showed that the highest median for independent variables is the level of personal resilience (4.00), followed by the level of knowledge (3.00) and level of training (3.00).

In addition, Fig. 6 shows the relation between the level of CBRNE preparedness and personal resilience. The figure demonstrated that 36 HCP (32%) with a good level of personal resilience represented an excellent level of readiness towards CBRNE crises. Besides that, 7 of them (6%) showed a good level of CBRNE preparedness due to an excellent level of personal resilience.
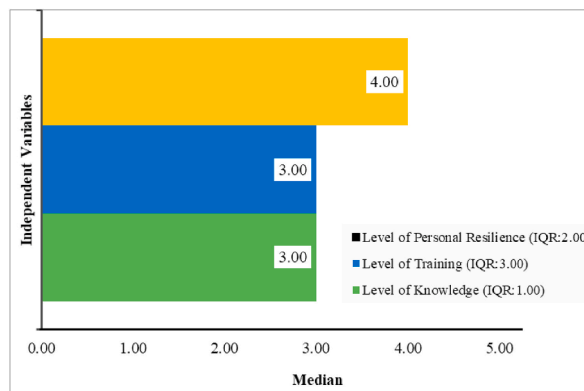

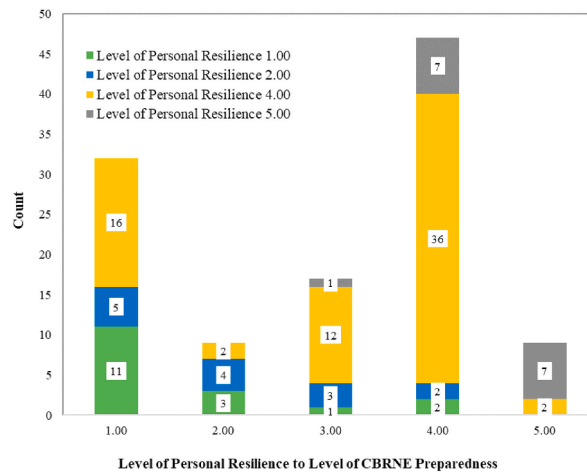**Fig. 5.** Median of factors that affected the level of CBRNE preparedness.

Fig. 6. Cross-tabulation of personal resilience to the level of preparedness towards CBRNE.

6. Discussions

The result of the study can be deliberated in view of the preparedness level towards the CBRNE and related to resilience level, knowledge, training and socio demographic profile.

The adequate level of CBRNE preparedness among HCP might be due to a good level of personal resilience. The analysis demonstrated HCP scattering with a very low level of personal resilience represented with a low level of preparedness towards CBRNE whereas the HCP with good level of personal resilience represented an excellent level of readiness towards CBRNE crises. The higher personal resilience within HCPs in Pasir Gudang might be due to good relationships and emotional support between staff and great psychological support from the psychiatric and mental health department. In HSI, we can see there was active Psychological First Aid (PFA) approach since 2019 chemical pollution of Kim-Kim River as well as pandemic COVID-19 later in 2020 [20]. That might be the reason the HCPs able to go through stressful situations with ease. PFA could help reduce stress among frontline workers due to increased workload and overall pandemic concerns [21]. A study carried by Stevens et al. [13] also proved that personal resilience including ability to cope in stressful situations was linked to CBRNE readiness. Psychological negative effects, concern for family members, fear of contamination in nuclear disasters, and infectious disorders are among the most significant hurdles leading to low preparedness towards CBRNE [17,22].

The moderate level of CBRNE preparedness among HCP was attributed to their fair acceptance of CBRNE education, skills and their exposure to CBRNE emergencies, particularly those with more than 5 years of working experience in the Pasir Gudang area. There are several CBRNE incidents in Pasir Gudang areas within 5 years, such as pandemic COVID-19, chemical pollution of Kim-Kim River in 2019, chemical factory explosion in 2019 and industrial factory explosion in 2021 [3,8]. Hung et al. [23] evidenced that doctors' lack of preparedness originates from their lack of experience with CBRNE situations. Working experience, as well as participation in crisis management, were linked to an adequate level of preparedness [24]. Thus, previous disaster experience, expertise in crisis response were proved as an element contributed to the level of CBRNE's preparedness.

According to Hung et al. [23], there is a correlation between the amount of education and level of preparation. Emergency doctors must be knowledgeable in order to be prepared to tackle an unforeseen incident. Whereas, Kotora [25] stated that a lower percentage of knowledge suggests a poor level of CBRNE preparedness. It is also proved by Hung et al. [23] that extra training can boost preparedness. It is also crucial for healthcare workers to be professionally prepared to perform critical tasks, precisely CBRNE disaster [17,26]. As a result, it will be desirable to take preventative measures to reduce the risk and reinforce the ethical requirements of personnel in this field during times of crisis.

In order to maximise the degree of preparedness among all HCP in Pasir Gudang, it is recommended that a regular CBRNE course or drill being conducted, with experienced HCPs serving as facilitators and assisting in the implementation of an effective CBRNE learning technique. The boundless organisation of CBRNE training through expert leadership can assist in increasing the level preparedness towards CBRNE. By organising the training and drill based on real case studies through the involvement of transdisciplinary approach (TDA) will absolutely profit in disaster preparedness as each of stakeholders will sharing ideas, simultaneously producing information, and contribute to ideal solution [27]. Besides, the PFA program should be included into the syllabus of CBRNE courses in future.

It is recommended that all HCPs in the Pasir Gudang area boost their level of preparedness by involving experienced HCPs through regular CBRNE courses or drills oriented at staff from Health Clinics, particularly those with a low level of CBRNE preparedness. Fig. 7 listed the recommendations of best strategies with the enforcement of three main factors with related important aspects to maximising the level of CBRNE preparedness specifically based on this study findings. These strategies will be a huge undertaking to increase the CBRNE awareness and level of readiness among HCP in the Pasir Gudang area.

Fig. 7. The CBRNE's strategies chart.

7. Conclusion

Briefly, CBRNE preparedness was moderate among HCP in the Pasir Gudang area, which was significantly associated with three independent variables. The impact of knowledge and resilience level proved to be strongly linked to CBRNE preparedness.

In a nutshell, the assessment tool developed for this study might be useful to assess levels of preparation among other HCP and first responders. Therefore, the analysis can help gauge the readiness of other key healthcare professionals and first responders. Furthermore, the preparedness component is crucial for effective response and "Build Back Better" in recovery, rehabilitation and reconstruction. The strategies to boost CBRNE preparedness with relevant CBRNE course, workshop, training, drills, and psychological programs will enhance disaster preparedness, and effective response in the future.

Finally, it is intended that the research would increase preparedness, reduce catastrophe risk, improve disaster response, and expand the provision of high-quality care among HCP in the context of CBRNE threats.

8. Limitations and future studies

The items designed in this quantitative study were found to be a good internal consistency level and proved reliable and good to measure the level of CBRNE preparedness. This feature may lead to evaluation of CBRNE preparedness in a different setting of CBRNE prone areas. In the future, the study could be extended outside of the Ministry of Health backgrounds such as frontliners from the Fire and Rescue Department, Royal Police Malaysia, Malaysia Armed Forces, non-government agencies, and frontliners from outside Malaysia. The expanded scope of the study would allow a healthy comparison regarding CBRNE preparedness among first responders. It is also suggested for future studies to include qualitative analysis regarding the level of CBRNE preparedness, which can assist in exploring further and grasping the specifics information that impact the level of readiness towards CBRNE among the first responders. The qualitative method will permit respondent's particulars opinions and recommendations on certain variables.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijdrr.2022.103235.

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