Original Research

Exploring the non-technical competencies for on-scene public health responders in chemical, biological, radiological, and nuclear emergencies: a qualitative study

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ABSTRACT

Objectives: The purpose of this study was to define and delineate specific non-technical competencies for first-line public health responders in Chemical, Biological, Radiological, and Nuclear (CBRN) emergencies in China.
Study design: A qualitative study was conducted in China involving interviews with key informants in the field of health response to CBRN disasters.
Methods: One-on-one in-depth interviews were carried out with 20 participants, including expert members of National Medical Response Teams for CBRN disasters, officials at emergency management authorities, and scholars of academic institutions related to CBRN emergency. Interviews were recorded using audio equipment, transcribed, and coded into codable passages as per grounded theory using NVivo software. Themes were identified within the transcriptions by using thematic analysis.
Results: A total of 159 codable passages were produced. Eight domains of non-technical core competencies were identified: (1) situation awareness, (2) communication skills, (3) collaboration, (4) resource management, (5) task management, (6) cultural competency, (7) austere environment skills, and (8) physical stamina.
Conclusions: The study identified a variety of competencies for on-scene public health responders in CBRN emergencies. The findings of this study could specifically benefit development of strategy and improvement of content of education and training. Further research that involves input from the disaster response community at large is needed for the validation of these competencies.

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Introduction

Increasing Chemical, Biological, Radiological, and Nuclear (CBRN) threats are a public health challenge in China. China has experienced 200—600 accidents every year in hazardous chemical industry,[1] frequent emerging epidemics[2] (e.g. coronavirus disease 2019, severe acute respiratory syndrome (SARS), H5N1, and African swine flu), more than 43 planned nuclear reactors,[3] and unpredictable terrorism attacks. China has invested heavily in the development of CBRN medical response capacity including the

CBRN Medical Response Teams (CBRN-MRTs) designed to be deployed on the site.

Despite the fact that public health responders adequately respond to the clinical or public health aspects of disasters, they are not always prepared or trained to work in a real hazardous environment and complex temporary situation.[4] The unique nature of intense working relationships and particularly austere environment requires not only technical skills but also non-technical competencies. A body of previous studies has explored the components of non-technical competency for health workers in a critical environment.[5—10] It has been established that interpersonal, social, and cognitive skills play an important role in response performance.[11] Those non-technical competencies broadly involve a range of knowledge, attitude, and skills in communication,[12—14] collaboration,[15,16] leadership,[17—19] situation awareness,[12] and other individual personal attributes.[20] However, the literature

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search revealed relatively few studies specifically focusing on public health staff working at a CBRN incident site.

Complicating a straightforward emergency response is the addition of CBRN factors that add an extra layer of complexity to the emergency response.[21] CBRN emergencies cause trauma on a large scale and demand complex responses including triage, monitoring, diagnosis, decontamination, and self-protection for public health workers.[11,22] CBRN mass casualty situations are normally chaotic. Casualties may have single or multiple injuries or may have conventional injuries that are complicated by CBRN exposure (such as in a toxic spill or nuclear power plant accident). The treatment of CBRN casualties should reflect the conventional incident and casualty management paradigms with additional safety and treatment considerations.[23] CBRN incidents present different challenges for all responders, necessitating the rapid decontamination and treatment of a significant number of casualties while taking critical measures to ensure the well-being of the personnel managing the incident.[24] CBRN events have an additional 'fear factor' and expose responders to potential agents and possible hazards, and it has been reported that health professionals may not respond to CBRN events as willingly as they would to a conventional disaster event.[25–27]

There are differences in particular context and nature among various disasters, so it is difficult to define a consistent set of competencies across disciplines and jurisdictions. The present study aims to define and identify specifically non-technical competencies for on-scene public health workers in CBRN disasters.

Methods

Study participants

A qualitative study was performed in China involving interviews with key informants in the field of health response to CBRN disasters. Semistructured in-depth interviews were used to seek deep perspectives of the experts. A purposive sampling approach was conducted to ensure that included interviewees could reflect on their experiences training and working in a CBRN-MRT. Those public health responders who had significant on-scene experience and direct involvement in real CBRN disaster management or full-scale disaster drills were involved. To increase data quality, the sample was also interprofessional, representing diverse healthcare professions on the team. In addition, several academic experts were included based on their relevant study background.

Data collection

The interview took place by phone or face-to-face in the respective institutions with a single interviewer and lasted 30–60 min. Open-ended main questions were asked to gain insights into requirements of non-technical competencies for an on-scene medical responder in CBRN emergencies. To ensure that the interviewees elaborated on their experiences, the interviewer also explored with additional probing questions. Questioning was informed and evolved according to responses of the interviewees. The interview guide is presented in Appendix 1.

This study used a constructivist grounded theory approach encompassing the notion that interpretation of the data is co-constructed by interactions between participants and researchers. As per grounded theory, analysis occurred alongside data collection and was able to inform the next interview and develop an emergent understanding of the themes and findings. Substantive coding facilitated the process of theoretical sampling and directed the evolution of the interview guide. As interviews were conducted and coded, the competencies were revised iteratively. Theoretical

sampling was carried out until the researchers reached theoretical saturation, that is to say, when conducting more interviews would add little value to the research and when data saturation was achieved and the interviewing ceased.

Data analysis

Each interview was recorded, transcribed, and imported into NVivo 10 software (released in 2012 by QSR International). The usual grounded theory approach to data analysis was undertaken. The initial coding stage was undertaken during data collection and theoretical coding stages. The lead author then reviewed each transcript again to yield final codable passages and undertook validity checks. Moving on to theoretical coding, codable passages similar in meaning content were merged into larger units as sub-competencies, which were further condensed into competency domains. The questions that were used during coding initially inquired about 'what specific competency or subcompetency is these data a study of?' followed with 'what competency category does these data indicate?' Domains and subcompetencies were refined through comparable responses. A second author conducted cross-verification of the whole data to minimize missing an important competency category and optimize the rigor of the study. Disagreements in coding were resolved by discussion between the two reviewers. Discussions among all researchers were also used to develop the relationships between analytic themes of the competency domain.

Results

Interview participants' characteristics

A total of 20 experts from across the nation participated in the interviews. The demographics of interviewees are summarized in Table 1. Most of them had a master's or doctoral degree (70%) and

Table 1
Demographic details of the interviewees.

Characteristic	No. (%)
Education	
Bachelor's degree	6 (30)
Master's degree	8 (40)
Doctoral degree	6 (30)
Specialization	
Preventive medicine	5 (25)
Public health administration	5 (25)
Chemical medicine and pharmacy	3 (15)
Medical imaging sciences and nuclear medicine	2 (10)
Medical laboratory science and biomedical technology	2 (10)
Others[a]	3 (15)
Agency	
Centers for Disease Control and Prevention	9 (45)
Hospital	5 (25)
Authority	3 (15)
College and academic institution	3 (15)
Job position	
Public health communicable disease staff	4 (20)
Public health laboratory staff	4 (20)
Public health officials	3 (15)
Environmental health staff	2 (10)
Public health clinical staff	2 (10)
Scholar	2 (10)
Others[b]	3 (15)
Age (years), **median** (range)	46 (32–75)
Years of practice in CBRN emergency, median (range)	20 (4–40)

CBRN = Chemical, Biological, Radiological, and Nuclear.
[a] Epidemiology, logistics management, and veterinary medicine.
[b] Logistics officer.

worked in the Centers for Disease Control and Prevention or hospitals (70%), with a median age of 46 years (range from 32 to 75 years), and a median of 20 years of practice in the field of CBRN emergency (range from 4 to 40 years). Half of them were specialized in preventive medicine or public health administration, covering multiple professions.

Identified non-technical competencies

A total of 159 codable passages were produced from the interview transcript. Eight non-technical competency domains were identified: (1) situation awareness, (2) communication skills, (3) collaboration, (4) resource management, (5) task management, (6) cultural, ethnic, and legal competency, (7) austere environment skills, and (8) physical stamina. Table 2 contains detailed descriptions of these domains with definition of the competency domain, subcompetencies, and illustrative examples from the interview transcripts.

Discussion

Systematic development of a competent medicine workforce prepared for a CBRN crisis requires a targeted non-technical competency framework used to guide workforce planning, recruitment, placement, assessment, and demand-driven training.[8,28,29] The present study developed 8 non-technical core competencies specifically required for first-line public health responders in CBRN emergencies. As per the similarities and differences in response methods between CBRN emergencies and other general disasters, those identified competencies are discussed in three groups: common, enhanced, and specialized non-technical competencies.

Common non-technical competencies

The challenges posed and the response requirement for CBRN and accidental incidents differ but are similar or the same in many respects. For that reason, some of the competencies explored within this study are equally applicable to both situations and can be implemented for all levels of incidents. Some components of non-technical competencies identified through this study thus confirmed correlations with the common skills defined in prior research involving health professionals working in general critical situations, including communication,[12–14,17,30] collaboration,[15,16,31] and cultural competencies.[32] Owing to widespread public concern about mass casualties and diverse participation of multiple professions, public health responders in CBRN incidents are required to do well in communicating internally and externally, along with interprofessional and intra-agency collaboration within complex managerial structures.[11,13,16,26,33] Understanding of cultural backgrounds, ethical principles, and regulations is also necessary for CBRN public health responders to deal with common interest conflicts and dilemmas.[22] In addition, this study added specific understanding of those common competencies by description of the corresponding subcompetencies that are required in the CBRN context.

Enhanced non-technical competencies

Compared with other disasters, emphasis and enhancement should be placed on the competencies of situation awareness, resources management, and task management. CBRN missions in contrast have often involved unknown or unidentified substances, with a greater emphasis on the need to identify the substance through sampling and intelligence collection. Situation awareness of public health responders thus plays a more important role

because responsive actions are based on timely recognition of the uncertain status and trends of CBRN harm closely correlated with dynamic weather conditions and the geographical environment.[33] CBRN events, usually leading to mass casualties, have the potential to rapidly overwhelm—or threaten to exceed—the local capacity available to respond, and therefore, public health responders during CBRN disasters should also do better in resource management of detection devices and special reagents needed in CBRN responses which are characterized with more diversity, precision, and vulnerability to environmental impact.[11] Task management not only directly affects response performances, which has been widely cited in the previous literature,[8,9] but also may have indirect influence by affecting other non-technical competencies. Most of the interviewees indicated that having a good knowledge of professional task procedures and standards is a type of fundamental non-technical competency that can make contributions to better communication, collaboration, and mental quality. This finding suggests that effective CBRN training should integrate and synchronize courses based on non-technical and technical competency.

Unique non-technical competencies

Because rescuers and victims are continually under life threats from CBRN contamination, responders must take measures to protect the airway, skin, and eyes before entering the contaminated area, which is a unique and indispensable component of emergency response.[22] Austere environment skills involving physical/psychological self-care are definitely perceived as a priority for the CBRN public health responders because limitations to the use of personal protective equipment (PPE) are restriction of physical activity, heat-related illness, dehydration, and psychological effect. Most study participants started their discussions with personal safety considerations and skills in a hot or warm zone, and psychological self-care was also highlighted as essential for medical workers at high risk of suffering severe stress or even anxiety disorders from the fear of CBRN hazards. In addition, overwhelming workloads are frequently encountered by medical staff dressed in heavy PPE in austere hazardous environments, where they encounter an influx of patients. In contrast to prior studies,[9,15,19] physical stamina was frequently discussed in this study as a non-technical competency that makes a substantial contribution to response performance.

Limitations

The present qualitative study is subject to several limitations. The raw data were the expressed opinions of a purposive sample of experts. Although inclusion criteria for subjects were based on their experience in the field of CBRN responses and their varying backgrounds, it is possible that a potential source of bias exists in respondents. Second, the interpretivist framework raises questions about the validity of the findings and empirical generalizability of the study, although validity checks on the coding and data analysis are allowed. Finally, this qualitative study was intended to identify categories, not to quantify their relative importance to the participants.

Further studies should continue to identify and validate potential non-technical competencies using multiple approaches based on a broader sample to explore the attributes of effective public health responders in new CBRN emergencies. With the changing characteristics of CBRN incidents, the competency framework should keep updating to match the emergent needs of response and to advance the evolvement of workforce development processes. More efforts are also needed to explore relative contribution of each non-technical competency to the comprehensive

Table 2
Non-technical competency domains, subcompetencies for on-scene public health responders in CBRN emergencies.

Competency domain (definition)	Subcompetency	Example quotes coded for each subcompetency
1. Situation awareness (ability to perceive environmental elements and events with respect to time or space, the comprehension of their meaning, and the projection of their future status)	1.1. Knowledge applied to detect, project, and identify CBR agents.	1. Knowledge of the CBR agent categories (ZJP). 2. Be familiar with population density, the location of the plant, and other critical infrastructures (FQS). 3. Describe incident types and corresponding causes (ZZJ).
	1.2. Understanding the impact of environmental factors on CBR hazard dispersion.	1. Have knowledge of transmission of infectious disease (FQS). 2. Investigate the local whether, wind, transportation around the incident site (ZZJ). 3. Understand local terrain (ZJP).
	1.3. Knowledge of potential health and environment effects of typical CBR agents.	1. Project number of the casualties (GHD). 2. Determine the extent of the damage (FZL). 3. Correctly anticipate likely consequences (ZJP).
	1.4. Identify limits to individual and team knowledge, skill, and authority.	1. Ability to identify and solve key problem (FZL). 2. Awareness of possible contaminants (FQS).
	1.5. Evaluate and project effectiveness of all actions taken.	1. Understand the critical steps necessary to respond to a range of CBR events (ZZJ). 2. Evaluate and project the needed rescue actions … evaluate the urgency of the actions (CWL).
2. Communication skills (ability to exchange information, ideas, thoughts, or recommendations between or among individuals or organizations through a common system of symbols, signs, or behavior)	2.1. Describe communication role(s), channels, and processes in response to a CBRN incident.	1. Communication is essential- with our own team members, relevant professionals in other organizations, and, with victims and the public (FZL) 2. Communication should be established with local, regional and national authorities, with private sectors, and with the media (FQS). 3. Know the audience and use discretion in sharing data (SXC).
	2.2. Demonstrate correct use of all communication equipment while wearing personal protection equipment in hazardous environments.	1. Use the communication tools in CBR environment (ZZJ). 2. Be flexible and adapt communication tools to the contaminated environment, such as megaphone (SXC). 3. Use the telephone and walkie-talkie (ZP).
	2.3. Outline principles of risk communication in response to CBR events.	1. Use plain language to explain technical issues (FZL). 2. Correctly interpret technical reports of the detection of CBRN agents (ZJP). 3. Recognize the urgency and timeliness of communication (FQS). 4. Be familiar with the techniques of risk communication … Release only confirmed facts … be aware of probable audience emotions and show concern (ZZJ).
3. Collaboration (ability to work together with two or more people or organizations to accomplish a task or achieve a goal)	3.1. Understand and identify agency and partner agency roles, responsibilities, and capacities in response to a CBRN incident.	1. Identify roles and responsibilities of each position within team … collaborate with chemical corps (CWL). 2. Identify and evaluate other response teams at the incident site and propose a plan for collaboration of efforts (ZJP). 3. Know the chain of command, the process and each team's responsibilities (ZZJ). 4. Integrate the volunteers (ZW).
	3.2. Identify and locate agency and relevant partner response plans for CBRN incidents.	1. Become familiar with institutional plans and with local and national response plans (ZJP). 2. Create a plan for organization and deployment (SXC).
	3.3. Understand the methods of identifying and requesting regional, national, and international support.	1. Collaborate on evacuation and patient transportation (CWL). 2. Knowledge of the chain of command and the process (ZZJ). 3. Effective inter-agency coordination on scene (GDH).
4. Resource management (ability to use limited resources effectively and efficiently)	4.1. Ability to identify and predict specific crucial resources needed for response to CBR incidents.	1. Knowledge of the function and limitations of special equipment for CBRN response (FZL). 2. Knowledge of the proper drug treatments for the CBR contamination (FZL). 3. Estimate the pharmaceutical supplies needed for response (GHD).
	4.2 Identify special resources available for the CBRN incident site from state, regional, and federal agencies.	1. Knowledge of pharmaceutical stockpiles for CBRN incidents and the supply chain logistics (FZL). 2. Know the distribution and storage of vaccines and other reagents (ZZJ).
	4.3. Ability to construct process to mobilize, request, and manage resources.	1. Know storage location of the medical supplies, how to get authorization to obtain them and how to deliver them (ZJP). 2. Be up to date with drug renewal processes (SXC & ZP). 3. Demonstrate the safe administration of vaccines (GDH).

Table 2 (continued)

Competency domain (definition)	Subcompetency	Example quotes coded for each subcompetency
5. Task management (ability to identify, monitor, and progress the work through its life cycle)	5.1. Ability to identify the critical tasks in the CBR response. (e.g. triage, detection, decontamination, psychological counseling, dispose of medical waste, specimen collection and moving, fatality management, and scene management)	4. Know and communicate the recommended maintenance of the equipment (ZZJ & ZW). 1. Identify the first priority tasks on the scene (CWL). 2. Recognize the importance of psychological protection and mental support (ZZJ).
	5.2. Knowledge and maintenance of the principles, guidelines, and protocols of the critical tasks.	1. CBRN operation is characterized by professionalism. Every medical responder should have a relevant professional background (LYD). 2. You do require expertise in every field, but you must understand the core requirements and key processes to finish the task (LYD).
6. Cultural competency (ability to effectively deliver medical services that meet the social, cultural, religious, and linguistic needs of victims under ethical and legal regulations)	6.1. Knowledge of domestic health and safety legislation and its relevance to CBRN response.	1. Know relevant regulations governing infectious disease prevention and CBR response (FQS). 2. Have some knowledge of the law related to CBRN response (DB). 3. Abide by regulations on disposal of the CBR wastes (ZW). 4. Follow requirements for contaminated water disposal (GDH).
	6.2. Consider international support and conventions (IAEA, WHO, OPCW).	1. Know the core content of the international agreements and conventions, such as Chemical Weapons Convention (JJC). 2. Understand how to deal with the refugees (ZW). 3. Be aware of the legal issues when dealing with the refugees (SXC).
	6.3. Maintain general ethical principles in the context of emergence.	1. Utilize privacy considerations during decontaminations such as separate areas for men and women (ZJP). 2. Know medical ethics and how to face the expected casualties (ZP).
	6.4. Cross-cultural respect.	1. Speak native languages when operating overseas (ZP). 2. Have knowledge of the local cultural values and belief system such as cultural attitudes regarding death and burial (FQS).
7. Austere environment skills (ability to survive and maintain health in the austere environment)	7.1. Physical protection in CBRN contaminated areas.	1. Physical protection competency is imperative. Use appropriate protection but not excessive protection. Understand the protection levels required for different zones (ZP). 2. Take advantage of terrain and architecture as cover (ZJP). 3. Self-protection- the knowledge of the protective measures for the hazardous materials present is essential (FQS).
	7.2. Mental protection in CBRN contaminated areas	1. Psychological resilience is important when facing chaotic circumstances such as food contamination (FQS). 2. Be optimistic and strong-willed. Practice emotional self-control (ZZJ). 3. Overcome the psychophobia of WMD (JJC).
	7.3. Flexibility/adaptability	1. Be able to follow and understand the changing dynamics of the situation (CHL & DB). 2. Be prepared to deal with the surprise and devastation of emergency events (TH). 3. Expect the unexpected, such as communication interruptions and mass casualties (ZP).
8. Physical stamina (ability to sustain prolonged physical effort)	–	1. Physical endurance is a critical consideration. The workload is multiplied when wearing personal protection equipment (FQS). 2. Long periods of work in an austere environment requires good physical conditioning. Decontamination is an exhausting physical task (ZW). 3. Heat acclimatization is necessary (ZP).

WHO = World Health Organization; CBRN = Chemical, Biological, Radiological, and Nuclear; IAEA = International Atomic Energy Agency; OPCW = Organization for the Prohibition of Chemical Weapons.

performance of public health responders and relationship among those competencies. Moreover, studies could be conducted to further classify competencies by phases of the CBRN management and to delineate levels of proficiency needed based on occupations.

Conclusions

Non-technical competencies are as critical as technical ability for the health workers to respond effectively in CBRN emergencies. There are specific requirements in non-technical competencies for public health responders in CBRN events besides some common competencies. Those identified competencies could be useful to develop a workforce for CBRN emergencies, such as outlining competency-based training and updating job description for recruitment. The proposed competency framework can be used to support developers of public health emergency preparedness training initiatives by ensuring that public health professionals are able to demonstrate the non-technical knowledge and skills needed for successful performance when preparing and responding to CBRN incidents. It can also help update and revise job descriptions as well as orient public health practitioners to their emergency roles and responsibilities. The changing practical context and requirements for CBRN responses in the future demand the constant updating and redefining of the competency framework.

Author statements

Ethical approval

This project was approved by the Ethics Committee of Academy of Military Medical Sciences. All the interviewees gave their consent before the interviews and agreed to the dialog being recorded using audio equipment. The participants were assured that their participation would be voluntary and anonymous.

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Competing interests

The authors declare that they have no competing interests.

Author contributions

All the authors took part in the design of the study. X. Hu conducted the interviews and worked with H. Chen to code the text data. M. Yu supervised the data analysis and interpretation. All authors worked together on manuscript preparation and revision.

Consent for publication

Not applicable.

Availability of data and materials

The data sets generated and analyzed during the present study are not publicly available owing to consideration of the interviewees' privacy but are available from the corresponding author on reasonable request and form.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.puhe.2020.04.015.

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