

Disaster Preparedness in Case of Chemical, Biological, Radiological, Nuclear and Explosive (CBRNE) events: A Review

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Abstract

Chemical, Biological, Radiological, Nuclear and Explosive (CBRNE) threats are one of the main safety concerns and a global threat. Recent Coronavirus disease 2019 (COVID-19) for example has caused much concern for the public and killed more than 2 millions people worldwide and badly affected healthcare facilities, economy and communities. First responders usually the first on the scene play a vital role to mitigate the impact of these CBRNE treats with the minimum health cost to them. In order to maximize first responders potential with minimum health impact to them, it is important to have a good understanding of the demands of their work. Thus, this article provides a review of critical factors on preparedness of the first responder to CBRNE threats by highlighting important findings and areas of uncertainty.

Keywords: First responder, Paramedic, Preparedness, Readiness

1. Introduction

The United Nations Office for Disaster Risk Reduction (UNISDR) has defined disaster as a serious interruption in the normal functioning of community life which caused by harmful incidents relating to vulnerability and exposure, leading to widespread human, material, economic and environmental impacts [1]. Also, mass casualty incident as well-known as a major incident is defined as any incidents which trigger disturbance to public well-being, normal lifestyle, environment thus needs urgent event management involving a various collaboration of stakeholders [2].

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In Malaysia, the first responder responsible to manage the mass casualty incidents including the Chemical, Biological, Radiological, Nuclear and Explosive (CBRNE) disaster [3]. The first responder including healthcare personnel from Ministry of Health and, emergency medical rescue services and Hazardous Material Unit Team (HAZMAT) from Fire and Rescue Department of Malaysia, Royal Malaysia Police and emergency response team from Non-Governmental Organizations (NGOs). By its very nature, there is significant concern regarding the level of preparedness among first responder dealing with such threats.

The first responder conventionally comprises of emergency medical service (EMS) providers, fire and rescue service, health care workers (HCW), paramedics, police, and search and rescue team which important characters in event of a catastrophe [4]–[14].

They are the first-line emergency provider arriving and interface with the natural or man-made disaster which holds a major component of safety issues to community and responders. Kollek [8] listed a few of challenges experienced by EMS such as detecting the incident and lethal element involved in CBRNE, deciding the treatment area as well as guarantee safety for all responders.

The World Health Organization (WHO) also recognized Emergency Medical Teams (EMT) as a vital part for effective and efficient health systems [15]. Thus, the first responder is the high-risk group for injuries, death or infection especially from the primary exposure of CBRNE crisis which on the other hand could develop as a cause of spread [10], [16]–[20]. It is proved by Khan [10] that health care workers contribute as a victim of MERS-CoV with almost 20% of the statistic. Therefore, Kollek [8] urges for an advanced safety measure to prevent from further exposure.

Extensive toxic chemical exposure, pandemics of coronavirus (COVID-19) or swine flu virus, radiological incidents, nuclear power plant accident and contagious disease are an example of attended cases by the first responder. The study by Brennan [21] showed the MCI could cause by chemical exposure in a populated zone and approved by Kollek [8]. On the other hand, Rebera and Rafalowski [22] focus on first responder dilemma in handling extensive chemical exposure disaster.

The MCI consequently altered the perception of the risk of catastrophe among HCW [23]. Hence, the first responder needs to be prepared with several proficiencies in dealing with the unpredictable MCI.

2. Factors Affected Cbrne Preparedness

Several aspects have been considered by authors in this review regarding the factors which gave impact to CBRNE preparedness. Generally, the factors that had been deliberated in this review are from the theory and the practical point of view.

Healthcare personnel basically had to have adequate awareness, education and equipment to respond with potential CBRN threats while providing care to victims affected from the threats [24]–[28]. Kollek [8] mentioned the importance of competency among the first responder to save community lives. However, Woude [29] recognized the combination of education and drill brought the major impact to CBRNE preparedness. In accordance, Mitchell [2] suggested the importance of competency in CBRNE and the need for sufficient training to prepare the first responder in an emergency. On the other hand, Hung [30] stated the significant handling such mass destruction are knowledge followed by readiness. Khan [10] urge the importance of emergent awareness especially in infectious control among HCW in combating the transmission of CBRNE agent. Whereby, Stevens [9] highlighted the training as a crucial point in preparedness among first responder dealing with CBRNE.

Hence, factors influence emergency responder's preparedness is important in order to deal effectively with CBRNE threats hence reduce the risk involved in CBRNE incidents for the community and responders in future. This article will review the factors required for first responder preparedness. Hopefully, the findings relating the big impact factors toward first responder preparedness could be achieved through a various review of the article. By that, the study of emergency responder preparedness toward CBRNE in Malaysia should be conducted in future.

A. Competency

The indicator of preparedness among front liner especially HCW is based on the level of awareness [24]. Education among staff is important which affected preparedness to respond efficiently to the disaster [31].

As mentioned earlier, the first responder is the primary personnel dealing with the CBRNE hazard and exposed to the risk of infection. Thus, it is necessary for the first responder to know the hazard of the emergency and put on suitable personal protective equipment (PPE) to manage the threat efficiently. Proper PPE's theory is the basis of safety measure for the first responder before reporting to the incident site [8]. Furthermore, it is essential for EMS and HCW to ensure accessibility of four different levels of PPE dealing with chemical

disaster [11], [32]. PPE is one of the competencies areas to develop future preparedness in managing CBRNE [2]. Alsahafi and Cheng [18] suggested further education programs especially focus on the use of PPE among HCW since they found the level of knowledge regarding infectious disease is low.

It is also fundamental for the first responder to alert and capture the information of hazard involved in the event of a disaster [8]. Situation alertness defines as non-technical main competencies field mandatory for paramedic dealing with CBRN emergencies [33]. Malaysian first responder should competent to handle all types of CBRNE hazard to enhance preparedness [34].

The significant subjects should adapt to CBRNE educational syllabus to improve preparedness among the first responder. The subject suggested to cover the safety of responder and community, sensibility of CBRNE, handling the polluted atmosphere, and CBRNE preparedness specification in order to recognize other essential education to gain a higher level of readiness dealing with CBRNE [8]. Additional competency subject requires to emerge future CBRNE preparedness are triaging rules during a disaster, decontamination principles, waste management, command and control, and protocol and management [2]. Education curricula regarding isolation and infection control measures are important to form higher-level preparedness managing infectious disease [18].

Mitchell, Kernohan and Higginson [2] recommended standardized outline for CBRNE competencies among HCW. In order to improve knowledge in managing CBRNE effectively, thus there is a need to design educational curricula for HCW [23]. Ministry of Health (MOH) should organize a CBRNE informative campaign which attributes to adequate knowledge of first responder [35], [36]. The strategies to reduce the gap of CBRNE knowledge of HCW is by providing health teaching seminar which concentrating in less educated areas [10], [37]. Thus, it is important to adapt science and research into CBRNE education which can enhance first responder preparedness [34].

Another non-technical area of competencies comprises of communication, collaboration, resource and task management, cultural skill and physical stamina to increase performance discovered as a foundation for organizing knowledgeable first responder dealing with CBRNE crisis [33]. Therefore, integrated technical and non-technical competency should be a basis to formulate effective CBRNE training [33], [38].

Fifteen of the studies evaluated the competency aspect emerged as a factor influenced CBRNE preparedness. However, the authors report basically investigated on medical CBRN awareness among healthcare professional and compared the level of health professional's preparedness is based on fatality tolls during bioterrorism incidents [24], [31]. One study found only focus investigating on the availability of PPE among urban EMS responders [11]. Therefore, the author able to evaluate the capability of EMS to operate in warm or even hot zone. Meanwhile, there are some studies resulted from low response rate which led to non-response bias that may postulate the result of CBRNE preparedness [8], [32], [33], [37]. It is condemnatory to judge all EMS providers had inaccessibility to equipment responding to CBRN disaster and it is impractical to blameworthiness all EMS were unable in recognizing contaminated scene due to low response rate study. Thus, it is unfeasible for all EMS personnel to involve in CBRN advance level training on how to identify polluted scene and work in contaminated environment. Hence, the study should reinforce more involvement of emergency care provider to produce consistent significant correlation of knowledge to CBRNE preparedness. There is one study conducted due to prolonged outbreak of Middle East Respiratory Syndrome (MERS) coronavirus since 2012 in Kingdom of Saudi Arabia which the situation had affected respondents emotional and stress during survey [18]. The result of this study create bias since respondent's performance lessen due to prolong outbreak period which somehow reported with anxiety about contacting MERS-CoV from patients. Furthermore, survey showed almost 20 percent of HCW acquired MERS-CoV from patients which proved low level of infectious precaution among HCW in Kingdom of Saudi Arabia. Thus, higher level preparedness in infectious control is vital for HCW. In some way, one author conducted study by analyzing twenty expert opinions across nationwide form various backgrounds thus produce overall view of CBRNE preparedness which comes from their experience in field [33]. This study could generate general expertise's background aspect of view regarding correlation of environment alertness to responsive actions toward CBRN hazards. Therefore, timely recognition of hazardous material led to proactive role to reduce harm to the public. However, one author covered wide range of six competencies in his study guided by Major Incident Medical Management and Support (MIMMS) manual [2]. The study emerges with six key-areas for future CBRNE preparedness which developed from representative Emergency Department's nurses' level of knowledge from only one NHS Trust in Northern Ireland. Nevertheless, the result was limited to assist future CBRNE preparedness programs for another EMS personnel worldwide due to minor responder types. Similarly, a cross-sectional study was conducted in only one tertiary hospital which create bias regarding the satisfactory level of HCW's disaster preparedness [23]. There are some studies concerning MERS-CoV moderate level of knowledge among HCW in southern Saudi Arabia is due to lack of MOH educational campaign especially in the era of science and

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technologies [18], [35]. However, HCW can reach the biological disease information from genuine website through social media tools rather than depending only on MOH information. It is realistic to promote HCW worker preparedness by gaining information from internet in this advance technology's epoch. However, the source of knowledge must be genuine to avoid any unwise decision. It is important for the MOH regularly update and health issue in official website for HCW. An author mainly reviews the accessible primary and secondary source form government official regarding bioterrorism readiness plan in Malaysia [34]. The recommendation to adapting science and research in CBRNE showed there are only minor research conducted regarding CBRNE preparation to view Malaysian preparedness toward CBRNE.

B. Training

CBRNE preparedness is gained through significance roles of training or drill [9]. The curricula of CBRNE should include training session which comprises of important competencies areas [2]. Emergency preparedness syllabus could contribute to monitoring the training requirement among first responder [23]. The competency-based training is vital to establish well-prepared personnel of CBRN emergencies. It is recommended to collaborate training and education, thus can improve and profit development of CBRN emergency response [33].

Through training or drill, paramedics will be more prepared toward CBRNE setting and deliver effective action and redressing possible willingness in managing disaster [9]. However, training can emerge self-confidence among HCW which benefit preparedness toward CBRNE threats in future [30]. Emergency medical personnel with sufficient training and education portrayed their positive attitude in managing the disaster. It is even proved that personnel with high participation in disaster response and training linked with an advanced score of CBRNE practice [39].

All agencies are required to provide capable and adequately trained HCW to anticipated in emergency roles [2], [23], [40], [41]. The first responder is well-prepared to manage mass fatality incident due to regular training and drill with various stakeholder provided by their organization which encourage personnel participation from various agencies [42]. Regular training and drill could assist and guide deliberate idea to realize preparedness among HCW as well as expand the quality of emergency services [23]. Continuous drill and training which consist of theoretical and practical programs are beneficial to generate long-standing CBRN preparedness among emergency service personnel [24].

There is an absence of basic training among the first responder, however undeniably it is crucial [29], [43]. Kollek [8] urge the organization to strengthen the CBRNE training among front lines. It is proved that training provides general knowledge of CBRNE as well as improving medical skill among CBRN responders [29].

Additional training curricula may emerge knowledge regarding infectious disease among HCW [18]. Local training assists the HCW in build-up knowledge [44]. Thus, HCW showed their positivity to anticipate in training session especially in form of several day workshop training or drill [30]. Web-based training using up-to-date syllabuses could assist the first responder to acquire preparedness toward mass fatality incident [42]. It is important to held repetition pieces of training to enhance awareness on CBRN [24].

Training consequences of CBRNE preparedness among first responders are not clearly known. Most of the studies proved feasible relation between CBRNE readiness with paramedic's training involvement. The author study by exclusively weighted paramedic readiness to CBRNE incidents [2], [9]. Roughly of the study integrate lesson learnt to generate knowledge into training survey for evaluating CBRNE preparedness. Thus, it is vital to major in CBRNE command from theory and exercise to develop efficient disaster management. Restricted data size should be expand to paramedic which majorly involve in disaster management rather than physicians, emergency doctors and nurses which showed satisfactory level of disaster preparedness [2], [30], [45]. The result only showed one third of preparedness level among emergency doctors, thus create bias for only small percentage of result. The survey raised the issue of bias to other categories of first responders. The limited data only showed the staff preparedness managing disaster in hospital rather than the staff preparedness in incident site which primarily the staff in incident site are the first-person encounter and responsible to contain the secondary disaster. However, emergency preparedness syllabus can be enforced among paramedic to monitor training requirement among first responder. The study which analyses deep perspective of CBRNE expertise are reliable for CBRNE development in emergency response since it is considering nationwide views [33]. Experts specified that synchronization of education and training highly contribute to effective emergency response in CBRNE event. The dependable survey including various category of HCW provide valuable information regarding responder awareness toward CBRN attack [24]. Author identified HCW weaknesses related to medical decontamination and CBRN treatment which recommended to regular training and theoretical education for long-term CBRN preparedness. The feasible study recognized congress feedback mainly acknowledged education and training for CBRN responder's preparedness [5]. Thus, it is practicable to enforce

training which can lead to better knowledge and skill towards CBRNE. Short term survey specifically eleven days survey conducted to various category of front liners revealed low response rate from Nottingham University Hospitals NHS Trust and Birmingham Women's and Children's NHS Foundation Trust [44]. The unfeasible result showed most of respondent gain knowledge related to local COVID-19 training and the rest referred on WHO guidance and social media to carry out their roles in hospital. The result create bias since it is taking place in February 2020 which is at early stage of COVID-19 pandemic. Thus, the low response rate from only two hospital is prejudice to generalize the result to all HCW worldwide. The survey only assessed the levels of confidence rather than competence. Finally, this review achieves the author and expertise's agreement on the CBRNE preparedness is wisely related to integration of knowledge and training.

C. Self-Perceive and Resilience

As Level of preparedness is influenced by responder self-perceived toward a stressful condition in managing CBRNE crisis. Responder with lesser self-concern to deploy to CBRNE incident have high individual resilience. Thus, a paramedic with high perceived personal resilience will develop higher willingness in combating CBRNE crisis [9], [46], [47]. The robust indicator for preparedness in CBRNE response is responder personal resilience [9]. Good emergency preparedness among HCW originates from responder self-perceived confidence in combating CBRNE threats [48]. Therefore, training can support higher self-confidence which develops CBRNE response preparedness [30]. Highest degree of risk particularly from biological, chemical and nuclear crises which could severely affected responder and family safety perceived lower preparedness for CBRNE [2], [49], [50]. HCW perceive psychological and physical self-care as importance to response in CBRNE crisis due to stressful condition in restriction of using PPE [33].

On the other hand, firefighters have self-confidence dealing with radiation disaster showed a great level of preparedness. Additionally, firefighters perceived the crisis management will give a positive result in future since they are confident in managing the material with proper PPE and equipment [51].

Approximately of the self-perceive studies present with bias in the sample which resulted from low response rate and specific background of participant point of view. There is also study which only evaluate the perceived willingness to response without identifying actual task performance regarding CBRNE in order to ascertain the readiness of the respondent and not consider particular factors that have affected the degree of preparedness and desire combating the CBRNE events [9], [44]. There are only data studied define the level of training and knowledge among the respondent based only in Emergency Department [2]. Meanwhile, some author only examined paramedics in hospitals of Tehran which might not be useful to other geographical regions [49]. In the meantime, some author only investigated the confidence level among firefighter to respond radiation disaster in the area without nuclear plant which only one of the respondents had experience dealing with radiation disaster [51]. Hence, the study proved imprecision factor affected first responder's confidence level toward different threats with focus on single group of responders. Thus, it is recommended to carry out wide context of study in future to develop dependable result of CBRNE preparedness and individuals self-perceives.

D. Experience Level

Personnel with more participation in disaster drill and event as well as longer service experience portrayed better training score in emergency response [39]. According to Stevens [9] relevant occupational factors such as CBRNE experience or training were believed to be correlated with better response in CBRNE incidents. Besides, more experience involvement in disaster training represented with a higher level of confidence managing CBRNE crisis [30].

One of the factors linked with readiness to report duty in a pandemic is working experience in previous influenza crisis [52]. Thus, Experience level should be considered as one of the criteria in developing standardized educational syllabus and lessen the knowledge gaps between emergency care provider thus enhance CBRNE preparedness [37].

However, HCW with inadequate experience with less than five years' involvement in mass fatality incidents still reported with good preparedness due to participation in training and drills [42].

It is found from thirty-two studies indicate the relation between experience and preparedness toward pandemic disaster. The findings documented in this review assist in addressing the issue of willingness of HCW to work during influenza emergencies. However, some study exposed bias regarding CBRNE preparedness related to training and drills instead of experience in managing CBRNE since majority of respondent with 82 percent were not having any experience dealing with disaster for the past 5 years [42]. Thus, this study unable to determine the relation between experience level and responder's preparedness. As mentioned before, some of the studies only received lower response rate with about 30 percent feedback which generate bias to indicate that respondent's involvement in training correlate with higher confident level dealing with chemical and explosive

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threats [30], [37]. Furthermore, the small sample size could create another potential bias to lack of generalizability. The survey may be prejudice to indicate poor level of CBRNE preparedness among emergency healthcare providers in United States since the survey only received lower response rate with 32 percent responds. Bias correlations between previous experience with knowledge gaps in CBRNE were found. It is suggested to conduct larger samples with robust recruitment in future to assess preparedness toward Mass Fatality Incidents. Thus, robust study with larger sample should be conducted in future to create precise result indicating CBRNE preparedness.

3. Conclusion

CBRNE incidents recently had triggered the world through a biological agent of COVID-19 transmission to the whole world. Indisputably to the risk of chemical, radiation, nuclear and explosive disaster which have a bad impact on the life and livelihood of the community as well as responder. Hence, the features associate with preparedness in managing CBRNE needs to recognize to attain virtuous preparedness among the first responder.

In this review, the authors discussed various possible aspects that benefit to the preparedness of CBRNE response. Evidently, the implementation of up to date and integrated syllabus in education programs is the precise strategies to reduce the gap of CBRNE knowledge among the first responder. The reviews included Malaysia assessment which importance of research and development for CBRNE education and preparedness. Additionally, education should integrate into training and drills to improve CBRN emergency response. It is also demonstrated that high personal resilience and self-confidence presented the first responder with a great level of readiness responding to CBRNE incidents. The competence CBRNE framework benefit for future development strategy of disaster preparedness exclusively in Malaysia and also worldwide.

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