Summary report of systematic reviews for public health emergency operations centres

Plans and procedures; communication technology and infrastructure; minimum datasets and standards; training and exercises

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Recognition is given to the authors of materials that were included in the above systematic reviews. Full lists of references for each review are included in this summary report.

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Note to the reader

In an effort to provide a full overview of the information on which this summary is based, separate reference sections are included for each of the reviews summarised. Each of these is identical to the reference section in the full version of the relevant review.

If an in-text reference is used in this summary, the reader is asked to consult the reference list relevant to the particular review under discussion at that point in the text.

[1] http://www.who.int/ihr/eoc_net/en/

Summary 1

A public health emergency operations centre (PHEOC) exists to coordinate information and resources in order to manage responses to public health events or emergencies.

Emergency operations centres (EOCs) are used in a variety of emergencies, including natural disasters; foodborne disease outbreaks; radio-nuclear events; bioterrorism; chemical incidents; mass gatherings; blackouts; humanitarian emergencies; and disease outbreaks or pandemics. They are employed at a variety of jurisdictional levels, and range from field EOCs to local, regional, national or international EOCs. Effective communication and coordination within and between EOCs and response agencies is critical to the successful management of an emergency.

The structure and function of EOCs varies across countries and organisations; they have different capacities and resources, and use different staff, terminologies, procedures and tools. These variations pose significant challenges to the interoperability that is essential to effective coordination between EOCs and responding agencies.

In 2012, WHO's Department of Global Capacities, Alert and Response (GCR) established the Public Health Emergency Operations Centre Network (EOC-NET)[2]. EOC-NET exists to support Member States as they strengthen their capacity for effective response to public health emergencies, in line with the requirements of the 2005 International Health Regulations.

EOC-NET has four working groups focussed on priority areas in public health emergency response:

1. The EOC Communication Technology and Infrastructure (CTI) working group, which provides guidance on minimum CTI requirements and assessment tools.
2. The EOC Minimum Data Sets and Standards (MDSS) working group, which develops guidance on minimum datasets, data structure, standards and common terminologies to ensure interoperability, effective data collection, display and exchange of operational information.
3. The EOC Procedures and Plans (P&P) working group, which identifies or develops generic procedures and plans, and standard operating procedures (SOPs).
4. The EOC Training and Exercises (T&E) working group, which develops training programmes and exercises for EOC personnel

In December 2013, WHO conducted a systematic review of public health emergency operations centres[3] , in collaboration with Emory University. This review documented best practices and barriers in establishing and using EOCs for effective responses to public health emergencies. This review has been followed by four more focussed reviews exploring key elements of EOCs: communication technology and infrastructure, minimum datasets and standards, plans and procedures, and training and exercises. The results of all five reviews will be used to inform the development of a series of guidance resources and recommendations for PHEOCs.

This report summarises the four focussed reviews.

1.1. Plans and procedures review

The core objective of the plans and procedures review was to identify and describe standards, regulations, planning frameworks, guidelines, plans and procedures related to public health emergency operations centres (PHEOCs). Other objectives were to identify and conduct in-depth documentation of the core components of PHEOCs.

The report recommends that planning frameworks for health emergencies should incorporate the following approaches and characteristics: risk management; all-hazards planning (plus hazard-specific planning where necessary); all agency approaches; prepared, resilient communities able to respond to disaster at local level; and a comprehensive approach incorporating risk prevention/mitigation, preparedness, detection (when communicable diseases are involved), response and recovery.

[2] http://www.who.int/ihr/eoc_net/en/
[3] http://www.who.int/ihr/publications/WHO_HSE_GCR_2014.1/en/

The cycle of emergency planning and preparedness should include assessment of an agency's capacity (resources) and capabilities (such as training and credentialing) to respond; building and maintaining the necessary capacities and capabilities; testing them in exercises and real events; and reporting on the response in after action reviews, ensuring that lessons learned are incorporated into emergency plans.

EOCs should use an incident management system that is modular, scalable and flexible; has plans and (tele) communications that are interoperable across agencies; uses terminology that is uniform throughout the system; uses incident action planning and management by objectives; has a manageable span of control (ideally 1:5); has a clear chain of command within agencies, and unified command across agencies; has clearly defined information flows; and considers how scientific/technical expertise fits into the chain of command.

At a minimum, EOCs should include roles responsible for command; operations; planning; logistics; finance/administration; intelligence; investigations; information management; communication (internal, inter-agency and risk communication); reporting/briefing; staff safety; and security. Depending on the type of emergency, public health functions – such as surveillance, data collection and analysis, epidemiology, laboratory, and disease control – ¬should also be included. More research is required into the best way to incorporate these public health functions into a traditional incident management system.

The review team investigated how the effectiveness of a PHEOC could be measured, but concluded that this topic also requires further research. EOC effectiveness tends to be measured using indicators of preparedness (e.g. is there an emergency plan, have staff been trained, etc.), rather than by the effectiveness of the response as demonstrated by actual outcomes (e.g. timely end to an outbreak of disease).

Though indicators of preparedness are more common, there are few specific accepted benchmarks or response time objectives (such as time taken to activate the EOC and recruit an incident management team). Useful benchmarks might include time taken to identify and control the cause of an outbreak; time taken to issue risk communication messages; existence of predefined processes for intra- and interagency communication flows and approvals; availability of decision support documents; and timely development of incident action plans once an emergency has arisen.

Priority topics for future research in the planning and procedures domain include how to adapt a traditional incident management system to include public health functions, and how best to measure the effectiveness of a public health emergency operations centre.

1.2. Training and exercises review

This review examined peer-reviewed literature, grey literature and web-based information resources to identify standards and best practices, describe current training programmes and exercises, and appraise their key components.

The capacity and skills of PHEOC staff are a key factor for effective management of public health emergencies. Most existing training programmes provided by large, reputable and established organizations, governmental and otherwise, vary in their objectives, target audiences, modules, methods, locations and cost. Training is usually available for the basic EOC functions of: policy; planning; management and coordination; communication; event monitoring; logistics; operations; and finance/administration.

The competencies required by EOC staff to cope with the duties and increased workload in an EOC are usually divided into the core abilities that all public health professionals should possess (such as those covering planning and use of resources, confidentiality, protection of individuals, and personal safety) and the specific competencies necessary for specialized public health roles such as environmental health, epidemiology or health policy.

Competencies are usually organized in domains. These include: policy and programme planning; model leadership; communication management; information management; incident management systems; safety and security; administrative support; informatics; public health law and ethics;
and public health sciences (assessment and analysis).

The curriculum requirements cover management (in categories including general, public health emergency, incident, surge, information and communication); EOC basics; ethics and integrity; biosurveillance; community resilience; countermeasures and mitigation; finance; administration; and IT and communications.

Exercises are used to practice, test, evaluate and improve an agency's preparedness plans and procedures, and should be considered an integral part of an organization's overall planning cycle. Different types of exercises (discussion- and operations-based) may be selected based on the risk assessment profile, experience, and preparedness levels of the organization. All data gathered at the evaluation phase of the exercise should be compiled into an after action report identifying strengths and areas for improvement.

The literature suggests that emergency operations coordination and information sharing are the most prominent challenges referred to in after action reports, regardless of the incident type or the jurisdiction assessed.

This review concludes that future research should be directed towards standardization of the definitions of competencies and related terminology, as well as their categorization. This will also contribute to the development of a training curriculum.

1.3. Minimum datasets and standards review

Operational information is required during an emergency response in order to manage response activities. It assists in building situational awareness, organizing resources and controlling activities. Operational information can be a dynamic result of an incident as it develops, or may be given as static information related to fixed data such as location of buildings, infrastructure, population, etc.

Information management is a critical enabler of an EOC's functions. Generally, information should be represented in commonly available formats that are easy to use, in order to ensure it can be accessed and easily retrieved by all stakeholders. There are, however, a multitude of information sources and formats in existence, meaning information on emergency response operations is often poorly shared within and between EOCs . The development of a minimum dataset and standards for EOCs will improve information management and interoperability, and allow more effective communication and coordination.

There should be an agreed minimum data set for collecting data from emergencies. This tool could be used to collect the most important information for the purposes of decision-making in a public health emergency response.

A data dictionary with associated descriptors relating to data entry codes is also required to assist in differentiating between categories of information, and to assist in providing consistency in reporting.

A suggested minimum dataset has been developed as part of this project and is laid out in the conclusion.

1.4. Communications technology and infrastructure review

This review looked at the current status of communications and infrastructure technology in public health EOCs in order to provide a practical reference for design and construction.

Sharing of information among EOCs and agencies is a crucial aspect of an effective emergency response. However, the diversity of EOC requirements and functions creates difficulties with interoperability, one of the most common CTI challenges in the PHEOC context.

The lack of unified requirements has led to heterogeneous system designs that hamper compatibility and prevent emergency information from being used and shared efficiently. This not only poses difficulty for multi-party collaboration between EOCs, response forces, and professional organisations, but also affects media and public understanding of emergency information.

The barriers to information sharing can be aggravated by the lack of a unified information platform. While multiple agencies are involved in emergency management, the media, general public and other groups not familiar with the organisational structure of an emergency response may have difficulty in finding information and advice.

Technological challenges hamper the provision of a comprehensive analysis of emergency situations based on massive amounts of information from various sources of different natures (often referred to as "big data"). The huge volume and diversity of data and the computational complexity involved in analysing all this information requires specialised hardware and software.

The report proposes a CTI framework that incorporates communication and information systems, infrastructure and security - all essential to the effective functioning of an EOC. Recommendations are made for setting up basic, general and optimal CTI systems for public health EOCs. ■

Introduction 2

A public health emergency operations centre (PHEOC) is the central location where responsible personnel gather to coordinate operational information and resources for strategic management of public health events and emergencies. It provides staff support to commanding officers in making decisions and coordinating responses to emergency incidents. It is usually a physical place where personnel can assemble and response activities can be managed. But the functions of an emergency operations centre (EOC) are arguably more important than its physical location, and in fact its basic functions can be undertaken by one or two people in routine office space if the incident is small and/or few resources are available or required. They may also be undertaken in a virtual space: NFPA 1600, the US Standard on Disaster/Emergency Management and Business Continuity Programmes, permits EOCs to be either physical or virtual.

> « Since September 11, 2001, public health has played an increasingly large role in emergency response, thus expanding the functions of what is typically thought of as public health.»[3]

EOCs are usually staffed by a team operating within an incident management system. The nature of this system varies, but often follows the US Incident Command System (ICS). This system has been used for at least 30 years in fighting forest fires in the US and has gradually been accepted in other crisis management areas. It arose from an outbreak of wildfires in California in 1970; as fires crossed jurisdictions, it became clear that the coordination of different responding agencies was a major problem. Responders did not have a common language, management concepts, or communication systems. California's fire fighting agencies subsequently designed a system that tried to clarify who was in charge. The resulting incident command system (ICS) provides a hierarchical structure intended to coordinate a network of responders from different organisations under a temporary hierarchical authority. While originally intended for scene management between responding fire-fighting units, it has since evolved into a more generic incident management system, with the common functional components of incident command, planning, operations, finance/administration and logistics. Perry notes that law enforcement agencies tend to use the term 'incident command systems,' while modern fire services tend to use the term incident management system (IMS). There are many approaches to, and names for, IMS, but all have in common the notion of coordinating the actions necessary to manage disasters and emergencies.

Since terrorist attacks in the USA on September 11, 2001 and the subsequent national directives and guidance on the use of the National Incident Management System (NIMS), US emergency management agencies – including health organisations – have adopted and adapted the ICS. After looking at the world's best practices, the Government of India found that the system evolved for fire-fighting in California was very comprehensive and also decided to adopt the ICS. Major incidents with public health impacts such as SARS in 2003 and the influenza pandemic of 2009, both of which involved multiple jurisdictions and responding agencies, have seen health agencies around the world gradually adopt an incident command system in an attempt to respond more effectively to public health emergencies. ■

[2] Freedman, A.M., et al., Addressing the gap between public health emergency planning and incident response. Disaster Health, 2014. 1(1): p. 13-20.

2.1. Review questions

2.1.1. Plans and procedures review

This review is focussed on the key roles and components of a PHEOC, and the frameworks, plans and standards that support its operation. The specific questions were:

1. What are the existing national and international standards and regulations (including legislation, codes of practice and treaties) related to preparing for and responding to public health emergencies (i.e. what regulatory frameworks exist for responding to emergencies)? Do these standards specify the role of PHEOCs? Do they specify the core components of public health emergency (PHE) plans?
1. What frameworks and guidelines exist for developing plans for public health emergencies (i.e. planning frameworks)?
2. What PHE plans exist, both general and hazard-specific? What are the core components of these plans? Appraise the components according to a set of predetermined criteria.
3. What frameworks and guidelines exist for managing an EOC (i.e. operational/response frameworks)?
4. Do EOC frameworks/guidelines/plans or SOPs address general public health emergencies, or are they hazard-specific, or both (e.g. do they have annexes about specific hazards)?
5. What usual roles do these EOC plans and procedures describe?
6. What core components of an EOC do these EOC frameworks describe? Include a case study. Identify minimum and optimal requirements for a functional EOC regarding plans and procedures.
7. How is the effectiveness of a PHEOC measured?
8. What are the barriers to complying with any plans and operating procedures that are activated in an EOC setting?
9. What are the gaps in research around measuring the effectiveness of a) PHE plans and b) PHEOCs?

2.1.2. Training and exercises review

1. What are the existing national and international standards and regulations related to public health emergencies training programmes and exercises (i.e. what regulatory frameworks exist for conducting training programmes and exercises)? Do these standards refer to EOC training programmes and exercises?
2. What frameworks and guidelines exist for developing and conducting PHE training programmes and exercises (i.e. how a curriculum is developed)? What are the key staff competencies/standards for competencies? What types of training activities and techniques exist? How are training activities and exercises evaluated?
3. What training and exercises exist for public health emergencies, both general and hazard-specific? What are the core components of these training programmes and exercises?
4. What frameworks and guidelines exist for public health EOC training programmes and exercises ?
5. What PHEOC training programmes and exercises exist, both general and hazard-specific? What are the core components of these training programmes and exercises? How are they evaluated for their effectiveness?
6. What are the gaps in research on evaluating PHE and PHEOC training programmes and exercises?

2.1.3. Minimum datasets and standards review

1. What operational data and information were needed for responses to public health emergencies?
2. What are the common components and elements of operational information for public health emergency preparedness and response in existing international, regional, and national standards, protocols, and researches?
3. What are the sources of operational data/information pertaining to public health event management?
4. How is operational data used?
5. Are there any operational standards for public health emergency preparedness and response in existing international, regional, and national EOCs?

2.1.4. Communications technology and infrastructure review

1. What are the existing standards, guidelines, regulations (laws) and policies at international, regional and national levels with respect to communications technology and infrastructure (CTI) for public health EOCs? What requirements are specified?
2. What are the current best practices pertaining to EOC CTI?
3. What are the challenges/barriers associated with EOC CTI for public health response?
4. What frameworks can be recommended as CTI solutions for public health EOCs? What core components are specified?
5. What are the existing finance/cost-sharing models for public health EOCs? How is their performance measured, and how effective are these models?

2.2. Overview of search strategies

Plans and procedures review: Searches were conducted of both grey and peer-reviewed literature. Grey literature searches focussed on: US and European CDC websites; disaster/emergency response agencies; NGO websites; a limited number of government websites representing each WHO region; WHO websites (including library databases and pages related to emergencies); standards and regulations websites; and grey literature websites. Peer-reviewed literature searches were undertaken on Web of Science, Medline and Scopus databases.

Training and exercises review: Peer-reviewed journal articles were sought from the following electronic databases: Medline/PubMed; the Cochrane Library; Health System Evidence; regional databases for biomedicine and health sciences; WHO databases; IndMED; KoreaMed; Australasian Medical Index; and Biomed Central. Grey literature documents were sourced from Disaster Lit; WHO's Library Database; the six WHO Regional Office websites; the Grey Literature Network Service; and the Open Grey system for information on grey literature in Europe. Focused research was conducted on the government websites of select countries; regional and international standards organizations; public health and aid organizations; academic research institutes and associations; training sites; unpublished material relevant to review questions; and in-use training and exercise materials shared by the four review teams.

MDSS review: The electronic databases searched for peer-reviewed journal articles were PubMed, Scopus, Web of Science and ACM. Sources of grey literature included WHO; ITU; OpenGrey; CABI Global Health Database; POPLINE; government websites in select countries; and in-use materials shared by the four review teams. Standards reviewed included ASTM, NFP, ISO, USA CDC, HL7, NEMSIS and HITSP. The results of expert consultation at the preparation workshop for the development of WHO's EOC framework held in April 2015 was included in the review.

CTI review: The electronic databases searched included Medline/PubMed, Scopus and Web of Science. Peer-reviewed literature was sought on CTI in EOCs, especially in the areas of communication, facility, software, training and exercises, and human resources and organisation. Grey literature searches included UN websites; select government websites; select university and NGO websites; standards and regulations websites; internal reports related to EOC functions and facilities; interview reports with professors; practices and hardware/software system developers in international organisations; industrial solutions/ reports/tests; independent reports/tests; internet/media articles; end-user surveys; documents shared by different review teams; and an online forum. The review also included the results of expert consultation at the preparatory workshop for the development of WHO's EOC framework, held in April 2015.

2.2.1. Inclusion and exclusion criteria

Sources were included for assessment if they met the following inclusion criteria:

- They were related to at least one of the review questions
- They were produced between 2004-2014 (to ensure that information was current)
- They were in English, or in the case of the CTI review, English or Chinese (the languages of the reviewers)
- They were unpublished material relevant to review questions
- Full text was available (accessed through WHO if necessary)
- For the CTI team in particular: they were able to answer specific questions related to hardware, software and facilities.

Sources excluded:

- Materials produced prior to 2004 (although some important sources were included)
- Materials unrelated to any of the review questions.

EndNote was the reference management software used.

2.3. Search results

The plans and procedures team selected 298 sources of information for review. Given the nature of the review, most were from the grey literature, with only 23 peer-reviewed articles selected.

The training and exercises team selected 262 sources for review.

The MDSS team selected 152 sources for review. This included 93 peer-reviewed sources and 59 records from grey literature, including standards. The team also selected 14 in-use information systems/platforms to review.

The CTI team selected 155 peer-reviewed articles and 75 records from the grey literature, including national and international standards.

2.4. Critical appraisal and data extraction

Several appraisal tools were checked for suitability for this review, including Critical Appraisal Skills Program (CASP), a measurement tool to assess systematic reviews (AMSTAR), and the Centre for Evidence-based Medicine (CEBM) tools; but most of these appraise scientific literature and research studies, which were not the key focus of this review. Documents were selected for review if the source was identifiable, credible and authoritative; if the document was in use; and if it was generalisable to other settings. Data identifying the publication, setting and type of emergency were extracted, along with key findings (such as core components of an EOC) and any recommendations made within the source document. The training and exercises team also considered other criteria for selection, such as the size of population served, the type of intervention, the legal status of the organization (private or public entity), the type of training provider, the types and methods of training, and the nature of trainees. ■

Discussion 3

3.1. Plans and procedures review

About 200 websites were searched for relevant grey literature, and three electronic databases for peer-reviewed literature. A total of 298 sources were selected for review; only 23 were peer-reviewed articles while the rest were grey literature.

Only eight standards or regulations include information about the role of EOCs and only six specify the core components of a PHE plan. However, many of the regulations concerning general emergency management could also apply to public health, such as the standards for general EOC development and management.

3.1.1. Standards and legislation

This review found a wide variety of legislation, policy and standards (13, 14) relating to general emergency management. Many of these regulations can apply to the more specific field of public health emergencies, such as the standards for EOC development (15) and management (16), and for incident response. Thirty-five relevant standards and regulations were selected from sources found in the grey literature. Of these, eight included some information about the role of EOCs and six mentioned the core components of a PHE plan. For example:

- *ISO 22320 Societal security — Emergency management — Requirements for incident response* (17) describes the roles of an EOC as being command and control, management of operational information, and cooperation and coordination.
- *NFPA 1600: Standard on Disaster/Emergency Management and Business Continuity Programs* (7) briefly discusses EOCs and their role in communication, coordination and incident management, but does not detail the roles within an EOC. The EOC's functions are to include mitigation, preparedness, response, continuity and recovery activities; and the emergency response should be guided by an incident action plan.
- *The Emergency Management Standard* (18) describes the incident management system as formalised and institutionalised, addressing the principles of command and basic functions of planning, operations, logistics, finance and administration.
- *The USCDC Public Health Preparedness Capabilities: National Standards for State & Local Planning* (19) states that written plans should have standard operating procedures that include activation procedures and levels, stipulating who is authorised to activate the plan and under what circumstances; and procedures for recalling or assembling required incident management personnel.
- *ISO 11320 Nuclear criticality safety — Emergency preparedness and response* (20) outlines managers' coordination responsibilities without stipulating an incident command system.
- The ASTM *Standard Guide for Emergency Operations Centre Development* (15) sets out functional areas that need to be accommodated within a physical emergency operations centre, while the ASTM *Standard Guide for Emergency Operations Center (EOC) Management* (16) outlines the processes that may be necessary for an incident management team to function effectively within an EOC. The latter standard notes that EOC management should be consistent with the incident management system used by the EOC team (such as NIMS in the US). It only mentions two specific EOC roles – that of Planner (who manages and develops the EOC facility, systems and procedures prior to activation) and the EOC coordinator (who manages the EOC during activation). It discusses the need for an EOC support manual (a handbook of administrative, logistical and facility processes) and standard operating procedures for routine tasks in activating, operating and deactivating the EOC, but otherwise does not detail the roles and functions of an EOC.

There is a general sense within most legislation reviewed that the incident command system is the preferred mechanism for achieving the level of coordination required to respond to emergencies, with significant work having been published on the operation of EOCs (15),(17). Laws and directives in most countries mandate a co-ordinated response to emergencies, including public health events, and some of them detail the mechanisms to be implemented (21). The *US Pandemic and All Hazards Preparedness Act 2006*, for instance, mandates the use of the National Incident Management System (NIMS) in public health preparedness and response (22). The United States Federal Emergency Management Agency (FEMA) mandates that federal departments and agencies make the adoption of NIMS by local, state, territorial and national jurisdictions a condition to receive federal preparedness grants and awards. *The NSW Health Public Health Emergency Response Preparedness Minimum Standards [Australia]* (23) stipulates that public health incidents must be managed in an ICS framework.

The World Health Organization's *International Health Regulations 2005* (24, 25) have prompted governments to establish coordination mechanisms to respond to disease outbreaks of international concern. Agencies such as the United States Centers for Disease Control and Prevention (CDC, through its Division of Global Health Protection) offer support to countries that have limited capacity for public health emergency response (26). CDC also provides standards for public health response planning for states and local authorities within the US (27). Standards are also in place internationally in an attempt to define terminology around emergency response (28).

The *Core Humanitarian Standard on Quality and Accountability* (29) has been developed in an attempt to drive quality within the humanitarian assistance community; this document outlines the principles of co-ordination in emergency response, such as the commitment that staff be competent and well managed. This voluntary standard aligns well with current best practice in emergency management.

3.1.2. Frameworks and guidelines for public health emergencies

Following a search of grey literature, 105 frameworks and guidelines were selected for review. As there are not a lot of publicly available frameworks and guidelines that relate specifically to public health emergencies, the final sources selected for this review also cover general emergencies and disasters. Some of the key themes (general or health-specific) in these frameworks and guidelines are:

General themes:

- Most frameworks and guidelines took a similar approach to emergency management, although the terminology often differed. The key approaches are:
  - Risk management, which variously included risk identification, assessment or analysis, prioritisation, reduction (or mitigation or treatment) and monitoring
  - All-hazards approaches (or all-risks), with hazard-specific programmes underneath this umbrella, as required
  - Whole health (health planning and response unified in one unit)
  - All agency approaches (or multidisciplinary/intrasectoral, and multisectoral/across agencies)
  - Prepared or resilient communities (able to respond to disaster at a local level)
  - Comprehensive frameworks including prevention (and/or mitigation), preparedness, detection (when communicable diseases are involved), response (crisis management to prevent an emergency, consequence or impact management to mitigate effects of emergency), and recovery.

- Emergency responses are generally based on an agency's (or country's) incident management system. Many agencies use a structure of command, control, coordination and, occasionally, communication. 'Command' is the authority to give direction vertically within an organisation, 'control' is the authority over staff and assets and operates horizontally across organisations, and 'coordination' is the integration of multi-agency efforts to ensure an effective response.

- Many frameworks include details of the incident management system (IMS) used to respond to emergencies, with common elements of an IMS including: modularity, scalability, flexibility, multidisciplinary/multiagency character, clear lines of responsibility/identified lines of authority, being knowledge-based, having standardised systems across agencies, interoperability of (tele)communications across agencies, interoperability of plans, use of common terminology, management by objectives, incident action planning, possessing a manageable span of control (ideally 1:5), possessing a chain of command within agencies, unity of command across agencies, and clearly defined information flows.

- The UK included two elements or principles which were not found elsewhere: the principle of 'subsidiarity,' which means decisions are made at the lowest appropriate level, while coordination of the response occurs at the highest appropriate level; and the principle of 'continuity,' which means the response should be grounded in existing functions and familiar ways of working.

- The cycle of emergency planning and preparedness is described in various ways: it usually starts with risk analysis and monitoring, followed by minimum preparedness actions which are not risk-specific (such as establishing incident management arrangements), followed by advanced preparedness actions for scenarios that are identified as high risk. Risk analysis may also be accompanied by vulnerability analysis (of the responding agency and of local communities). Planning may include an assessment of an agency's capacity (physical resources) to respond to an emergency, identification of competencies/capabilities required to respond, and then building and maintaining both capacity and capabilities. A capability assessment reviews the ability of a government, individual or company to address identified hazards; it should incorporate technical ability, financial resources, legal and institutional frameworks, and political will.

- Frameworks often noted the need to assign a category, level or grade to an incident, depending on the incident's severity, impact, scale and/or urgency of mounting a response. This grade helps to determine the type of response that is required. Lower levels or grades can be handled at a local level in the first instance, with higher levels requiring a regional, national or international response. Triggers for escalating the response to a higher level need to be agreed upon by all relevant agencies.

- The timing of response activities is usually determined by an emergency's phase or stage. Different phases of an emergency will trigger specific actions by responding agencies. These phases usually start with an alert or warning phase when a threat has been identified and preparedness activity needs to increase. This is followed by a standby phase when the emergency is imminent and agencies must be fully prepared to respond. Next is the response or activation stage, then finally comes the stand-down phase. The terminology and number of phases varies across countries and agencies, but generally follows the pattern of alert, response and stand-down.

- Many guidelines emphasise the need for institutional or national preparedness – ensuring financial resources are available for preparedness and response activities, national policies are developed to guide or support preparedness programmes, legislation/legal powers/instruments are in place (e.g. quarantine protocols), and compensation policies or arrangements are established.

- Other key elements of planning identified in various frameworks include:
  - Management of data, knowledge and information – its collection, analysis, reporting and dissemination; maintaining situational awareness and a common operating picture
  - Engaging partners – establishing relations with other responding agencies, the media, and community leaders
  - Risk communication, including ensuring public awareness, education and engagement; early public warning; communication for behavioural impact, social mobilisation and health promotion; media liaison – all elements that help ensure a 'prepared community'
  - Internal communication (sharing information within an agency)
  - Inter-agency communication protocols – e.g. for developing, approving and disseminating public messages, and for sharing sensitive information
  - Management of human resources, which can be assisted by a database of national experts, ensuring surge capacity, rostering and shift changes, credentialing of EOC staff and responders, pre-deployment training/briefing and demobilisation procedures (such as debriefing)
  - Ensuring an incident action plan is developed that is specific to the emergency
  - Methods of capturing lessons learned, not only after the event, but also during an emergency – documenting activities and impacts, and monitoring the progress of the response towards achieving set objectives and adjusting the response accordingly
  - Contingency plans or business continuity processes to ensure essential services are maintained (and non-essential ones scaled down)
  - Decision-making (and clearance or approval) processes that are predefined and streamlined, with decisions based on evidence
  - The ethical, cultural and legal implications of specific responses need to be considered
  - A continual improvement process, which might include not only regular training and exercises, but also annual risk, capacity and vulnerability assessments.

- With regard to the specifics of emergency plans, they should include elements such as objectives and scope, a description of the incident command system, annexes (such as SOPs and checklists), approval and dissemination processes, training plans, validation of the plans in exercises and emergency responses, and plan review, revision and maintenance.

- An important theme in many frameworks was the need for plans to identify how and when a response should be activated – ensuring early warning systems are established, defining alert thresholds or triggers or criteria for activation (e.g. how many cases of disease, or how widespread the damage), and determining who has the authority to activate the plan and/or establish an emergency operations centre.

Health-specific themes

- The approach to public health emergency preparedness may be considered as two–tiered: the first tier is about planning (exercising, evaluating and reviewing documented plans); the second tier is about increasing readiness (e.g. establishing stockpiles, building capacity for activities such as enhanced surveillance and risk communication, staff training, equipping and supplying etc.).

- Some countries approach public health emergency preparedness with separate programmes for specific hazards (such as outbreak control, or responding to the public health impact of a natural or manmade disaster), while others take an all-hazards approach to the management of health emergencies.

- An important aspect of the public health incident management system is the provision of scientific/technical/evidence-based advice or expertise. The way scientific expertise is best incorporated into an incident command system has been the subject of recent discussion in the literature and is a theme worthy of further exploration.

- While the management of general emergencies often takes a prevention, preparedness, response and recovery approach, management of public health emergencies may be considered to have three key phases: a preparedness phase (establishing elements such as a rapid response team, disease surveillance, training, infection prevention & control, communication, and laboratory capacity);

a response phase (including field investigation and field response); and a monitoring and evaluation phase (which occurs at the same time as phases 1 and 2 but is also ongoing).

- Apart from the key elements of planning noted above for general emergencies, public health emergency planning for epidemics needs to consider outbreak prevention and control, in particular: enhanced surveillance; epidemic intelligence; disease detection; case definition/diagnosis/confirmation; alert thresholds/triggers; rapid assessment; contact tracing; treatment protocols; vaccine/drug stockpiles; laboratory supplies and capacity; vaccination; point of entry surveillance/control; and any other actions to mitigate the impact on public health.

- Planning for public health emergencies which have an environmental health (EH) impact may need to consider water supply safety; faecal disposal; re-establishment of licensed premises relevant to public/environmental health; emergency food distribution; EH assessment of emergency shelter and evacuation centres; safe re-establishment of housing and communities; solid waste management; hazardous waste management (including for asbestos); vector and vermin control; deceased persons; and disposal of dead stock.

Two documents from CDC of particular relevance to this question are the *Public Health Preparedness Capabilities: National Standards for State and Local Planning,* and the *Framework For the Development of CDC Emergency Response Plans*.

The Standards document suggests the following planning methodology:

1. Assess current state: organisational roles and responsibilities (who does what); resource elements (planning, skills & training, equipment & technology); and performance (i.e. assessing whether resources meet needs through exercises or real events)
2. Determine goals: review jurisdictional inputs (current plans, data, funding, after action reports); prioritise capabilities and functions (especially biosurveillance, community resilience, countermeasures & mitigation, incident management and information management); develop short-term (one year) and long-term (two to five years) goals
3. Develop plans: plan organisational initiatives; plan capability building/sustain activities; plan capability evaluations/demonstrations.

The Framework document's plan hierarchy has four elements: an all-hazard plan, category-based annexes, agent-specific appendices, and attachments. (The information in an annex or appendix should not duplicate information included in the higher-level plan.) The plan hierarchy, in descending order, is:

1. Emergency Operations Plan (EOP): broadly outlines the framework and all-hazard capabilities for CDC's response to a public health emergency. Supporting the EOP are annexes, appendices, and attachments that provide greater detail on the type of activities performed by CDC during a response to specific public health emergencies.
2. Annexes: these are classified according to general emergency response categories (e.g., biological, chemical, radiological, or natural disasters). The annexes identify the capabilities or activities that are specific to incidents or events occurring within that particular category, but are not applicable across all the response categories.
3. Appendices: these provide even more focused (i.e., agent-specific or incident-specific) information than the annexes they support. Each appendix details the scientific and technical information, policies and procedures specifically related to responding to a specific threat.
4. Attachments: these are documents that accompany the plan, or annexes or appendices which provide supplementary or reference information (e.g. disease-specific case report forms or pre-scripted mission assignments) or which may address specific areas of importance to CDC response actions that affect more than one annex or appendix, but do not require development of a separate agency-wide plan. Examples include documents addressing issues specific to vulnerable and affected populations, mass casualties, emergency use authorizations, communications, mental health, strategic national stockpile operations, etc.

3.1.3. Public health emergency plans

Following a search of grey literature, 52 plans were selected for review. These include three types of plan:

- Disaster management plans, which were broad, overarching plans at an international, national or regional level, with a public health component and an all-hazards approach (49-61)
- General public health emergency plans, which were at a state, local or municipal level, and espoused an all-hazards approach (62-71). This review profiles PHE plans from the Western Pacific region, where plans were more accessible to the research team.
- Hazard-specific public health emergency plans, which were also at a state, local or municipal level. These plans focussed on specific public health emergencies such as pandemic influenza, natural disasters, Ebola, heat wave, infectious disease or CBRNE incidents (72-96). Pandemic influenza plans written prior to the 2009 pandemic were excluded to ensure currency; greater weight was given to those written after the release of *Pandemic Influenza Risk Management: WHO Interim Guidance* (2013) (97)

Format and core components

In the plans reviewed, the content was usually divided among four different elements:

1. The basic plan, or main body of the plan (with elements such as introduction, concept of operations and emergency phases)
2. Functional annexes (describing the function of cells or staff in the EOC)
3. Hazard-specific annexes
4. Other appendices (with elements such as checklists, forms and templates).

This finding broadly reflects the format of emergency plans as described in FEMA's *Developing and maintaining emergency operations plans* (98) and CDC's *Framework For the Development of CDC Emergency Response Plans* (47). FEMA's guideline notes that there are various formats for emergency operations plans, including the traditional functional format that has a basic plan, functional annexes and hazard-specific annexes. Apart from emergency operations plans, the FEMA guideline notes that agencies may have separate preparedness plans, continuity plans, recovery plans and mitigation plans. Although most of the plans in this review were labelled as operational/response plans, many also detailed strategies related to preparedness, mitigation and recovery. A small number of plans focused on prevention, primarily the general disaster management plans.

In the 52 plans selected for this review, a total of 85 different components were identified and listed according to where they best fit within the four key elements of an emergency operations plan. Within the basic plan, some components were also grouped according to type of strategy – prevention/mitigation, preparedness, response or recovery (99). While the plans were diverse in nature and function, and their core components varied, there were common themes.

Common themes

It is widely accepted that PHE plans should ideally be based on overarching planning frameworks and standards that guide their development. From the 35 PHE standards selected for this review, only six specify the core components of a PHE plan. The information within these standards varies, with some standards highlighting a singular component of a plan, such as the importance of business continuity, records management, having a risk management plan or establishing trigger points for normal business to resume. Other PHE standards include more comprehensive guidance, such as standard operating procedures for EOCs. One standard, the EU Civil Protection legislation (103) clearly stipulates the core components of a PHE plan: information management; communications; scientific advice; liaison and command and control structures; preparedness of the health sector; and preparedness in all other sectors and inter-sectorally. These components are consistent with what was found in the PHE plans included in this review.

FEMA's *Developing and maintaining emergency operations plans (comprehensive preparedness guide).* (98) and CDC's *Framework For the Development of CDC Emergency Response Plans* (47) suggest a range of core components that should be included in an emergency plan. The FEMA framework suggests that the basic plan should contain sections on introductory material (approvals, records of changes, distribution); purpose and scope of the plan, situation overview and planning assumptions; the concept of operations; assignment of responsibilities; command and control; information management; communication; administration and finance; plan development and maintenance; and authorities. Most plans incorporate these elements, although the terminology differs. In addition to these elements, public health emergency plans often incorporate prevention/mitigation, preparedness and recovery strategies within their plans, rather than in separate plans. Other important features in public health emergency plans include alignment with other plans, incident grades, activation triggers and activation authority.

Considering the complex and diverse nature of PHE plans, and acknowledging existing PHE planning guidelines and standards, the reviewers surmise that public health emergency plans should include the following core components:

- The basic plan
  - Introduction
  - Purpose, scope, situation overview, guiding principles, and planning assumptions
  - Concept of operations: response phases, incident levels or grades
  - Triggers and authority for EOC activation
  - Assignment of responsibilities
  - Incident management/command system
  - Prevention/preparedness/response/recovery components, either as separate plans or within the PHE plan
  - Authorities

- Functional annexes
- Hazard-specific annexes
- Appendices.

Additional recommendations:

- Uniform terminology should be used to describe the core components of a PHE plan, such as concept of operations, activation or alert phases, and incident levels or grades
- Triggers and the responsibility for activating an EOC or plan should be clearly stipulated in PHE plans
- There should be a clearer distinction between a 'functional annex,' a 'hazard-specific annex,' and 'appendices.' These terms were used interchangeably among the plans reviewed.

3.1.4. Frameworks and guidelines for EOCs

Core components

A review of grey literature revealed that the most common (and perhaps by implication, the most important) roles of an EOC are command; operations; planning; logistics; finance/administration; intelligence; investigations; information management; communication (internal, inter-agency and risk communication); reporting/briefing; safety; and security. A public health EOC would need to add – depending on the emergency – public health functions such as disease control, environmental health and social mobilisation/ health promotion. It should be noted that a lack of consistency in terminology across agencies and plans makes comparing and categorising these components difficult.

Minimal and optimal requirements

Very few documents stipulated either the minimum or optimal elements of an EOC. However, the 'minimum' elements could be inferred from similar terminology used across these documents, including terms such as 'core', 'primary', 'normal', 'common', 'essential', 'fundamental', 'key' or 'principal' elements.

The minimum requirements of an EOC appear to be a command/control/coordination function; operations; planning; logistics; public communication/information; finance/administration/policy; and intelligence/data/ information management. No frameworks referred specifically to the optimal requirements of a public health EOC, although several documents reviewed for this project (1,22) mentioned that to the normal incident management functions could be added public health functions such as surveillance monitoring; public health data collection and analysis; quarantine; epidemiology; laboratory functions; and community mitigation.

3.1.5. Measuring the effectiveness of EOCs

Thirty-one documents from the grey literature were found to have some reference to benchmarks, competencies or indicators for emergency preparedness, although no documents were found relating specifically to measuring the effectiveness of public health EOCs. Overall, the grey literature mostly discussed outputs or outcomes of EOCs rather than the impacts of their strategies or interventions, though it is arguably the latter that will provide a truer measure of the effectiveness of an EOC. Similarly, the peer-reviewed literature tended to focus on benchmarks for preparedness, rather than response. Given that public health emergencies are relatively rare, this is an understandable approach; but it means that what is measured is EOC preparedness rather than effectiveness. If the true measure of an EOC's effectiveness is the impact it has (rather than the products or processes it generates) – and this is a matter for further research – then ways of measuring that impact are required.

In the grey literature, CDC comes closest to measures of effectiveness with its public health preparedness capabilities, although the number of capabilities for measurement could arguably be expanded. In the peer-reviewed literature, Burkle (29) discusses the impact of public health emergency response when he writes about measures for managing infectious disease outbreaks such as mortality and morbidity, and distribution of health information and resources such as staff and drugs, although he suggests no specific objectives. Similar measures of the effectiveness of a public health response would also be relevant to events other than communicable disease outbreaks, such as manmade or natural disasters. No peer-reviewed literature was identified that discussed measurable response time (or other) objectives in relation to public health EOCs.

Several sources discuss whether the traditional incident management system is in fact appropriate for managing a public health emergency. Buck, Trainor and Aguirre note (30) that ICS has been "most successful among firefighting organizations and less successful with law enforcement, public health, and public work organizations." Ansell and Keller (31) argue that while ICS "has demonstrated its value for fire-fighting, there have been lingering concerns in the public health community about whether the incident command model is appropriate for responding to infectious disease outbreaks." They describe how, during the 2009 influenza pandemic, CDC adapted the traditional IMS to bring its scientific and technical expertise to the fore, creating functional cells or task forces based on epidemiology, community mitigation, medical care and countermeasures, vaccines, and state coordination. CDC's role in an outbreak includes collecting, analysing and disseminating information; with a central mission of "rapid mobiliza¬tion of authoritative knowledge"; CDC also elevated the role of its Joint Information Centre during the pandemic. In reference to the CDC model, Papagiotas et al (32) argue that the traditional ICS needs to be adapted for public health events by incorporating public health activities. Freedman et al (3) note that ICS and EOCs are relatively new concepts to public health, which typically uses a more collaborative and less hierarchical approach to organising staff.

Parker et al also note that the top-down nature of decision-making in an ICS "can conflict with the more consensus-based decision-making style common to public health practice" (33). And despite the use of ICS in fire-fighting for 30 years - and its more recent adoption by public health - Lutz and Lindell note that "there have been very few empirical studies of its effectiveness" (34).

The measures that were most commonly correlated to EOC effectiveness in the literature are set out in the Conclusion.

3.2. Training and exercises review

3.2.1. General

According to the Education and Standards Committee of the World Association for Disaster and Emergency Medicine, the process of setting standards for curricula for training involves two major steps to set the context: the identification of target populations to receive training; and the identification of the context (environment and conditions) in which these populations will perform their tasks.

With that in mind a multi-year training and exercise plan should be in place for all EOCs and should integrate strategic, high-level priorities informed by existing assessments, strategies, and plans. A training plan should include the training goal, learning strategies, training prerequisites, logistics and equipment requirements, trainee and trainer identification, time and place of training, and details of the assessment process.

Training can either be individual, involving personal study and participation in courses, seminars and workshops; or organizational, involving training and single- or multi-agency exercises. Preparedness exercises and especially joint training exercises help familiarize EOC personnel with emergency plans, allowing different agencies to practice working together, and identify gaps and shortcomings in emergency planning.

A number of countries have developed an incident management system on which all personnel involved in emergency management and response should be trained to the level of their involvement.

3.2.2. Training design

Needs assessments should be conducted in order to establish the purpose of training, determine its frequency and content, and establish the number of participants. Training should be conducted periodically or as needed. Where no frequency is established, at minimum annual exercises and testing are recommended.

A key step before developing a course curriculum is to specify learning objectives—i.e. clear statements of what each learner is expected to know and be able to do after completing the course.

The literature suggests that there are 'core' competencies that all public health care workers should possess, and specific competencies for particular roles, positions or professions. Each role also requires a particular level of proficiency ('awareness,' 'knowledgeable' or 'advanced'). According to the WHO Guidelines on Health Emergency Management Manual for Operations Centres, competencies should be aligned to the functions of the EOC and its staff should possess knowledge of:

- Sectoral plans, policies and guidelines
- Communications skills
- Negotiation skills
- Skills in decision making and risk assessment
- Knowledge of all HEMS reporting forms and templates
- Data collection
- Data evaluation
- Data analysis and dissemination
- Epidemiology
- Statistics and surveillance
- Report preparation and presentation
- IT skills
- Knowledge on the steps in mobilizing human resources (i.e. medical teams; etc.) and material resources to reach affected communities
- The incident command system
- Media handling
- Administrative functions such as maintaining databases of contact persons, experts, facilities, logistics, etc.
- Filing
- Recording of important documents and updating files.

Full records of all training activity should be kept by training providers, organized in such a manner as to be identifiable, retained, and accessible. States or respective agencies should also keep a central electronic database of all trained emergency management personnel, course instructors and available preparedness courses, and use their internal reporting systems to promote accountability for education and training activities and transparency and fairness in training budgets.

3.2.3. Exercise design

Exercises should be considered an integral part of the overall planning cycle of an organization, and not as isolated events to test processes or capabilities. Priorities for exercise programmes are usually defined after conducting a needs assessment. These assessments are based on information sources including risk, threat and hazard analyses; experience of prior real incidents or exercises; after action reports and improvement plans; an organization's current state of emergency preparedness and plans; changes in regulating standards; and levels of staff knowledge.

When planning an exercise the first step is to set objectives, which can either be 'general' (providing an overall exercise objective of the agency) or 'functional' (outlining the expected outcomes of what is being tested). These help determine what type of exercise to carry out. The exercise objectives not only define specific goals, but also provide a framework, guide scenario development, and set the exercise evaluation criteria. The exercise objectives must be reasonable in number; clear, concise and simple; and specific, measurable, achievable, relevant and time-bound (also referred to as 'SMART goals').

Examples of areas to be tested include but are not limited to elements of emergency plans, decision processes, information sharing, and internal and external cooperation to address problems.

Based on the needs assessment and exercise objectives, exercise scope defines the parameters within which the exercise will be conducted. In other words, it determines realistic limits on the personnel involved, the participation of various agencies, and the resources required to conduct an exercise activity.

Ensuring the correct individuals are present is crucial. Players are selected according to the aims and objectives of the exercise, but those most in need of the experience should be included. Exercise roles include:

- Controllers – responsible for monitoring the flow of the exercise and making sure it is being conducted in accordance with the scenario and the timelines
- Players – individuals performing a specific role during the exercise
- Evaluators – those observing and recording the response of the players during the exercise and evaluating effectiveness based on the goal and objectives of the exercise
- Observers – these individuals do not have an official role in the exercise, but are usually invited guests and may be asked to submit their observations as part of the evaluation process.

A common trend identified throughout the literature is for organizations to engage in series of exercises of increasing complexity, a method usually called 'a building-block approach,' which enhances the organization's long-term preparedness goals. This approach begins with basic exercises that test particular aspects and then gradually progresses to use exercises more complex in nature, requiring greater resources and time. Each exercise within the progressive series is linked to a set of common programme priorities and designed to test associated capabilities. This progressive approach, with exercises that build upon each other and are supported at each step with training resources, will ensure that organizations do not rush into a full-scale exercise too quickly.

There are two broad categories of exercises: discussion-based and operations-based. Both types require a scenario including the hypothetical situation/hazard that satisfies the set objectives and provides all the necessary information for the required actions. For the scenario to be realistic, it is often necessary to consult experts on the threat presented in the exercise.

Discussion–based exercises include seminars, workshops, tabletop exercises (TTXs) and games. Workshops and seminars can also be classified as a separate category called "orientations".

This kind of exercise has a focus on strategic, policy-oriented issues rather than operational factors. Orientation exercises are simple and low cost and should be considered the absolute minimum requirement for validating an EOC plan or sections thereof and/or a facility under development. Discussion-based exercises aim to familiarize participants with plans, policies, agreements and procedures, and often to develop them.

Tabletop exercises (TTX) are guided discussions on a hypothetical simulated emergency, based on a scenario and pre-defined 'injects' (paper messages, telephone calls etc.) that direct the players. Their main characteristic is that they focus not only on training but also on problem solving, through discussion of responses to the scenario. The goal of this kind of exercise is to validate plans and procedures, enhance public awareness, and train participants to react efficiently to an emergency.

Operations-based exercises include drills, functional exercises (FEs) and full-scale exercises (FSEs); the focus is on operational factors (actual reactions to an exercise scenario).

Drills are coordinated and supervised operation-based exercises, the main aims of which are to provide training on new equipment, validate procedures, or practice/maintain current skills at a single- or multi-agency level. Drills may test notification and communication systems, command posts, and evacuation procedures.

Functional exercises are planned to validate and evaluate EOC capabilities, functions, or particular activities within a function. Their aim is to exercise plans, policies and procedures in time-sensitive environments. They are usually conducted in the EOC facility, so available tools and technologies can be used and evaluated.

Full-scale exercises (FSE) are the most complex type of exercise, involve a number of agencies, and are designed to test many aspects of public health emergency response and recovery. A full-scale exercise includes all the activities taking place at the Emergency Operations Centre (EOC) as well as on-scene. Full-scale exercises simulating actual emergencies or disasters, although they test the preparedness system directly, are relatively infrequent because they are so resource-intensive.

3.2.4. Training and exercise development

CDC proposes focusing training on the following public health preparedness capabilities:

- Biosurveillance (public health laboratory testing, public health surveillance and epidemiological investigation)
- Incident management (emergency operations coordination)
- Information management (emergency public information and warning, information sharing)
- Community resilience (community preparedness and community recovery)
- Surge management (mass care, fatality management, volunteer management and medical surge)
- Countermeasures and mitigation (medical countermeasure dispensing, medical material management and distribution, non-pharmaceutical interventions and responder safety and health).

Summarizing all the above and taking into consideration the required competencies, the following training modules/courses may be proposed as the basis for public health EOC staff:

- General management (planning and use of resources, team building and negotiation, mentorship, networking/coordination)
- Public health emergency management (public health priorities in complex emergency situations, roles of different agencies at national, regional and international levels, responsibilities stemming from international regulations and legislation)
- EOC basics (organizational structure and staffing, main functions, roles and responsibilities, design, technology and equipment)
- Ethics and integrity (confidentiality, conflicts of interests)
- Incident management (emergency operations coordination)
- Information management (emergency public information and warning, information sharing)
- Communication management (risk communication, media handling, use of new technologies)
- Finance and administration
- IT and communication technology
- Biosurveillance (public health laboratory testing, public health surveillance and epidemiological investigation, data management)
- Community resilience (community preparedness, community recovery)
- Countermeasures and mitigation (medical countermeasure dispensing, medical material management and distribution, non-pharmaceutical interventions, responder safety and health, risk-specific topics for specific public health hazards (i.e. hazardous materials and CBRN terrorism – triage and management of mass casualties, hospital-based CBRN defence & planning)
- Surge management (fatality management, mass care, medical surge, volunteer management)
- For rapid response teams: outbreak investigation and control, infection control and decontamination (inspecting, inventorying, storing and purchasing personal protective equipment), social mobilization and communication, specimen collection and transportation, chemical event investigation and management and, if applicable, radiation event investigation and management.

Training assessment methods should be defined early in the development phase of a training programme as they allow instructional designers to find out if learning objectives have been met and how well the course was received. Possible assessment methods include pre/post tests, observation, presentations, exams, exercises, drills, self-reporting and many more.

Several international standards require trainers to demonstrate that they have the necessary experience, knowledge and understanding of the sector in which they are providing training.

A well-planned evaluation mainly includes three components: reliable and valid performance criteria or metrics for measurement; tools to track those metrics; and experienced evaluators.

3.2.5. Training and exercise delivery

Adults have special needs as learners and these needs should be considered when planning effective training in emergency management.

There are several methods of training delivery. These include classroom training and discussion-based workshops; self-paced courses based on printed content; webinars (online presentations during which participating viewers can submit questions and comments); and online/web-based courses in which teaching and learning are completed primarily through communication on the internet.

3.2.6. Training materials and tools

The materials and tools used for public health emergency management training can be searched for, examined and categorised according to the following aspects:

- Learning objectives
- Competencies and capabilities to be acquired after completion
- Information on the topic/title
- Minimum description of the course
- Available dates and modules
- Prerequisites
- Hours
- Delivery method
- Course provider and CEU credit (if any)
- Searchability of training by keywords or phrases
- Catalogues or calendars of upcoming events [227]
- Downloadable recordings, slides, presenter biographies, agendas, and evaluation forms (where available)

In customized learning management systems, like CDC's Train system [77] or CDC Training and Continuing Education Online [228], there are comprehensive searchable catalogues listing thousands of learning products.

3.2.7. Evaluation

Training evaluations should be used as quality control cycles for training providers to improve course delivery and/or instructional techniques.

Evaluation is the most important part of an exercise, as it leads to identification of strengths and weaknesses, lessons to be learned, and proposals for improvement.

Prior to the exercise, evaluators must be trained in how best to observe key tasks or activities found in the evaluation exercise guides [94, 129, 178-180, 193]. The evaluation team gathers all data from the exercise conducted and determines whether the objectives and targets were met.

"Hot debrief" is conducted immediately after the exercise is completed, giving participants the opportunity to provide their feedback for the exercise, and in particular on the successes and challenges observed. "Cold debrief" is conducted after a short period of time has elapsed, with key agency representatives and exercise staff highlighting areas of concern, as well as the positive outcomes of the exercise [178, 189, 193]. The After Action Report (AAR) is used to provide feedback to participating organizations on their performance during the exercise. The importance of after action reports is their proven ability to promote measurable system improvements.

The most common challenges reported in after action reports are emergency operations coordination and information sharing. These cross-cutting challenges should be taken into account by exercise planners when designing future emergency preparedness exercises, as they represent lessons that do not need to be 'learned again' in future disasters.

The formal evaluation of exercise performance has historically been inconsistent, and there is little research to describe how data acquired from simulated emergencies actually support conclusions about the quality of the public health emergency response system.

3.2.8. Continuous improvement

The final phase of a training and exercise plan is the improvement planning. After completing the evaluation phase, organizations identify strengths and develop a set of improvements based on gaps in core capabilities. These improvements are translated into concrete corrective actions that result in continually improving response capabilities (and hence preparedness) and are tracked as part of a corrective action programme or plan.

As regards exercises, it is widely suggested throughout the literature that when conducted systematically, they can highlight the gaps in the adequacy, validity and relevance of preparedness plans and established routines, as well as gaps in the capability of the organization to respond to the threat/incident simulated in the exercise.

Corrective actions should address the necessary changes to plans and procedures, organizational structures and management processes, as well as pinpoint training and equipment required to improve performance. However, improvement can be made only when the organization goes from identifying corrective measures to implementing them. For this reason, the corrective action plan should include concrete deadlines for implementation, and those responsible should report on progress at appropriate intervals to measure progress towards implementation.

3.2.9. Accreditation

The accreditation of courses and training providers should comply with statutory and regulatory requirements, although such requirements vary in nature.

3.3. MDSS review

3.3.1. EOC information needs

The major roles of an effective public health EOC are dependent on information. Throughout EOC activation, the ongoing collection and interpretation of information helps EOC leaders maintain the situational awareness required in order to respond effectively. Data are used to support responses to public health events in the following aspects:

- Supporting the key business processes of public health professionals at the local level
- Helping decision makers prioritize immediate needs and guide future system enhancements by identifying the critical cues of potential public health events
- Providing real-time information using data filters to enable understanding of what is happening, and how, when and where it is happening
- Determining the availability of staff to deliver services during routine and emergency operations
- Improving the design, testing, and execution of plans, preparedness, mitigation, coordination, and communication.

EOCs provide a platform for experts for collaboration and connectivity to the online community; provide communications between agencies and jurisdictions; and inform the public and elected officials of key emergency and responder details [15]. EOCs seek to secure all necessary information and ensure that it is properly reported and disseminated to all partners (e.g. the health cluster, donors, first responders) in a timely manner and at the appropriate levels [34, 35]. An effective EOC information system undertakes the following information management tasks:

- Collection
- Collation
- Processing
- Analysis
- Production
- Dissemination.

EOCs collect and process information from inside and outside their facilities to clarify the common operational picture required by emergency responders, and for planning, preparation for emergencies, and response to and recovery from emergencies.

Data collection during a response can be accomplished through direct observation, deployment of rapid assessment teams, use of health system data, population based surveys, and ongoing surveillance systems. The necessary information may be available in many forms, including on paper, in Excel files, in text files, in Access files, and in ArcView shape files. EOCs receive up-to-date information from various government departments, and data are also collected, using a variety of tools, from a range of sources including but not limited to EOC staff, other agencies, community members, and situation reports.

The MDSS review focussed on the type of operational information that would support EOCs in public health emergency preparedness and response. The review defined data elements as atomic units of EOC data that have precise meaning or precise semantics (e.g. date of birth, preliminary diagnosis) and which could be described by the following four aspects: name (name of the data element, e.g. patient ID); definition (e.g. unique patient identifier); representation format (e.g. coded values); and recommended standard (e.g. ICD-10).

During this review the data collection flows listed below were analysed with the goal of producing a suggested minimum data set for EOCs:

- Pre-hospital/emergency medical service (EMS)
- Hospital/emergency department (ED) information
- Death reporting/fatality management information
- National notifiable conditions information
- Syndromic surveillance information
- Laboratory surveillance information
- Immunization information
- Daily facility status reports (bed status).

One of the critical principles of the EOC minimum data set is its re-usability and interoperability. This principle allows for re-use of the same data categories and elements for different purposes (i.e. making different analytical products, sending reports to stakeholders etc.). A table of PHEOC functions, an example data set and example data elements are provided in the conclusion.

3.3.2. Current status of PHEOC operational information

Typical problems regarding collection and use of EOC operational information

Though it has been found that there is a positive relationship between the availability of information and emergency preparedness, communication between responding agencies remains a major shortfall in effective emergency response. Effective collection and quick communication of information and data—essential resources that translate into supplies, logistics and cooperation among relief agencies—are keys to success. However, the biggest challenge in a community could be that data and information are widely distributed and owned by a large number of organizations. Some relief agencies have their own data sources, while others do not, and some have no idea what information other agencies have that might help them in decision-making or emergency response.

A number of factors often prevent or delay access to vital information by governments, health professionals, and communities before, during, and after emergencies. These include inadequate information technology, lack of awareness about what information is available, and lack of training or skills necessary to obtain and manage the information.

The review suggested that insufficient information is shared between those at different levels – for example between field level, local EOCs, hospitals, and the state. This is partly because of a lack of defined and practical information gathering and reporting procedures among state and local authorities.

Poor communication makes it difficult to put together clear, accurate pictures of the effects of an emergency, or of what is happening at local level. Moreover, there is no standard definition of certain terms: for example it was found that 'hospital evacuation' could mean either moving patients out of one particular ward or total evacuation of the facility, depending on who was using the term. These findings indicate the need for standards and protocols for communication.

Data redundancies and duplication are major issues in information management. In addition, the data available in a public health emergency are usually complex, fragmented, and focused on individual patients and care providers, and not explicitly on public health needs. This is exacerbated when, as demonstrated in the relief phase layout of some EOCs in the review, existing EOC structures do not support good information management or provide unified command and control over relief operations.

Data collection and use during emergencies can be facilitated by strengthening ongoing surveillance systems, public health events systems, etc. before EOC activation.

3.3.3. Recommended EOC operational dataset

A minimum (essential) data set for EOCs should be defined and agreed, along with corresponding data/information exchange standards. This will support seamless exchange of data and information between multiple stakeholders in a timely manner. In addition, an e-Health architecture for EOC information exchange should be developed and/or augmented, based on health IT and health information data standards.

Given the range of existing stakeholders and contexts, there are numerous ways in which to view a framework for information interoperability in emergency management. The review showcases both the expansive impact and complexity of information interoperability for emergency management.

A suggested minimum dataset has been developed as part of this project and is laid out in the Conclusion, table 1.

3.4. CTI review

3.4.1. Existing EOC CTI framework & practice

ISO 22320:2011 Societal Security - Emergency management - Requirements for incident response defines information-sharing requirements for incident response. Specifically, it states that the success of joint multi-organisational or multinational responses depends on effective sharing of timely and accurate information. A common operational picture is essential for an effective information-sharing environment, and facilitates enhanced situational awareness.

The overall CTI architecture of EOC is typically divided into five components:

1. Facility systems
2. Communication systems
3. Database system
4. Emergency management system
5. Frontend display & terminals.

The review shows that EOC systems differ notably from country to country. The reasons for this vary widely according to factors including geography, population and level of economic development. In some countries the public health EOC may not be an independent system, but rather an integral part of a government EOC.

3.4.2. Challenges and barriers for public health EOC CTI

The requirements and functions of EOCs at different levels vary notably, and this diversity creates difficulty in interoperation—one of the most common challenges for effective operations of public health EOCs. The lack of unified requirements has led to heterogeneous system designs, causing incompatibility and preventing emergency information from being shared efficiently. This not only poses difficulty for multi-party collaboration among EOCs, response teams, and professional organisations, but is also detrimental to media and public understanding of emergency information.

Barriers to information sharing can also be aggravated by the lack of a unified information sharing strategy. While multiple departments, response teams and agencies are involved in emergency management, the general public—which is not familiar with organisational structures—may have difficulty finding correct information and advice.

Specific technical and operational challenges also exist, including those listed below.

Massive data
In various phases of the emergency management cycle, huge amounts of data are collected, generated and disseminated by CTI systems, posing a challenge for data storage capacity. Furthermore, these data are typically heterogeneous (consisting of plain text, digits, images, audio, video, etc.), entailing a need for specialised techniques for efficient management.

Interconnection and interworking
The operation of an EOC involves various departments and agencies, and therefore requires standardised operational mechanisms at different levels to guarantee effective connectivity and operational performance. It also gives rise to technological requirements related to issues such as network capacity, real-time information synchronisation, etc. This can be a challenge for older EOC systems.

Information sharing platform
An information-sharing platform such as the Global Disaster Alert and Coordination System (GDACS) should be established to facilitate data exchange and prevent organisational boundaries from hindering emergency management. Such a platform should incorporate data in various formats generated by heterogeneous departmental/organisational systems, and should provide a unified one-stop information portal for public health emergency operations.

Standard specification of API
Standardised application programme interfaces (APIs) are required to ensure the feasibility and efficiency of data transmission, especially for legacy systems based on outdated standards and technologies.

3.4.3. Construction of CTI for EOCs

The step-by-step process of constructing a public health EOC can be summarised as follows:

- **Planning and site selection**
  Location, operational mechanisms and other factors are considered in order to make appropriate planning and site selection decisions.
- **Workplace design and construction**
  Workplace design and construction focus on the operational infrastructure of application platforms. This may include rooms and systems, command & control, call-taking & dispatch, expert seminars, monitoring and a crisis room.
- **Decoration and wiring**
  Interior decoration and wiring are done after workplace construction.
- **Hardware installation**
  Hardware equipment and devices are installed following interior construction.
- **Testing of equipment**
  All hardware equipment must be tested to spot and rule out defects or malfunctions.
- **Software deployment**
  According to requirements of EOC business, software products are developed or procured. This includes generic and EOC-specific software.
- **Operation training**
  Software and hardware training includes operational techniques for various systems of the emergency platform.
- **Piloting operation and acceptance check**
  In order to guarantee that the system runs stably and each function performs as expected, a piloting operation and acceptance check process for the software system should be carried out before the project is finally delivered.
- **Operation & maintenance**
  Operation & maintenance (O&M) services are essential to ensuring the function of an EOC. O&M is a guarantee of technical stability and ongoing improvement of the system.

3.4.4. Public health EOC finance/cost-sharing models

Finance/cost-sharing models for EOCs that ensure effective emergency response are different in individual countries. Various funding sources worldwide include governments, NGOs, private companies, insurers, and citizens.

3.4.5. Recommended CTI Framework for public health EOCs

The conclusion of this review was a recommended framework for communication technology and infrastructure for public health EOCs. The framework is described in terms of key components of communications systems, facilities, software, security systems, exercise & training, and human resources & organisation systems, and is laid out in the Conclusion, table 2. ■

Limitations of data 4

Plans and procedures review

Study level: while there is a very large overall amount of grey literature on PHE plans, there is very little peer-reviewed literature that specifically identifies the core components of PHE plans or EOCs.
The lack of uniform terminology in emergency management has made it difficult to be consistent in searching grey or peer-reviewed literature: for example, one country's 'health EOC' may be another country's 'command centre' or 'situation room.'

At the outcome level, the primary limitation of this study was the limited time available to conduct thorough searches of both grey and peer-reviewed literature and thereby ensure key documents were identified. Staff availability varied throughout the project, and this resulted in some inconsistencies in the robustness of searches and data extraction.

Training and exercises review

This review looked at English-language studies only.

At the study level, it appears that few if any studies explicitly describe the core components of training programmes and exercises for PHEOCs. The lack of agreed common terminology and standardization on competencies, curricula and key performance indicators has been a barrier to identifying relevant documents. In addition, the review team faced difficulties identifying information on structured training programmes for public health emergency and EOC personnel in the peer reviewed literature.

Grey literature findings have indicated that in countries where an incident management system is developed, public health agencies adapt such systems in order to manage their responses to public health emergencies, and their trainings are consequently geared in this direction. However, taking into account the more consultative, consensus-seeking working culture of public health as compared to the more assertive command and control operations of a traditional ICS, the review team did not have enough time to discover whether and how such differences are reflected in the respective training.

It is also likely that the results of this review will be quickly outdated, as training is a dynamic process.

Minimum data sets and standards review

The review demonstrates that analyzed standards do not describe a direct relationship between EOC functions and data categories. However, they do contain substantial evidence on how these standards may apply to describe EOC-related data categories and elements.

Communications technology and infrastructure review

The search was restricted to publications in English and Chinese due to the limited linguistic capacity of team members. Evaluation of studies in other languages was impossible and therefore there was no inclusion of standards, regulations, policies or practices regarding CTI for public health EOCs in countries that do not use English or Chinese as a working language.

There is a lack of peer-reviewed studies of detailed CTI frameworks for generic or public health EOCs. Inconsistent terminology can present problems: The bulk of the literature on CTI frameworks consists of technical reports and industrial solutions which tend to utilise interchangeable names for similar systems and different taxonomies of technologies and services.

The main issue at the outcome level has been limited availability and continuity of team members. Throughout the process of searching the literature and compiling the recommended framework, staff members had to attend to additional commitments. This led to a degree of inconsistency in some parts of the report, where tasks initially assigned to specific members were later reallocated to others. ■

5 Gaps in research

5.1.1. Plans and procedures

At least two authors argue that literature on public health emergencies tends to rely on weak evidence or study design. Savoia et al note that since 2001, research literature on PHE preparedness has grown at about 33% per year, but "most studies lack a rigorous design, raising questions about the validity of the results"(155). Yeager et al assert that most of the PHE preparedness literature is based on commentaries and non-empirical works, "forcing policymakers and practitioners to rely on weak anecdotal evidence or opinions for decision making"(156).
This review has found few peer-reviewed articles that address the issue of whether or not an incident command system is the best way of managing a public health response, or how best to measure the effectiveness of a public health EOC. The key gaps in research therefore include the following questions:

This review has found few peer-reviewed articles that address the issue of whether or not an incident command system is the best way of managing a public health response, or how best to measure the effectiveness of a public health EOC. The key gaps in research therefore include the following questions:

- Is the traditional incident command system the most effective way of operating a public health emergency operations centre? Can the traditional ICS be adapted to respond better to public health emergencies? For instance, are scientific/technical experts best placed at the core of an ICS, or in the supporting functional cells (such as operations)?
- There is an assumption that all countries use an incident management system, but this may not be the case. If a 'model' public health IMS or EOC is developed, will it be adaptable to all countries?
- What is the best way to measure the effectiveness of an EOC? Is it possible, useful and/or best practice to measure outputs, outcomes and impacts? (e.g. output = number of vaccinators; outcome = number of people vaccinated; impact = outbreak is stopped).
- Apart from disease-related indicators, what other indicators should be measured? (e.g. environmental health measures on water quality, asbestos risk, and waste management; risk communication measures on awareness of risk and behaviour change)
- What are the barriers to complying with plans and operating procedures activated in an EOC?
- A lot of PHE preparedness literature focuses on communicable disease control. What is the risk of non-communicable diseases (NCDs) after a disaster and what is the role of public health in responding to them?

5.1.2. Training and exercises

A WHO global assessment of national health sector emergency preparedness and response found that although educating and training programmes have been progressively implemented by international, regional, governmental and non-governmental organizations during the last decade, the professional development of public health professionals for emergency preparedness and response remains largely inadequate. In the UK research studies on the same issue have implied that although training and exercises are a key component of developing preparedness, knowledge is lacking regarding their effectiveness.

It has also been suggested that because of the heterogeneity of public health systems and the variety of public health emergencies for which professionals must prepare, there is no "gold standard" for appropriate public health preparedness and response and optimal performance,
and hence the evaluation of exercises is rendered difficult.

The literature also suggests that although many groups have undertaken efforts to set agreed-upon competencies and standards for training and exercises, many variations exist, making it difficult to design and implement training that is cost-effective and applicable to everyday practice. ■

Conclusions 6

6.1. Plans and procedures review

The objectives of the plans and procedures review were to identify and describe standards and regulations, planning frameworks and guidelines, and plans and procedures related to public health emergency operations centres (PHEOCs). Other objectives were to identify the core components of plans and PHEOCs.

Planning frameworks

Planning frameworks for health emergencies should incorporate the following approaches:

- Risk management
- All-hazards approach (plus hazard-specific planning where it is necessary)
- All agencies approach
- The prepared or resilient community (able to respond to disaster at a local level)
- Comprehensive:
- Prevention/mitigation
- Preparedness
- Detection (when communicable disease are involved)
- Response and recovery.

Health emergency planning frameworks should use an incident management system that:

- Is standardised across emergency agencies
- Is modular, scalable and flexible
- Has interoperable plans and (tele)communications across agencies
- Uses uniform terminology
- Uses incident action planning and management by objectives
- Has a manageable span of control (ideally 1:5)
- Has a clear chain of command within agencies, and unified command across agencies
- Has clearly defined information flows
- Considers how scientific/technical expertise fits in the chain of command.

The cycle of emergency planning and preparedness should include:

- Risk assessment and monitoring
- Assessment of vulnerabilities in local populations
- Assessment of an agency's capacity and capability to respond
- Building and maintaining capacity (resources) and capabilities (training, credentialing)
- Testing capacity and capability to respond (exercises and real events)
- After action reviews
- Incorporation of lessons learned into plans.

Planning frameworks should include processes for:

- Building relations with other responding agencies, the media, and communities
- Predefined, streamlined decision-making processes within and across agencies
- Effective management of data, knowledge and information
- Protocols for inter-agency communication, internal communication within an agency, and risk communication with the public
- Effective management of human resources, including briefing, credentialing and rostering
- Planners should also ensure financial, legal and policy instruments are in place at a national and institutional level.

PHE plans

Public health emergency plans should include the following core components:

- The basic plan
  - Introduction
  - Purpose, scope, situation overview, guiding principles, planning assumptions
  - Concept of operations: response phases, incident levels or grades
  - Triggers and authority for EOC activation
  - Assignment of responsibilities
  - Incident management/command system
  - Prevention/preparedness/response/recovery components, either as separate plans or within the PHE plan
  - Authorities (legislation)
- Functional annexes
- Hazard-specific annexes
- Appendices.

Public health EOCs

Public health EOCs should operate within an incident management system, although how this IMS incorporates public health functions is debatable and constitutes a topic for further research. At a minimum, EOCs should include the roles of:

- Command
- Operations
- Planning
- Logistics
- Finance/administration
- Intelligence
- Investigations
- Information management
- Communication (internal, inter-agency and risk communication)
- Reporting/briefing
- Staff safety and security.

Depending on the type and scale of emergency, a number of roles may be combined, and some or all positions may be virtual. Careful consideration needs to be given to how public health functions – such as surveillance, data collection and analysis, quarantine, epidemiology, laboratory and disease control – ¬can best be integrated into the PHEOC's IMS to ensure an effective response. For instance, public health functions could be incorporated into one or more of the primary functional cells of an IMS (e.g. surveillance may be incorporated into intelligence), or they may have separate cells (e.g. for technical/scientific expertise). The chain of command for this public health expertise needs to be clearly articulated; it may be direct to the incident commander or it may be through the officer in charge of one of the primary functional cells.

Measures of EOC effectiveness

Measures and benchmarks may include:

- Assessments of risk, vulnerable populations, and an agency's capacity (resources) and capability (competency) to respond. These should be completed along with action or mitigation plans for priority issues or risks
- Resources adequate for a response should be built and maintained – covering physical, financial and human resources (including three-deep cover for key IMT roles)
- All-hazard response plans and standard operating procedures should be in place
- Legal and policy frameworks should be in place
- A standardised, scalable IMS should be identified that allows for effective coordination of all responding agencies
- The IMS should combine the most useful features of the traditional system with the necessary public health functions, such as surveillance, disease control, environmental health and vector control, social mobilisation and communication for behavioural impact

- Trained, competent staff should be available to be deployed at short notice (benchmark: staff deployed to IMT within 60 minutes)
- Surveillance and early warning systems should be in place (benchmark: decrease in time to detect/report public health threats)
- Minimum, standardised sets of indicators should be established
- Standardised and validated forms for effective capture of information and data should be available
- Disease control strategies should be in place (benchmarks: decrease in time to identify causes, risk factors and interventions; decrease in time to provide countermeasures and guidance to the affected; demonstrated decline in mortality and morbidity; demonstrated control of transmission rates)
- A risk communication plan should be in place (measure: time to issue a risk communication message to public)
- Methods for developing, maintaining and sharing situational awareness within and across agencies should be in place
- Streamlined, predefined processes for decision-making within and across agencies (including clearance and approvals processes) should be in place
- Decision support documents should be available, outlining the risks and benefits of different interventions
- Mutual aid agreements should be in place for sharing resources across jurisdictions and agencies
- Incident action plans (IAPs) should be developed during an emergency, with objectives that are continually measured and corrected during an operation (benchmark: IAP developed before start of second operational period)
- Post-exercise and post-event evaluations should be undertaken and lessons learned captured in after action reports, with subsequent action/implementation plans (measure: time from end of operation to date draft is submitted).

Priority topics for future research

- Can the traditional ICS be adapted to respond better to public health emergencies, i.e. by better incorporating scientific, technical and public health functions and expertise?
- Is it possible to develop a 'model' public health IMS or EOC; and if so, will it be adaptable to countries with different (or no) incident management systems?
- What is the best way to measure the effectiveness of an EOC or a public health emergency response?

6.2. Training and exercises review

Training and exercises (T&E) events should be conducted as part of an overall programme. A well-planned and developed T&E programme helps to ensure that T&E events are consistent, progressive and focused on common goals that will complement and build on each other.

The T&E programme should blend training and exercise events to engage trainees and reflect lessons from previous T&E events and actual emergencies.

Training

Training is any activity that transfers or modifies knowledge, skills and attitudes through learning experiences and helps individuals achieve a given level of proficiency. It can be performed for a number of reasons, including the need to maintain competence and respond to the demands of changing circumstances. Exercises, on the other hand, validate existing emergency plans, programmes, policies, roles, responsibilities and training curricula by testing staff capabilities, providing gap analyses, familiarizing personnel with plans and procedures, and increasing staff confidence while strengthening emergency response abilities.

Educational models, such as core competencies and learning outcomes, serve as benchmarks through which educators and administrators can consider the knowledge, skills and attitudes recommended for public health emergency professionals. For EOC training purposes competencies—the abilities required to perform work to expected standards— are usually organized in domains including but not limited to policy and programme planning; model leadership; communication management; information management; incident management systems; safety and security; administrative support; informatics; public health law and ethics; and public health sciences (assessment and analysis).

The mix of learning methods is selected for maximum effectiveness depending on the learning outcomes that must be achieved, the training environment, audience characteristics, and the experience of the trainer. Preparedness efforts rely primarily on three conventional training methods:

1. Classroom-based instructive teaching
2. Web-based training that consists primarily of pre-recorded, user-paced presentation materials
3. Real life drills and table-top exercises of varying scales. Though the advent of approaches using virtual reality environments appears to have gained ground in recent years, their implementation still poses some challenges.

Learning requires active involvement. As people learn best in different ways, a variety of training opportunities and techniques should be in place. Options range from short courses to long-term placements in training organizations, domestically or elsewhere, and all options should be weighed against the immediate operational needs of the EOC.

Clearly defined and consistent credit systems facilitate recognition of training programmes between institutions and countries and improve student learning and choice, but the systems of credits vary widely between different countries and even within countries.

Through training evaluation, both at course and programme level, data is collected on how well the learners achieved the course objectives and how satisfied they were with the training experience. The impact of training on job performance, although difficult to assess, can help identify the need for additional training or reinforcement of newly acquired skills.

Exercises

Exercises are events that allow participants to apply their skills and knowledge in order to improve operational readiness. An exercise is a simulated emergency in which players carry out actions, functions, and responsibilities that would be expected from them in a real emergency. Exercises can be used to validate EOC plans and procedures, to practice prevention, mitigation, preparedness, response, and recovery activities, and to build relevant capacities. Exercises should therefore be considered an integral component of an organization's preparedness planning.

Inter-agency, regional or international exercises also help improve interagency cooperation and interoperable communication.

The literature suggests key steps for developing an effective exercise programme; these are listed below.

- Review existing emergency plans and gather data from previous training and After Action Reports in order to address: hazards; most vulnerable areas; functions most in need of exercising; potential participants; and exercise requirements and capabilities
- Define achievable goals and objectives for the exercise programme
- Identify participants and appropriate type of exercise based on above assessments. Ideally include different types of exercises of increasing complexity over time, including discussion-based and operations-based exercises
- Develop scenarios that are hazard-based, realistic, plausible, and challenging
- Define an evaluation process (select lead evaluator; develop evaluation exercise guides; recruit, train and assign evaluators; develop and finalize evaluation documentation; and conduct a pre-exercise briefing for controllers and evaluators)

- Secure resources for execution (financial, equipment and facility-related)
- Establish a training area and brief participants on their respective roles and responsibilities
- Execute the exercise(s)
- Evaluate the training objectives and criteria by analysing data gathered during the exercise(s).
- The final phase of a training and exercise plan is the improvement planning. After completing the evaluation phase, organizations identify strengths and develop improvements based on core capability gaps. This set of improvements is translated into concrete corrective actions that will result in continually improving response capabilities (and hence preparedness), and which are tracked as part of a corrective action programme or plan.

Priority topics for future research

From the gaps in the literature, it seems that several areas need to be taken into account in order to develop future research. Additional work is needed to develop reliable measures to gauge exercise performance, inform follow-up actions and assess the impact of post-exercise interventions. Moreover, in order fully to explore possible advantages, further studies should be undertaken as comparative research looking at virtual reality-based and traditional modalities of training.

Extended effort must go into developing a framework and standardized terminology for universally accepted and adapted competency sets for public health emergency preparedness. The content of the curriculum will be determined by the competencies that EOC staff should possess.

As training should be designed in such a manner as to be relevant and applicable to practice, it is advisable that the basis of a training and exercise programme for Public Health Emergency Operations Centres be developed on the basis of the findings of the reviews looking at EOC Communication technology and infrastructure; minimum data sets and standards; and procedures and plans.

Finally, two other things must be developed: a set of common standards devised through collaborative networks, which will be guaranteed across countries; and a certification system to support high-level training activities in this field.

6.3. MDSS review

A minimum (essential) data set and corresponding data/information exchange standards should be defined and agreed to support seamless exchange of data and information between multiple EOC stakeholders in a timely manner.

In addition, it is necessary to develop and/or augment existing e-Health architecture for EOC information exchange, based on health IT and health information data standards.

A suggested minimum dataset has been developed as part of this project and is laid out in Table 1.

Table 1: Suggested minimum dataset of a PHEOC by functions

Function	Essential activities	Information need/ category	Data elements	Recommended data elements format	Mini-mum	Optio-nal	Data elements description
1. Managing & commanding							
	1.1. Decisions and approvals	***1.1. Activate/deactivate decision***	Event ID	Free text	✔		A unique event identifier
			Decision activate/deactivate	Coded value			This is a flag that shows the purpose of the action (activate or deactivate)
			Event description	Free text			Provides characteristics of the event (i.e., time, location, casualties, etc.)
			Trigger description	Free text			Defines conditions that trigger early response
			Threshold	Free text			Defines conditions that terminate event
		1.1.2. Plan approval	Event ID	Free text	✔		Unique event identifier that is associated with plan
			Plan title	Free text			Title of the plan
			Plan purpose	Free text			Description of the plan's purpose
			Plan approval date	Date, month and year format			Date when the plan was approved
			Date, month and year format	Date, month and year format			Date when the plan's actions should be completed
			Planning authority	Free text			The name of the organizational entity that approved the plan
	1.2. Coordination	***1.2.1. Partner list***	Partner name	Free text	✔		Name of the organization partnered with EOC
			Partner organization contact information	Free text			Partner organization contact information (address, phone, email)
			Contact person	Free text			Name and contact information of the contact person in a partner organization
			Capabilities	Free text			Description of what the partner could/should do in relation to the response
		1.2.2. Partner tasking	Assigned task	Free text	✔		Description of tasks assigned to the partner for a specific event
			Due date	Date, month and year format			Due date for a task that was assigned to a partner
	1.3. External communication	***1.3.1. Public communications***	Public communication document type	Free text	✔		Type of public communication document
			Name of event or disease associated with public communication	Free text			The name of an event or disease that was associated with a document release
			Document name/title	Free text			Name or title of the communication document

		Public communication templates	Free text		List of public health communication templates with codes for each template
		Target groups	Free text or coded value		Description of target groups for a communication document
		Context of a public communication	Free text		Context of a public communication document (situational or rumor surveillance report, alert or warning, etc.)
		Region for alert or warning	Free text or coded value		Region covered by alert, warning or other document
		Date of public communication release	Date, month and year format		Date when a communication report was released
	1.3.2. Intra-agency communications	Intra-agency communication document type	Free text or coded value	✔	Type of intra-agency communication document, e.g. situational report, alert or warning, etc.
		Name of event or disease associated with public communication	Free text		Name of event or disease associated with a document release
		Context of a intra-agency communication	Free text		Context of an intra-agency communication document
		Date of intra-agency communication	Date, month and year format		Date when a communication report was released
1.4. Leadership assigned	***1.4.1. Incident commander (IC) information***	Incident commander (IC) name	Free text	✔	Incident commander (IC) name
		IC professional background	Free text		Description of a skill set related to EOC
		IC contact phone	Free text		IC contact phone number
		IC contact email	Free text		IC contact email
	1.4.2. Response section information	Response section's responsibility	Free text	✔	Description of response section's tasks
		Response section chief's name	Free text		Response section chief's name
		Response section chief's contact phone	Free text		Response section chief contact phone
		Response section chief's contact email	Free text		Response section chief contact email
	1.4.3. Response plan	Issue/updated date	Date, month and year format	✔	Date when a plan was issued or updated
		Response plan content	Free text		Response plan content

	1.4.4. EOC daily schedule	Date/time of EOC daily task schedule	Date, month, year and time format	✔	Date/time of tasks in EOC daily schedule
		Place of EOC daily task schedule	Free text		Place of tasks in EOC daily schedule
		Content of EOC daily task schedule	Free text		Description of tasks in EOC daily schedule
		Participants in EOC daily task schedule	Free text		List of staff assigned to the tasks
1.5. IMS	*1.5.1. Start/terminate response*	Event ID	Free text	✔	Unique event identifier
		Event description	Free text		A list of the characteristics of the event (e.g. time, location, casualties, etc.)
		Trigger description	Free text		Defines which conditions trigger early response
		Threshold	Free text		Defines conditions in which certain responses should be terminated
		Response status	Free text		Description of a response status
	1.5.2. Response team	Event ID	Free text	✔	Unique event identifier associated with the response team activation/deactivation
		Trigger description	Free text		Defines conditions that trigger response team activation
		Threshold	Free text		Defines conditions that trigger response team deactivation
		Response status	Free text		Defines the current status of a team's participation in an event (example values: pending/dispatching)
		Team leader name	Free text		Team leader's name
		Team leader title	Free text		Team leader's title
		Team leader contact information	Free text		Phone and email of the team leader
		Team member name	Free text		Team member's name
		Team member title	Free text		Team member's title
		Team member contact information	Free text		Phone and email of the team member
		Responsibility	Free text		Description of tasks that were assigned to the team for a specific event
2. Operating					
2.1. Task tracing	*2.1.1. Task information*	Task ID	Free text	✔	A unique task ID
		Task description	Free text		Details of the task
		Assigned to	Free text		Title, name, position of a person to whom a task was assigned

		Assignment date	Date, month and year format		Date of task assignment
		Due date			Due date for task
		% Complete			Percentage of task completion on a specific date
2.2. Event investigation	***2.2.1. Event status***	Date	Date, month and year format	✔	Date of report
		Location	Free text or coded value		Location of the event
		Type of event	Free text or coded value		Event type (e.g. infectious disease, earthquake, etc.)
		Cases in past	Numeric value		Number of cases that occurred in the past
		Event/disease name	Text or coded value		Name of event/disease
		Daily new cases	Numeric value		Number of new cases daily
		Cumulative cases	Numeric value		Number of cases in total (number is equal to daily new cases plus cumulative cases)
		Epidemiological investigation	Free text		Results of epidemiological investigation
		Etiology analysis	Free text		Description of event etiology
		Symptoms	Free text		Description of symptoms
		Event level	Free text or coded value		Event level (i.e., minimal, minor, moderate, major, severe)
	2.1.3. Risk assessments	Date	Date, month and year format	✔	Date of assessment
		Reason for assessment/incident name	Free text		Reason for the assessment or/and incident name
		Participants	Free text		Name of the participants
		Result	Free text		Description of assessment results
	2.1.4. Laboratory operations report	Report date/time	Date, month, year and time format	✔	Date and time for submission of laboratory operations report
		Total number of tested people	Numeric value		Total number of tested people
		Total number of people with final confirmed positive laboratory diagnosis	Numeric value		Total number of people with the final confirmed positive laboratory diagnosis
		Total number of people with preliminary positive laboratory diagnosis	Numeric value		Total number of people with the preliminary positive laboratory diagnosis
		Total number of people with final negative laboratory diagnosis	Numeric value		Total number of people with the final negative laboratory diagnosis

2.3. Controlling	***2.2.1. Countermeasures operations***	Incident name	Free text	✔	Incident name associated with a countermeasure
		Countermeasure name	Free text		Countermeasure name
		Countermeasure report date/time	Date, month, year and time format		Countermeasure report submission date/time
		Countermeasure description	Free text		Description of the countermeasure
		Countermeasure assignments status	Free text		Status of tasks related to the implementation of a countermeasure (e.g. number of antibiotics doses that were administrated, number of vaccinated people)
3. Planning/Intelligence					
3.1. Situation analysis	***3.1.1. Infectious diseases reporting and surveillance***	Patient ID	Free text	✔	Unique patient identifier
		Name	Free text		Patient name
		Sex	Free text or coded value		Current sex of the subject of the report (i.e., female, male, undifferentiated). Example of a value set may be found in CDC implementation notes at: https://phinvads.cdc.gov/vads/ViewValueSet.action?id=6358110D-9517-E011-87A0-00188B39829B
		Age	Numeric value		Age of the subject of the report
		Detailed address	Free text		Home address
		Disease/Injury name/code	Free text		Disease or injury name and code
		Illness onset date	Date, month and year format		Date of first appearance of the signs or symptoms of an illness
		Diagnosed date	Date, month and year format		Date/time the diagnosis was made
		Confirmed or suspected	Free text or coded value		Disease diagnosis confirmation likelihood in regards to symptoms and clinical/laboratory confirmation (probable case, suspected case or confirmed case)
		Disease outcome type	Free text or coded value		Result of disease (i.e., full recovery, partial recovery, death)
		Disease outcome date	Date, month and year format		Date when an outcome of disease occurred (may provide a date of death or recovery)
	3.1.2. Laboratory reporting	Reporting laboratory identifier	Free text or coded value	✔	Identifier for the laboratory sending the result
		Report date/time	Date/time format		Date/time of report
		Report status	Free text or coded value		Status of report (examples of coded values: preliminary, final, corrected)
		Specimen collection date/time	Date/time		Date and time for a specimen collection
		Specimen origin	Free text or coded value		Domain from which the specimen comes (e.g. blood culture, anaerobic bottle). For example of a value set, see HL7 Table 0488, Specimen Collection Method

	Specimen type	Free text or coded value		Description of the precise nature of the source material for the observation (e.g. lesion, fluid, respiratory etc.). For example of a value set, see HL7 Table 0487, Specimen Type
	Diagnostic test performed	Free text and code if available		Diagnostic test name and code (if available) from reporting laboratory
	Test result date/time	Date/time		Date/time when a test was completed
	Test result status	Coded value		Describes a completion or status of the result (preliminary, final, corrected). For example value see at H17 Table 0123, Result Status
	Test result	Free text and code if available		Description of test result
	Test result interpretation	Free text and code if available		Interpretation of test results (i.e., abnormal, above high normal). For examples of values see HL7 Table 0078, Abnormality Flags
3.1.3. Public health emergency event surveillance	Date	Date, month ,year and time format	✔	Date/time of report
	Location	Free text		Location of report
	Casualties	Quantity		Persons reported injured or killed
	Event type	Text or coded value		Description of the event (e.g. food poisoning, natural disaster, unclear accident, etc.) or event type code
	Likelihood	Coded value		Probability of an event occurring (examples of coded values: very unlikely, unlikely, likely, highly likely, almost certain)
	Consequence	Coded value		The downstream effects resulting from an action or condition that may be negative or positive. A negative public health consequence causes or contributes to ill health. Consequences may include social, technical and scientific, economic, environmental, ethical, or policy and political effects. (Examples of coded values: minimal, minor, moderate, major, severe)
3.1.4. Rumour surveillance	Date	Date, month and year format	✔	Date when event occurred
	Provenance	Free text		Newspaper or website where record was found
	Event title	Free text		Event title
	Key words	Free text		List of key words that characterize event
	Content	Free text		Event description as it appeared in the original reference source

			Reliability	Free text		The degree of stability of results exhibited when a measurement is repeated under identical conditions
			Timeliness	Free text		Timeliness of the record
			Level	Free text or coded value		Level of severity
			Supervision department	Free text		Name of the organization
	3.1.5. Daily watch-keeping record		Date/time	Date, month, year and time format	✔	Date/time of reception
			Incident name	Free text		Name of the incident associated with the daily watch-keeping record
			Approach	Free text or coded value		Informer's method of approach (i.e., telephone, e-mail)
			Content	Free text		Content of the record
			Informer name	Free text		Name of the informer
			Informer contact information	Free text		Contact details of the informer (i.e., telephone, e-mail)
			Result of processing	Free text or coded value		What has been done based on the information
	3.1.6. Risk assessment and consultation(conferencing)		Date/time	Date, month, year and time format	✔	Date of the consultation meeting
			Incident name	Free text		Name of the incident associated with the risk assessment
			Conference location	Free text		Location of the consultation meeting
			Participants	Free text		Names, titles of participants
			Result	Free text		Result of the consultation
	3.1.7. Situation report		Date/time	Date, month, year and time format	✔	Date/time when a situation report was developed
			Incident name	Free text		Name of the incident associated with the daily watch-keeping record
			Situation description	Free text		Description of a situation
			Reporter	Free text		Name and a title of the person who submitted a report
3.2. Planning	***3.2.1 Plan development***	3.2.1.1 Authority to plan	Activation decision	Free text or coded value	✔	Description of the activation of an action plan based on the assessment of the situation
			Planning period	Date/time		Date, month, year and time format
		3.2.1.2 Situation report	Overview	Free text		Overview of a situation
			Key Issues to resolve	Free text		Description of key issues that should be resolved by specific plan's action/task
		3.2.1.3 Plan components	Objectives	Free text		Development of initial operational objectives for public health emergency response
			Target outcomes	Free text		Desired outcomes after the actions are taken

3.3 After action review	***3.3.1 After action report***	Objective achievement	Free text		Identification of successes during emergency operations
		Problem analysis	Free text		Identification of problems during emergency operations
	3.3.2 Improvement plan	Responsible person	Name		Person responsible for implementing improvements
		Activity	Free text		Describes and defines a series of actions for implementing improvements
3.4. Information management	***3.4.1. Document management***	Key words	Free text		Significant words used in indexing or cataloguing
		Document type	Free text or coded value		Document type (e.g. plan, standard operation procedure)
		Title	Free text		Heading of the document
		Source	Free text or coded value		Where the record was from
		Content	Free text		The subject that the document addresses, or the ideas that it expresses
		Issue date	Date		Date on which the document was announced or received
4. Logistics					
4.1. Resources management	***4.1.1. Health agencies***	Agency type	Free text or coded value	✔	Public heath or medical agency
		Staffing quantity	Numeric value		Level of staffing in a medical agency (e.g. 200)
		Staffing specialty	Free text		An area of study or business in which a staff member specializes or of which they have special knowledge
		Equipment	Free text		Name, type and quantity of equipment
		Hospital beds quantity (general/special)	Numeric value		Availability of hospital beds (number)
		Expansile beds	Numeric value		Availability of expansile hospital beds (number)
		Laboratory test items	Free text or coded value		Description of lab test an agency could do
		Contact information	Free text or coded value		Telephone, e-mail
	4.1.2 Experts and staff	ID	Free text	✔	Unique staff identifier
		Name	Free text		Staff name
		Age	Quantity		Age of the subject of the report. May be a numerical value (e.g. 43)

	Sex	Coded value		Current sex (i.e., female, male, undifferentiated) Example of a value set may be found in CDC implementation notes at: https://phinvads.cdc.gov/vads/ViewValueSet.action?id=6358110D-9517-E011-87A0-00188B39829B
	Skill	Free text		An area of study or business in which a staff member specializes or of which they have special knowledge
	Organization	Free text and coded value		Name of the organization to which a staff member is affiliated
	Education	Free text		Staff member's education level, certificate/s and/or training
	Title	Free text and coded value		Staff member title. Example of coded values: professor, associate professor, investigator, associate investigator, technical officer, etc.
	Contact information	Email, mobile phone		Staff contact details: email, mobile phone
	Health emergency experience	Free text		Description of health emergency experience
4.1.3 Rapid response team	Name/title	Free text	✔	Team name (e.g. emergency rescue team, radiological emergency medical team, etc.)
	Category	Coded value		Example of coded values: emergency rescue teams, radiological emergency medical team, etc.
	Responsibility	Free text		Description of tasks that were assigned to the team for a specific event
	Team member (name)	Free text		Name of the person
	Equipment	Free text		Name, type and quantity
	Team leader	Free text		Name of the person
	Competent organization	Free text		Name of organization
4.1.4 Volunteers	Name	Name		Volunteer name
	Age	Quantity		Age of the subject of the report. May be a numerical value (e.g. 43)
	Sex	Coded value		Current sex (e.g. female, male, undifferentiated) Example of a value set may be found in CDC implementation notes at: https://phinvads.cdc.gov/vads/ViewValueSet.action?id=6358110D-9517-E011-87A0-00188B39829B
	Specialty	Free text		An area of study or business in which a staff specializes or of which they have special knowledge
	Contact information	Free text		Staff contact details: email, mobile phone

	4.1.5 Reserves of emergency supplies	Items	Free text and coded value	✔	Nature of supplies
		Category	Free text and coded value		Examples of coded values: medical materials, equipment, etc.
		Organization	Free text		Name of organization
		Location	Free text and coded value		Storage location
		Stockpile	Number		The amount of supplies kept ready for future use
		Expiry date	Date		Expiry date of the supplies
		Suppliers	Free text		Name of the organization
	4.1.6 Shelter	Name	Name	✔	Name of the shelter
		Location	Free text		Location of the shelter
		Infrastructure	Free text		Infrastructure of the shelter
		Responsible organization	Free text		Name of the organization
4.2. ICT support	***4.2.1. Technology assessment***	Technology type	Free text	✔	Type of ICT technology (e.g software, database, etc.)
		Technology name	Free text		Technology name
		Technology description	Free text		Technology description
		Technology steward first name	Free text		Technology steward first name
		Technology steward last name	Free text		Technology steward last name
		Technology steward contact information	Free text		Technology steward contact information
	4.2.2. Physical security assessment	Assessment subject	Free text	✔	Subject of the physical security assessment (e.g. flood prevention, fire protection etc.)
		Name of the task or system	Free text		Name of the security system
		Description of the task/system	Free text		Description of the security system and tasks
		Assigned to/person's title	Free text		Title of the person assigned to the system
		Assigned to /person's first name	Free text		First name of the person assigned to the system
		Assigned to /person's last name	Free text		Last name of the person assigned to the system

5. Finance/administration					
5.1 Budget management	***5.1.1 Budget***	Amount	Numeric value	✔	Budget amount
		Source	Free text		Where the budget comes from. Example values: government, NGO, etc.
		Activity	Free text		Budget breakdown and justification
		Implementing unit	Free text		The unit enforcing the budget
	5.1.2 Donor	Name	Free text	✔	Name of the donor organization
		Contact information	Free text		Donor contact information: email, mobile phone
		Items	Free text		Nature of a donation
		Quantity	Numeric value		Amount of a donation
5.2 Purchase and dispatch	***5.2.1 Purchase***	Amount	Numeric value	✔	Amount of money
		Activity	Free text		Appropriation expenditure
		Implementing unit	Free text		The unit enforcing the budget
	5.2.2 Dispatch	Items	Free text	✔	Record of dispatching
		Receiver	Free text		Destination/intended recipient of emergency supplies
		Quantity	Numeric value		The amount of distribution
5.3 Human resources management	***5.3.1 Human resources***	Category	Free text or coded value	✔	Staff, volunteer, etc.
		Name	Name		Staff name
		Age	Numeric value		Age of the subject of the report. May be a numerical value (e.g. 43)
		Sex	Coded value		Current sex (i.e., female, male, undifferentiated) Example of a value set may be found in CDC implementation notes at: https://phinvads.cdc.gov/vads/ViewValueSet.action?id=6358110D-9517-E011-87A0-00188B39829B
		Skill	Free text		An area of study or business in which a staff member specializes or of which they have special knowledge
		Organization	Free text and coded value		Name of organization or branch to which the staff member belongs
		Education (certificate/training)	Free text		Staff member education level, certificate/s and/or training
		Professional title	Free text and coded value		Title of staff member. Examples of coded values: professor, associate professor, investigator, associate investigator, technical officer, etc.
		Contact information	Free text		Staff contact details: email, mobile phone
		Health emergency experience	Free text		Description of health emergency experience

6.4. CTI review

The conclusion of this review was a recommended framework for communication technology and infrastructure for public health EOCs. This is laid out in the table below. To improve the practicality of this recommendation, technological items are categorised as follows:

- **Basic** components include those CTI components meeting the core requirements of a functional public health EOC
- **General** components are elements widely utilised and observed in developed countries around the globe
- **Optimum** components are those additional technologies and devices recognised as having a potentially important role in the ideal vision of public health EOC. These are listed as "optimum" because they are not currently widespread, due to technological or cost factors.

Where possible, countries with relatively limited budgets should use freeware or open source alternatives to commercial software.
The software should be arranged so that an integrated emergency management platform is established that incorporates:

- Hazard identification
- Risk assessment
- Monitoring and surveillance
- Pre-plan and pre-warning systems
- Dynamic decision-making
- Response coordination
- Simulation & training
- Information sharing.

A number of software packages and/or systems are recognised as pertaining to emergency management. These include the emergency & crisis management system (ECMS); the epidemic intelligence information system (EPIS); the incident management system (IMS); and the joint information system (JIS). They display capabilities and responsibilities that overlap and which make them, to some extent, similar. While ECMS accounts for the entire management cycle of an emergency, EPIS (which was developed by the European Centre for Disease Prevention and Control, or ECDC) can be seen as a version of ECMS tailored to public health. IMS is concerned with the full life-cycle management of incident information; and JIS was devised as a standardised mechanism for information exchange between agencies and with the public.

The components, existing communication technologies and infrastructural elements of public health EOCs are summarised in the following table.

Table 2: Recommended CTI framework for public health EOCs

			Portable/Field EOC	Static/Permanent EOC
1. ICT hardware, services and security (office equipment, telecommunications equipment, technological infrastructure, telecommunications infrastructure including telecommunications software, IT security)	1.1 Office equipment	Printer	B	B
		Copier	B	B
		Fax (if applicable)	B	B
		Scanner	B	B
		Multi-functional printer (as alternative to the above)	B	B
		Plotter	O	
		Multi-line fax system (if applicable)	O	
		Supplies for office equipment	B	B
	1.2 Telecommunication equipment and services	Radio base station	G	G
		Handheld portable radios	G	G
		Satellite data communication (primary or backup)	O	O
		Satellite telephones	O	G
		Public switched telephone network (PSTN)	B	O
		Basic internet connectivity	B	B
		High speed internet connectivity	G	G
		Audio-visual multi-point conferencing bridge or equivalent services	G	O
		Repeater/tactical communication bridge	S	S
		Permanent network connections between sites and centres located outside EOCs (if applicable)	O	O
		Private automatic branch exchange (PABX)	G	O
		Telephone/video conferencing	B	G
		Web conferencing	G	G
		Messaging system (telephone, instant messaging)	G	G
		E-mail system/services	B	B
		Voice/video over IP (VoIP)	G	O
		Integrated communications control system (ICCS) (radio & telephone)	S	S
	1.3 Network infrastructure	Network devices (switch, router)	B	B
		Local area network (LAN)	B	O
		Wireless network	G	G
		Information broadcast and exchange	O	O
		Network redundancy	O	O
		Network virtualisation/ software-defined networks (SDN)	S	S
	1.4 Technological infrastructure	Computers (desktop/laptop/ tablet)	B	B
		Data storage (physical/virtual)	B	B
		Servers (physical/virtual)	G	G
		Cable/Satellite/Internet Television	G	G
		DVD/Blu-Ray player/recorder	B	G
		Large video display/video wall/projector	B	B
		Video & audio matrix switch	G	O
		Central (remote) control system	O	O
		Media streaming	O	O
		Field substance detectors	S	S
		Audio system	B	B
		Wireless sensor networks	S	S
		Radio frequency identification (RFID)	S	S
		GPS devices	S	G
		Remote imaging system	S	S
		Digital recorder	O	O
	1.5 IT security	Firewall	B	B
		Encryption	B	B
		Virtual private networks (VPN)	G	G
		Anti-virus/-malware	B	B
		Vulnerability scanning	G	G
		Local data redundancy	B	B
		Network data storage/ redundancy	G	O
		"Cold" off-site backup strategy	B	B
		"Warm" off-site backup strategy	G	G
		"Hot" off-site backup strategy	O	O
		Rapid service recovery	O	O
		System administration security	G	G
2. Information management software	2.1 Functions	Predictive analysis & modelling	GA	GA
		Surveillance (health/ all hazard), analytics, and statistics	GA	GA
		Alert/early warning	BP	BP
		Planning	BP	BP
		Emergency call-taking & dispatch	GA	GA
		Emergency evacuation system	SR	SR
		Risk management	GA	SA
		Data/situation analytics	GR	GR
		Tasking & on-scene command	BA	BA
		Roster/human resource management	GA	GA
		Resource management (administrative)	GA	GA
		Contact management	BA	BA
		Conferencing & communication scheduling system	BA	BA
		Activity logging	BA	BA
		Collaboration platform	GR	GR
		Data management (collection/analysis/sharing)	BA	BA
		Document management	BA	BA
		Knowledge management	GA	GA
		Training	GA	GA
		Reporting/visualisation	BA	BA
		Geographic information system (GIS)	GA	GA
		Electronic health record (EHR) system	GA	GA
		Public communication	BA	GA
	2.2 Characteristics	Server-based	G	G
		Cloud-based	O	O
		Standalone	B	B
		Real-time/dynamic	G	O
		Optimised for mobile devices	G	G
		Offline mode	O	G
		Interoperability	G	O
		Scalability	G	O
		Modularity	O	O

Legend: B=Basic, G=General, O=Optimal, S=Specialized, M=Mitigation, P=Preparedness, R=Response, A=Throughout all phases

			Portable/Field EOC	Static/Permanent EOC
		High availability	B	G
		Multi-language interface	O	O
		Open source	O	O
		Proprietary	S	S
		User friendly	B	B
		Specialized (for experts)	O	O
		Virtual EOC	O	O
3. Infrastructure (facility, security, furniture)	**3.1 Premises support**	Dedicated building in proximity to decision makers	O	O
		Multi-purpose space converted within reasonable time frame (e.g. one hour)	B	B
		Dedicated room/suites	G	G
		Emergency service call room	B	B
		Separate meeting rooms for priority discussion	G	O
		Conference room	G	O
		Surveillance room	G	O
		Operation room	G	G
		Briefing space for visitors and media	G	O
		Public information office/joint information centre (PIO/JIC) and media	G	G
		Room to house external and non-jurisdictional entities	O	O
		Communication equipment room	G	O
		Separate communication centre (emergency call room)	O	O
		Storage room	G	G
		Cloakroom	O	O
		Medical treatment space	O	O
		Break and recreational space	O	O
		Staging area for transport (air or land)	O	O
		Access to personal hygiene facility	B	B
		Personal hygiene (shower and laundry) and related supplies	G	O
		First aid	G	G
		Water & food availability & storage	B	B
		Standalone water supply	S	S
		Lighting	B	B
		Mains electricity power supply	B	B
		Backup diesel generator	B	B
		Uninterruptible power system (potentially with filtering capability)	B	G
		Broadcasting system	G	G
		General environment control (air conditioning, ventilation, lighting, etc.)	G	O
		Stand-alone HVAC (heating, ventilation and air conditioning) system	O	O
		Cabling system infrastructure	B	O
		Acoustic treatment	O	O
		Built-in levelling system	S	G
		Light tower/remote area lighting system	S	O
		Emergency alarm system	G	G
		Weather-resistant fold-out shelter system	S	B
		Mobile signal blocker/booster	S	S
		Dedicated space for ICT support	G	O
	3.2 Furniture	Workstation with space for computer, display, keyboards, mouse, telephone, stationery, etc. Retractable or arm stand for display may be considered	B	B
		Chairs	B	B
		Console with adjustable viewing angles and sight lines	G	G
		Easily access to personal power outlets	B	B
		360 degree chair rotation	G	G
		Pneumatic seat height	G	G
		Backrest angle/height/depth	G	G
		Ergonomic and modular design of console	O	O
		Dimmable workstation task lighting	O	O
		Seat angle and tension control	O	O
		Seat lumbar pump	O	O
		Seat armrest height/rotation/ swivel/width	O	O
		Seat headrest height/depth	O	O
	3.3 Premises security	Surveillance/integrated video management system (IVMS)	G	G
		Perimeter protection	G	G
		Dangerous goods scanning	G	G
		Access control	G	G
		Flood prevention	G	G
		Disaster protection (natural or human-incurred)	B	B
		Public address system	G	G
		Fire protection	B	B
4. Training and exercises for ICT and infrastructure	**4.1 Improve relevant ICT skills of the EOC users**		B	G
	4.2 Specialised training for ICT support staff		G	G
	4.3 Induction for EOC users on facility utilisation		B	G
	4.4 Simulation involving use of facilities and ICT infrastructure		G	O
	4.5 Evaluate readiness based on results of simulation(s)		O	O
5. Human resource needs for ICT and infrastructure	**5.1 EOC facility manager**		G	O
	5.2 Information management		G	G
	5.3 ICT support		B	B
	5.4 GIS specialist		O	O
6. Support	**6.1 Hardware support and maintenance**		B	B
	6.2 Software support and maintenance		B	B
	6.3 Maintenance of premises		B	B

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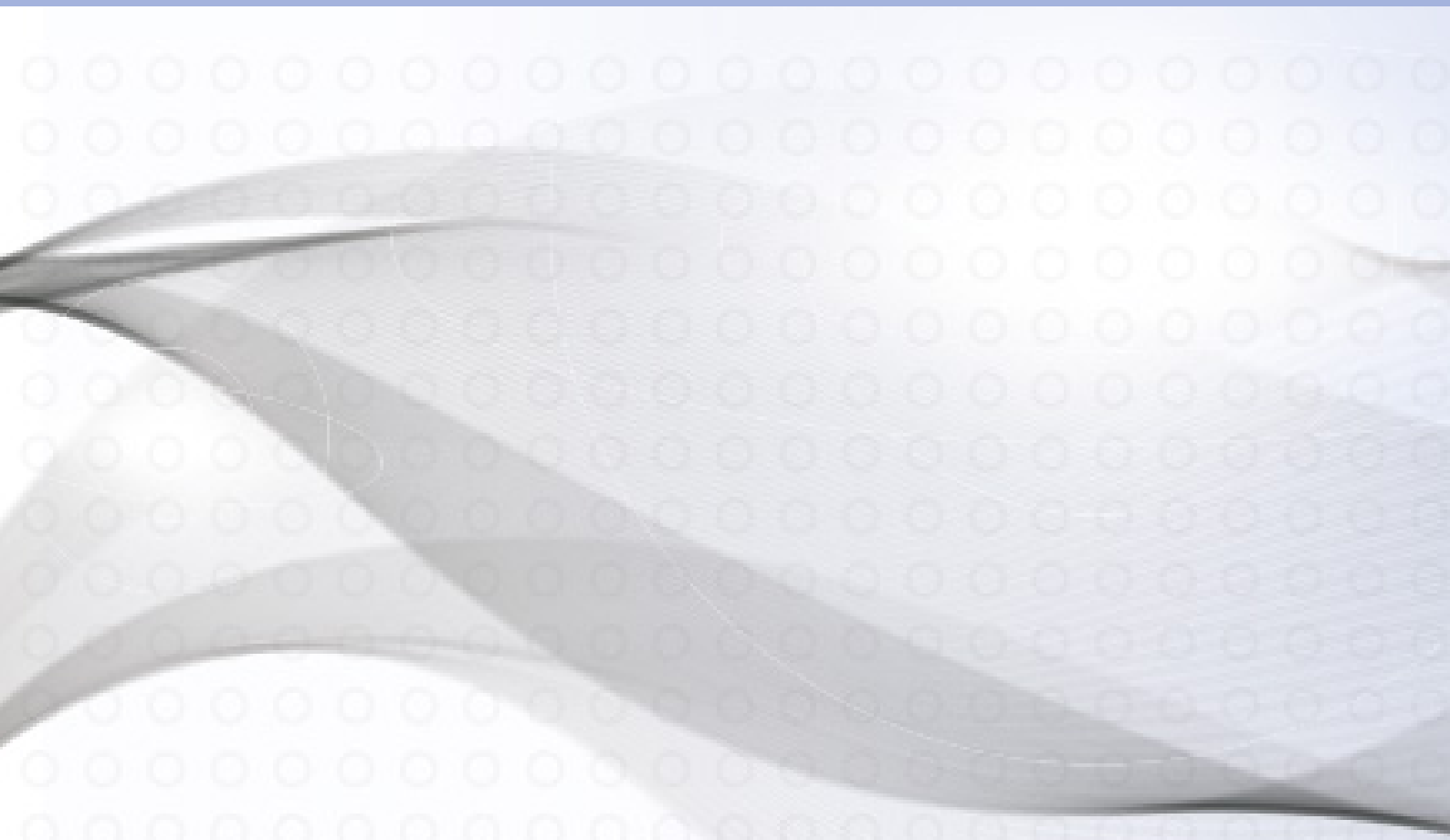

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