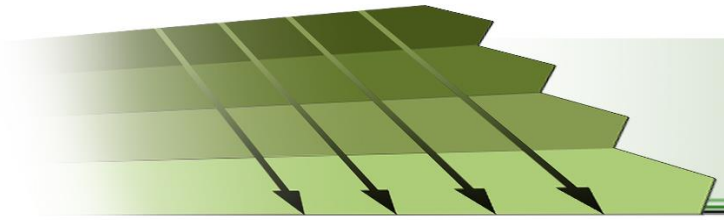

CORE
Public Health Functions for BC

Evidence Review:

Public Health Emergency Management

Population and Public Health
BC Ministry of Health

April 2013

This is a review of evidence and best practice that should be seen as a guide to understanding the scientific and community-based research, rather than as a formula for achieving success. This review does not necessarily represent ministry policy, and may include practices that are not currently implemented throughout the public health system in BC. This is to be expected as the purpose of the Core Public Health Functions process—consistent with the quality improvement approach widely adopted in private and public sector organizations across Canada—is to put in place a performance improvement process to move the public health system in BC towards evidence-based best practice. Health authorities will develop public performance improvement plans with feasible performance targets and will develop and implement performance improvement strategies that move them towards best practice in the program component areas identified in the Model Program Paper. These strategies, while informed by the evidence in this review, will be tailored to local context.

This Evidence Review should be read in conjunction with the accompanying Model Core Program Paper.

Evidence Review prepared by:
Dr. Audrey Campbell
Dr. Bonnie Henry

Evidence Review accepted by:
Population and Public Health, Ministry of Health (April 2013)
Core Functions Steering Committee (TBD)

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EXECUTIVE SUMMARY

This document was prepared to support the development of the evidence-based core program in Health Emergency Management in British Columbia. This evidence review represents an update to a previous review conducted in 2006, yet differs in that the focus is specifically Public Health Emergency Management.

The aim of this review is to identify best practices in emergency management specifically for the public health system. A comprehensive literature review was conducted to examine activities in the four phases of emergency management (prevention/mitigation, preparedness, response and recovery), and what evaluation has revealed about impact, utility, effectiveness or other outcomes.

The derivation of best practices is largely based on anecdotal evidence (e.g., lessons learned). Yet there does exist a smaller body of literature documenting formal qualitative or quantitative evaluations, particularly in the areas of public health preparedness and communication.

The application of the traditional hierarchy of evidence based solely on study design poses challenges in public health emergency management, where events are often rare and unpredictable, and where population impact depends on a multitude of factors other than the actions of public health. For this reason, an alternative evidence scale has been used for this review. There is a comparatively stronger evidence base related to practices that promote effective communication between public health and the public, other responders and health care providers during an emergency. The existence of multi-sectoral relationships in advance of an emergency is key for promoting effective communication between responders. Advance preparation to ensure that communication can continue with all stakeholders if power has failed is important. As well, when communicating with health care providers, limiting emails to a single credible source, identifying new information so clinicians do not have to search, and providing notifications when recommendations differ along with explanations of the reason, are evaluated favorably.

There is also strong evidence related to emergency preparedness training (e.g., exercises and drills) in increasing the self-reported knowledge, skills and confidence of public health staff. Assessment of preparedness should not be limited to structures, but should also assess processes or capabilities to take action in an emergency. Embedded assessments (i.e., integrated into daily public health practice) hold particular advantages in enabling assessment of both structures and processes, with enhanced feasibility, cost considerations and avoidance of 'preparedness burnout' compared to isolated exercises; however, evaluation is generally anecdotal.

There are also specific activities that are relevant to public health emergency management, that have fair evidence. These include the importance of establishing baseline data for surveillance (and generally using data sources that involve ongoing data collection so that comparisons can be made); utility of electronic databases, and in some cases database linkages, for promoting continuity of care for populations affected by disasters; and the importance of promoting the care of chronic conditions and medication reconciliation for affected individuals.

The early activation of an Incident Management System (IMS) and Emergency Operations Centre (EOC) are important components of emergency responses, from which other public health actions flow. Evaluation evidence primarily relates to how the IMS and EOC worked when deployed, and areas for improvement. Similarly, the implementation of a Rapid Needs Assessment (RNA) early after an emergency has occurred, is consistently reported and evaluated favorably, and highly valued as a guide for public health decision-making and resource allocation, although the evidence base is generally anecdotal.

The practice of hazard analysis/risk assessment is theoretically at the basis of all subsequent emergency management efforts, yet there are limited examples of actual conduct by public health. On the basis of largely theoretical evidence, it is suggested that an expert team should conduct the assessment (i.e., possessing understanding of the potential hazards, community vulnerability, clinical knowledge, and risk assessment process), and that risk assessment should be based on the combined criteria of hazard, vulnerability, and ability to manage. Similarly, while there is strong evidence that certain groups have been consistently found to be at greater risk during disasters (e.g., socially and economically vulnerable), the literature advocating the assessment of community vulnerabilities and resources, necessarily paired with prevention and mitigation, has a limited evidence base. One suggested tool is 'community vulnerability mapping', and although examples of such mapping exist, no literature was found that formally evaluated utility.

Regarding actions that build community resilience in the context of emergency management, there is favorable evidence of the contribution of volunteer corps in actions relevant to public health, creation of a community resources inventory, and the provision of public health emergency management education to community-based health care providers.

The application of continuous quality improvement (CQI) throughout all phases of emergency preparedness clearly holds potential benefits, yet the bulk of the literature in this area focuses on CQI in preparedness. An assessment of whether public health emergency preparedness is 'adequate' must be based on clear performance standards that include objective indicators derived through a systematic process.

1.0 OVERVIEW/SETTING THE CONTEXT

In 2005, the British Columbia (BC) Ministry of Health released the *Framework for Core Functions in Public Health*.[1] This framework specified core programs (i.e., long-term programs representing the minimum level of public health services that health authorities would provide in a renewed and comprehensive public health system), and public health strategies that can be used to implement the core programs. A key next step is to assemble an evidence base so that the question 'what works?' can be answered for each core program. This will involve completion of an evidence review that will subsequently form the basis for a model core program paper. The challenges of assembling an evidence base is highlighted in this document, as the type of research included in population health intervention studies is often different from the 'gold standard' randomized controlled trial (RCT) of clinical medicine.[1]

1.1 Introduction

Health Emergency Management is identified as one of the core programs. The purpose of this evidence review is to now identify best practices in Public Health Emergency Management, during prevention/mitigation, preparedness, response and recovery phases. This document will present a detailed summary of evaluation research evidence that will form the basis for best practice recommendations. This review represents an update to a previous review conducted in 2006;[2] however, the focus of this review is explicitly Public Health Emergency Management (rather than Health Emergency Management generally) focusing on the considerations, actions, roles and responsibilities of the public health system. Therefore both the search strategy and included articles are different from that of the 2006 review.

Emergency management involves the management of emergencies (defined as present or imminent events that require prompt coordination of actions to protect the health, safety or welfare of people, or to limit property or environmental damage), and involve actions in prevention and mitigation, preparedness, response and recovery.[3] In this document, the term "public health" refers to the discipline of public health within the health care system, and "public health staff" or "public health officials" refer to public health practitioners and leaders.[4] Public health emergency management therefore refers to emergency management undertaken by the public health system, along the continuum from prevention/mitigation through to recovery. While many other sectors within the health care system are involved in emergency management (e.g., emergency medical services [EMS], acute care within hospitals, etc.), often in partnership with public health, this document is specifically focused on public health services. The scope of emergencies/disasters to which public health responds include those that are directly health related, such as influenza pandemics, as well as others that have health consequences, such as hurricanes, forest fires, floods or earthquakes.[4]

2.0 METHODOLOGY

A variety of literature sources were searched on the topic of public health emergency management. This document presents a review of the evidence to August 31, 2012, using the search strategy specified below. In light of the devastation caused by Hurricane Sandy in October 2012, this review was updated involving a targeted search for articles pertaining to this disaster up to and including January 31, 2013.

2.1 Database Review

The following databases were searched using the search terms and strategy presented in Appendix A:

- Ovid Medline
- Excepta Medica Database (EMBASE)
- Cumulative Index to Nursing & Allied Health Literature (CINAHL)
- Evidence Based Medicine (EBM) Reviews: Cochrane Database of Systematic Reviews, ACP Journal Club, Database of Abstracts of Reviews of Effects (DARE), Cochrane Central Register of Controlled Trials.

Articles required terms from each of the following categories: public health category; emergency/disaster category; emergency management category; and evaluation category. The search was limited to articles between 1992-2012, with full text publication in English.

Inclusion and exclusion criteria are specified in Appendix A. In short, included articles must discuss the actions of public health (local, provincial/territorial/state, federal/national or international levels) in some aspect of emergency management (prevention/mitigation, preparedness, response, and/or recovery), and must include an evaluation for effectiveness, impact, or other outcomes measures.

2.2 Internet Search Engine

The following terms were searched in Google: "evaluation of public health emergency management", "evaluation of public health emergency preparedness", and "evaluation of public health emergency response". As well, as each component of the public health emergency response was identified, this search term was entered into Google (e.g., "evaluation of Rapid Needs Assessment").

2.3 Issues of Key Journals

The following journal issue was reviewed in its entirety [article titles ± abstracts]: *Annual Review of Public Health* 2007; Volume 28 – Symposium: Public Health Preparedness.

2.4 Reference Documents

National Framework for Health Emergency Management: Guidelines for Program Development

2.5 Reference Lists

Reference lists of all included articles were reviewed for additional relevant literature.

3.0 BACKGROUND

The organization of emergency management in the province of BC is described in Appendix B. The responsibility for emergency response is shared between the federal government (e.g., Public Safety Canada); provincial government (e.g., Emergency Management BC [EMBC] formerly called the Provincial Emergency Program [PEP], and the BC Ministry of Health); local health authorities and regional districts (e.g., BC health authorities); as well as the private sector. The general circumstances under which activation of each level occurs are also discussed.

4.0 FRAMEWORK AND REPORT STRUCTURE

4.1 Framework

The ultimate purpose of emergency management is to save lives, preserve the environment, and protect property and the economy.[4,5] Public health, with a focus on the improvement of the health and well-being of populations, prevention of disease/illness/injury, and reduction of inequities, has key roles in all phases of emergency management: prevention and mitigation, preparedness, response and recovery. The body of literature documenting emergency management initiatives across the globe highlight the essential role of public health in partnership with other sectors (e.g., Emergency Medical Services [EMS], law enforcement, hospitals and other health care facilities, etc.). Within this report, best practices will be presented for each of the following phases: before an emergency has occurred; during an emergency; and after an emergency (long-term). Quality improvement should be undertaken throughout all phases. Table 1 summarizes these phases and the public health actions that will be discussed in each phase. These phases are adapted from the National Framework for Health Emergency Management, however the combined phase "during and after an emergency" has been divided into "during an emergency" and "after and emergency" to support the presentation of the identified data:

Table 1: Report Framework

Phase	Public Health Actions
Before an emergency	Hazard analysis/risk assessment Mitigation/prevention Community needs and capacity assessment Community capacity/resilience building Preparedness training and assessment Surveillance preparation Communication preparation Emergency plan development and evaluation
During an emergency	Activate emergency plan Integrated Management System (IMS) Emergency Operations Centre (EOC) Rapid Needs Assessment (RNA) Surveillance Communication (with public, health providers, staff responders) Other public health activities
After an emergency	Surveillance Continuity of care Recovery, including restoration of key public health services
Throughout the process	Quality improvement

4.2 Report Organization

This report details the best practices in public health emergency management, divided into the four phases listed in Table 1 and multiple public health actions. For each public health action, the relevant literature will be summarized in the text, and in some cases an additional description of the literature will be presented in tables in Appendix C. These tables are intended to supplement the text for readers that are interested in learning more about the evidence base pertaining to a

topic. Each sub-section will conclude with a summary about the level of evidence associated with the public health action (see Levels of Evidence, section 4.3) and identification of best practices related to the action. At the end of the document, a summary table for all public health actions and corresponding levels of evidence will be presented.

4.3 Levels of Evidence

Nutley, Powell & Davies[6] state that there is no simple answer to the question of what counts as good evidence, as it depends on what we want to know, for what reason and in what contexts the information will be used. Although it is common to base hierarchies of evidence on study design, this may present a number of challenges:[6]

- Hierarchies based on study design tend to underrate the value of good observational studies.
- Using such hierarchies to exclude all but the highest-ranking studies from consideration can lead to the loss of useful evidence.
- Hierarchies based on study design pay insufficient attention to the need to understand what works, for whom, in what circumstances and why.

The application of the traditional hierarchy of evidence poses challenges in emergency management, where events are often rare and unpredictable, and population impact depends on a multitude of factors other than the actions of public health. RCTs and even observational studies involving a control group, are unlikely to be conducted. Yet the available evidence should not immediately be classified as being of limited value without broader considerations.

The Core Programs Steering Committee supports the evidence scale presented in Figure 1.[7] This scale has appeal for the topic herein as it considers both theoretical and empirical grounds, as well other factors of relevance in population-level interventions.

Figure 1: Evidence Scale

Intervention Evidence Ratings

0	Limited investigation.
☒	Evidence is contra-indicative.
⚐	Warrants further research.
★	Evidence for implementation.
★★	Evidence for outcome effectiveness.
★★★	Evidence for effective dissemination.

0 **Limited investigation**: No relevant effectiveness studies are located and there are no empirical or theoretical grounds suggesting the intervention might potentially impact the outcome; may also indicate that the evidence is inconsistent or contradictory.

☒ **Evidence is contra-indicative** for the use of this strategy to prevent the targeted outcome: consistent null or negative findings in well-controlled evaluation studies.

⚐ **Warrants further research**: applied to strategies that appear theoretically sound or have some promising evidence for their implementation or outcome, but the operational specifics of the delivery format are not clearly resolved or have been investigated only in small-scale or inadequately controlled studies. Policies and programs utilising these strategies might be considered priority targets for future research funding focusing on innovations to better define service delivery.

★ **Evidence for implementation**: published studies report a sound theoretical rationale, a clearly specified service delivery format, acceptance within service delivery organisations, target population recruitment on a scale sufficient to usefully contribute to population health impacts, and adequate consumer approval measured using indicators such as program retention. The proportion of positive demonstrations of impacts on risk factors, protective factors or outcome behaviours is reported. Although this rating requires a clear service delivery format, in some cases not all other criteria are satisfied and in such cases this is indicated in the summaries. Policies and programs utilising these strategies might be supported for implementation where there are few costs and obvious benefits. In other cases wider implementation may await rigorously controlled outcome evaluation to better establish benefits.

★★ **Evidence for outcome effectiveness**: applied where positive outcomes are consistently published in well-controlled interventions. Interventions are required to be of sufficient scale to ensure outcomes within the constraints imposed by large-scale population health frameworks. Policies and programs utilising these strategies might be carefully monitored for their impacts while being supported for wide-scale dissemination.

★★★ **Evidence for effective dissemination**: published reports of impacts where programs are delivered on a large scale, not by research teams, but rather by government auspice bodies or other service delivery agents. Evidence for dissemination is only sought for strategies demonstrating evidence for outcomes. Policies and programs utilising these strategies might be accorded some priority for dissemination. Initial Canadian dissemination trials should monitor for impacts. Where possible, cost-effectiveness has been considered for programs using these strategies.

Source: Adapted from Toumbourou JW, Patton GC, Sawyer S, Olsson C, Webb-Pullman J, Catalano R, et al. Evidence-Based Interventions for Promoting Adolescent Health. Melbourne, Australia: Centre for Adolescent Health; 2000.

5.0 BEST PRACTICES IN PUBLIC HEALTH EMERGENCY MANAGEMENT

5.1 Before an Emergency

5.1.1 Hazard Analysis/Risk Assessment

Hazard analysis, also called risk or vulnerability assessment, involves the identification of potential hazards (considering natural, technological and man-made hazards) and an assessment of the relative levels of risk for each hazard. It is important to identify threats that have previously affected the community as well as new potential threats.[8] Emergency planning is most effective when based on the disaster scenarios most likely to occur locally.[9] Hazard analysis plays a key role in emergency management, for depending on perceived levels of risk, policies are established, actions are prioritized, responses are dimensioned and funding is allocated.[10]

Literature that documents public health actions in this area generally involves assessment of specific hazards, e.g., assessing the risk of particular infectious disease agents in a community, or assessing potential environmental contaminants.[11,12,13] The World Health Organization (WHO) Programme on Vulnerability and Risk Analysis & Mapping (VRAM) in the Mediterranean Centre for Health Risk Reduction, which helps Member States strengthen their capacity for assessing and analyzing health risks and integrating the results in emergency preparedness and response programs, includes pilot projects, such as the Government of Oman mapping risks related to cyclones, and flood risk assessment reporting in Kazakhstan. However, publications describing methodology and results were not found.[14]

Shook (1997)[15] documents and evaluates the conduct of a broad hazard analysis. As part of a disaster risk assessment conducted in Thailand, a questionnaire was administered to 18 key informants with knowledge of Thai society, government organizations related to disasters, and disaster management. This included government representatives, yet it is not clear whether public health representatives participated in this process. The questionnaire listed the 12 most common disasters in the country, with questions about hazard (perceived frequency, severity and potential impact), vulnerability, and management (preparation, legislation, quality of warning system). Subjective ratings of low/medium/high translated into a 3,2,1 rating, respectively. Anecdotal assessment of the process concluded that it had value in informing national emergency planning.

Literature describing the theoretical process of hazard/analysis risk assessment provides useful general principles and suggestions of best practices. The overall risk that a given health disaster will occur is described as the being the product of four probabilities: the probability that a health hazard exists or will occur; the probability that the hazard will produce an event; the probability that the event will produce damage; and the probability that the damage will result in disaster.[10]

Arnold (2005)[10] also suggests general best practices in risk assessment methodology:

- A multi-disciplinary coalition of participants should perform the risk assessment (i.e., possess knowledge of the system at risk, knowledge of hazards and associated events, clinical knowledge of health damage and underlying vulnerability of the population, and knowledge of the risk assessment process).
- An evidence-based approach to information use should be taken, including a hierarchy for the predictive evidence concerning events.
- Evidence used in risk assessments should be evaluated according to its geographic, temporal, demographic, social, and cultural relevance.
- The entire causal chain or fault tree that underlies the probability that a situation will occur should be described; each micro-event or node in the causal chain is necessary for the situation to occur and represents a point of failure without which the situation will not occur.

Summary
★ **Level of Evidence: Evidence for Implementation – for assessment of environmental contaminants and communicable disease agents**
⚐ **Level of Evidence: Warrants Further Research – for assessment of other hazards**
The practice of hazard analysis/risk assessment is theoretically at the basis of all subsequent emergency management efforts. While the role of public health in risk assessment of certain hazards such as environmental contaminants is documented, there is limited literature pertaining to other hazards (e.g., weather-related, technological). On the basis of largely theoretical evidence, it is suggested that an expert team should conduct the assessment (i.e., possessing understanding of the potential hazards, community vulnerability, clinical knowledge, and risk assessment process), and that risk assessment should be based on the combined criteria of hazard, vulnerability, and ability to manage.

5.1.2 Community Assessment

Emergency preparedness should involve the assessment of a community's vulnerabilities, resources and threats.[16] There are numerous examples from actual disasters that certain groups of people are at greater risk throughout the disaster (e.g., poor, elderly, women-headed households, recent residents, tourists and others). For example, during Hurricane Andrew evacuations, there were reports of public-housing residents having to walk or hitchhike out of evacuation zones.[17] During hurricane Hugo on St. Croix, hurricane Andrew in Miami and hurricane Marilyn in St. Thomas, housing units had lesser window protection and many were heavily damaged, some for a second time. Thus, hundreds to thousands of households, primary women and children, had to live in tent cities, temporary shelters and caravans.[17] Hurricane Katrina disproportionately affected the most socially vulnerable.[18] It is clear that disasters may initiate new, or exacerbate existent, disparities in health and health care within affected populations.[19] While the relationship between socio-economic status and disaster impact is introduced here, this theme persists throughout the continuum of emergency management and is addressed further in other sections.

Morrow[17] recommends the development of a community vulnerability inventory (also called community hazard and risk assessment or access profile) to know where the higher-risk groups are concentrated within communities. Zoraster[18] also advocates for risk mapping of social vulnerabilities. The hope is that this will lead to a greater knowledge of risk factors and thereby spill over to interventions that generally improve health and well-being. Knowing which

locations have high numbers of elderly, children, or specific language or cultural groups may allow for more efficient and effective disaster preparation and management.[18] If sophisticated technologies, such as GIS, are available, this vulnerability data may be merged with hazard-related databases or risk assessment models, to predict impact and anticipate local needs. Examples of such vulnerability mapping exist and some offer perceptions about utility (e.g., as offering the first step toward tools that can help public health professionals prepare plans for communities); however, what is lacking is an evaluation of the utility of such mapping in an emergency. It is also unclear whether or how public health has used this information.

For example, Reid et al.[20] describe the mapping of vulnerability factors for heat-related morbidity/mortality (demographic characteristics, household air conditioning, vegetation cover and diabetes prevalence), resulting in a cumulative heat vulnerability index value that could be used to make heat vulnerability maps; however, there was no evaluation of the utility of these maps in an emergency. Cutter et al.[21] used county-level socio-economic and demographic data to construct an index of social vulnerability to environmental hazards, called the Social Vulnerability Index (SoVI) for the United States. There is also a report of a 'low-technology' example in the Philippines, where residents of a rural community created a 3-dimensional town map on plywood, using flour water dough to depict the most vulnerable locations and homes,[22] yet there is no evaluation of utility reported.

Summary

Level of Evidence: Warrants Further Research

While there is strong evidence that certain groups have been consistently found to be at greater risk during disasters (e.g., socially and economically vulnerable), there is limited literature documenting the conduct, and particularly the use of information from, community assessments that identify higher-risk groups. One suggested tool is 'community vulnerability mapping', and although examples of such mapping exist, no literature was found that formally evaluated utility.

5.1.3 Mitigation/Prevention

Both hazard assessment and community assessment need to be paired with prevention and mitigation efforts, to reduce the level of risk where possible. The precise interventions will vary based on assessed risk and vulnerability.

There is good evidence of effective public health-specific mitigation/prevention interventions, particularly related to communicable diseases. Many activities seen as traditional public health roles have potentially significant contributions to emergency prevention. For example, routine immunizations, education about handwashing and safe food preparation, and inspection of food service establishments are important in the prevention of communicable disease outbreaks. One of the many examples of this is described by Jayawardene et al.,[23] who examined the effect of an eight-week mosquito control program involving students in grades 7-9 in Sri Lanka, on dengue fever. In this region, epidemics often occur during certain times of the year. Interventions were delivered in partnership with public health professionals (e.g., public health inspectors and public health midwives), and evaluation data was obtained from public health surveillance systems. All proportions of larval indexes were significantly lower, and there was a 73 per cent and 61 per cent reduction in dengue fever cases in the urban and rural areas, respectively, during the year following the intervention.

Through ongoing efforts to reduce inequities (e.g., child poverty), public health initiatives may address the underlying causes of vulnerability and serve as powerful prevention strategies; however, evaluations (which are complex) were not identified. Section 5.1.4 discusses public health strategies in the area of building community resilience that may serve to mitigate/prevent the effects of emergency events on communities.

With respect to other types of emergency events (e.g., natural disasters), there are examples in the literature about the effectiveness of prevention in averting or reducing adverse impact from emergency events, although it is often uncertain what role public health had in activities such as natural disaster monitoring techniques and instruments, and predictions of events.[24] However, partnerships of public health with organizations that conduct primary detection are noted. For example, as part of the Philadelphia Hot Weather–Health Watch/Warning System, when a heat warning is issued, public health has contacted nursing homes and other facilities with vulnerable residents to offer advice on protecting residents.[25] The overall program evaluation of the system (which has multiple components other than the actions of public health) indicated that issuing a warning saved 2.6 lives on average for each warning day and for 3 days after the warning ended, and the system saved 117 lives over 3-years.[26] Tan et al.[27] developed a synthetic evaluation model intended to be used to analyze flood hazards and assist public health workers to provide flood disaster management. They conducted a study in Hunan Province, China involving a random sample of families in flood-affected villages (n=49,897) selected by a multi-stage sampling method, compared with controls (n=25,136). They found that the investment in flood prevention strategies before and during the flood years was negatively related to the economic loss caused by the flood; the cost-benefit ration of investment in anti-flood strategies was 1:250.[27]

There are also suggestions (although unevaluated) derived from reviews of previous disasters, which may be potentially relevant to public health services that are involved with emergency management. For example, providing public education about developing evacuation plans that do not require the use of personal resources such as a vehicle; advocating for the availability of alternative methods of transportation; providing premade disaster kits; and assisting communities with organizing their own response initiatives.[17,18]

Summary
★ **Level of Evidence: Evidence for Implementation – for communicable disease emergencies**
⚐ **Level of Evidence: Warrants Further Research – for other emergencies (e.g., natural disasters)**
The importance of mitigation/prevention is clear in theory. The literature documenting the role and favourable impact of public health is primarily related to communicable disease hazards, while impact with respect to other emergencies (e.g., natural disasters) is uncertain.

5.1.4 Community Capacity/Resilience Building

Community resilience is the capability to rebound from a disaster. Enhanced resilience is considered critical to mitigating vulnerabilities, reducing negative health consequences, rapidly restoring community functioning, as well as being important for limiting the need for prolonged assistance post disaster.[28] Resilience is increasingly applied in the field of disaster management and is emerging as a major public policy priority within disaster management.[29,30] Building the resilience of communities and nations is advocated in The Hyogo Framework for Action 2005–2015, also known as 'The Hyogo Declaration', by the United Nations International

Strategy for Disaster Risk Reduction (UNISDR).[30,31] A number of factors are suggested to contribute to community resilience, such as community cohesion and the ability to mobilize resources quickly. Moore et al.[29] extracted information relevant to community resilience from unpublished case studies, describing 'exemplary practices' from 11 natural disasters occurring between 1985-2005 internationally, and mapped 49 practices to the following seven community resilience elements: community education; community empowerment; practice; social networks; familiarity with local services; physical security and economic security.

A prominent area of study in promoting community resilience is developing volunteer corps; this can be conceptualized as supporting the ability to mobilize human resources quickly. Volunteers have been involved in a variety of emergency response efforts, including after hurricanes Katrina and Rita,[32] World Trade Center attacks,[33] and others. Glick et al.[34] report that in their Virginia community, there were a small number of health professionals working for the local public health district, thus alliances were created with the local University school of medicine that had a volunteer Medical Reserve Corps. Much of the literature documenting these volunteer corps offers anecdotal evaluations of utility (i.e., lessons learned). Schaffzin[35] offers a numerical dollar value associated with the volunteer response (i.e., cost savings). Barsky et al.[33] conducted qualitative research among focus groups with 83 members of 10 task forces and in-depth structured, open-ended interviews with 11 managers of the Federal Emergency Management Agency's (FEMA) Urban Search & Rescue system, and discussed the paradox that volunteers can be both a help and hindrance at the scene of an emergency. A reminder that where volunteer networks are utilized, it is essential to consider long-term impact, such as stress and grief.[32]

Of note, there is a 'Disaster Psychosocial Services Volunteer Network' through the Provincial Health Services Authority (PHSA) in BC;[36] however, an evaluation of impact was not identified for this review.

Related to the concept of volunteers, the idea of using medical students in an emergency management situation where EMS is overwhelmed (e.g., a mass casualty situation) might provide an important community resource that lessens the burden on EMS personnel. Sapp et al.[37] evaluated the accuracy of the triage decisions made by 315 newly enrolled medical students, after receiving a brief educational intervention. These students achieved triage accuracy scores similar to those of emergency physicians, registered nurses, and paramedics in previous studies.[37] This might be relevant to public health where they are part of a team directing an emergency response, although public health was not specifically mentioned in this article.

Troy et al.[38] note that a local resource database of suppliers providing physical, information and human resources for use in disaster response (e.g., construction equipment and operators; medical facilities and personnel; transportation; food; housing; and animal shelters) can serve to both mobilize resources as well as raise awareness within the community and aid in assessing local knowledge and resources.[38] The authors describe a pilot study implementing a community-based resource database through collaboration with local American Red Cross chapters and public and private community organizations. Assessment of the effectiveness of this database was conducted over a two-year period using individual interviews with Red Cross chapter managers in semi-annual focus group meetings and written surveys. Pilot sites utilized this database to serve individuals displaced by hurricane Katrina. This Community Disaster

Information System (CDIS) reportedly improved service coverage and efficiency, increased information on available resources, helped monitor and provide for quality referrals, encouraged community collaboration and networking, and assisted with recruitment, training, and retention of volunteers. Public health information was included as part of the list, although it is unclear whether public health partnered in list development or administration.

Elements of community resilience may be developed through the actions of other sectors/practitioners that in turn receive training and support from public health. Studies by Chen et al.[39] and others reveal the importance of emergency preparedness training in enabling health care providers to know what to do, and how to obtain information, in the event of an emergency. Thus, a relevant consideration in building community capacity is developing the capacity of community-based health providers. Available evidence suggests that positive effects may result from training efforts. Hites et al.[40] conducted an evaluation of an online and face-to-face Public Health Emergency Preparedness training program, adapted to the training needs of tribal Community Health Representatives. This was a partnership between the Arizona Centre for Public Health Preparedness and Dine College of the Navajo Nation. Among a sample of 83 Navajo Nation Community Health Representatives, pre- and post-tests were completed (scenario-based, decision-making tests) that assessed the following core competencies: description of the public health role; chain of command; personal function role; communication roles and use of communication equipment in an emergency response; and recognition of deviations from the norm that might indicate an emergency and description of actions. Significant improvements in scores were observed for all core competencies except regarding the use of communication equipment.

Summary

★ **Level of Evidence: Evidence for Implementation**

There is evidence about actions that build community resilience in the context of emergency management. Many of these have potential relevance for public health in an emergency, although public health is not specifically discussed in all cases: the contribution of volunteer corps and potential contribution of certain volunteer groups such as medical students; and creation of a community resources inventory. There is also positive evidence that the provision of public health emergency management education to community-based health care providers can improve competencies in key areas.

5.1.5 Preparedness Training and Assessment

Fortunately, large-scale public health emergencies are rare. Therefore, there are limited opportunities to observe or measure the responses of public health organizations and partners to emergencies, and difficult to know if they are prepared to respond. In addition, if emergencies do occur, there is variability in scope, severity, and numbers of people affected; as well, there may be limited advance warning. These factors make it difficult to systematically evaluate the public health response. As a result, using 'proxy events that capture key elements of public health emergencies'[41] can simulate responses to major emergencies and provide hands-on practice,[41,42] and is widely advocated. This process can serve to familiarize personnel with emergency plans, allow different agencies to practice working together, and identify gaps and shortcomings in emergency planning.[34,42]

In general, assessments of preparedness may focus on 'structures' (e.g., quantities of material resources, infrastructure), processes (e.g., ability to undertake functional or operation actions using available resources to effectively engage in emergency response), or both.[41] Previous emergency events have demonstrated that the availability of resources is only one predictor of a successful emergency response, thus an assessment that is limited to structures may not provide a full picture.

A variety of techniques for preparedness and assessment of structures and/or processes exist. Appendix C, Table A describes four such methods along with associated strengths and challenges: written assessments (discussion-based); exercises and drills; embedded assessments; and look-backs. Appendix C, Tables B and C present literature evaluating various forms of assessment. In all cases, the outcomes are self-reported knowledge, skills, abilities, confidence, etc. related to preparedness. This means that self-report measures are used as a proxy for response capacity, as they measure participant's perceptions rather than direct abilities.[43]

There is the suggestion that embedded assessments hold unique benefits over other methods, as this method allows for the execution of an operational exercise, and thus ability to test both structures and processes, but offers benefits with respect to cost and feasibility compared to an exercise conducted in isolation. Embedded assessments can involve the integration of an operational assessment, such as a drill or exercise (e.g., implementing a mass immunization clinic, activating an IMS), within routine or other public health activities. Seid et al.[44] assert that public health emergency preparedness will be most successful when integrated into routine public health practice and daily work, as this provides an opportunity to practice skills and improve processes while avoiding preparedness burnout which may occur if staff members are asked to add on additional work to address preparedness. Table B focuses on literature evaluating embedded assessments.

A general limitation that applies to all methods of assessment is that without clear and specific performance standards, utility is uncertain. It is essential to develop metrics with clear operational definitions - that is, including indicators. For example, the 'number of minutes/hours it takes to do x', or 'the number of staff who can do y'. These metrics should be accompanied by clear performance standards (i.e., what constitutes adequate performance for each indicator). The development of metrics and performance standards has occurred through expert judgment and consultation with leaders, as well as through a systematic Delphi process method (sees Appendix C, Table D). Another option of a methodology to use in standards development is engineering-style process analysis. As Nelson et al.[45] describe, "the argument is less that process x is correlated empirically with outcome y, but rather that ensuring y logically requires x." An example of this technique is critical path analysis (CPA). CPA involves maps of system processes to identify key rate-limiting factors response processes, which may help to identify high-priority areas for standards development.[45] However, no literature was found that documents the use of this method.

Nelson et al.[46] present 13 elements of public health emergency preparedness;[a] however, objective indicators are not provided. Gebbie et al.[47] do provide such indicators.[b]

Finally, continuous quality improvement (CQI) is key throughout preparedness efforts, and is discussed in section 5.4.1.

Summary
★ **Level of Evidence: Evidence for Implementation**
There is evidence that emergency preparedness training (e.g., exercises and drills) increases self-reported knowledge, skills and confidence of public health staff. How this impacts responses during actual emergency events is not certain. Preparedness assessments should not be limited to structures, but should also assess processes or capabilities to take action in an emergency. Embedded assessments (i.e., integrated into daily public health practice) hold particular advantages in enabling assessment of both structures and processes compared to isolated exercises; however, evaluation is generally anecdotal.

5.1.6 Preparation for Surveillance

Some of the literature that describes the surveillance experience of health authorities during an emergency event also identifies actions that were taken, or should have been taken, before the emergency occurred to enhance surveillance capability. One key recommendation is to identify baseline data (i.e., rates of disease/illness/injury before an emergency has occurred).. This may be necessary to determine if an emergency in fact exists (e.g., establishing the existence of an outbreak), and determine whether a disaster is the cause of observed health outcomes, thus informing public health actions. A number of literature sources report the absence of baseline data and identify this as a limitation. For example, Williams et al.[48] note that pre-hurricane baseline data were not available to assess the magnitude of increase in illnesses and injuries post-hurricane Katrina. The Centers for Disease Control and Prevention,[49] reflecting on lessons learned from surveillance post-Katrina, recommend that the "calculation of historical proportional morbidities for syndromes of public health concern before a disaster will enable local health departments and health-care facilities to provide useful background for post-disaster comparison."

There are examples of emergency events where baseline data has been used effectively, and this literature offers ideas about the source of such data (see Appendix C, Table F). Data sources that provided baseline comparisons in emergencies included data from the Canadian Hospitals Injury Reporting and Prevention Program (CHIRPP) for injuries;[50] calls to a regional poison centre for carbon monoxide poisoning;[51] and numerous examples of electronic health care data systems that capture emergency department data and other health records data.[51,52]

Identifying what baseline data is required in the first place must be informed by the results of the risk assessment.

[a] The 13 elements presented by Nelson et al. can be found at http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1854988/.
[b] The indicators provided by Gebbie et al. can be found at http://www.impact.arq.org/doc/kennisbank/1000011447-1.pdf.

Another area related to preparation for surveillance is the access to existing, or development of new, surveillance tools. Particularly when rapid surveillance is implemented (e.g., Rapid Needs Assessment—a form of surveillance—described in section 5.2.4), having a template that can be quickly accessed and modified as needed is identified as important.[53]

Summary
★ **Level of Evidence: Evidence for Implementation**
The strongest evidence related to preparing for surveillance is the identification of baseline data. This facilitates the understanding of the existence of an emergency event (e.g., a communicable disease outbreak) and population impact, in order to guide public health actions.

5.1.7 Preparation for Communication

Urgent requests for information, at the level of the public and responders, characterize every public health emergency.[52] Through the evaluation of communication conducted during actual emergencies, a number of best practices that are appropriately implemented before an emergency has occurred have been identified (see Appendix C, Table F).

The importance of pre-existing communication networks is emphasized in the literature (i.e., relationships that are established before an emergency event occurs). Chess & Clarke[54] interviewed multi-sectoral key informants in New Jersey, USA, within communities that had varying degrees of contamination during the 2001 anthrax attacks. They found that successful communication during the crisis was positively influenced by pre-existing organizational and professional networks operating prior to the emergency (e.g., a bioterrorism workgroup, informal networks among police and health agencies, etc.). This produced networks of people who trusted each other, even if the mandates of their organizations 'were at odds'.[54] DiBiase et al.[55] evaluated the mass vaccination experience of 25 local health departments in North Carolina, and found that existing partnerships with external organizations were important (e.g., with schools, daycares, nursing homes, schools, churches, health care providers). Fifty-six per cent (14/25) of health departments relied on existing relationships, while 52 per cent established new partnerships and/or improved their existing relationships.

A second important area in preparation for communication, specifically with public health staff responding to the emergency, is highlighted by Beatty et al.,[56] who conducted a retrospective program evaluation of the emergency responses of the New York City Department of Health and Mental Hygiene during the 2003 blackout. Personnel working in the EOC were asked to complete a quality assessment form during the blackout (35 per cent response rate). The absence of power generally made communication difficult on multiple levels. One area highlighted was difficulties in communicating with staff that were attempting to learn if they should report to work. The preparation of protocols in advance specifying which, when and where employees should report during emergencies, is suggested, as is the development of a directory of employee skills and emergency contact information that would be readily accessible during an emergency. Employee awareness of this information should be supported through drills and other training sessions.

With respect to communication with the public, it is suggested that public health advisories be developed prior to an event that focus on health issues that have been commonly encountered during emergencies. Preparing these documents during an emergency where computers are rendered non-functional (e.g., as a result of prolonged power outages) results in delays.

A number of other suggestions are offered to ensure that communications proceed in the absence of electricity: for example, ensuring that the EOC has adequate supplies on site to be self-sufficient for 48 hours including flashlights, batteries for laptops and battery-operated printers; ensuring that the EOC is stocked with phones that do not require additional power, and a paper library of important documents; as well as having emergency power available to re-charge radios.

Summary
★ **Level of Evidence: Evidence for Implementation**
Preparation in advance of an emergency is important to ensure that communication proceeds to members of the public and other responders during an emergency event. The existence of multi-sectoral relationships in advance of an emergency is key for promoting effective communication between responders. It is also important to prepare in advance to ensure that communication can continue if power has failed.

5.1.8 Emergency Plan Development and Evaluation

It is recommended that strategic planning should be used for the development of an emergency plan;[57] however, no literature sources were found that specifically evaluated the strategic planning process of a public health organization.

Limited literature was found that evaluated a final plan. Norman et al.[58] in Ghana evaluated the National Integrated Strategic Plan for Pandemic Influenza (2009-13) against the State and Local Pandemic Influenza Planning Checklist of the Department of Health and Human Services and the CDC. The authors concluded that the national plan was not adequate, and identified things like the proportion of health care facilities that lacked preparedness plans, mutual aid agreements, surge capacity, etc.[58] This study highlights the importance of comparing an emergency plan against a standard to evaluate comprehensiveness.

Summary
⚐ **Level of Evidence: Warrants Further Research**
Clearly emergency planning is important, yet no evaluation of the strategic planning process of a public health authority was found, and the evidence base is limited on the evaluation of a plan.

5.2 During an Emergency

Activation of the emergency plan may involve implementation of a number of the following components or actions:

5.2.1 Incident Management System and Incident Command System

Please see Appendix E for a discussion of Incident Management System (IMS) and Incident Command System (ICS). Note that in BC, the BC Emergency Response Management System (BCERMS)—an adaptation of the ICS—is used.

Examples exist of early IMS deployment, although not all provide adequate detail to evaluate process and impact. An exception is Beatty et al.,[56] who describe the New York City Department of Health and Mental Hygiene (DOHMH) response to the 2003 blackout. The response began with the immediate deployment of an all-hazards, scalable public health IMS. The principal of having an 'all-hazards' approach means that individual plans specific to each type of incident are not developed, rather the assumption is that certain public health issues are common to most incidents.[56] Preparedness improvement initiatives were taken prior to the blackout and included orienting staff to the IMS structure and their respective sections; providing wallet cards with 24-hour contact information; providing information about the location and directions to the EOC, etc.[56] An evaluation of the DOHMH's response to the blackout suggested that the IMS was "an efficient means of managing response" and "allowed for easier communication among emergency response agencies…due to adoption of a common command structure and familiarity with response-specific language and procedures."[56]

Phillips and Williamson,[59] as part of the lessons learned in using the IMS for mass immunization clinics during a vaccine shortage, concluded that prompt implementation of the IMS contributed to the success of a mass clinic initiative. They reported that the IMS provided clear leadership roles, chain of command, delegation of duties, a personnel reporting system, easy identification of key personnel, use of existing personnel by function, and a record-tracking system of activities.[59]

Similarly, DiBiase et al.[55] conducted surveys and key informant interviews among 25 local health departments in North Carolina, to examine their mass vaccination experience in response to the pandemic H1N1 influenza event during the 2009-2010 season. Sixty per cent (15/25) of the health departments activated their ICS; and of these 14/15 felt that activating the ICS was useful.

Summary
★ **Level of Evidence: Evidence for Implementation**
The IMS is recognized as being an important component of the emergency response, and while the evidence base documenting process and impact is small, there is evidence of positive impact in actual emergency events.

5.2.2 Emergency Operations Centre

Early activation of the Emergency Operations Centre (EOC) is mentioned in a number of public health responses to emergencies. For example, during the 2003 blackout, the New York DOHMH immediately established the EOC and provided continuous staffing coverage.[56]

Evaluations of the EOC primarily relate to the ability to contact staff when needed, and to the communication that emerges from the EOC (see sections 5.1.7 and 5.2.5). Recommendations include ensuring that the EOC is properly supplied in advance, ensuring that contact information (pager, cell phone, home phone) is updated, etc. As noted in Appendix C, Table F, it is also essential that the EOC be able to operate if power has failed. Ensuring the availability of battery-powered equipment, including radios, laptops and printers, is a key recommendation.

Summary
★ **Level of Evidence: Evidence for Implementation**
The early activation of the EOC is presented in the literature as an important component of an emergency response. Evaluation evidence primarily relates to how the EOC worked in an emergency, and areas for improvement.

5.2.3 Surveillance

Surveillance is a key role for public health after an emergency has occurred. It is essential to understand the impact that the event has had on affected communities in order to inform public health actions. Surveillance can take various forms, and implementation can begin early after an emergency has occurred and continue in the short-, medium- and long-term.

Rapid Needs Assessment (RNA), discussed in 5.2.4, involves the timely and direct survey of a sample of individuals/households to determine health experience as well as wider experiences with things like access to services, utilities, etc. Derived data is disseminated quickly and used to inform decisions during the early phase of a disaster response.

Wider surveillance of health impact has been conducted in numerous emergency responses, using such sources as emergency department visit data, provider diagnostic codes, electronic health records of various kinds, etc. This has established rates of injuries, illness, disease, or mortality, and when paired with baseline data (as discussed in 5.1.6, see Table E) this has provided information about morbidity and mortality that is above baseline and therefore may be attributed to the emergency event.

There are also studies of health surveillance efforts where baseline data is not included. These are implemented after an emergency has occurred and generally aim to assess specific outcomes among affected communities (e.g., prevalence of certain syndromes among evacuees in a shelter, or the proportion of evacuees requiring medication refills for acute or chronic conditions).[60,61] One valuable lesson that has been learned from these types of studies is that chronic diseases tend to be a major reason for requiring care among affected populations, and that ongoing medication needs exist.

Ebi and Shmier[26] discuss the challenges of surveillance during the 2003 heat wave in Europe. The authors state that in France, surveillance systems were limited in that they were initially not designed to recognize increases in morbidity and mortality among individuals with chronic diseases (e.g., cardiovascular and respiratory conditions).[26]

Summary
★ **Level of Evidence: Evidence for Implementation**
The collection of surveillance data is clearly indicated post-emergency, and can reveal information about a wide range of outcomes and help inform public health decisions and resource allocation. The specific data to be collected is dependent on the emergency event, population experience and information needs and must ensure that impact of the emergency on the health of affected populations is captured (including among those with pre-existing chronic diseases).

5.2.4 Rapid Needs Assessment

A critical early step is determining and addressing the acute needs of an affected population. Early assessment provides information that is used to appropriately and efficiently match available resources to a population's emergency needs.[62] While it is essential to have information quickly that accurately reflects the needs of affected populations, the methodological rigor needed to obtain valid, precise population based needs assessments after disaster may cost too much, take too long, or be too difficult to be useful in guiding relief operations. Rapid Community Needs Assessment (RNA) is a tool that can be used to quickly obtain accurate information on the status of a community[63] and has been an essential component of many disaster relief operations.[64]

Key components of RNA:

- Provide valid information.
- Provide information quickly.
- With limited resources.
- Sometimes under adverse circumstances.
- Inform decisions about resource allocation.

Further, in many instances, RNA has also been used as an opportunity to distribute education material/resources to affected community members. In some cases the contact with members of the public that occurs during a RNA has facilitated controlling rumours post-disaster.

The methodology of RNAs vary, yet they generally share the common features of a multi-stage sampling strategy that arrives at a sample of households, collects data, and then disseminates information to key decision makers and other stakeholders within a 'rapid' timeframe. A common technique is modeled after the World Health Organization (WHO) Expand Program on Immunization (EPI) method, which was originally developed to assess immunization coverage in areas where baseline demographic information is unknown.[65] This involves a two-stage cluster sampling methodology, in which 30 blocks are selected in identified community(ies), and then seven households are selected from each block. However, other cluster sampling strategies have been used.

Appendix C, Table G presents examples of the implementation of RNA in response to emergency events, and perceived effect (within the community and among shelter populations). The evidence, although primarily in the form of anecdotal reports of effect rather than formal quantitative or qualitative assessment, is overwhelmingly supportive of RNAs as being valuable

to quickly understand population health needs and make decisions about resource allocation during the early post-emergency period.

Summary

★ **Level of Evidence: Evidence for Implementation**

There is consistent evidence in favour of the implementation of RNA in the early period after an emergency event. Although the evidence is largely anecdotal, this method of surveillance has been repeatedly demonstrated to be effective in assessing the needs of populations and providing valuable information to guide planning. While the methodological rigor of the studies is not high, there is corroborating evidence that reports value and effectiveness.

5.2.5 Communication

Effective methods to communicate with target audiences during an emergency event have been explored in a variety of literature sources. Audiences include the public; health providers in the community (hospitals, community sites) that are in turn key sources of information for the public; and other staff that are involved in the emergency response both within and outside of public health. A number of literature sources have considered how these stakeholders wish to receive communication. Staes et al.[66] conducted a cross-sectional survey of 509 office-based primary care providers in Utah (response rate 28 per cent), collecting qualitative and quantitative data, regarding communication with public health during the 2009 pandemic influenza event. It was suggested that public health agencies should connect with existing health institution communication channels to distribute guidance to their clinicians, as this source was most trusted. Further, to limit email to a single credible source, identify new information so clinicians don't have to search for it, and note when local recommendations differ from federal recommendations and explain why differences exist.[66]

Gray et al.[67] conducted a qualitative study exploring community responses to health messages in the 2009 and 2010 H1N1 campaigns in New Zealand. Eight focus groups (n = 80) were composed of groups felt to be increasingly vulnerable to H1N1. A range of recommendations relevant to public health communication with the public were reported, including:

- Primary information sources were workplaces (including workplaces intranets), and the community (e.g., health care centres, church groups, forums and the family).
- Simplicity in framing messages is important – communication should identify the most critical facts.
- Messages must include what people can do to protect themselves and their families.
- Messages should be conveyed in appropriate languages.
- There are differing opinions about who should front communication campaigns (i.e., who is credible and trusted). Some felt that community figures that the public could readily relate to were preferable, while others felt that medical professionals or the Ministry of Health, District Health Board, or WHO representatives would be better. Therefore, a multi-disciplinary approach is advisable.

Howard et al.[68] studied the association of certain characteristics of local health departments in Kentucky with the receipt of information by physicians and pharmacists during the H1N1 event in 2009 using cross-sectional surveys. The most common health department characteristics

associated with receipt of information was the presence of a public information officer (76 per cent), followed by a pandemic influenza plan (64 per cent). Physicians and pharmacists in areas without a public health information officer had significantly higher odds (by a factor of six) of not receiving information from the local health department. Note however, that among respondents, 72 per cent did not receive any information from the local health department.[68]

Other studies have evaluated the effectiveness of communication mediums during an emergency. In Germany during flooding (2002), it was found that radio combined with loud-speaker (on top of police cars) message dissemination was the a particularly effective combination for communication with communities affected by flooding.[69] During a Q fever outbreak, two public health alert faxes were sent asking physicians to submit serum samples on any patient meeting a clinical case definition of Q fever and an association with the area where the outbreak occurred. By examining laboratory reports, Van Woerden et al.[70] found a statistically significant difference between the number of patients tested for Q fever in the target population after the alerts had been sent as compared to a comparable two-week period one year before. However, this type of study does not compare one communication method to another to determine the best communication medium.

There is a promising study underway that may answer this question. In the REACH Trial (ongoing), authors are using a randomized, community-based trial method to investigate the effectiveness of various message delivery systems (email, fax, and SMS) for communicating public health emergency preparedness and response messages from public health agencies to health care providers. The primary aim of REACH is to determine the effectiveness of various message delivery systems (email, fax, and SMS) and to compare the effectiveness of communication methods across diverse communities.[71,72]

Tappero and Tauxe[73] examined the emergency response to the cholera epidemic in Haiti (2010). They reported the conduct of focus groups in the midst of public health messaging to the public, which revealed that residents were confused about how cholera was spreading and how to prevent it, but that they understood the need to treat diarrheal illness with ORS, how to prepare ORS, and how to disinfect water with purification tablets. In the Dominican Republic, a knowledge, attitudes and practices (KAP) survey of residents of Santo Domingo revealed that 89 per cent had received cholera messages through various mediums. Although detailed data is not provided, this study raises the importance of conducting some form of evaluation in the midst of a communication campaign to understand if messages are reaching and being understood by the public, identify gaps, and therefore provide information to tailor future/continued messaging.

Chess & Clarke[54] interviewed multi-sectoral key informants in New Jersey, USA, within communities that had varying degrees of contamination through the anthrax attacks in 2001. They found that it was questionable whether centralization and increased control are the remedy for conflict and communication problems. This study suggests that the effective networks were more flexible and adaptable. This calls into question the utility for centralization and control for communication that was found in some sources to be helpful, such as Davis et al.[53], who conducted 32 key informant interviews and document reviews. This study provides a rare example of an area that experienced an emergency event, hurricane Floyd in 1999, then implemented public health capacity building activities in the ensuing years, then evaluated how

these changes affected responses to hurricane Isabel in 2003. One action involved the creation of a Public Health Command Centre to serve as a base for public health operations during an emergency, as an extension of the Emergency Operations Centre. During hurricane Isabel, the Public Health Command Centre was positively felt to provide a "single point of contact for public health needs and a structure process for answering questions".

Appendix C, Table F summarizes a selection of the communication literature.

Summary
★★ **Level of Evidence: Evidence for Outcome Effectiveness**
There is a large volume of literature on the topic of communication during an emergency event, with some strategies offering evidence of effectiveness. Whether the audience is the public, other responders or health care providers, it is essential to consider how they want to receive information (i.e., medium, content, location of dissemination, etc.). When communicating with health care providers, it is recommended to limit emails to a single credible source, identify new information so clinicians do not have to search for it, and provide notifications when recommendations differ along with explanations of the reason for the differences.

5.2.6 Other Public Health Actions

In addition to the common elements of deployment of the IMS, EOC, surveillance (including RNA) and communication with various audiences, public health may engage in a variety of other actions post-emergency, as required based on the nature of the emergency and impact on affected populations. These include the following: [53,56,74,75]

- Liaise with hospitals/medical providers (e.g., advise about vaccine spoilage, open cooling centres).
- Make decisions about evacuation/sheltering-in-place during disasters. In one article discussing the lessons learned from Hurricane Sandy, the authors suggest that public health did not take charge to coordinate strategic decisions regarding evacuations from health care facilities, and evacuations were delayed in some cases. It is suggested that public health and emergency management agencies in collaboration with health care facilities should develop protocols, ensure capacity, and guide crucial evacuation decisions in a disaster.[75]
- Liaise with housing authorities (e.g., in facilities with vulnerable populations ensure functioning generators to enable the operation of cooling equipment, conduct needs assessment).
- Environmental health (e.g., routine microbial monitoring of potable water, restaurant inspections to ensure that spoiled food is discarded, baiting rodent traps to control pests which may occur in response to increased refuse amount).
- Public health laboratory services.
- Mental health services.
- Infectious disease case investigation.
- Maintenance of routine public health activities (e.g., poison control centre, West Nile Control program larvicide application, limited services of clinics).

An area that has been the subject of study is that of school closures in the early stages of an outbreak. A number of literature sources discuss the impact of school closures on influenza transmission during outbreaks (although not all school closures were due to public health decisions).[76,77] In a review, Cauchemez et al. estimate that based on the experience of US cities in 1918 and in France during a period from 1984-2006, closure of schools might have had an estimated 15% reduction in the total number of cases, with larger reductions of about 40 per cent in peak attack rates.[77] However, the 2008 Hong Kong outbreak, 1957 pandemic in France, and 1918 pandemic in some US cities demonstrate the possibility of no discernible effect, especially where decisions are made too late. There may also be increased mortality for older persons who care for children when schools close.[77]

Another area in the literature is the delivery of mass vaccination (as well as antivirals, etc.). There are a number of examples related to pandemic H1N1 influenza during the 2009-2010 season. DiBiase et al.[55] administered a survey to a stratified random sample of local health departments (n 25) in North Carolina, and interviewed key informants. Each health department utilized a different approach in response to the challenges they experienced during their mass vaccination campaign. Many health departments felt that optimizing staffing procedures allowed them to meet the increased demands (e.g., flexing work hours, training more staff and hiring temporary staff). Other important strategies included: having a Continuity of Operations Plan and pandemic influenza plan; building on existing community partnerships; implementing a variety of vaccination strategies; and using a variety of sites.[55] Strategies and sites included HINI-specific mass walk-in clinics at the health department and community sites (e.g., nursing homes, retail stores, churches, shelters, etc); vaccination appointments at the health department and community sites; drive-through clinics; school-based clinics; and outreach to other sites including childcare facilities, private employers, and in one case, home-bound community residents. Each had identified strengths and challenges.

5.3 After an Emergency

5.3.1 Surveillance

In some disaster situations, surveillance has been instituted after the immediate disaster period. This may establish whether new sequelae from the emergency event are occurring (e.g., the presence or absence of infectious disease after a natural disaster disrupts housing and utilities; and carbon monoxide (CO) poisoning in disasters where there is prolonged power loss); whether patterns of illness/disease/injury that were seen during the emergency are changing; and generally to guide ongoing public health actions. Many of the surveillance principles previously discussed apply here, such as the importance of having ongoing data collection that allows for the assessment of trends.

This data can be very valuable in guiding public health messaging and resource allocation in the medium- and long-term. For example, up to three weeks after hurricane Sandy, CO poisoning reports at poison centers in eight states revealed that 263 reports of CO exposure had been recorded, and of these four were fatal (all related to the use of a generator in a garage).[78] Based on previously collected data after hurricane Irene during August/September 2011, there were 10-times more reports post-hurricane Sandy. Information about safe generator use was reiterated in this publication, as was the importance of a CO alarm and other preventive actions.[78]

Yzermans et al.[79] conducted surveillance over a longer period, involving a 2.5 year longitudinal study among 9,000 individuals affected by the explosion of a firework depot and 7,000 controls using electronic medical records of general practitioners. Elevated rates of psychological problems, medically unexplained physical symptoms, and GI morbidity were found among affected individuals.

Summary
★ **Level of Evidence: Evidence for Implementation**
There are examples in the literature of surveillance that extends over the medium- or long-term post-emergency event. This provides valuable data about the population health impact of emergencies, with the potential to guide ongoing public health actions.

5.3.2 Continuity of Care

The need for chronic disease management among populations affected by an emergency is discussed in numerous literature sources. Public health may be involved with the organization and/or delivery of care in shelters for evacuees, such as occurred at the Fosco Park Hurricane Victim Welcome and Relief Center where the Chicago Department of Public Health provided medical and mental health care to hurricane Katrina evacuees.[80] Jhung et al.[60] highlight the importance of maintaining care continuity for chronic conditions and medical continuity among evacuees. Among 180,000 hurricane Katrina evacuees in Texas, using a syndromic surveillance system based on chief complaint as well as medication dispensing records, within the first 31 days, 15 per cent of health care encounters were for the care of chronic medical conditions. Further, 68 per cent of all medications dispensed to evacuees were for the treatment of chronic disease.[60]

It is important to consider that chronic health issues may have a relationship with socio-economic status. Ahern & Galea[81] conducted a representative cross-sectional telephone survey using random digit dialing (n = 1355), in New York City, six months after September 11, 2001. Among those with low income (<$20,000), there was a significant association between income inequality and depression in the past six months, however there was no association among those with higher income. Davis et al.[82] highlight media accounts discussing that many of the areas affected by Hurricane Katrina contained residents that had sub-optimal health care prior to the hurricane, and chronic diseases that were adversely affected by sub-optimal health care; and post-disaster this group experienced severe impact.

There are reports in the literature of attempts to promote continuity of care among evacuees displaced by emergency events. For example, Boom et al.[83] describe the connection of the Houston-Harris County Immunization Registry to the Louisiana Immunization Network for Kids Statewide, within days after hurricane Katrina. The aim was to find immunization records for evacuees that arrived in Houston, Texas (many without records). An evaluation of this system revealed that 18,900 immunization records were found by one year later, representing $3 million in cost savings for vaccine (that may otherwise have been administered unnecessarily) and administration fees.[83] Brown et al.[84] describe the use of the Department of Veterans Affairs (VA) electronic health data after hurricane Katrina to support health providers who were caring for evacuees in identifying personal health information. In a retrospective evaluation using cross-sectional data collected sequentially over time, in the month after the hurricane clinical data were

accessed electronically for 38 per cent of patients cared for prior to the hurricane by New Orleans VA facilities. Health care data was successfully transmitted to more than 2,300 users in 200 sites in 48 states.[84]

Summary
★ **Level of Evidence: Evidence for Implementation**
There is a role for public health in supporting the identification of pre-existing health conditions, medication use and other factors (e.g., immunization status) that can facilitate continuity of care for populations affected by emergency events, particularly where there is displacement.

5.3.3 Recovery, Including Restoration of Key Public Health Services

Practical accounts of the process of returning to the delivery of routine public health services was found in limited literature sources, although several literature sources state that this is an important consideration for public health. Chen et al.[85] describe the public health response to the Chi-Chi earthquake in Taiwan, 1999. As the continuation of routine immunization programs was considered critical, but public health staff in the affected region were unavailable and exhausted, the Department of Health developed a 'buddy system' that enabled unaffected counties to provide support to affected areas.

Summary
⚐ **Level of Evidence: Warrants Further Research**
While the return of routine public health services is clearly important post-emergency, limited study and evaluation of this process was found.

5.4 Throughout the Process

5.4.1 Continuous Quality Improvement

Quality improvement (QI) in public health emergency management involves a systematic approach for understanding and measuring performance, identifying solutions to performance shortfalls, and implementing changes to improve outcomes.[86] As described by Nelson et al.[87] measures are the observable 'yardsticks' used to judge performance, and standards are the thresholds that define how good is good enough on the measures. Clear measures and standards are critical to QI. Within public health, there are two general options with respect to utilizing performance standards: develop their own or access, and adapt if necessary, existing standards. In the case of the former option, systematic techniques such as the Delphi process have been used in standards development (see section 5.1.5 on Preparedness). In the case of the latter option, the standards developed by Gebbie et al.[47] are a metric that provides a uniquely high level of detail (see Appendix D). They involved a panel of 26 experts in a 2-round Delphi process to develop criteria for the evaluation of agency performance during a preparedness drill or exercise. Criteria were developed within selected categories (initial response command and control, communication, early recognition/surveillance and epidemiology, sample testing, evidence management, mass-patient care, mass-fatality management and environmental surety).

Actual examples of implementing QI in practice accompanied by evaluation are not as plentiful as literature that outlines theory and instructions about conducting QI. Lotstein et al.[86] describe the Promoting Emergency Preparedness and Readiness for Pandemic Influenza (PREPARE for

PI). This pilot QI learning collaborative around pandemic influenza preparedness involved a convenience sample of five public health departments over a 9-month period. It is based on the Institute for Health Improvements Breakthrough Series QI learning collaborative model that includes four components: improvement aims and goals; performance measures related to the targeted process or outcome; strategies and ideas for change; and the use of the plan-do-study-act (PDSA) cycle.[88] The PDSA cycle involves trying out a new idea or change in the smallest way possible, then using the results to inform the next cycle of improvement. For each aim, teams developed process maps. Teams were encouraged to integrate their improvement work with daily public health activities to avoid 'preparedness burnout'. The preparedness activities they targeted were surveillance, case investigation, command and control, and disease control and treatment. Evaluation data was collected via an online survey, monthly progress reports, and team interviews at the conclusion. Evaluation revealed that participants rated the likelihood that they would use QI methods in their future work as 4.2 out of 5, and the majority felt that the pilot was valuable.

Seid et al.[44] suggest that measurement of public health emergency preparedness can take place through 'critical incident monitoring'. This was originally used in military aviation and has expanded to critical care and out of hospital patient transportation.[89] This involves voluntary, anonymous reporting of incidents that may have led to adverse outcomes but did not necessarily cause harm. Flabouris[89] evaluated the utility of critical incident reporting as a quality improvement tool during deployment of Medical Disaster Response Teams during the 2000 Sydney Olympics. Incident reporting forms contained a free narrative section and directed questions. Analysis of 53 forms revealed, among other things, the proportion of incidents felt to be preventable (89 per cent), contributing factors, and recommendations for prevention or better management of the incident in the future. Although this study did not specifically document the actions of public health, the utility of analyzing public health incidents that might have relevance to emergency management might be considered.

Summary

★ **Level of Evidence: Evidence for Implementation**

The application of continuous quality improvement (CQI) throughout all phases of emergency preparedness clearly holds potential benefits, yet the literature largely focuses on CQI in the area of preparedness. An assessment of the adequacy of public health emergency preparedness must be based on clear performance standards that include objective indicators derived through a systematic process.

6.0 CONCLUSION

This review of public health-specific emergency management has revealed a body of literature documenting the actions of public health in emergency management over the past 20 years. While many of these literature sources offer an evaluation in the form of anecdotal evidence (e.g., lessons learned), a selection of evaluations are based on the analysis of qualitative and/or quantitative data. This data is often retrospective, although in a minority of studies data was collected in real-time (i.e., while the emergency response is ongoing). Choosing to use a hierarchy of evidence that is not solely based on study design has allowed for the consideration of broader issues as the basis for assessing evidence.

Preparedness assessment and communication had the largest volume of evidence. Communication also represents the only area that has the promise of a pending randomized controlled trial (the REACH trial) to evaluate preferred methods of communication. There was also a fair body of evidence relevant to surveillance, including the importance of establishing and utilizing baseline data, and the value of conducting a Rapid Needs Assessment in the early period post-disaster. Common elements of public health emergency responses included the early activation of the Incident Management System and Emergency Operations Centre.

It is important to use performance standards with objective indicators in order to measure emergency preparedness, and integrate this into continuous quality improvement.

Table 2 summarizes the level of literature evidence associated with various public health actions.

Table 2: Summary Table of Public Health Actions and Levels of Evidence

Public Health Action	Level of Evidence*
Before an Emergency	
Hazard Analysis/Risk Assessment	★ for communicable disease agents and environmental contaminants ⚐ for other hazards
Community Assessment	⚐
Mitigation/Prevention	★ for communicable disease emergencies ⚐ for other emergencies (e.g., natural disasters)
Community Capacity/Resilience Building	★
Preparedness Training and Assessment	★
Preparation for Surveillance	★
Preparation for Communication	★
Emergency Plan Development and Evaluation	⚐
During an Emergency	
Incident Management System	★
Emergency Operations Centre	★
Surveillance	★
Rapid Needs Assessment	★
Communication	★★
After an Emergency	
Surveillance	★
Continuity of Care	★
Recovery	⚐
Throughout	
Continuous Quality Improvement	★

* Levels of Evidence

- **0** Limited investigation.
- ☒ Evidence is contra-indicative.
- ⚐ Warrants further research.
- ★ Evidence for implementation.
- ★★ Evidence for outcome effectiveness.
- ★★★ Evidence for effective dissemination.

APPENDIX A: DATABASE SEARCH STRATEGY

	Search terms and selection criteria	Component
Initial search	[public health OR public health administration OR public health practice] AND [emergencies OR disasters OR disaster planning OR earthquakes OR avalanches OR landslides OR droughts OR volcanic eruptions OR cyclonic storms OR tornadoes OR snow OR ice OR fires OR explosions OR terrorism OR bioterrorism OR riots OR civil disorders OR civil defense OR equipment failure OR radioactive hazard release OR mass casualty incidents OR epidemics OR pandemics OR disease outbreaks AND [emergency response OR emergency management OR emergency preparedness OR disaster planning] AND [evaluation OR evaluation studies OR evaluation studies as topic]	*Public health* *Emergency/disaster* *Emergency management* *Evaluation*
Criterion 1	Does the article specifically include the actions of **Public Health** (local, province/state or national level)?	
Criterion 2	Does the article include public health actions in some aspect of **emergency management** (prevention/mitigation, preparedness, response, and/or recovery)?	
Criterion 3	Does the article include an **evaluation** of public health actions during an emergency event (whether based on qualitative or quantitative data, or anecdotal) OR does the article propose emergency management-related performance standards that have been derived from a process with clear methods?	

APPENDIX B: ORGANIZATION OF EMERGENCY MANAGEMENT IN BRITISH COLUMBIA

In general, local authorities (e.g., municipalities, regional districts, First Nations and federal parks) are responsible for planning and responding to emergencies within their jurisdictional areas;[90] therefore, local governments often lead the initial emergency response in their communities. The provincial emergency management structure is activated when a BC community, or any significant infrastructure, is threatened by an emergency that may overwhelm the ability of local authorities to respond.[91]

The Provincial Emergency Program (PEP), now called **Emergency Management BC (EMBC)**, a division of the Ministry of Public Safety and Solicitor General, provides leadership in emergency management on behalf of the province. EMBC has its headquarters in Victoria and has six regional offices throughout the province.[92] PEP is administered under the *Emergency Program Act* (described below). The PEP emergency co-ordination centre in Victoria can be reached by a toll free number 24-hours/day for provincial emergency reporting.[91,93]

In 2000, the Province of British Columbia emergency management structure developed and adopted the **British Columbia Emergency Response Management System (BCERMS)**.[5] BCERMS provides the framework for a coordinated, organized and standardized provincial response and recovery to emergency incidents in BC.[94] Although it is the recommended system for emergency response activities, its use is not mandated. This management system is based on the Incident Command System (ICS). The framework of BCERMS is divided into five components: operation and control; qualifications; technology; training; and publications. There are four levels of BCERMS emergency response: Site Level; Site Support Level; Provincial Regional Coordination Level; and Provincial Central Coordination Level. At each level there are different site support and activations (e.g., Emergency Operations Centre [EOC] activation during Site Support Level; Provincial Regional Emergency Operations Centres activation during Provincial Regional Level, etc.).[95]

The Emergency Management Unit (EMU) is part of the Population and Public Health Division of the BC Ministry of Health. The EMU ensures that the provincial health system is capable of planning for, responding to and recovering from the impacts of extreme events, whether natural, accidental or intentional in nature.[93] The EMU, along with the five regional health authorities, Provincial Health Services Authority (PHSA), BC Centre for Disease Control, Providence Health Care and BC Ambulance Service, facilitates the Health Emergency Management Council, which was established in 2000.[96]

The key provincial emergency management legislation is the ***Emergency Program Act, 1996***[97] that set out the preparedness, response, and recovery roles and responsibilities of the Province and local authorities, as well as established the Provincial Emergency Program (PEP) and gave PEP certain powers and duties.[98] The Act includes the following regulations: Emergency Program Management Regulation (outlines the emergency planning requirements for each provincial minister; Local Authority Emergency Management Regulation (outlines the roles and responsibilities of a local authority, including powers and duties of a local authority as well as

the components of a written local emergency plan); and the Compensation and Disaster Financial Assistance Regulation.[98]

Declaration of a local state of emergency is a temporary emergency measure authorized by the *Emergency Program Act* that allows a local authority access to very specific emergency powers that are intended to facilitate actions to effectively respond to the emergency within the authorities local jurisdiction.[92] Examples include the following, where considered necessary to prevent, respond, or alleviate the effects of a disaster or emergency: acquisition or use of land or personal property; control or prohibit travel in BC; evacuation; authorize entry into buildings or land, etc. Declaration of a local state of emergency has to be issued by either a local government bylaw or order by the head of a local authority (e.g., mayor in a municipality, or board chair in a regional district)), and is valid for seven days. The latter is most common because there is often not time to establish a local government bylaw or resolution.

If an emergency escalates beyond provincial resource capabilities, additional assistance is provided at the federal level. **Public Safety Canada** manages requests from the province to the Government of Canada. Public Safety Canada maintains the Government Operations Centre that operates 24/7.

Public Health Act – Emergency Powers[99]

The *Public Health Act* outlines emergency powers that may be enacted by Health Officers, the Provincial Health Officer (PHO), and the Minister, where specified conditions are met (see below). Some of these powers are described below. Note that this is not an exhaustive list, nor does it detail the criteria that must be met; please see Part 5 of the Act for full information (http://www.bclaws.ca/EPLibraries/bclaws_new/document/ID/freeside/00_08028_01#part5).[99]

Health Officers

- Act in a shorter or longer time period than is otherwise required.
- Not provide a notice that is otherwise required.
- Do orally what must otherwise be done in writing.
- Suspend or vary a license or permit over which they have authority, without providing an opportunity to dispute the action.
- Conduct an inspection at any time, with or without a warrant, including of a private dwelling.
- Collect, use or disclose information, including personal information, that could not otherwise be collected, used or disclosed, or in a form or manner other than the form or manner required.

Provincial Health Officer

- Order that a specified infectious agent, hazardous agent, health hazard or other matter be reported.

In an emergency, the PHO may make an order authorizing:

- A **health officer** to exercise a power or perform a duty in a geographic area for which the health officer has not been designated.
- An **environmental health officer** (EHO) to exercise a power or perform a duty of EHOs that is not permitted by his or her designation.

PHO or Medical Health Officer (MHO)
The PHO or a MHO may order a person to take preventive measures in an emergency. A detailed discussion around compliance of this order is contained in the Act.

Minister
In an emergency, the Minister may make regulations:

- Exempting a person, place or thing from a provision of this Act or the regulations made under it; or modifying a requirement of this Act or the regulations made under it.
- Authorizing the PHO to make an exemption or modify a requirement as described above.
- Authorizing persons to exercise powers and perform duties as health officers, with or without conditions.

APPENDIX C: TABLES AND FIGURES

Table A: Methods to assess public health emergency preparedness (PHEP)

Assessment Method	Examples	Strengths	Challenges	Suggestions for Improved Effectiveness
Written Assessments	Checklists Surveys	Modest amount of time and effort required for completion. Can be administered to large samples. Relatively straightforward and easy data analysis Less cost compared to drills/exercises.	Focuses on public health structures, but structural measures may not be valid indicators of preparedness (i.e., presence of structures and resources is no guarantee that these can be deployed effectively in an emergency). Reliability may be poor if clear definitions are not included. Self-report may hinder validity.	Clear performance standards. Administer assessments during site visits or site inspections to reduce concerns about self-report.
Drills and Exercises	Discussion-based (e.g., table-top exercises – staff discuss response to a scenario). Operations-based – actual reactions to simulated situations.	Operations-based: provides an opportunity to directly execute and assess emergency response-related capabilities (i.e., ability to deploy structures and resources, as well as assess processes).	Cost Time Difficult to interpret if not paired with clear performance standards and measures (i.e., what level of performance is 'adequate'?). Poorly designed, or un/inadequately evaluated, executed exercise or drill may lead to a false sense of security and result in poor performance during an actual emergency.	Clear performance standards. Conduct as part of continuous quality improvement cycle (i.e., small-scale exercises that test performance on smaller components precede full-scale exercise(s) that address a broader array of functions). Act on lessons learned from each exercise. Repeated exercises allow for the assessment of whether jurisdictions have addressed performance gaps revealed in previous exercises.
Embedded Assessments	Operational assessments embedded in routine or other public health activities (see Table 3).	Reduces the need to assemble staff, equipment, etc. for the sole purpose of an exercise, thus a way to respond to the costs of an exercise. Allows for the application of existing knowledge in new situations.	The degree that experience in relatively small-scale responses can provide information about ability to respond to larger-scale emergencies is uncertain.	Clear performance standards. Note that this approach is felt to hold particular benefits in PHEP.
Look-backs	Retrospective analysis of past responses to public health events.	Can learn from events (e.g., annual influenza), and a review of rare events (e.g., outbreaks) that contain some of the same dynamics and challenges as occur in larger scale emergencies.. May generate recommendations to strengthen preparedness to deal with events if occur in the future.	Relevance of smaller-scale responses in other areas to ability to respond to public health emergencies	Clear performance standards.

Table B: Examples of embedded assessments (integrating PHEP into public health work)

Reference	Location	Situation	Method of Evaluation	Results of Evaluation
Phillips & Williamson (2005)	Maryland, USA	Fall 2004 influenza vaccine shortage led the Department of Health (DOH) to change plans for vaccine distribution to only reach high-risk residents. Opportunity to test capacity to mobilize mass clinics within short timeframe. Utilized pre-existing DOH mass immunization plans (smallpox) and mass clinic plans. Conducted in school settings (included assessing capacity for layout, equipment, accommodation for Incident Management Centre, etc.). Partnered with local police department. Implemented IMS	Not reported.	After the clinic, staff reported feeling more confident in their ability to perform, control crowds, and address the needs of residents in a mass setting).
Matteson (2006)	New York State, USA	2005 DOH implemented large point of dispensing (POD – mass medication or vaccine administration) emergency preparedness exercise. Intended to test capacity to provide mass vaccinations with seasonal influenza to target population (New York State employees that had been invited to receive free vaccination) in specific timeframe. Immunization of 1800+ employees occurred in 4 hours. Education of public health nurses and security staff beforehand re: roles, POD layout, and the Incident Command System.	Survey conducted post-exercise among participating nurses (n=67).	All nurses were satisfied with the experience, education provided, and felt competent to respond to a public health emergency.
Fishbane et al. (2012)	Florida, USA	Fall 2005 Hurricane Wilma struck Palm Beach County; this caused interruption to annual school-located influenza vaccination clinics for elementary students. The Incident Command Structure that was used for the emergency management related to the hurricane was adopted for the school-based vaccination clinics. Common lessons learned felt to be applicable to both the hurricane emergency response and vaccinate clinics: need for simple, flexible, easy to execute plan; importance of partnerships; training needs, etc.	Not reported	Beneficial in gaining buy-in from organizations and volunteers because it provided detail about role expectations and boundaries, thus allowing estimation of workload in advance.
Erwin et al. (2009)	Tennessee, USA	During outbreak of foodborne hepatitis A, two regional health departments implemented an emergency mass clinic for providing immune serum globulin (ISG) to several thousands potentially exposed people. Used the CDC's smallpox post-event clinic plans to guide the mass clinic (wished to see if plans feasible and adaptable to clinics other than smallpox).	Determined doses of ISG per person-hour administered.	1.45 ISG doses per person-hour were administered (close to CDC's plan target of 1.58 doses). CDC guidelines were felt to be useful and practical in actual application in a mass clinic setting.

Reference	Location	Situation	Method of Evaluation	Results of Evaluation
Davis et al. (2007)	North Carolina, USA	DOH and Office of Public Health Preparedness and Response (DPHP&R) implemented a rapid needs assessment to investigate an outbreak of Legionnaire's disease. DOH and PHP&R opened the Public Health Command Centre (created after Hurricane Floyd 1999, and utilized during Hurricane Isabel 2003) as part of an outbreak investigation of shiga toxin-producing E. Coli infections.	Not reported	

Table C: Summary of evidence of effect of other PHEP assessments

Reference	Description	Evaluation Methodology	Evaluation Results	Recommendations
Ablah et al., 2007 (6 Kansas counties)	Simulated CD outbreak. Electronic, real-time, multi-county, done from in-office.	-Pre- and post-exercise quantitative surveys using an Internet survey tool (Zoomerang).	Results pre vs. post exercise surveys - not all participants completed both surveys: -Statistically significant improved rating of health department's abilities' to identify the need for and implement surge capacity; and participant's own ability to participate in a response to ID cases. -Improved ratings of ability to implement risk communication skill set, and ability to identify and locate agency's ID resources, but not statistically significant.	Longer duration of the exercise allowed participants to communicate over longer periods, which reinforced partnerships. Electronic format allow participants to participate from their offices, which is the likely place they would work from if a real incident occurred.
High et al, 2010 (North Carolina Office of Public Health Preparedness and Response.	Table-top exercise. Test preparedness for chemical disasters. (Part of wider series of drills and exercises).	Post-exercise questionnaire - what participants learned and were the goals of the exercise met. Also reviewed attendance roster to determine the mix of agencies involved, and observed the exercise and debriefing at the conclusion of the exercise. Note that 43% functional or operational leaders, 11% ground-level response. personnel, 41% executive or administrative.	-51% felt much/somewhat more certain about how: public and private sectors would interact in the situation; local level with state agencies; and state level with federal agencies. 28-35% unchanged understanding. 6-11% less certainty (difficult to interpret as this may represent a more realistic understanding of limitations). -91% thought their organization needed to make adjustment to existing plans; 68% thought the organization would do this within next 6 months.	-Recruit participant who know the plans and policies of the organization they represent; and require participants to bring organizational plans. -Ensure discussion questions promote action-based decisions, and allow time to develop actions plans as needed based on what learned. -Disseminate after-action reports to involved agencies and participants.

Reference	Description	Evaluation Methodology	Evaluation Results	Recommendations
Biddinger et al., 2010 (Harvard School of Public Health Center for Public Health Preparedness)	38 PHEP exercises: table-top, functional; full-scale exercises; and drills.	-Qualitative and quantitative data collection methods from participants, facilitators and evaluators, as well as content analysis of after action reports. -Results not presented by exercise type, however it is noted that most results refer to discussion-based exercises.	Survey of participants (n=1145) post-exercise, proportion agreed/strongly agreed exercise achieved: -practice working together to respond to ER (77%) -opportunity to evaluate plans and procedures (73%) Assess connectivity within/across agencies (70%) -Clarify understanding of their agencies role and responsibility during public health emergency (69%) -increasing knowledge of resources/assets among other agencies (56%). -Where a workshop was hold before tabletop exercise, knowledge and confidence increased.	
Sarpy et al., 2005 (South Central Center for Public Health Preparedness and Arkansas DOH)	Tabletop exercise Simulated Severe Acute Respiratory Syndrome event among public health workers.	Quantitative and qualitative data collected via questionnaire administered pre- and post-exercise.	Public health workers and external partner participants – note that not all completed both pre- and post-surveys (pre n=49, post n =44). Statistically significant improvement in post exercise self-reported perceptions: prepared to effectively respond to a SARS event; use the chain of command to perform emergency response tasks; maintain effective protocols for individual roles and responsibilities; recognize the threat of a SARS outbreak including signs and symptoms or trends; establish contact and coordinate with appropriate individuals/partners; determine what should be communicated to the media; and monitor progress and action through surveillance protocols.	Among numerous qualitative and quantitative results, the following are a selection of recommendations: -Ensure that key perspectives/partners are represented (e.g., EMS, mayor, hospital administrators, community members, etc.). -In general, the collection of qualitative and qualitative evaluation data can be used to refine and continuously improve the effectiveness of the tabletop exercise.

Reference	Description	Evaluation Methodology	Evaluation Results	Recommendations
Savoia et al. (2009)[100]	Table-top exercise Pandemic H5N1 -assessed knowledge and confidence in legal authorities for ID emergencies.	-Pre- and post-exercise questionnaire covering 6 issues (declaring emergency, isolation and quarantine, movement restrictions, curfew, close public places, mass prophylaxis). Likert scale rating of availability and sufficiency of legal authorities, policies and procedures, for each category. N = 56 (43% public health officials).	25% increased proportion of questions answered. Significantly increased knowledge of policies and procedures in all topic areas. Significantly higher level of confidence in the availability and sufficiency of legal authorities in all areas. 12% increased proportion of participants reporting that legal authorities are available and sufficient. Proportion reporting policies and procedures are available and sufficient increased in 4 areas (did not increase in declaration of emergencies, and isolation and quarantine). Gathered information about gaps.	Experiential learning through a table-top exercise, combined with didactic teaching, can be effective in imparting knowledge and gathering information about gaps.
Dausey et al. (2007)[101]	31 table top exercises with public health departments in 13 states.	Varied design of exercises (2-8 hours long; 10-40 participants included public health and others; different CD scenarios; varied facilitator involvement). Common elements: began with single case report or series of case reports identifying an outbreak; collective discussions, etc. Evaluation forms consisted of structured and semi-structured questions: what participants learned, gaps in preparedness identified, and evaluation of structure and conduct.	Common challenges in surveillance and investigation; communications; command and control; and medical surge capacity. For example: -reactive, passive media contacts -communication with response partners -reaching vulnerable populations -recruiting, training and mobilizing volunteers -full implementation of ICS and EOC.	Exercises should be: Designed to achieve a specific objective Focus on areas that require concrete decision in limited timeframes Be as realistic as possible while being logistically feasible. Designed around issue areas based on local preparedness needs and priorities.

Table D: Examples of methods to develop PHEP performance standards

Reference	Methodology Used to Develop PHEP Standards
Savoia, Testa, Biddinger et al. (2007)	Modified Delphi technique. Panel of experts identified the public health functional capabilities (what a public health system needs to be a able to perform during an emergency) that could reasonably be tested during a tabletop exercise.
Gebbie et al., 2006	2-stage Delphi process Expert panel of 26 individuals (from boards of health, local and state public health agencies, CDC, DHS, and FEMA) to develop criteria for the evaluation of public health agency emergency exercise performance. Project team developed an initial list of potential criteria that were circulated to panel members by email or mail. Members commented on the criteria (whether to retain, modify or eliminate each criteria, as well as suggested additional criteria. Round 1 survey results were redistributed during Round 2.

Table E: Examples of emergency surveillance that provides baseline and ongoing data

Reference	Emergency Event	Surveillance Methods	Results	Interpretation and Recommendations
Hartling et al. (2011)	Ice storm, 1998 (Eastern Ontario and Quebec)	Sites: 2 emergency departments in Kingston, ON. Described the patterns of unintentional injury caused by the ice storm that presented for ER care, using the Canadian Hospitals Injury Reporting and Prevention Program (CHIRPP): -data abstracted from charts, computerized -operates in sentinel Canadian hospitals	Overall number of injuries slightly lower at this time compared to same time last year. 38% of injuries resulted from the ice storm (directly and via power loss, loss of access to medical services, hazardous debris, etc.). Of these 64% minor, 25% moderate, 11% severe. No deaths (deaths outside of hospital during study period not captured by CHIRPP). Most common cause of injuries: ice (58%), brush/trees clearing (44%), chainsaw/axe cut (21%), falls from tree/ladder (18%). Injury peaked immediately after storm and 4-6 days later (when major restoration efforts initiated and gradual return to activities).	Reason for fewer injuries not certain, as the ice storm resulted in injuries however other activities were avoided (e.g., use of roads during the winter). Role for public health in education around safety during clean-up activities. Education about hazards of carbon monoxide and indoor use of gas and charcoal appliances.
Lutterloh et al. (2011)	Ice storm, 2009 (Kentucky)	Sites: Kentucky Regional Poison Centre (calls from health providers or public) – ongoing data collection enabled baseline comparison Hyperbaric oxygen treatment facilities Coroners mortality data Statewide ER department and hospitalization data (baseline available)	115 exposure calls to poison center (representing possible exposures of 275 people) vs. 9 calls the previous year. 202 emergency department visits for CO poisoning vs. 11 the previous year. 26 hospital admissions vs. 0 previous year. 8 confirmed and 2 suspected deaths (28% of storm-related deaths.. Most cases 204 d after storm when temperatures below freezing & power outages.	Public health education encouraging the use of CO alarms, safe use and placement of CO-producing devices, multiple communications methods need to reach individuals without electricity.

Reference	Emergency Event	Surveillance Methods	Results	Interpretation and Recommendations
CDC (2008)	Wildfires, 2007 (California)	Electronic health care data CDC "Biosense" system: ER department chief complaint information and physician diagnosis codes from 6 hospitals in the affected area (of a total 400+ hospitals providing data). Accessible through CDC Secure Data Network. Available to public health officials (local, state, national) and hospital personnel.	In the 5-day fire period (pooled) compared to the preceding 20 weekdays, visits for dyspnea increased from 49 to 73/day, and asthma diagnosis increased from 22 to 40/day.	Public health staff (local, state/province, national) collaborative efforts re: automated surveillance systems to ensure timely information is available during an emergency.
Mann et al. (2011)	Outbreaks of influenza-like illness , 2009-10 school year (Florida)	School-based absenteeism surveillance system. Automated, provide real-time notification of possible outbreaks of influenza-like illness. Compare daily all-cause absenteeism data against historic baseline to detect ILI outbreaks.	SBASS gave 61 red alerts, 28 yellow alerts, and 67 warnings during the study period (Table). After active investigation, 9 of 89 alerted schools were confirmed to have influenza outbreaks, and 71 persons with ILI were identified. The SBASS detected all influenza-related outbreaks among public schools studied.	Limitation with school attendance data is the effect of school holidays and other planned school closures.
Cookson et al. (2008)	Hurricane Katrina (evacuees in Georgia)	Multiple methods, data entered into state-wide internet based surveillance system Send SS (State Electronic Notifiable Disease Surveillance System – ongoing). -Syndrome and disease surveillance using internet-based form in shelters (no baseline). -Internet-based death registry; cause of death and whether due to hurricane (no baseline). -Retrospective data from 7 emergency departments that regularly participated in internet-based Send SS and 2 additional ERs after the hurricane (baseline). Data on Louisiana and Mississippi residents that visited the ER 8 months before the hurricane compared to those that visited 1 month after.	Shelters: One confirmed outbreak of norovirus. Most conditions were chronic conditions. Mental health problems reported as frequently as infectious disease symptoms. ERs: 7-fold increase inc cardiopulmonary complaints after the hurricane. Non-significant increases in medication refill requests and skin rash/infections. Death registry: 33 deaths among evacuees, 91% from natural causes. No deaths directly related to the hurricane, indirect deaths reported.	A state-wide internet-based surveillance system allows for the collection of health data from different people in multiple locations, for multiple types of health encounters (not all had baseline).

Table F: Examples of public health communication - public, staff and health providers

Reference	Emergency Event	Evaluation Methodology	Evaluation Results	Recommendations
Staes et al., 2011	Pandemic influenza, 2009	Cross-sectional, mixed methods survey of office-based primary care providers in Utah (509 surveyed, response rate 28%) to explore communication between public health and front-line clinicians.	Public health websites were used but not frequently enough to keep up with changes. Volume of email too great to process efficiently. Email came from multiple sources but preference was their institutional source for guidance about testing and treatment. High levels of correct knowledge about testing and treatment when guidance is stable, but low after guidance changed.	Overall preference: a single email from an institution with any differences from national (state) guidelines explained. Public health should connect with health institutions to distribute guidance to their clinicians. Email limited to a single credible source. Identify new information so clinicians don't have to search for it. Note when local recommendations differ from other sources, and explain why.
Schnitzler et al. (2007)	Floods in Germany, 2002	Conducted telephone surveys among randomly selected households in flood-affected neighborhoods in 42 communities. N=477 respondents, 91% of homes were flooded.	Listening to the radio together with loudspeaker messages was reported to be the most effective communication combination, providing information to 80% of the affected population. Only 6% used the Internet as an information source, however this may reflect the date (10 years ago). 80% of the 150 individuals who left their homes stated that evacuation should be ordered and enforced, and similarly 78% of 1999 who had not left their homes felt this way.	Radio plus loudspeaker messages were an effective communication combination in this situation. Note that loudspeakers hold benefits in that electricity is not required; recommend that the public possess battery-powered radios. Orders from public health to evacuate were supported.
Tappero & Tauxw, 2011	Cholera epidemic in Haiti and the Dominican Republic, 2010	Within Haiti, public health messages distributed using a various mediums (banners, text messages, mass media). Focus groups held in the midst of the communications effort (details not specified). In the Dominican Republic, public information distributed through various mediums and a KAP survey of residents in Santo Domingo conducted but no details provided.	Focus groups in Haiti: respondents were confused about how cholera was spreading and how to prevent it, but they understood the need to treat diarrheal illness with ORS, how to prepare ORS, and how to disinfect water with purification tablets. Survey in the Dominican Republic: 89% had received cholera prevention messages.	The conduct of some form of DAP evaluation in the midst of a communication campaign can help authorities understand if messages are reaching, and being understood by, the public; as well, gaps can be identified that can inform ongoing messaging.

Reference	Emergency Event	Evaluation Methodology	Evaluation Results	Recommendations
Chess & Clarke, 2007	Anthrax attacks, 2001 (New Jersey)	Key informant interviews in 4 geographic areas (ranging from extensive contamination to no contamination): public health professionals, emergency responders, elected officials, police etc. Number not specified.	Successful communication supported by pre-existing organizational and professional networks, operating prior to the emergency (e.g., bioterrorism workgroup with multi-sectoral partners; informal networks among police and health agencies).Effective networks were more flexible and adaptable.	Develop partnerships on a routine basis that can support effective communication if an emergency occurs. Flexible and adaptable communication networks may be advantageous in an emergency.
Davis et al., 2007	Hurricane Isabel, 2003 (North Carolina) Preceded by hurricane Floyd, 1999, prompting capacity building.	32 key informant interviews with a convenience sample of individuals who had roles in planning, preparation or response to hurricanes Floyd or Isabel (DOH, local health departments, Public Health Surveillance Team, etc.).	Public Health Command Centre was established to serve as a base for public health operations during an emergency, as extension of the EOC (managed RNA and surveillance). Positively felt to provide a 'single point of contact for public health needs and structured process for answering questions'. Communication not flawless (e.g., when managers could not be reached).	Public Health Command Centre had an important role in facilitating contact between response personnel. This was felt to enhance the capacity of public health to respond to hurricane Isabel compared to the response to hurricane Floyd 4 years prior.
Beatty et al., 2006	Blackout, 2003 (New York City)	Retrospective program evaluation: personnel working in the EOC asked to complete a quality assessment form during the blackout (n =45, response rate 35%). Requested listing of activities that achieved their intended goal efficiently, barriers encountered during the response, and suggested ways to improve the response.	All respondents listed at least one communication problem, examples: DOMHA employee call centre inadequate phone lines to respond to employee queries about reporting to work, plus insufficient back-up battery charge; radios for communication with staff and the EOC had limited battery life; EOC phones required additional power to function which was not met; and delays in preparing press releases and public health advisories without functioning computers.	Develop protocols specifying which, when and where employees should report during emergencies. Establish a directory of employees' skills and emergency contact information that would be readily accessible during an emergency. Prepare information resources on general public health issues that may occur during an emergency, in advance (avoid reliance on computers that may have limited operation during power failure). EOC recommendations: use phones that don't require additional power; stock extra batteries or emergency power to recharge radios; create a paper library of important documents; have supplies on site to enable self-sufficiency for 48 hours.

Table G: Examples of RNA implemented after disaster (community)

Reference	Emergency Event	RNA Methodology	Results (Selected)	Evaluation
Bayleyegn et al., 2006	Hurricane Ivan (Florida)	Modified cluster sampling method used to select 30 clusters in each of the two most heavily damaged counties (WHO EPI method). Seven households interviewed in each cluster (began at central area in each cluster then moved in random direction along roads to reach seven housing units) Survey questionnaires administered 6 days after hurricane landfall. Included Spanish-speaking interviewers. Referral for immediate health and safety needs sent to the health department. Survey team comprised of nursing student volunteers and staff from Florida Disaster Community Health Assessment Teams. Distributed printed public health information.	-60-87% response rates -75% of homes damaged -27-54% using a generator; 10% in one county placed generator in dangerous locations. -20-40% no regular garbage pick-up; 27-34% no electricity; 13-16% no functioning telephone. -9-10% problems obtaining medication; 4-11% problems obtaining medical care; 12-14% injuries; 17-18% illnesses (sleep disturbance, respiratory, GI, skin rash).	-Anecdotal. -RNA identified that the major needs were restoring power, telephone services and debris pick-up. -Need for mental health services, primary care services, information about safe generator use, and ways to access medical care and medications. -Interaction with interviewers helped affected individuals with a sense of reconnection to the outside among resident who felt isolated. -Communications disruption highlighted the need for alternative means of communication due to disruptions (e.g., holding community forums, posting information at gas and ice stations).
McNeil et al., 2005	Hurricane Katrina, 2005 (Mississippi)	2-stage sampling plan selected 200 households in the most severely affected county. 1st stage involved randomly selected census blocks; 2nd stage randomly selected 'waypoints' within each selected block. Survey teams deployed 2 weeks after hurricane landfall, used GPS to identify 'waypoints' and selected home closest to waypoint. Questionnaire (?) assessment Distributed telephone numbers (local health care and relief agency), insect repellant and public health education material.	-36% of homes destroyed. -53% had no telephone services; 41% no electricity, 37% no(?) functioning indoor toilets,; 26% dependent on relief agencies for water; 33% problems with trash removal. -6% of households had member that sustained injury; 20% experienced illness; 13% mental health problems; 29% needed prescription filled within 3 days; and 34% needed medical care.	-Anecdotal -Results provided to the Department of Health and Emergency Management Agency officials. -Emphasized need for continued relief agency support for supplying water; expediting restoration of trash and debris removal services; publicizing names and locations of functioning local medical care facilities, pharmacies and mental health services.

Reference	Emergency Event	RNA Methodology	Results (Selected)	Evaluation
Hladey et al., 1994	Hurricane Andrew, 1992 (South Florida)	Modified cluster sampling method (EPI method) – systematic sampling of 30 clusters/area, then # households sampled within each cluster. Aerial surveillance identified the 2 most severely affected communities; these were surveyed twice and a less severely affected community nearby was surveyed once. Questionnaire administered by volunteers (medical students) or PHU staff. Informed residents about location of medical treatment and supply distribution sites, and distributed public health education material.	-91%(?) of households had no electricity; 86% no telephone service; 30% no functioning toilet; and 17% without enough for immediate needs. 7% had injured residents (bruises, laceration, puncture wounds – felt to be relatively low proportion and minor injuries). No significant change in prevalence of injury in 2nd survey. Similar levels of illness in nearby, less-severely affected area, suggested that outbreaks hadn't occurred.	Information quickly released to media to inform public and control rumors (e.g., of CD outbreaks). Multiple sectors used this information (health departments, law enforcement, utility companies). Changed the focus of medical relief away from mass casualty trauma services towards primary care and preventive services, and restoration of pharmacy services.
Zane et al. (2010)[102]	Hurricane Ike, 2008 (Texas)	30 census blocks randomly selected in three communities. Seven households randomly selected from each block. 1-page questionnaire. Assessments conducted by Texas Department of Health Services, US Public Health Service and CDC.	In Galveston: 45% had no electricity; 26% no garbage collection; 46% felt residence unsafe to inhabit; 16% had one household member with an injury. In Liberty: 7% had no access to food, 4% no working toilet, 2% no electricity, 2% no running water. In Manvel: 5% had no access to food, 3% no running water, 2% no regular garbage collection, 3% no electricity.	Despite response efforts, Galveston households were still lacking electricity and garbage pick-up, 17 days post-storm. Injury rates highlighted the importance of increasing public education on injury prevention during clean up. This resulted in an extensive public health outreach education program. In Manvel and Liberty, the RNA reassured local health officials that most households were receiving basic utilities and that services were being restored.
Chen et al. (2003)[85]	Chi-Chi earthquake, 1999 (Taiwan)	Shelters in two counties were divided in 30 clusters/county. In each cluster Temporary Medical Service Systems representative interviewed an adult member from each of 7 randomly selected households. Data compared with similar data from the normal sentinel surveillance system.	Rates of acute respiratory infections and gastroenteritis were significantly higher in the affected area post-earthquake vs. neighbouring unaffected counties. Age-adjusted mortality rate was significantly higher in 1999 than comparable period in 1998 (OR = 2.1). Proportion of households reporting the following: injured person (47%); drinking water purification (91%); access to flushing toilet (40%), electricity (25%), telephone (34%), garbage collection (39%).	This survey provided some of the earliest objective data describing the status of the affected populations. Useful in guiding relief efforts (e.g., officials decided not to provide bottled water in selected areas because a high proportion of the affected population had access to purified water).

APPENDIX D: IMS, ICS AND BCERMS

Incident Management Systems (IMS): A system that defines the roles and responsibilities of personnel and the operating procedures to be used in the management and direction of emergency incidents and other functions.[3]

Many provinces/territories in Canada use an incident management system that is based on the Incident Command System (ICS).[3] The common components of ICS are as follows:[3]

- Incident Commander and Command Staff functions
- Planning Functions
- Operations Functions
- Finance/Administration Functions
- Logistics Functions

In BC, the British Columbia Emergency Response Management System (BCERMS) is used at the provincial level.[3,5] BCERMS is based on the ICS (see Appendix B for a detailed description).

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