Evidence Report/Technology Assessment
Number 207

Allocation of Scarce Resources During Mass Casualty Events

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Number 207

Allocation of Scarce Resources During Mass Casualty Events

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The information in this report is intended to help health care decisionmakers—patients and clinicians, health system leaders, and policymakers, among others—make well-informed decisions and thereby improve the quality of health care services. This report is not intended to be a substitute for the application of clinical judgment. Anyone who makes decisions concerning the provision of clinical care should consider this report in the same way as any medical reference and in conjunction with all other pertinent information, i.e., in the context of available resources and circumstances presented by individual patients.

This report may be used, in whole or in part, as the basis for development of clinical practice guidelines and other quality enhancement tools or as a basis for reimbursement and coverage policies. AHRQ or U.S. Department of Health and Human Services endorsement of such derivative products may not be stated or implied.

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Preface

The Agency for Healthcare Research and Quality (AHRQ), through its Evidence-based Practice Centers (EPCs), sponsors the development of evidence reports and technology assessments to assist public- and private-sector organizations in their efforts to improve the quality of health care in the United States. The reports and assessments provide organizations with comprehensive, science-based information on common, costly medical conditions and new health care technologies and strategies.

The EPCs systematically review the relevant scientific literature on topics assigned to them by AHRQ and conduct additional analyses when appropriate prior to developing their reports and assessments. To bring the broadest range of experts into the development of evidence reports and health technology assessments, AHRQ encourages the EPCs to form partnerships and enter into collaborations with other medical and research organizations. The EPCs work with these partner organizations to ensure that the evidence reports and technology assessments they produce will become building blocks for health care quality improvement projects throughout the nation. The reports undergo peer review and public comment prior to their release as a final report.

AHRQ expects that EPC evidence reports and technology assessments will inform individual health plans, providers, and purchasers, as well as the health care system as a whole, by providing important information to help improve health care quality.

We welcome comments on this evidence report. Comments may be sent by mail to the Task Order Officer named in this report to: Agency for Healthcare Research and Quality, 540 Gaither Road, Rockville, MD 20850, or by email to epc@ahrq.hhs.gov.

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Allocation of Scarce Resources During Mass Casualty Events

Structured Abstract

Objectives. This systematic review sought to identify the best available evidence regarding strategies for allocating scarce resources during mass casualty events (MCEs). Specifically, the review addresses the following questions: (1) What strategies are available to policymakers to optimize the allocation of scarce resources during MCEs? (2) What strategies are available to providers to optimize the allocation of scarce resources during MCEs? (3) What are the public's key perceptions and concerns regarding the implementation of strategies to allocate scarce resources during MCEs? (4) What methods are available to engage providers in discussions regarding the development and implementation of strategies to allocate scarce resources during MCEs?

Data Sources. We searched Medline, Scopus, Embase, CINAHL (Cumulative Index to Nursing and Allied Health Literature), Global Health, Web of Science®, and the Cochrane Database of Systematic Reviews from 1990 through 2011. To identify relevant non–peer-reviewed reports, we searched the New York Academy of Medicine's Grey Literature Report. We also reviewed relevant State and Federal plans, peer-reviewed reports and papers by nongovernmental organizations, and consensus statements published by professional societies. We included both English- and foreign-language studies.

Review Methods. Our review included studies that evaluated tested strategies in real-world MCEs as well as strategies tested in drills, exercises, or computer simulations, all of which included a comparison group. We reviewed separately studies that lacked a comparison group but nonetheless evaluated promising strategies. We also identified consensus recommendations developed by professional societies or government panels. We reviewed existing State plans to examine the current state of planning for scarce resource allocation during MCEs. Two investigators independently reviewed each article, abstracted data, and assessed study quality.

Results. We considered 5,716 reports for this comparative effectiveness review (CER); we ultimately included 170 in the review. Twenty-seven studies focus on strategies for policymakers. Among this group were studies that examined various ways to distribute biological countermeasures more efficiently during a bioterror attack or influenza pandemic. They provided modest evidence that the way these systems are organized influences the speed of distribution. The review includes 119 studies that address strategies for providers. A number of these studies provided evidence suggesting that commonly used triage systems do not perform consistently in actual MCEs. The number of high-quality studies addressing other specific strategies was insufficient to support firm conclusions about their effectiveness.

Only 10 studies included strategies that consider the public's perspective. However, these studies were consistent in their findings. In particular, the public believes that resource allocation guidelines should be simple and consistent across health care facilities but should allow facilities some flexibility to make allocation decisions based on the specific demand and supply situation. The public also believes that a successful allocation system should balance the goals of ensuring

the functioning of society, saving the greatest number of people, protecting the most vulnerable people, reducing deaths and hospitalizations, and treating people fairly and equitably. The remaining 14 studies provided strategies for engaging providers in discussions about allocating and managing scarce medical resources. These studies did not identify one engagement approach as clearly superior; however, they consistently noted the importance of a broad, inclusive, and systematic engagement process.

Conclusions. Scientific research to identify the most effective adaptive strategies to implement during MCEs is an emerging area. While it remains unclear which of the many options available to policymakers and providers will be most effective, ongoing efforts to develop a focused, well-organized program of applied research should help to identify the optimal methods, techniques, and technologies to strengthen our nation's capacity to respond to MCEs.

Contents

Tables

Figures

Appendixes

Executive Summary

Background

Most experts define a mass casualty event (MCE) as a natural (e.g., earthquake, pandemic) or manmade (e.g., detonation of a nuclear device, conventional explosive, bioterror attack) incident that suddenly or progressively generates large numbers of injured and/or ill people who require medical and/or mental health care. The magnitude of demand for medical care resources has the potential to vastly outstrip the ability of a health care facility or a local, regional, or national public health and health care delivery system to deliver medical care services consistent with generally established standards of care.

An MCE can occur suddenly, as is typical of an earthquake, tornado, or terrorist bombing;[1] or it may evolve over hours to days, as is typical of a hurricane, flood, or disease outbreak;[2] or would likely happen following a bioterror attack.[3] Regardless of its rate of onset, the scope and complexity of an MCE can severely challenge even the most highly experienced and well-equipped health care providers and systems.[4]

By definition, an MCE generates a level of demand for health care resources that outstrips available supply. Under those circumstances, local and regional health care providers are unable to meet victims' needs at the level normally expected of a modern health care delivery system. Because such situations are difficult to predict and can occur with little or no warning, health care systems and providers must be prepared to swiftly implement contingency plans to reduce less-urgent demand for health care services; optimize the use of existing resources; and secure additional resources, if possible, from backup sources. If these measures are insufficient to meet demand, providers may be forced to shift from the traditional treatment approach, which strives to deliver optimum care to every patient, to one that seeks to do the most good for the most people with the available resources. This latter concept has come to be known as "crisis standards of care."

Objectives

In 2009, the Institute of Medicine (IOM) Committee on Guidance for Establishing Standards of Care for Use in Disaster Situations published a landmark Letter Report recommending that health care providers, organizations, government officials, and the public approach the challenge in a thoughtful and proactive way, anchored in four values: fairness; equitable processes; community and provider engagement, education, and communication; and the rule of law.5 The IOM Letter Report also recommended that State plans incorporate, among other things, evidence-based clinical processes and operations.

To help Federal, State, and local policymakers, providers, and interested members of the public address the issue with the best available evidence, we were asked to build on the work of the IOM and previous reviews by conducting a thorough review of the evidence regarding allocation of scarce medical resources during MCEs.

This report addresses the following Key Questions:

- **Key Question 1.** What current or proposed strategies are available to policymakers to optimize the allocation and management of scarce resources during MCEs? What outcomes are associated with these strategies? What factors act as facilitators or barriers to their implementation or effectiveness?

- **Key Question 2.** What current or proposed strategies are available to providers to optimize the allocation of scarce resources during MCEs? What outcomes are associated with these strategies? What factors are identified as facilitators or barriers to their implementation or effectiveness?
- **Key Question 3.** What are the public's key perceptions and concerns (e.g., values, equity, transparency, communication, and public input) regarding the development and implementation of strategies to allocate and manage scarce resources during actual and potential MCEs?
- **Key Question 4.** What current or proposed methods are available to engage providers in discussions regarding the development and implementation of strategies to allocate and manage scarce resources, both in planning for and during an MCE? What outcomes are associated with these strategies? What factors are identified as facilitators or barriers to engaging providers in these discussions?

Analytic Framework

Given the heterogeneity in key aspects of study design across the four Key Questions, we elected to use the PICOTS framework (populations, interventions, comparators, outcomes, timings, and settings) as the analytic framework for the review.

Methods

Input From Stakeholders

The Agency for Healthcare Research and Quality (AHRQ) and the Office of the Assistant Secretary for Preparedness and Response (ASPR) developed the research topic and its four Key Questions. Investigators at the Southern California Evidence-based Practice Center then refined the questions in consultation with two nationally recognized experts in disaster medicine and health system preparedness and an AHRQ-appointed technical expert panel (TEP) of experts from the fields of public health, disaster preparedness and response, hospital medicine, transplant surgery, adult and pediatric emergency medicine, nursing, law, health care ethics, military medicine, risk communication, and public engagement. The TEP provided clinical and methodological expertise and offered insights on identifying and defining key parameters for the review, such as criteria for including and excluding studies.

Data Sources and Selection

Our search strategy leveraged existing reviews of the literature, particularly the IOM's Letter Report and Summary on Crisis Standards of Care[5,6] and the AHRQ and ASPR Mass Medical Care with Scarce Resources: A Community Planning Guide.[7] These reviews helped identify relevant medical care resource management and allocation strategies that existed when the documents were published and provided summary information on the relevant outcomes of the strategies. Our subsequent literature search comprised four parts: (1) a formal search using multiple research databases, (2) a scan of the "grey" literature, (3) consultation with our TEP to identify any additional sources, and (4) a review of State plans for allocating scarce resources during MCEs.

Searched databases included PubMed, Scopus, Embase, CINAHL (Cumulative Index to Nursing and Allied Health Literature), Global Health, Web of Science®, and the Cochrane

Database of Systematic Reviews, from 1990 through 2011. We also searched online library catalogs, such as the National Library of Medicine's LocatorPlus, to identify relevant books. (Appendix A provides details of our search strategy.) We supplemented these searches with a search of the grey literature using the New York Academy of Medicine's Grey Literature Report. This helped identify reports from research and advocacy organizations, including non–peer-reviewed reports. As a final check of comprehensiveness, TEP members identified relevant studies as well as organizations that sponsored research or issued guidance on proposed strategies for allocating resources during MCEs. We compiled a list of relevant organizations and used scans of relevant related Web sites to extend our search.

We also reviewed State plans, which were provided to us by ASPR. We identified a small number of additional plans through reference searches.

For all four Key Questions, we included articles found in the peer-reviewed literature and grey literature, including but not limited to empirical studies, State and Federal Government reports, State plans, peer-reviewed reports and papers by nongovernmental organizations, policy and procedure documents, and clinical care guidelines developed by specialty societies. We considered both U.S. and international (English and non-English language) sources. For Key Questions 1, 2, and 4, we included studies that used randomized controlled trials and observational studies reporting data from real events, drills, exercises, or computer simulations in which a comparison group or pre- and post- design was used. For Key Question 3, we included studies reporting the outcomes of systematic data collection efforts (e.g., focus groups, surveys) that documented patients' perspectives on resource allocation during MCEs. We excluded articles published before 1990, publications that presented only conceptual frameworks, non-systematic reviews, and studies that did not consider strategies in the specific context of an MCE—for example, a study of emergency medical services or emergency department triage in the context of routine operations.

Data Extraction and Quality

After the literature search was completed, two researchers screened all titles to eliminate citations that were clearly unrelated to the topic. Next, two researchers independently reviewed study abstracts to determine whether the study should be included in the review, based on our inclusion and exclusion criteria. If no abstract was available, they reviewed the full text.

Two researchers independently reviewed full-text articles and excluded those that (1) failed to address a Key Question, (2) did not meet our inclusion criteria, or (3) related to training but did not report changes in actual performance outcomes. When necessary, we resolved disagreement between reviewers by consensus or third-party reconciliation.

Our data extraction approach was tailored to each Key Question. Because of the volume of studies describing tested strategies that were relevant to Key Questions 1 and 2, we developed an electronic data collection form using DistillerSR (see Appendix B) to capture the necessary data elements. For Key Question 3 and our analysis of State plans, we abstracted data directly into spreadsheets because of the relatively small number of data elements required for each review. For Key Question 4, we used a paper-based data collection form (see Appendix B). Although the number and type of data elements varied by Key Question, they generally included the following: study design, geographic location, type of MCE, details of the strategy, outcomes reported, and implementation facilitators and/or barriers.

Few studies included randomized controlled trials; thus we were unable to use the standard, validated instruments that are typically used to assess the quality of studies in CERs.[8] Instead, we determined that a more generic quality rating system would allow for greater comparability across the diverse research methodologies and outcomes used in the studies. We therefore conducted an environmental scan of existing rubrics. Finding no single scale that seemed appropriate for our topic, we developed our own composite scale, drawing heavily on the quality assessment scale from the Substance Abuse and Mental Health Services Administration's National Registry of Evidence-based Programs and Practices and on two other scales commonly used to appraise the quality of qualitative research.[9-11]

Data Synthesis and Analysis

Due to the diversity of topics covered in the Key Questions, we structured our findings around several broad categories, graded by the overall strength of the evidence: (1) strategies intended to reduce or more effectively manage less-urgent demand for health care services, (2) strategies intended to optimize the use of existing resources, (3) strategies designed to augment existing resources, and (4) strategies for ethical decisionmaking regarding allocation (or reallocation) of scarce medical resources in crisis situations. Within each of these categories, we considered the weight of evidence regarding the impact of applicable strategies on health outcomes (e.g., reduced mortality and/or morbidity, adverse events). When no evidence was found regarding the impact of the strategy on health outcomes, we looked for evidence of its impact on process measures, such as rates of use of consumable health care resources.

We used the approach for grading the strength of evidence outlined in the Methods Guide for Effectiveness and Comparative Effectiveness Reviews.[12] That approach requires assessment in four domains: risk of bias, consistency, directness, and precision. After making assessments in these four domains, we graded the strength of the evidence using the four-point scale (i.e., high, moderate, low, or insufficient). "High" strength of evidence indicates high confidence that the evidence reflects the true effect. "Insufficient" strength of evidence indicates that evidence either is unavailable or does not permit the formulation of conclusions.[12]

Results

Key Question 1: What Strategies Are Available to Policymakers To Optimize the Allocation of Scarce Resources During Mass Casualty Events?

Policymakers—governments at all levels from local to national—play a key role in providing policy and operational guidance for allocating scarce resources during MCEs. This review includes 27 studies that provided information on strategies available to policymakers. The specific strategies are presented in Table A.

Table A. Summary of strategies addressing Key Question 1, by category

	Strategies
Reduce or manage less urgent demand for health care services	**Biological countermeasures (12 studies)** • POD strategies (e.g., centralized vs. hybrid structure; eliminating conventional steps; using simulation and decision support to optimize staffing) • Optimizing strategies for allocating medication from stockpiles (e.g., level of preallocation, level of tailoring to population needs, amount for prophylaxis vs. treatment) • Mass vaccination, contact tracing, and school closure • Mass distribution of antibiotics using postal carriers **Nonbiological countermeasures (3 studies)** • Distribution of surgical masks or N95 respirators to the public • Restriction of nonurgent demand for hospital care • Training for public health officials in their legal authority to implement strategies to limit the spread of pandemics
Optimize use of existing resources	**Load sharing (2 studies)** • Central command structure to optimize distribution of patients to hospitals • Establishment of site emergency management centers in low vulnerability locations • Robust and interoperable emergency communications systems • Coordinated regional trauma systems to facilitate the rapid transfer of hospitalized and special needs patients
Augment existing resources	**Temporary facilities (3 studies)** • Alternate-site surge capacity facilities • Mobile field hospitals • Activating mobile provider units from other Federal agencies to provide hospital surge capacity **Temporary facilities (3 studies)** • Mutual aid agreements that allow transshipment of antivirals between counties
Crisis standards of care	None

POD = point of dispensing

In the category of reducing or managing less-urgent demand for health care services, there is **low** to **medium** strength of evidence to favor a "push" method to deliver medications, such as via U.S. Postal Service letter carriers, over conventional approaches that "pull" patients to a fixed point of dispensing (POD). There is also **low** to **medium** evidence that better management of POD operations can speed throughput and therefore more rapidly distribute biological countermeasures. There is **low** strength of evidence that public distribution of nonbiological countermeasures, such as N-95 respirators or surgical masks, will reduce demand for hospital beds, intensive care unit (ICU) beds, and ventilators. There is **insufficient** evidence for any strategies available to policymakers to optimize the use of existing resources. Both studies reviewed in this area provided highly applicable evidence from real MCEs, but only one of the studies was high-quality.

The strength of evidence for strategies available to policymakers to augment health care resources is **low**. Three studies examined different approaches to augmenting health care resources following a major hurricane. Each used a vastly different strategy and examined effectiveness using different end points. Nonetheless, each described an empirically tested strategy deemed successful by the authors, ranging from opening alternative care sites to a mobile field hospital to more efficient distribution of patients via a regional medical operations center.

The small number of studies that met the inclusion criteria (n = 27) and the marked variability in design, focus, and content for this Key Question provide a relatively weak evidence base for informing policymakers. Over half of the included studies comprised computer simulations rather than intervention studies, and only a few of these examined similar scenarios using similar end points.

Key Question 2: What Strategies Are Available to Providers To Optimize the Allocation of Scarce Resources During Mass Casualty Events?

Numerous studies included in the review provide evidence on a range of strategies intended to help providers optimize resource allocation during MCEs. A total of 119 studies met our criteria for inclusion. The specific strategies are presented, by category, in Table B.

A wide range of provider-oriented strategies has been tested in various contexts, including actual MCEs, exercises, drills, and computer simulations. However, with the exception of prehospital or "field" triage during MCEs, the body of high-quality evidence addressing any single strategy is rather small. Typically, not more than one or two studies provided evidence for any particular strategy. As a result, there is currently insufficient evidence to favor adoption of one strategy over another.

Three studies described strategies to reduce or manage less-urgent demand for health care services. Two studies examined techniques to rapidly dispense prophylactic medication. The third study assessed the effectiveness of a centralized public information system implemented in Israel. Although each of the studies cleared the threshold for evidence, we rated both simulations as low quality. Moreover, the incident command system proposed as a solution to address bottlenecks in the operation of PODs had not been tested in an actual MCE. The applicability of the public information system to the U.S. context is uncertain. We rated the strength of evidence provided by these studies as **insufficient**.

A total of 48 studies included a test of a strategy for optimizing existing resources during an MCE. Because of the large number of studies reporting the development or implementation of triage systems, we synthesized evidence on these strategies separately from the remaining optimization strategies.

Triage systems and explicit triage acuity scales have been used in emergency departments for many years and have been extensively studied. But triage in the setting of MCEs is quite different, particularly triage practiced in prehospital settings where first responders may be required to assess large numbers of victims in a very short time frame. Many of the studies on this topic raised significant concerns about the performance of current triage systems during actual MCEs. Studies that tested triage systems during exercises or drills provided evidence with limited applicability. The strength of evidence for the set of triage studies is **low**.

Although a clear majority of the other (i.e., nontriage) resource optimization strategies were found to be effective, the limited level of evidence for each type of strategy does not allow definitive conclusions to be drawn. Only three studies used randomized designs, and nearly all studies were limited by small sample sizes. Many studies failed to include a comparison group and instead typically relied on performance benchmarks from prior events—a potentially subjective standard. Thus the strength of evidence for the nontriage studies is also **low**.

Table B. Summary of strategies addressing Key Question 2, by category

	Strategies
Reduce or manage less urgent demand for health care services	**Biological countermeasures (2 studies)** • Emergency mass clinic based on CDC guidelines • POD strategies (e.g., dynamic staffing) **Public information (1 study)** • Automated central information distribution system for families
Optimize use of existing resources	**Case managers (1 study)** • Hospital-based case managers to ensure care coordination **Decontamination (1 study)** • Strategies to increase decontamination effectiveness (e.g., instructions, providing washcloths) **Health care worker prophylaxis (1 study)** • Influenza prophylaxis for health care workers **Health information technology (2 studies)** • Electronic triage tags to monitor vital signs and transmit information to first responders • Regional telemedicine hub to support delivery of specialty care **Imaging (4 studies)** • Focused assessment of sonography for trauma (FAST) for triage • Sonographic screening for abdominal/pelvic injury or bleeding for triage • Accelerated CT protocols **Load sharing (4 studies)** • Load-sharing protocols • Central allocation of patients to hospitals based on available resources **Medical interventions (2 studies)** • Medical interventions for the prevention of acute renal failure in crush victims • Novel drug infusion devices **Space optimization (3 studies)** • Conversion of lobbies, clinics, and other units to accommodate surge • Reverse triage to create surge capacity (e.g., early discharge, increasing use of community care options) **Training (6 studies)*** • Hospital staff training (e.g., disaster drills, computer simulations, tabletop exercises) • Triage training (e.g., JumpSTART training program, virtual reality, podcasts, computer games) **Triage (24 studies)*** • Triage systems (e.g., START, mSTART, American College of Surgeons Committee on Trauma criteria, Radiation Injury Severity Classification, CBRN-specific system, Revised Trauma Score, Sacco triage method, SALT, Influenza-Like Illness Scoring System, TAS Triage Method, Simple Triage Scoring System, Model of Resource and Time-based Triage) • Triage strategies (e.g., combining triage categories, adding categories, one- vs. two-stage triage) • Simplified biodosimetry protocol to triage exposed victims
Augment existing resources	**Resource conversion (1 study)** • Conversion between formulations of nerve agents to augment supply
Crisis standards of care	**General (1 study)** **Orthopedics (1 study)** • External fixation of fractures rather than definitive orthopedic care **Pediatrics (1 study)** • Provision of only "essential" interventions **Trauma surgery (2 studies)** • "Damage control" approach (e.g., for orthopedic surgery or more generally)

CBRN = chemical/ biological/radiological/nuclear; CDC = Centers for Disease Control and Prevention; CT = computed tomography; POD = point of dispensing; mSTART = modified simple triage and rapid treatment; SALT = sort, assess, life-saving interventions; START = simple triage and rapid treatment; TAS = triage assessment system
*Includes one meta-analysis.

A single study tested a strategy for augmenting scarce resources during an MCE. It examined a protocol to convert between formulations of nerve agent antidotes to augment the supply. We rated the strength of evidence in this category as **insufficient**.

Several studies evaluated outcomes of strategies involving implementation of crisis standards of care during actual or simulated MCEs. Examples of the identified strategies include the use of “damage control” surgery to treat the initial influx of complex trauma victims and the use of very early discharge decisions by a triage committee to allocate ICU care in a field hospital. Collectively, these studies present encouraging findings. However, we judged most to be of low quality because they used study designs that did not adequately control for potential confounders. Moreover, in the studies of actual events, data collection was typically nonsystematic, and the measures of effectiveness often relied on historical benchmarks that are open to interpretation. Several studies did not measure health outcomes or even the most relevant process outcomes. Instead, most of the studies focused on measures of throughput. These challenges may be unavoidable in the setting of actual MCEs, which often require providers to employ multiple interventions at once under stressful conditions. We judged the strength of evidence from these studies to be **insufficient** to support firm conclusions.

Key Question 3: What Are the Public’s Concerns Regarding Strategies To Allocate Scarce Resources?

We identified 10 studies that provide information relevant to Key Question 3. The results regarding public perceptions of how scarce resources should be allocated and managed during MCEs are generally consistent across studies. While the studies have some limitations, because they are relatively well-designed we rated the strength of evidence as **medium**. Findings from these studies can be summarized as follows:

A successful allocation system should balance the goals of ensuring the functioning of society, saving the greatest number of people, protecting at-risk populations, reducing deaths and hospitalizations, and treating people fairly and equitably.

Participants used multiple criteria to prioritize recipients of resources during an MCE. Health care professionals, health care workers, and first responders were among the highest priority groups; politicians were among the lowest.

Many participants accorded high priority for receipt of care to children and young adults.

Most participants rejected prioritization criteria based on ability to pay, “first come, first served,” or random selection (lottery system).

The public showed a high degree of faith and trust in medical professionals to make appropriate allocation decisions based on their expert opinions.

Resource allocation guidelines should be generally consistent but should allow health care institutions some degree of flexibility to make allocation decisions based on their specific demand and supply situation.

Key Question 4: What Methods Are Available To Engage Providers in Developing Strategies To Allocate Scarce Resources During MCEs?

The 14 studies reviewed for this Key Question employed a wide array of engagement strategies. They largely focused on planning and exercises, yet they addressed a diverse range of relevant planning scenarios, resource allocation issues, and stakeholders. The specific strategies are summarized in Table C.

Table C. Summary of strategies addressing Key Question 4

	Strategies
Led by Providers	• Enrollment, education, training, and exercise of qualified laboratory staff for preparing biodosimetry specimens • Organization of de novo regional hospital planning group • Alternative planning models (decentralized regional planning, hospital-directed tiered regional planning model, third-party directed planning model) • Development of consensus on appropriate pediatric crisis standards of care • Development of evidence-based “reverse triage” classification system • Pilot testing of local-, regional-, and national-level tabletop exercises for the Veterans Health Administration • Pharmacy-led development of regional pharmaceutical preparedness policies and procedures
Led or co-Led by Policymakers	• Public health/business partnership for mass dispensing • Development and pilot testing of tabletop exercise template for local-level governments and providers • Organization of neighboring States into a voluntary disaster surge network • State or local public health department planning model, including development of mutual aid agreements • Incorporation of community health centers into surge plan, with training for community health centers and three event-based tests • Developing proposed ethical frameworks and procedures for rationing scarce health resources within a State (2 studies) • Broadly inclusive regional hospital-level planning process to identify surge beds

Although the evidence provided by these studies did not identify one engagement approach as clearly superior to the others, several important themes emerged. First, inclusive processes that engage all major stakeholders are important. This group includes officials from relevant provider institutions, key professional associations, State and/or local governments, academia, and the public. Second, systematic and often iterative processes produced more robust and satisfying products, such as a critical planning framework or a consensus plan. Third, the involvement of credible subject matter experts enhanced participation, provider satisfaction, and the quality of the final product. Finally, the initiative taken by nontraditional providers or groups added innovation and breadth to the range of engagement strategies proposed to enhance medical surge capacity. Because we judged the likelihood of bias to be low, and the 14 studies were generally consistent in their findings, we graded the strength of evidence as **medium**.

State Plans

We reviewed plans from 11 States and one U.S. territory. Collectively, these plans provide an important window into the current status of State planning for the allocation of scarce medical resources. The State plans that we reviewed proposed various strategies to reduce or manage less urgent demand for health care services, optimize use of existing resources, and augment existing resources when possible. Most tilted heavily toward strategies designed to optimize use of resources and paid less attention to describing specific methods to reduce demand or augment existing resources. Few plans proposed legal and operational frameworks for shifting to crisis standards of care. Fewer still offered providers specific guidance about how to allocate critical health care resources.

Discussion

The September 11, 2001, terrorist attacks and the anthrax attacks that followed transformed Americans' views of the danger of terrorism. In the decade that followed, the major causes of MCEs in the United States involved natural events, including hurricanes Katrina and Rita, numerous deadly tornados, severe acute respiratory syndrome (SARS), and the 2009 H1N1 influenza. The temblors that struck Haiti, Chile, New Zealand, and Japan remind us that earthquakes can wreak havoc, even in highly developed nations. As the U.S. population grows and ages, the odds that a future MCE will outstrip our capacity to respond increase day by day. This is the context that prompted AHRQ and the Department of Health and Human Services' Office of the Assistant Secretary for Preparedness and Response to commission this analysis.

Key Findings

There is limited evidence to help policymakers select the most effective strategies to maximize the use of existing resources or allocate scarce resources using crisis standards during MCEs. Rapid deployment of effective biological countermeasures could reduce demand for health care resources in the immediate aftermath of a bioterror attack or a rapidly spreading pandemic. There is low- to medium-strength evidence that "push" methods that deliver medications directly to households are more effective than methods that "pull" patients to a fixed POD. There is low strength of evidence that mass distribution of nonbiological countermeasures, such as surgical masks, reduces demand for health care resources. There is even less evidence to support current policies to optimize resource allocation and use. There is limited evidence that resource use can be optimized by load sharing, transferring patients to more distant hospitals, and opening temporary facilities.

The evidence base to guide providers on the best strategy or strategies for optimizing management and allocation of resources during MCEs is equally limited. The only provider-oriented strategy that has been subjected to comparative assessment is field triage during MCEs.

A systematic review of field triage systems, comprising 11 papers that evaluated 8 different triage tools, found limited evidence to confirm the validity of any of these tools.[13] For every other category of provider-based strategies, the evidence base was insufficient to support a conclusion at more than a low level of evidence.

Although the current evidence base regarding public perceptions of how scarce resources should be allocated and managed during MCEs is thin, published findings are generally consistent. All but one of the six studies we reviewed reported data collected from a single community. Nevertheless, because their findings were generally consistent, we judged the strength of evidence as medium. They indicate that citizens are interested and motivated to participate in community forums. Participants expressed the belief that a successful allocation system should balance the goals of ensuring the functioning of society, saving the greatest number of people, protecting the most vulnerable, reducing deaths and hospitalizations, and treating people fairly.

Promising strategies exist for engaging providers in discussions about the development and implementation of strategies for allocating and managing scarce resources during MCEs, but none has been sufficiently evaluated. The studies we examined indicated that it is possible to engage health care providers in productive discussions, but there was insufficient evidence to recommend one engagement strategy as superior to the others. Nonetheless, several important themes emerged. First, inclusive processes work better than those that do not. Second, systematic and iterative processes produce more robust and satisfying products. Third, involving credible subject matter experts enhances participation, satisfaction, and the quality of the final product.

Current consensus guidelines and recommendations from specialty societies and government advisory groups rest on an insufficient body of evidence. Few offer actionable guidance to policymakers, health care providers, or the public. Most of the consensus panel recommendations we reviewed were either dated or presented at a level that is unlikely to be useful to policymakers or providers. This was particularly true of guidelines produced by specialty societies. Two societies recommended that ICU resources be allocated on the basis of “first come, first served.” This guidance contradicts the wishes of the public, based on the limited number of surveys and public engagement studies published to date (see Key Question 3 above).

Some States have made progress toward adopting plans to manage and, if necessary, allocate resources under crisis standards of care. Most, but not all, of these plans described strategies that fit into one or more of four overarching domains: (1) Reduce demand for scarce health care resources through such measures as mass dispensing of vaccine, prophylactic medications, and self-quarantine; (2) optimize use of existing resources through triage, load balancing, repurposing of facilities, more efficient use of providers, and substitution of more plentiful alternatives; (3) augment existing resources by tapping stockpiles and other reserves and activating mutual aid agreements; and (4) implement crisis standards of care based on predefined priorities, with the understanding this means that some patients will receive comfort care rather than aggressive intervention. No State plan addressed all four domains.

Limitations of the Review Methods

We made a number of tradeoffs to accommodate the vast body of literature on this complex topic. First, because we sought to identify resource allocation strategies from across the full spectrum of preparedness and response, we were unable to efficiently search the literature using a parsimonious set of search terms. Second, because of the challenges in conducting research on MCEs, we included study designs in this CER that are normally considered to produce lower levels of evidence, including cohort, before-after, quasi-experimental studies, and consensus recommendations by specialty societies and national panels. To further broaden our coverage of the topic, we included in a separate section studies that had some measure of feasibility or performance but lacked a comparison group. Third, we felt it necessary to develop our own quality assessment scale for the vast majority of studies covered in this review to accommodate the broad range of study types. Although the scale appeared to work well, it has not been validated. There was some degree of subjectivity in assigning scores to each item in our quality assessment scales; however we required two reviewers to independently rate and reconcile any discrepant scores to minimize potential bias. Fourth, while the scope of our review was broad, it may not have addressed key aspects of the management of MCEs, such as the clinical or logistical aspects of EMS care and transport of patients, other than the technique of field triage in the setting of MCEs. Finally, despite our use of an extensive literature, publication bias remains a concern.

Limitations of the Evidence Base

By their nature, MCEs are uncommon and largely unanticipated. MCEs also vary widely with respect to geography, cause, onset, setting, duration, scale, and many other characteristics. These aspects, coupled with the rapidly evolving nature of MCEs, make it difficult to draw generalizable inferences from any single event. Moreover, researchers interested in improving response to MCEs cannot prospectively enroll subjects in a real event, allocate subjects into treatment groups with precisely controlled study protocols, and systematically collect data.

Some research teams have attempted to model alternative interventions using computer simulation or have tested them in simulated exercises and drills. While these approaches are useful, they raise significant internal and external validity concerns. In particular, it is difficult for even the most realistic models and drills to reproduce the demanding environment of an actual disaster or MCE and to accurately model human behavior in such incidents.

The scarcity of rigorous methodology, the noncomparability of methods (including variability in effectiveness measures), and the relative paucity of studies that addressed any single strategy limited our ability to perform meta-analyses or to draw firm conclusions from existing studies of this topic. With the exception of prehospital (field) triage, most of the strategies we identified were assessed by no more than three studies. Many of the articles that we reviewed assessed the impact of a current or proposed strategy on a clinical process or some aspect of a process (often using inconsistent metrics); relatively few examined outcomes. When outcomes were measured, they were often secondary outcomes that served as proxies for the true outcome of interest (e.g., survival).

Future Research

Our findings have clear implications for future research. Despite the fact that our review spanned more than 20 years of preparedness research, including the decade following the September 11, 2001, attacks, it is evident that few strategies, even those widely accepted by the field, are backed by sufficient evidence to conclusively demonstrate their effectiveness.

Three obstacles are hindering progress in the field. The first and most formidable obstacle is that current levels of Federal funding for research in this area are not only insufficient, but in decline. Furthermore, the existing portfolio of extramural research is heavily weighted toward biological threats. Other threats, including natural disasters, and other challenges, such as health systems operations in an MCE, are receiving substantially less attention.

The second obstacle is a lack of coordination. Currently, each agency and each researcher pursues topics of organizational interest. There is little evidence that efforts are coordinated to minimize overlap or focus on the most urgent gaps. We recommend that the various stakeholder agencies and nongovernmental organizations come together and jointly develop a coordinated agenda of applied research. This will not occur without conscious effort.

The third major obstacle is the sheer difficulty of conducting scientifically rigorous research, especially randomized controlled trials, in an unfolding MCE. This need not block progress in the field, but it almost certainly calls for research methodologies that are better suited for these situations. Many successful business innovations have come from “focused empiricism”: identifying what works and what does not, refining it over time, and embracing a culture of continuous quality improvement. The same approach may work in the context of MCEs.

With adequate funding, greater coordination, and more flexible approaches to research, rapid progress can be made. Special attention might be directed to the following priorities:

- Identification of the optimal approach to rapidly distributing various biological and nonbiological countermeasures to the public. Promising and potential strategies include engaging a mix of the public sector (e.g., U.S. Postal Service letter carriers) and private sector (e.g., retail pharmacies, overnight shippers) to disperse products and services to homes or neighborhood locations that are easily accessible on foot. Studies of this sort could produce dramatic gains in a short amount of time.

- Research directed toward harnessing the capabilities of existing bidirectional communication devices, technologies, and social media for real-time disease surveillance, self-triage, community outreach, and coordination of recovery efforts.
- Better approaches to prehospital triage during MCEs.
- More widespread and substantive work, through public forums and other methods of engagement, to ascertain the public's views regarding allocation of scarce resources in MCEs. A special effort should be made to reach beyond general public forums to elicit the views of minorities and at-risk communities.
- Development of more realistic models and exercises to develop, assess, and refine optimal approaches to respond to MCEs, including affordable simulations and "no-notice" drills to public health and health system decisionmakers to exercise key elements of national, State, and community response in challenging situations
- Rapid engagement of health care professionals, ethicists, public health officials, and community members to devise contingent strategies for allocation of scarce resources in a variety of plausible scenarios—particularly allocation strategies to be implemented under crisis standards of care.

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Introduction

Background

Context

This evidence report is intended to advance our Nation's efforts to better prepare for and respond to large-scale health emergencies—one of 13 "urgent issues" flagged for immediate attention by the Government Accountability Office in 2008.[1,2] The Government Accountability Office's concern was based on observations by the Institute of Medicine (IOM) and other groups that our nation's emergency care system—encompassing emergency medical services, hospital-based emergency departments, inpatient wards, and intensive care units—is so overburdened that it could not readily cope with a large-scale public health emergency.[3-5]

In 2009, in compliance with provisions of Public Law No. 109-417 (also known as the Pandemic and All-Hazards Preparedness Act of 2006), the U.S. Department of Health and Human Services (HHS) released its first-ever National Health Security Strategy for the United States (hereafter referred to as the NHSS or the Strategy). In its introduction to the NHSS, HHS noted that considerable progress had been made in the previous decade, but many challenges remained:

> "…Emergency response efforts are sometimes disparate; and effective coordination is often lacking across governmental jurisdictions, communities, and the health and emergency response systems.[3] Additional steps must be taken to ensure that adequate medical surge capacity and a sufficiently sized and competent workforce are available to respond to health incidents, a sustainable medical countermeasure enterprise sufficient to counter health incidents is fostered, and increased attention is paid to building more resilient communities and integrating the public, including at-risk individuals,[4] into national health security efforts. Moreover, considerable variation remains in the degree to which individual States, territories, tribes, and local jurisdictions are prepared to address large-scale health threats. At the same time, few evidence-based performance measures and standards exist to gauge the effectiveness of national health security efforts and progress toward goals[5]—that is, to assess the extent to which the Nation is prepared for the types of health incidents that we have experienced in the past and may have to confront in the future."[6]

To achieve national health security, which HHS describes as "…a state when the Nation and its people are prepared for, protected from, respond effectively to, and able to recover from incidents with potentially negative health consequences," the NHSS establishes two overarching goals: (1) Build community resilience, and (2) strengthen and sustain health and emergency response systems. To pursue these goals, the NHSS calls for a "systems approach" to health security. This approach recognizes that many interrelated systems are needed to support and protect individual and community health. As depicted in Figure 1, the two overarching goals of the NHSS are supported by 10 strategic objectives. Two of these objectives, integrated, scalable health care systems and science, evaluation, quality improvement, are the primary focus of this comparative effectiveness review (CER). However, the issues and strategies addressed in this review are relevant to many of the other objectives (e.g., national health security workforce, effective countermeasures enterprise).

Figure 1. Achieving national health security

Source: HHS Web site[6]

The NHSS highlights the importance of improving coordination between Federal, State, local, and tribal planning, preparedness, and response activities. It further notes that planning should be guided by the principles articulated in the National Response Framework[7] and other key sources of national homeland security doctrine, such as the National Incident Management System.[8] These principles are particularly relevant for allocating scarce medical resources.

Definition of Terms

For the purposes of this report, we used the following definitions:

"Policymakers"

We defined policymakers as government officials and agencies at the Federal, State, regional, or local level who have authority to develop and enforce policies and protocols that drive decisionmaking. For example, policymakers include:

- Federal departments and agencies (e.g., HHS, Department of Homeland Security)
- State and local public health officials
- State governing officials (e.g., governor, State legislature)
- Local governing officials (e.g., mayor, city council, county supervisors)
- State and local emergency management officials

- Tribal officials
- International health officials (e.g., World Health Organization, Pan American Health Organization).

"Providers"

We defined providers as individuals who are licensed to provide health care services under State or tribal law, international standards, or the laws of their country and health care organizations or institutions that provide patient care. Providers include, for example:

- Licensed individuals, such as physicians, nurses, social workers, pharmacists, and emergency medical technicians, including paramedics
- Health care organizations, such as health maintenance organizations, private practices, home care agencies, community health centers, emergency medical services organizations, and nongovernmental organizations
- Health care facilities or institutions, such as acute care hospitals, skilled nursing facilities, long-term care institutions, and psychiatric care facilities
- Health responder teams to catastrophic events (e.g. international, nongovernmental organizations, military).

"Public"

We defined the public as all community members and individuals not addressed as policymakers or health care providers, regardless of gender, race, ethnicity, sexual orientation, age, disability, setting, health status, or other defining characteristics.

"Mass Casualty Events"

We defined a mass casualty event (MCE) as a natural (e.g., earthquake, pandemic) or manmade (e.g., detonation of a nuclear device, conventional explosive, bioterror attack, building collapse) incident that suddenly or progressively generates large numbers of injured and/or ill people who require medical and/or mental health care. The magnitude of this increase in demand for medical care resources has the potential to outstrip the ability of a facility or a local, regional, or national public health and health care delivery system to deliver medical care services consistent with established standards of care.

A mass casualty event can occur suddenly, as is typically the case with an earthquake, tornado, or terrorist bombing,[9] or it may evolve over hours to days, as frequently happens in a hurricane, flood, disease outbreak,[10] or bioterror attack.[11] Regardless of its rate of onset, the scope and complexity of an MCE can severely challenge even highly experienced and well-equipped health care providers and systems.[12] Typically in an MCE, demand for medical care resources quickly outstrips the day-to-day capacity of local and regional health care providers, rendering them unable to meet patients' needs at the level normally expected in a modern health care delivery system. When immediately available resources are clearly insufficient to meet patients' needs, health care providers and hospitals must be prepared to swiftly implement contingency plans to accelerate the delivery of services. If this response is inadequate to address the situation, they may need to shift from the individual approach to health care, which is intended to deliver optimum care to each and every patient, to one that that seeks to do the most good for the most people with the resources at hand. This concept has come to be known as "crisis standards of care."

"Scarce Resources"

For purposes of this review, our technical expert panel defined "scarce resources" as medical care resources that are likely to be scarce in a crisis care environment. Medical care resources include physical items (e.g., medical supplies, drugs, beds, equipment), services (e.g., medical treatments, nursing care, palliative care), and health care personnel (e.g., physicians, nurses, psychologists, laboratory technicians, other essential workers).

"Crisis Standards of Care"

The foundation for this Evidence-based Practice Center report was laid by the IOM Committee on Guidance for Establishing Standards of Care for Use in Disaster Situations, which published a landmark Letter Report in 2009.[13] In this report, the committee offered the following definition of "crisis standards of care":

"Crisis standards of care" is defined as a substantial change in usual health care operations and the level of care it is possible to deliver, which is made necessary by pervasive (e.g., pandemic influenza) or catastrophic (e.g., earthquake, hurricane) disaster. This change in the level of care delivered is justified by specific circumstances and is formally declared by a State government, in recognition that crisis operations will be in effect for a sustained period. The formal declaration that crisis standards of care are in operation enables specific legal/regulatory powers and protections for health care providers in the necessary tasks of allocating and using scarce resources and implementing alternative care facility operations."

To ensure that patients receive the best possible care during a catastrophic event, the IOM Letter Report recommended that health care providers, organizations, government officials, and the public approach this challenge in a thoughtful and proactive way.[13] The Letter Report proposed a national approach, anchored in four values:

1. *Fairness*. The approach should employ standards that are widely recognized as fair by all concerned, that are evidence-based, and that compassionately respond to the needs of individuals and the affected population. Proper stewardship of resources is essential to maintain the trust of patients and the community.
2. *Equitable processes*. The approach should be transparent in design and decision making and be consistent across populations and individuals without regard for race, ethnicity, ability to pay, socioeconomic status, preexisting health conditions, and other characteristics. When measures are taken, they should reflect the scale of the emergency and the degree of resource scarcity. Individuals who decide when and how to implement such standards should be accountable for their decisions. Governments must also be accountable for assuring appropriate protections and just allocation of resources.
3. *Community and provider engagement, education, and communication*. Stakeholder input (from institutions, organizations, providers, and the public) should be sought through a formalized process of engagement and collaboration.
4. *The rule of law*. Legal authority is required to properly empower necessary and appropriate actions during a crisis. Also, an appropriate legal environment is needed to facilitate implementation of crisis standards in a public health emergency. Otherwise, health care providers may be reluctant to make the difficult decisions that are needed.

Experts generally agree that optimizing resource allocation in an MCE will require a multifaceted approach that includes strategies to minimize less-urgent demand for health care services, effective techniques to boost the supply of medical resources for those who need them, and evidence-based guidance on how to make difficult resource allocation decisions in crisis care situations. The development and implementation of these strategies will require, in turn, a multidisciplinary approach that balances multiple considerations, including ethical and legal issues and the special needs of at-risk populations. To be successful, stakeholders from the provider community and the public must be actively engaged in the process of developing and implementing crisis standards of care.

One of the first and most critical steps in this process is to systematically review the literature to identify, grade, and summarize relevant evidence regarding how best to approach and manage this process. That is the task we undertook in preparing this report.

Our work builds on previous comprehensive governmental and nongovernmental reviews and reports.[9, 13-18] Collectively, these reports provided our team with a conceptual framework for approaching and evaluating the extant literature on this topic. In addressing the Key Questions, this report builds on the existing literature by identifying allocation strategies that are supported by evidence, describing strategies for engaging providers, and identifying key concerns of the public regarding the allocation of scarce medical resources.

Scope of the Review

This CER is intended to address four important dimensions regarding allocation of scarce resources in MCEs. By compiling a thorough, current, and comprehensive evidence review, we hope to help the Agency for Healthcare Research and Quality and the Office of the Assistant Secretary for Preparedness and Response provide State governments, as well as planning and provider communities, with the information they need to clarify processes and/or make difficult but necessary decisions in the setting of MCEs and other large-scale public health emergencies, as well as to identify future research and policy needs. While ideally we would have restricted this CER to incidents that triggered a formal disaster declaration, such as through a Stafford Act declaration, through the authority of the governor of a State, or within a single community or institution, such as a hospital, we learned that few studies reported this information consistently. Requiring such a declaration as an inclusion criterion would ensure comparability but might exclude important studies.

The scope of this review was intentionally designed to be broad for additional reasons. Because MCEs are, fortunately, rare, the number of opportunities to conduct rigorous empirical research is limited. Moreover, the assessment of strategies in the midst of an MCE and potential "diverting" of resources in the midst of more fundamental needs after the MCE raise important ethical considerations. Thus, our review comprised a broad range of study designs—several of which might not be considered sufficiently rigorous for inclusion in a typical systematic review.

An additional challenge is that the consideration of strategies to allocate scarce health care resources does not happen in an ethical, moral, or legal vacuum. In fact, it is critical to take not only patient preferences into account, but also the views of health care providers, family members, entire communities, and at-risk populations. In this issue, as in few others, the social context in which these decisions are played out is highly relevant to the conduct and relevance of a particular strategy. Our review specifically sought to assess a broad range of outcomes for the resource allocation strategies, including both health outcomes and ethical outcomes.

With these considerations in mind, this CER should be relevant to several important groups, including (1) policymakers charged with responsibility to devise and promulgate strategies to guide the actions of public health agencies and health care institutions during an MCE; (2) health care providers who may be faced with the need to allocate scarce resources during an MCE; (3) patients, family members, and loved ones who may be personally affected by these decisions;

and (4) members of the wider community, who also have a stake in how these decisions are made.

Key Questions

Before conducting the review, the study investigators and our technical expert panel refined each of the Key Questions. The populations, interventions, comparators, outcomes, timings, and settings (PICOTS) considered for each Key Question are described in the Methods chapter.

Key Question 1. What current or proposed strategies are available to policymakers to optimize the allocation and management of scarce resources during MCEs? What outcomes are associated with these strategies? What factors act as facilitators or barriers to their implementation or effectiveness?

Key Question 2. What current or proposed strategies are available to providers to optimize the allocation of scarce resources during MCEs? What outcomes are associated with these strategies? What factors are identified as facilitators or barriers to their implementation or effectiveness?

Key Question 3. What are the public's key perceptions and concerns (e.g., values, equity, transparency, communication, and public input) regarding the development and implementation of strategies to allocate and manage scarce resources during both actual and potential MCEs?

Key Question 4. What current and proposed methods are available to engage providers in discussions regarding the development and implementation of strategies to allocate and manage scarce resources both in planning for and during an MCE? What outcomes are associated with these strategies? What factors are identified as facilitators or barriers to engaging providers in these discussions?

Organization of This Report

In the sections that follow, we describe the methods used to identify, analyze, and classify published studies that address each of the four Key Questions. We then summarize the key findings for each of these Key Questions, with supporting tables and appendixes. As noted above, because we encountered a substantial number of studies that examined a promising resource allocation technique, technology, or practice but used study designs that lacked comparison groups, we grouped these "proof of concept" studies differently and summarized them in a separate section. We then include a summary of strategies that have been proposed by professional organizations or by the Federal government. Finally, recognizing the IOM Letter Report's call for thoughtful State plans, we reviewed a set of State plans for common themes, features, and gaps. Our objective is to provide readers with a comprehensive view of the current evidence regarding allocation of scarce resources during MCEs and propose options for strengthening the evidence base going forward. Moreover, by highlighting strengths and gaps in the existing evidence base, we hope to inform the development of a research agenda that will quickly improve our nation's capacity to prepare, mitigate, respond, and quickly recover from large-scale health emergencies.

Methods

Overview

The methods for this systematic review broadly follow those outlined in the Agency for Healthcare Research and Quality (AHRQ) Methods Guide for Effectiveness and Comparative Effectiveness Reviews (available at www.effectivehealthcare.ahrq.gov/methodsguide.cfm). To the degree feasible, our methods and analyses were determined a priori. However, in the course of identifying studies we modified the comparative effectiveness review (CER) protocol to better align with the types of studies we encountered. In particular, we found few studies that compared strategies in a head-to-head fashion and therefore included all studies that had a valid control group. In addition, because of the paucity of evidence we were finding in support of existing resource allocation strategies, we decided to compile a summary of evidence from studies that might have otherwise been excluded either because they lacked comparison groups or because they represented consensus guidelines from clinical experts or policymakers.

Because of extreme heterogeneity in the types of resource allocation strategies we encountered and the small number of studies addressing any particular strategy, we did not consider meta-analysis or other form of quantitative analysis. Rather, we reviewed individual strategies within meaningful categories (discussed below), providing synthesis to the extent that multiple studies addressed a similar topic.

In the remaining sections of this chapter we describe our conceptual framework; the PICOTS (populations, interventions, comparators, outcomes timings, and settings) framework that guided our literature search strategy and served as our analytic framework; inclusion and exclusion criteria; study selection process; data extraction and quality assessment procedures; approach to data synthesis, and our assessments of the strength and applicability of the evidence. The contents of this section (and the larger report) are informed by the PRISMA checklist for reporting systematic reviews.[19]

Topic Refinement and Review Protocol

AHRQ's Scientific Resource Center (SRC) and its cosponsoring agency, the Office of the Assistant Secretary for Preparedness and Response (ASPR), developed the research topic and its four Key Questions. Investigators at the Southern California Evidence-based Practice Center then refined the questions in consultation with a technical expert panel (TEP) appointed by AHRQ. The SRC approved the final version of the review protocol prior to the start of the review.

Technical Expert Panel and Expert Consultants

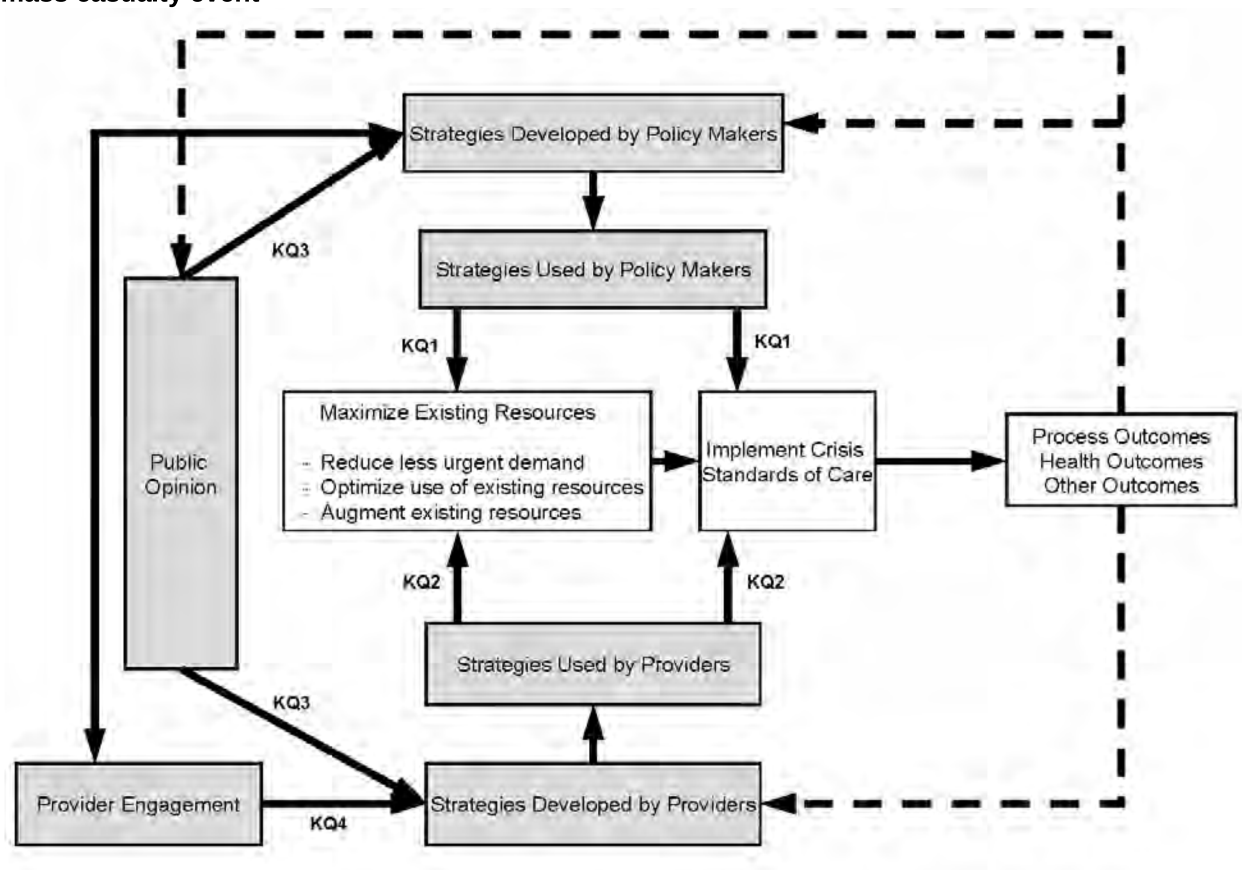
The TEP convened for this project included experts from the fields of public health, disaster preparedness and response, hospital medicine, transplant surgery, adult and pediatric emergency medicine, nursing, law, health care ethics, military medicine, risk communication, and public engagement.

We solicited additional input from two subject matter experts, neither of whom served on the TEP. Both experts were nationally recognized experts in disaster medicine and health system preparedness and were drawn from the private (academic) and public sector, respectively. Both experts helped to refine our methodology and identify additional sources of studies for the review.

Conceptual Framework

The conceptual framework for our evidence review is depicted in Figure 2. It illustrates the broad categories of adaptive strategies developed and used by policymakers and health care providers to allocate scarce resources during mass casualty events (MCEs) and how the thinking and actions of both groups are modified by the outcomes of these strategies and by public opinion. As illustrated in the figure, policymakers and providers develop and implement strategies using an escalating series of contingent actions, based on the nature, magnitude, scope, and duration of the MCE.

Figure 2. Conceptual framework for allocating and managing scarce medical resources during a mass casualty event



KQ = Key Question

During surge conditions, policymakers and providers will initially use strategies that have the goal of maximizing existing resources by:

- Managing or reducing less-urgent demand for health care services
- Optimizing the use of existing resources
- Augmenting available resources.

Many of these "resource maximization" strategies are aimed at extending use and making management of resources more efficient to forestall the development of serious shortages. If these measures prove to be inadequate, health care facilities may seek to augment existing resources by tapping stockpiles, invoking mutual aid agreements, and exercising other options.

The ultimate goal of these strategies is to preserve generally accepted standards of care. Specific examples of each type of strategy are included in our PICOTS framework discussed later in this chapter.

If these contingency measures are inadequate to meet extremely excessive demand, the institution may be forced to relax standards of care. The allocation or reallocation of resources under crisis conditions that may reduce the level of care delivered to individual patients is commonly referred to as “crisis standards of care.” Typically, these strategies are not employed unless every effort to maximize available resources has been exhausted. Under crisis standards of care, institutions and providers may shift their approach to allocating resources from one designed to maximize the outcome of each patient to one that seeks to do the greatest good for the largest number of people. Aside from strictly utilitarian goals, crisis standards of care may also have other objectives, such as preserving the long-term functioning of society. During a prolonged MCE, the health care system may shift into and out of “crisis care” over time, as the event evolves and stocks of supplies, equipment, and personnel rise and fall. Thus, multiple strategies may be sequentially employed during an MCE depending on its magnitude and duration, rate of onset, available resources, and the capacity of the medical care system.

The resource allocation strategies deployed by policymakers and providers influence individual and population outcomes through both processes of care and health outcomes. Other outcomes, including the ethical and economic consequences of these strategies, may also be important to providers, policymakers, and the public.

The outcomes of each strategy shape the refinement or development of new strategies—indicated in Figure 2 by feedback loops (dashed lines). For example, outcomes of strategies, particularly adverse outcomes, might provoke strong reaction from the public. Providers or policymakers may then integrate the expressed preferences of the general public into new or updated strategies. Provider engagement activities might inform the strategies developed by policymakers, while, at the same time, the planning efforts of policymakers might also serve as a catalyst for providers to engage in efforts to develop strategies to respond to MCEs.

While this conceptual framework was developed for the purposes of guiding this review, key elements draw directly on the Letter Report published by the Institute of Medicine (IOM) Committee on Guidance for Establishing Standards of Care for Use in Disaster Situations.[13]

Analytic Framework

Given the heterogeneity in key aspects of study design across the four Key Questions, we elected to use the PICOTS framework as the analytic framework for the review. We present this framework separately for each Key Question below.

Search Strategy

Our search strategy leveraged existing reviews of the literature, including but not limited to those considered in the IOM Letter Report and Summary on Crisis Standards of Care[13, 20] and the Community Planning Guide on Providing Mass Medical Care with Scarce Resources, developed by AHRQ and ASPR.[16] These reviews helped identify relevant medical care resource management and allocation strategies in existence at the time these documents were published and summary information on the relevant outcomes of these strategies. Building on this work helped us focus our search.

Our literature search comprised four parts: (1) a formal search using multiple research databases, (2) a scan of the "grey" literature,[a] (3) a review of current State plans regarding the allocation of scarce resources, and (4) consultation with our TEP for any additional sources. In addition to using an expert, in-house research librarian with special skills in health information, we benefitted from the services of an expert librarian at the National Institutes of Health (NIH) who had previously conducted literature searches on this topic on behalf of ASPR.

Because of the cross-disciplinary nature of this topic, our formal literature search used research databases beyond those covering the biomedical literature. In consultation with our TEP, we selected seven academic databases: PubMed, Scopus, Embase, Cumulative Index to Nursing and Allied Health Literature (CINAHL), Global Health, Web of Science®, and the Cochrane Database of Systematic Reviews. We also searched online library catalogs, such as the National Library of Medicine's LocatorPlus, to identify relevant books. Each search spanned the period from January 1990 through November 2011. We constructed search algorithms for each database (Appendix A), executed the search, downloaded the results into individual EndNote libraries, combined libraries from each search, and deleted duplicate references. Using the Web of Science® database, we also conducted "forward searches" to identify articles that cited key references.

Our search of the grey literature was confined to the New York Academy of Medicine's Grey Literature Report—one of the few existing databases that covers grey literature sources. We did not pursue additional searches of the grey literature (e.g., LexisNexis) out of concern that these sources might not provide the high-quality evidence needed to satisfy our inclusion and exclusion criteria.

Individual members of the TEP provided additional relevant studies, particularly those that were not published in the peer-reviewed literature. These studies included work that was funded by the Centers for Disease Control and Prevention and the Veterans' Health Administration, professional society guidelines, and research produced by nongovernmental organizations such as Trust for America's Health. We compiled a list of these sources and used scans of related Web sites to broaden our search.

An additional element of this project was a review of State plans for allocating scarce health care resources during MCEs. Officials at ASPR provided a sample of current State plans for analysis representing 11 States and the territory of Guam. Because there is no central national repository for this information, this list is unlikely to be exhaustive and may be regarded as a snapshot of current State-level efforts to define resource allocation principles and protocols.

Inclusion and Exclusion Criteria

Prior to designing our search strategy, we framed each of the four Key Questions along six dimensions that are commonly used in CERs: populations, interventions, comparators, outcomes timings, and settings (PICOTS). This section describes these dimensions and the resulting inclusion and exclusion criteria for each of the Key Questions, as well as general inclusion and exclusion criteria.

[a]The grey literature comprises evidence that "is produced on all levels of government, academics, business and industry in print and electronic formats, but which is not controlled by commercial publishers" (Grey Literature Network Service, 1999).[21] Grey literature sources can include abstracts presented at conferences, unpublished data, government documents, or manufacturer information and can be difficult to locate because these sources are not systematically identified, stored, or indexed (Relevo and Balshem, 2011).[22]

General Criteria

- Include articles found in the peer-reviewed and grey literatures, including but not limited to empirical studies, State and Federal government reports, State and Federal plans, peer-reviewed reports and papers by nongovernmental organizations, policy and procedure documents, and clinical care guidelines developed by specialty societies.
- Include studies from both U.S. and international sources.
- Include English- and non–English-language publications.
- Include the following:
    - Randomized controlled trials.
    - Observational studies reporting data from real events, drills, exercises, or computer simulations.
    - Recommended strategies proposed by national provider groups and/or task forces or work groups convened by or comprising representatives of the Federal government.
    - Studies reporting the outcomes of systematic data collection efforts (e.g., focus groups) that document patients' perspectives on resource allocation during MCEs.
    - Systematic reviews of strategies to allocate resources during an MCE.
- Exclude studies published prior to 1990.
- Exclude publications that present only conceptual frameworks.
- Exclude nonsystematic reviews.
- Exclude studies that do not consider these strategies in the context of an MCE.

Key Question 1: What Strategies Are Available to Policymakers To Optimize Allocation of Scarce Resources During MCEs?

PICOTS Framework for Key Question 1

Population

The *target population* includes policymakers charged with responsibility for developing and implementing strategies to optimize allocation of resources during MCEs. The *affected population* includes people who require medical treatment after an MCE. This group includes those who are physically injured and/or ill as a direct or indirect result of the MCE and those with unrelated, but urgent, medical needs (e.g., treatment for heart attacks, stroke, kidney failure, or cancer). We also address behavioral health needs in the setting of MCEs, including acute stress, grief, psychosis, and panic reactions.

Interventions

Strategies used by policymakers to maximize scarce resources. These include actions to manage or reduce less-urgent demand for health care services, optimize existing resources, or augment the supply of existing resources, and, when these actions are inadequate, to implement strategies consistent with crisis standards of care. Potential strategies included the following:

- Strategies focused on single or multiple components of the health system, including emergency medical services and dispatch, public health, hospital-based care, renal dialysis, home care, primary care, palliative care, mental health, and provider payment policies.

- Actions taken in advance to prepare for large-scale public health events that could trigger a huge surge in demand for medical and health care resources (e.g., stockpiling).
- Adaptive strategies that ensure effective incident command, control, intelligence gathering, and communication systems, since these are often necessary channels to implement other strategies that optimally manage and allocate resources.
    - Actions taken to maximize resources to avoid the need to shift to crisis standards of care—for example, actions to substitute, conserve, adapt, and/or reuse critical resources, including reuse of otherwise disposable equipment and supplies, expanding scope of practice laws, and altered approaches that maximize delivery of care.[13]
    - Actions taken to reduce or manage less-urgent demand for health care services in order to avoid the need to adopt a crisis standard of care—for example, activating call centers or Web sites that provide information about when and where to seek treatment and how to adequately care for oneself or family members at home.
    - Strategies for making ethical allocation decisions when critical resources will otherwise be insufficient to meet the population's needs (i.e., "crisis standards of care").

Comparators

Where possible, we considered studies that compared an intervention with one or more alternative interventions. We also considered studies that compared an intervention with no intervention (i.e., no change in the approach to resource allocation or management). Studies that demonstrated the feasibility of a novel technique or technology without a comparison group were not included in the full CER, but were summarized in a separate section.

Outcomes

Included outcomes depended on the type of intervention and represented one or a combination of the following:

- Process measures (e.g., number of patients treated, amount of resources obtained, ability to maintain conventional standards of care, avoidance of crisis standards of care)
- Health outcomes
    - Favorable (e.g., decreased mortality, decreased physical and/or psychological morbidity)
    - Unfavorable (e.g., adverse events, such as preventable morbidity and/or mortality)
- Other outcomes (e.g., ethical, legal, financial consequences; public perceptions of the intervention, public acceptance of or compliance with the intervention)

Timing

We confined our review to studies addressing preparedness and response to MCEs. We also considered strategies that address the triggers or timing for returning to normal operations. We only considered strategies specifically addressing long-term recovery from MCEs (e.g., community resilience) if these strategies were implemented during the course of an MCE, and not subsequent to an MCE.

Settings

All settings in which patient care might be directed/managed and delivered, including but not limited to prehospital triage locations (e.g., on-scene, in transport), emergency department triage and care, inpatient settings (e.g., operating room, intensive care unit, ward, community health centers, urgent care facilities, long-term care institutions, primary and specialty care practices, skilled nursing facilities, home care agencies, and alternate care facilities.

Inclusion and Exclusion Criteria

- Include studies that describe the processes and/or outcomes of strategies used by policymakers or studies that result from the strategic direction provided by policymakers to maximize and allocate scarce resources during an MCE. (See the Definitions section for descriptions of policymakers, scarce resources, and MCEs.)
- Include if the strategy has been prospectively tested in a real event or tested in the context of an exercise, drill, or computer simulation.
- Include if the strategy arose from a documented after-action report of a real event as long as the study describes a specific, implementable strategy and systematically reports the outcomes of the strategy, whether or not a comparison group was used.
- Include if the strategy has not been tested but rather proposed by a national provider organization or a task force convened by the Federal government. Studies must describe the method by which consensus was achieved by the committee, panel, or work group, which may include, but is not limited to, the Delphi process.
- Exclude if the study does not describe a specific, implementable strategy.
- Exclude if the strategy does not relate to scarce resources.
- Exclude if the study does not report the outcomes of a strategy, including studies that report only "lessons learned" from a real event, drill, or exercise.
- Exclude if the proposed strategy is not from a national provider organization or a task force convened by the Federal government or does not describe the consensus development process.

Key Question 2: What Strategies Are Available to Providers To Optimize Allocation of Scarce Resources During MCEs?

PICOTS Framework for Key Question 2

Population

The *target population* includes health care providers who hold responsibility for allocating scarce resources during MCEs. The *affected* population includes people who require medical treatment after an MCE. This group includes those who are physically injured and/or ill as a direct or indirect result of the MCE and those with unrelated but urgent, medical needs (e.g., treatment for heart attacks, stroke, kidney failure, or cancer). We also address behavioral health needs in the setting of MCEs, including acute stress, grief, psychosis, and panic reactions.

Interventions

Strategies used by providers to maximize scarce resources. These include actions to manage or reduce less-urgent demand for health care services, optimize existing resources, or augment the supply of existing resources, and, when these actions are inadequate, to implement strategies consistent with crisis standards of care. Potential strategies included the following:

- Strategies focused on single or multiple components of the health system, including emergency medical services and dispatch, public health, hospital-based care, renal dialysis, home care, primary care, palliative care, mental health, and provider reimbursement.
- Actions taken in advance to prepare for large-scale public health events that could trigger a huge surge in demand for medical and health care resources (e.g., training staff, exercising plans, stockpiling critical supplies and equipment).
- Adaptive strategies that ensure effective incident command and communication systems, since these are often necessary channels to implement other strategies that optimally manage and allocate resources.
- Actions taken to maximize resources in order to avoid the need to adopt a crisis standard of care; for example, actions to substitute, conserve, adapt, and/or reuse critical resources, including reuse of otherwise disposable equipment or supplies, reallocation of staff from nonclinical to clinical functions (i.e., expanding scope of practice), and altered approaches to using staff to deliver care.
- Actions taken to reduce or manage less-urgent demand for health care services in order to avoid the need to adopt a crisis standard of care; for example, activating call centers or Web sites that provide information about when and where to seek treatment and how to adequately care for oneself or family members at home.
- Strategies for making allocation decisions when critical resources will otherwise be insufficient to meet the population's needs (i.e., "crisis standards of care").

Comparators

Where possible, we considered studies that compared an intervention with one or more alternative interventions. We also considered studies that compared an intervention with no intervention (i.e., no change in the approach to resource allocation or management). Studies that demonstrated the feasibility of a novel technique or technology without a comparison group were not included in the full CER, but were summarized in a separate section.

Outcomes

A combination of any of the following:

- Process measures (e.g., number of patients treated, amount of resources obtained, ability to maintain conventional standards of care, avoidance of crisis standards of care)
- Health outcomes
    - Favorable (e.g., decreased mortality, decreased physical and/or psychological morbidity)
    - Unfavorable (e.g., adverse events, such as preventable morbidity and/or mortality)
- Other outcomes (e.g., ethical, legal, financial consequences, public perceptions of the intervention, public acceptance of or compliance with the intervention)

Timing

We confined the review to studies addressing preparedness and response to MCEs. We considered strategies that address the triggers or timing for returning to normal operations. We only considered strategies specifically addressing long-term recovery from MCEs (e.g., community resilience) if these strategies were implemented during the course of an MCE, and not subsequent to an MCE.

Settings

All settings in which patient care might be delivered, including but not limited to prehospital triage locations (e.g., on-scene, in transport), emergency department triage and care, inpatient settings (e.g., operating room, intensive care unit, ward), community health centers, urgent care facilities, long-term care institutions, primary and specialty care practices, skilled nursing facilities, home care agencies, and alternate care facilities.

Inclusion and Exclusion Criteria

- Include studies that describe the processes and/or outcomes of strategies used by providers to maximize or allocate scarce resources during an MCE. (See the definitions section for detailed descriptions of providers, scarce resources, and MCEs.)
- Include if the strategy has been prospectively tested in a real event or tested in the context of an exercise, drill, or computer simulation.
- Include if the strategy arose from a documented after-action report of a real event as long as the study describes a specific, implementable strategy and systematically reports the outcomes of the strategy, whether or not a comparison group was used.
- Include if the strategy has not been tested but rather proposed by a national provider organization or a task force convened by the Federal government. Studies must describe the method by which consensus was achieved by the committee, panel, or work group, which may include, but is not limited to, the Delphi process.
- Exclude if the study does not describe a specific, implementable strategy.
- Exclude if the strategy does not relate to scarce resources.
- Exclude if the study does not report the outcomes of a strategy, including studies that report only “lessons learned” from a real event, drill, or exercise.
- Exclude if the proposed strategy is not from a national provider organization or a task force convened by the Federal government or does not describe the consensus development process.
- Exclude strategies that involve training providers to allocate resources if the study reports only participants’ perceptions of improvement and/or satisfaction with the training program.

Key Question 3: What Are the Public’s Concerns Regarding Resource Allocation Strategies?

PICOTS Framework for Key Question 3

Population

The general public, with special attention paid to members of at-risk populations, including, for example, children and elders, individuals in minority groups, and individuals with special medical needs.

Interventions

Not applicable. This Key Question focuses on public opinions, perceptions, values, and norms regarding the development and implementation of strategies to allocate and manage scarce medical resources during an MCE.

Comparators

Studies may compare outcomes from a single setting when conventional standards of care are in effect, versus outcomes under constrained or crisis care standards. In addition, studies may compare outcomes of the same resource allocation strategy among individuals or communities with different characteristics, or they may compare outcomes of distinct resource allocation strategies in communities with similar characteristics.

Outcomes

Public opinions and/or perceptions of key issues related to the allocation and management of scarce medical resources during MCEs, including but not limited to values, priorities, and ethics.

Timing

We confined our review to studies addressing preparedness and response to MCEs. We also considered strategies that addressed the triggers or timing for returning to normal operations. We only considered strategies specifically addressing long-term recovery from MCEs (e.g., community resilience) if these strategies were implemented during the course of an MCE, and not subsequent to an MCE.

Settings

No exclusions.

Inclusion and Exclusion Criteria

- Include studies that use a systematic data collection method (e.g., surveys, focus groups) to describe public opinion regarding the implementation of strategies for allocating scarce resources during an MCE.
- Studies can consider the general population or subpopulations of interest, such as minority groups and other at-risk populations.
- Exclude studies that do not report public opinion directly, such as those reporting providers' or experts' perceptions of public opinion.

Key Question 4: What Methods Are Available To Engage Providers in Developing Strategies To Optimize Resource Allocation During MCEs?

PICOTS Framework for Key Question 4

Population

Health care providers, including executive and administrative personnel, chief medical officers, and other health care providers who lead or staff health care facilities or facilities that provide auxiliary services (such as laboratories or pharmacy departments) and professional associations, all regardless of race, gender, ethnicity, religion, sexual orientation, or disability.

Intervention

Strategies for engaging providers in discussions regarding the allocation and management of scarce resources. Strategies for engaging providers include a wide range of activities intended to accomplish the following:

- Contact and connect with providers (e.g., face-to-face, electronically, through provider associations).
- Elicit dialogue and discussion with and among providers (e.g., through workshops, discussion groups, or tabletop exercises to develop a plan or protocol related to decision making during “crisis care” situations).
- Encourage provider participation in collaborative activities (e.g., voluntary cooperative planning).

Comparators

Where possible, we considered studies that compared an engagement strategy to one or more alternative strategies. We also considered studies that used baseline assessments as the comparator. For example, studies might compare outcomes (including knowledge, attitudes, and self-reported or observed performance) over time (e.g., before and one or more times after an intervention). Other studies might not have used a comparator but, rather, assessed the impact of provider engagement on collaborative efforts at the local/regional, State, and national levels.

Outcomes

We considered any of the following outcomes:

- Process outcomes (e.g., number of providers reached, provider satisfaction with the process)
- Provider outcomes (e.g., changes in knowledge, attitudes, and self-reported or observed behavior)
- Local/regional, State, national outcomes (e.g., increased provider participation in Multi-Agency Coordination [MAC] groups)

Timing

We confined our review to studies addressing preparedness and response to MCEs. We considered strategies that addressed the triggers or timing for returning to normal operations. We only considered strategies specifically addressing long-term recovery from MCEs (e.g., community resilience) if these strategies were implemented during the course of an MCE, and not subsequent to an MCE.

Settings

No exclusions.

Inclusion and Exclusion Criteria

- Include studies that describe processes and outcomes of strategies used to engage providers in the development of strategies to allocate scarce resources during MCEs; for example, planning efforts to develop crisis standards of care protocols and the use of tabletop exercises to simulate medical decision making during “crisis care” situations.

- Include if description of provider engagement is a replicable, systematic planning process that resulted in a concrete plan, protocol, strategy, or framework.
- Include studies that describe engagement strategies for providers exclusively or that involve multiple stakeholders.
- Include studies that describe engagement strategies locally (e.g., within a single medical center), as well as strategies for regional or nationwide engagement.
- Exclude studies not related to provider engagement and surge capacity.
- Exclude studies that involve educational interventions only and do not describe engagement in the development of educational programs.

Study Selection

After conducting the literature search, two researchers screened all titles to eliminate citations that were clearly unrelated to the topic. Next, abstracts of each study were independently reviewed by two researchers for inclusion or exclusion according to predetermined criteria. If no abstract was available, the full text was reviewed. Reasons for study exclusion at the abstract phase included the following: (1) failure to include a quantitative or qualitative analysis (e.g., studies reporting "lessons learned" only); (2) failure to address an MCE context (e.g., studies involving organ transplantation); and (3) failure to address a Key Question. In cases of disagreement between the reviewers, an independent reviewer was asked to review the abstract and reconcile the difference.

In the next stage, two researchers independently reviewed full-text articles and excluded those that: (1) failed to address a Key Question; (2) included consensus recommendations (for Key Questions 1, 2, and 4) that did not meet our evidence threshold; or (3) related to training exercises but did not report changes in actual performance outcomes. Disagreement between the reviewers about whether a study should be included was resolved by consensus. We maintained a list of studies that were excluded at the full-text review stage with the reason(s) for exclusion (Appendix D).

Data Extraction

We tailored our data extraction approach to each Key Question. Because of the large volume of studies describing tested strategies that were relevant to Key Question 1 and especially Key Question 2, we developed an electronic data collection form using DistillerSR (Appendix B) to capture the necessary data elements. For Key Question 3 and for our analysis of State plans, data were abstracted directly into spreadsheets because of the relatively small number of data elements required for each review. For Key Question 4, we used a paper-based data collection form (Appendix B). Although the number and type of data elements varied by Key Question, data elements generally included the following: study design, geographic location, type of MCE, description of the strategy, outcomes reported, and implementation facilitators and/or barriers. For Key Question 4, we were also concerned with the types of stakeholders participating in the engagement strategy.

A total of nine reviewers, all of whom received formal orientation to the review process, performed data extraction. At least two reviewers abstracted each article that met one or more inclusion criteria. One reviewer took the lead for reviewing the article, and the second reviewer fact-checked to assure consistency and accuracy of coding. Differences were resolved by consultation and, when necessary, adjudication.

Abstracted data that were entered into DistillerSR and spreadsheets were then edited and manipulated to generate evidence tables (Appendix C).

Quality (Risk of Bias) Assessment of Individual Studies

Given the relative rarity and unpredictability of MCEs, we anticipated that few, if any, relevant studies would use a randomized controlled study design, where validated instruments to assess methodological quality exist and are widely used.[21] Given the diversity in study designs and outcomes we expected to encounter, we determined that a more generic quality rating system would be more feasible and allow greater comparability across studies. After conducting an environmental scan of existing rubrics and finding that no single scale seemed appropriate for our topic, we developed our own assessment scale. Our instrument combined two items drawn from the quality assessment scale from the Substance Abuse and Mental Health Services Administration's National Registry of Evidence-based Programs and Practices, and items from two other scales commonly used to appraise the quality of qualitative research.[22-24] Appendix B contains all of our data collection instruments, including quality scales.

We used this composite scale to appraise the quality of studies addressing Key Questions 1, 2, and 4. The five individual items assessed whether or not (1) the level of detail used to describe the resource allocation strategy was adequate, (2) data collection was systematic (and if so, whether it was retrospective or prospective), (3) fidelity (defined as the degree to which the strategy was implemented consistently) was measured or could be inferred from the data provided, (4) generalizability of the findings was assessed, and (5) potential confounders to the strategy's effectiveness were discussed. For Key Question 4, we excluded the item addressing confounders. For most items, reviewers could allocate up to two points. All quality scores are presented as the total number of points allocated in reference to the total number of points possible (e.g., "6 of 8 points"). Scoring each quality item may have entailed some degree of subjectivity; however, the pair of reviewers for each study reconciled any differences in scores for each item.

For two types of study designs--computer simulations and systematic reviews--we deviated from this approach because we believed more tailored quality items were appropriate and because valid scales were available, respectively. In our environmental scan, we identified one study[25] that offered recommendations for modeling disaster responses in public health. We identified several key aspects of model quality from this study and adapted our quality instrument accordingly. Specifically, we eliminated the data collection and fidelity items and replaced them with two items that assessed the degree to which the authors justified their model assumptions and/or data inputs and the degree to which the authors performed robust sensitivity analyses (if at all). For systematic reviews, we used the AMSTAR instrument,[26] an 11-item scale that measures such features as whether a comprehensive literature search was performed, whether duplicate study selection and data extraction were used, and whether or not the scientific quality of the included studies was assessed.

For Key Question 3, we elected to develop our own quality scale that reflected key differences in methodology across the small number of included studies. Using seven binary items, our scale assessed whether or not studies used a systematic data collection process, described in detail the subject recruitment methodology, recruited a representative sample, disclosed funding sources or sponsors, discussed limitations and generalizability, and permitted the results to be evaluated by an independent third-party.

Data Synthesis

We could not quantitatively synthesize data abstracted from the set of included studies because individual studies rarely addressed similar resource allocation strategies. Moreover, strategies that were assessed in multiple studies typically differed widely in their context and outcomes. Accordingly, for Key Questions 1 and 2, we summarized the outcomes of each strategy qualitatively, using the four broad categories of adaptive strategies described in our conceptual framework to synthesize our findings. To the extent that clusters of related strategies emerged within these four broad categories, we reported our findings at the subcategory level. Wherever possible, we described the degree of consistency in the magnitude and direction of outcomes for the most relevant outcomes. We also highlighted differences in populations, context, and methodology that we considered important in interpreting each set of results. Most of the information we present in our synthesis addresses key dimensions of the subsequent strength of evidence ratings and assessment of applicability.

Because the included studies for Key Question 3 addressed a narrow range of topics, we synthesized the evidence from these studies as a single set. For Key Question 4, we described engagement strategies that were led by providers separately from those that were led or co-led by policymakers. However, (as described below), we summarized the strength of evidence across both groups of studies because the nature of strategies did not differ systematically between the two groups.

For the subset of studies that we included in the review that lacked comparison groups, we provide a brief summary of the individual strategies described by each. We include these summaries in a separate section from those studies that underwent our full review. Finally, we include a qualitative summary of proposed strategies that have been included in consensus guidelines. We highlight the key recommendations from each provider organization or task force and emphasize differences in recommendations where they exist.

Strength of the Evidence

We used the approach outlined in the Methods Guide for Effectiveness and Comparative Effectiveness Reviews to grade the strength of evidence addressing each Key Question.[27] This approach requires assessment in four domains: risk of bias, consistency, directness, and precision. *Risk of bias* refers to the internal validity of each study and relies heavily on study design and the aggregate quality of the included studies; we scored risk of bias as high, medium, or low. *Consistency* is a measure of the extent to which effect sizes for the set of studies are similar in size and direction. We designated evidence in this category as consistent or inconsistent. *Directness* refers to the degree to which the strategies have an impact on health outcomes rather than intermediate outcomes. In this domain we rated evidence as direct or indirect. Finally, *precision* refers to the level of certainty surrounding the set of effect estimates. For this domain, we rated evidence as precise or imprecise. After making assessments in the four domains, we graded the strength of the evidence using the four-point scale (i.e., high, moderate, low, or insufficient). As defined by Owens et al., “high” strength of evidence indicates high confidence that the evidence reflects the true effect. “Insufficient” strength of evidence indicates that evidence either is unavailable or does not permit the formulation of conclusions.[27]

For Key Questions 1 and 2 we rated the strength of evidence within categories (or subcategories) depending on the number of studies available. For both Key Questions 3 and 4, we rated the strength of evidence across all studies. For Key Question 3, the paucity of studies precluded analysis by methodology (stakeholder forums, interviews or surveys). For Key Question 4, the vast majority of studies assessed engagement methods that were designed to develop strategies in multiple categories, and so category-specific ratings were less useful.

A single reviewer graded the strength of evidence for each dimension, which was then reviewed by a second reviewer. Differences were reconciled through discussion. We determined overall strength of evidence grades in an analogous manner using a qualitative assessment of the scores for each dimension. We summarize the strength of evidence grades in the Results section for each Key Question.

Applicability

In the course of our team's work, we considered the applicability of the evidence presented by each article. In seeking to develop MCE resource allocation strategies, providers and policymakers will want to know the extent to which outcomes realized in the studies we reviewed are generalizable to the populations, practice settings, and disaster contexts that are most relevant to them. We conducted qualitative assessments[28] of the applicability of evidence for each Key Question using both the PICOTS framework for each Key Question (see Key Questions, above) and by abstracting individual items pertaining to various dimensions of applicability. For example, we noted whether strategies were applicable to specific scales of events (e.g., local or regional in scope), whether or not the effectiveness of the strategy appeared to depend on factors unique to the jurisdiction involved (in terms of leadership required, populations served, stakeholders included, or availability of resources), the degree to which outcomes were relevant to patients, and the extent to which the strategy was "ready for use." For strategies tested outside of the United States, we also assessed the degree to which the strategy was applicable in the United States. One reviewer assessed the applicability of the evidence, while a second reviewer verified the appropriateness of the assessments. Areas of disagreement were resolved through discussion and, if necessary, adjudication.

Peer Review and Public Commentary

Experts from relevant fields and individuals representing stakeholder and user communities were invited to provide external peer review of this systematic review. The AHRQ Effective Healthcare Program SRC at Oregon Health Sciences University oversaw the peer review process. Peer reviewers commented on the content, structure, and format of the evidence report and were encouraged to suggest any relevant studies that had been missed. AHRQ and SRC staff also reviewed the report.

The SRC placed the draft report on the AHRQ Web site (http://effectivehealthcare.ahrq.gov/) for public comment and compiled all comments.

Each member of our TEP was invited to provide written comments on the draft report. We compiled all comments and addressed each comment individually, making revisions as appropriate. All changes were documented in a "disposition of comments report" that will be made available three months after AHRQ posts the final review on its Web site.

Results

Literature Search

The peer-reviewed literature searches identified a total of 5,146 potentially relevant citations. A search of the grey literature yielded 297 citations, and our technical expert panel (TEP) suggested an additional 56 titles. Reference mining contributed an additional 217 citations. All 5,716 citations were imported into EndNote and then into DistillerSR, a web-based application designed specifically for the screening and data extraction phases of a systematic review. Reviewers selected 2,395 relevant and unduplicated titles for abstract review. During the review, they excluded 995 articles either because the abstract did not appear to answer a Key Question (664 articles) or because the abstract did not indicate a quantitative or qualitative data analysis (331 articles). After the abstracts had been reviewed, 1,400 full-text articles were available for further review.

Screening these articles with the aid of a short form led to the exclusion of 1,000 additional articles. Articles were excluded for at least one of the following reasons: (1) The article did not answer a Key Question (692 articles), (2) the article described a training program but did not report outcomes using performance measures (14 articles), or (3) the article was a proposed strategy but was not based on adequate consensus (277 articles for Key Questions 1 and 2; 17 articles for Key Question 4).

For Key Question 1, we considered 57 articles for data abstraction. We included nineteen articles that described tested strategies. We included seven additional articles in a separate group because they lacked a comparison population. One additional article was included that described a proposed strategy with a level of consensus that met our criteria. The major reasons for excluding articles at the data abstraction stage for Key Question 1 were insufficient evidence or inadequate consensus.

For Key Question 2, we considered 295 articles for data abstraction and ultimately included 55 articles that described tested strategies. We included an additional 47 articles in a separate group because they lacked a comparison population, and seventeen articles that described a proposed strategy with adequate consensus in a third group. Reasons for excluding articles included either insufficient evidence or inadequate consensus.

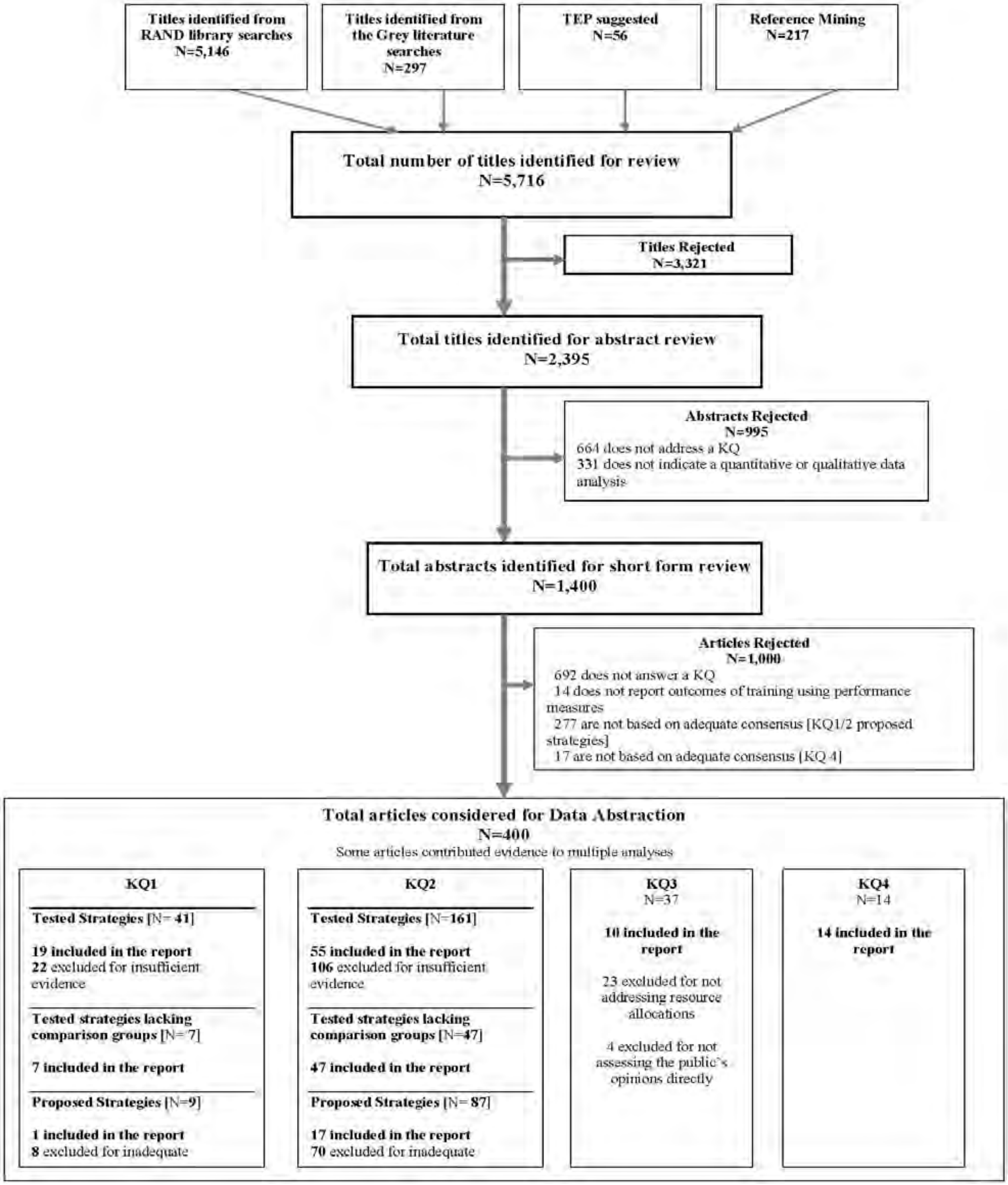
For Key Question 3, we identified 37 articles, ten of which we included in the review. Reasons for exclusion included either failure to address a resource allocation context or failure to assess the public's opinions directly.

For Key Question 4, we identified 14 articles and included all of them.

In summary, we considered 400 articles for data abstraction. Ultimately, 170 met our selection criteria, including 27 studies that focused on policymakers (Key Question 1), 119 that addressed the decisions of providers (Key Question 2), 10 that considered the perspectives of the public (Key Question 3), and 14 that addressed engagement of providers in developing resource allocation strategies (Key Question 4). Five articles were written in languages other than English (4 German and 1 Portuguese). No articles were excluded due to lack of translational resources.

Reviewers used data abstraction tools as shown in Appendix B. We provide the evidence tables containing key data from the included studies in Appendix C. Citations of articles that we excluded and the reason for exclusion appear in Appendix D. Figure 3 depicts the literature flow, indicating the number of studies included and excluded at each screening level and the reasons for exclusion.

Figure 3. Literature flow



KQ = Key Question; TEP = Technical Expert Panel

Key Question 1: What Strategies Are Available to Policymakers To Optimize Allocation of Scarce Resources During MCEs?

What current or proposed strategies are available to policymakers to optimize the allocation and management of scarce resources during mass casualty events (MCEs)? What outcomes are associated with these strategies? What factors act as facilitators or barriers to their implementation or effectiveness?

Key Points

- The small number of studies that met inclusion criteria (n = 19), and the marked variability in design, focus and content for this Key Question provide a relatively weak evidence base to inform policymakers. The 19 studies included more computer simulations (10) than intervention studies (9). Only a few studies examined similar resource allocation strategies using similar endpoints.
- Each computer simulation was distinctly different from the others. Thus, their results cannot be meaningfully compared across studies. The computer simulations were often of lower quality than the intervention studies.
- Three intervention studies examined the throughput achieved (or simulated) using different approaches to mass dispensing of medical countermeasures against anthrax. The standard "centralized" model for point of dispensing was efficient, but a decision-support software tool tested in Georgia further enhanced its efficiency.[29] A "push" strategy using U.S. mail carriers produced even higher throughput than administration through fixed sites.[30]
- We could not meaningfully compare results from the three studies that examined different approaches to augmenting health care resources following a major hurricane. Each employed a vastly different strategy and examined effectiveness using different end points. Nonetheless, each describes an empirically tested strategy deemed successful by the authors, ranging from opening alternate care sites to a mobile field hospital to more efficient distribution of patients via a regional medical operations center.
- None of the included studies examined the implementation of crisis standards of care.

Description of Included Studies—Tested Strategies

The 19 papers included in this review address tested strategies for policymakers to reduce or manage less urgent demand for health care services (15 studies[29-43]), optimize use of existing resources (two studies[44, 45]), or augment existing resources (four studies [32, 41, 46, 47]); two studies included strategies that were classified in multiple categories.[32, 41] No studies examining the implementation of crisis standards of care met our inclusion criteria. To meaningfully synthesize the available evidence we further classified strategies into subcategories (Table 1).

The 19 studies comprised three main types of analyses. Nine studies were intervention studies, including four drills and five analyses involving actual MCEs. Eight of the intervention studies occurred in the United States, and one study took place in Canada. The remaining ten studies were computer simulations.

Fifteen studies addressed biological threats, including anthrax (6), pandemic influenza (7), smallpox (1), and SARS (1). Three addressed natural disasters (hurricanes in each case, including Hurricane Katrina), and one addressed an explosive event (one of the September 11 attacks). All ten computer simulations addressed biological threats, including pandemic influenza, anthrax, and smallpox.

Among the five studies examining actual MCEs, three used a pre-post design, and two included only post-test assessments; none used a randomized controlled trial design. Studies assessing drills included one pre-post design and three post-only designs. Eight of the nine intervention studies had moderately high quality (50 percent or more of the total possible points across the quality domains) compared to six of the ten computer simulations.

Table 1. Summary of strategies addressing Key Question 1, by category

	Strategies
Reduce or manage less-urgent demand for health care services	**Biological countermeasures (12 studies)[29-33,35-38,41-43]** • Point of dispensing strategies (e.g., centralized vs. hybrid structure; eliminating conventional steps; using simulation and decision support to optimize staffing) • Optimizing strategies for allocating medication from stockpiles (e.g., level of preallocation, level of tailoring to population needs, amount for prophylaxis vs. treatment) • Mass vaccination, contact tracing, and school closure • Mass distribution of antibiotics using postal carriers **Nonbiological countermeasures (3 studies)[34,39,40]** • Distribution of surgical masks or N95 respirators to the public • Restrict nonurgent demand for hospital care • Training public health officials in their legal authority to implement strategies to limit the spread of pandemics
Optimize use of existing resources	**Load sharing (2 studies)[44,45]** • Central command structure to optimize distribution of patients to hospitals • Establishment of site emergency management centers in low vulnerability locations • Robust and interoperable emergency communications systems • Coordinated regional trauma systems to facilitate the rapid transfer of hospitalized and special needs patients
Augment existing resources	**Temporary facilities (3 studies)[41,46,47]** • Alternate-site surge capacity facilities • Mobile field hospitals • Activating mobile provider units from other Federal agencies to provide hospital surge capacity **Mutual aid agreements (1 study)[32]** • Mutual aid agreements that allow transshipment of antivirals between counties
Crisis standards of care	None

Detailed Synthesis of Tested Strategies

Strategies To Reduce or Manage Less-Urgent Demand for Health Care Services

Twelve of the 15 studies reviewed under the broad category of strategies to reduce or manage less-urgent demand for health care services involved biological countermeasures. The specific strategies included modeling stockpile allocation, exercising stockpile dispensing, and mass distribution of antibiotics using mail carriers. The other three studies assessed the effectiveness of nonbiological countermeasures. These studies included a simulation of the impact of physical barriers to disease transmission, an exercise to raise awareness of legally acceptable intervention measures to stop the spread of pandemic flu, and implementing restrictions on elective surgery.

Biological Countermeasures

The 12 studies in this group included three intervention studies and nine computer simulations. The three intervention studies, all judged to be of relatively high quality, addressed point of dispensing (POD) operations for medical countermeasures against anthrax (presumably ciprofloxacillin). Two of the three studies provided quantitative end points that suggested they could be compared across studies (Table 2). One provided evidence that a traditional "centralized" POD system—where persons come to a fixed site to receive a medical countermeasure—provided slightly faster and more accurate processing than a hybrid model that combined both the centralized "pull" approach and a "push" approach in which countermeasures are delivered to some persons at their work site.[31]

The second study compared the standard centralized "pull" model to a different "push" model—one that used U.S. Postal Service mail carriers to deliver the medical countermeasure. The push approach in that study served more people per hour per provider than the fixed dispensing sites.[30] When we converted the findings of one study into the units measured in the other, the "push" strategy using mail carriers appeared to produce the highest throughput. If the figures are indeed comparable, which is not entirely clear, then the centralized POD operations reported in the first study[31] were more efficient than those in the second,[30] and the "push" dispensing via mail carriers was the most efficient method of all.

The third study documented that POD operations supported by a specific decision-support software tool were demonstrably more efficient on several dimensions than traditional dispensing systems using no or existing software support. However, the quantitative endpoints were not comparable, and most comparisons between the one county using the tool and the seven counties not using it were mostly qualitative.[29]

Table 2. Comparison of different point of dispensing strategies

Source	Intervention and Comparison Groups	Findings
Ablah, 2010[31]	Centralized POD model vs. Hybrid model	Centralized: 0.75 patients/minute → 45 patients/hour Hybrid: 0.48 patients/minute → to 28.8 patients/hour
Koh, 2008[30]	(Centralized) POD dispensing vs. "push" method using mail carriers	Centralized: 1,988 persons/hour, or 33/hour/staff person Push: 3,833 persons/hour, or 120/hour/staff person
Lee, 2006[29]	One county using RealOpt software vs. seven counties not using the software	User: Was the only county to exceed 450 targeted households, and 50% greater throughput than next best county (not using software); qualitatively—most efficient floor plan, most cost-effective dispensing (lowest labor/throughput value), smoothest operations (shortest average wait time, average queue length, and equalized utilization rate Nonusers: No county reached 450 targeted households; best one achieved 71% of target

POD = point of dispensing

The nine computer simulations were more varied in focus. Five addressed pandemic influenza, three addressed anthrax, and one addressed smallpox. Most of the influenza simulations examined different questions and thus were not comparable to one another. One study examined the use of the same or different drugs for treatment and prophylaxis,[36] and one looked at allocation of the single stockpiled antiviral drug, including its use for treatment or prophylaxis.[32] In the former, the authors found that a two-drug strategy for pandemic influenza (one drug for prophylaxis and a different drug for treatment) is more effective in delaying the propagation of disease and the emergence of drug resistance (including multi-drug resistance) than the use of a single drug for both prophylaxis and treatment.[36] However, the simulation also indicated that the two-drug model is more likely to result in multidrug resistance than resistance to a single drug, which is a significant drawback. The other simulation provided useful, albeit somewhat less compelling, evidence. It noted that allocation of an antiviral stockpile should not be determined in advance; instead, it should be based on population attack rates and, potentially, age. It also indicates that when supplies of effective antiviral drugs are limited, they should be used for treatment rather than prophylaxis.[32]

Three studies assessed optimal vaccination-targeting strategies; two focused on the general population[38, 35] and one focused on health care workers specifically.[37] The first simulation, which we rated as high quality, reflects the importance of young children in influenza transmission and concluded that vaccinating children aged 5 to19 and their parents (ages 30 to 39) is a particularly effective vaccine targeting strategy, since these children are often vectors of transmission to others.[38] In the second simulation, prioritizing prophylaxis to health care workers was shown to be an effective use of an antiviral stockpile, and this strategy did not have a deleterious effect on disease control in the population.[37] Another simulation indicated that the most effective targeting strategy may depend on a policymaker's objective.[35] Specifically, to minimize population morbidity, the results suggested that children, adolescents, and young adults should be targeted; in contrast, to minimize mortality, infants, young adults, and older adults should be targeted.

One of the three anthrax simulations examined rapid mass distribution of prophylactic drugs versus treatment only of symptomatic persons. As expected, the simulation found that the former strategy prevents significantly more deaths than the latter.[41] That study also showed the significant impact of adequate hospital surge capacity on reducing patient deaths. A second simulation found that local dispensing capacity was a critical factor in determining the cost-effectiveness of other strategies, such as increasing the size of stockpiles and improving surveillance.[33] The other anthrax simulation was of poor quality and thus does not provide persuasive evidence to support its rather general findings.[42]

The smallpox simulation provided evidence to suggest that a combination of mass vaccination and targeted vaccination of contacts is needed to limit disease transmission. It also noted that school closures would further enhance the impact of such interventions.[43]

Several of the studies that tested strategies for implementing PODs involved relatively large-scale exercises that were conducted in different geographic regions. Evidence from these studies appears to be generalizable across locations and settings. The applicability of the evidence generated from computer simulations is exceedingly hard to assess. These studies may not provide highly applicable evidence if their conclusions rely heavily on assumptions or model parameters that are contextually inappropriate. Outcomes from tabletop exercises (e.g., increases in participants' knowledge and confidence) may not be the most relevant outcomes for policymakers, who might be more interested in health outcomes or public perceptions of fairness. But taken together, the studies of biological countermeasures provide reasonably applicable evidence.

Nonbiological Countermeasures

Three studies assessed nonbiological countermeasures. Two studies involved a pandemic influenza context, and one study was based on the 2003 SARS epidemic. Among the influenza-related studies, one was an intervention study and one was a computer simulation; because they addressed entirely different issues, they were not comparable. The intervention study was a tabletop exercise addressing measures that policymakers could legally take during an infectious disease event affecting a community. Compared to pre-exercise measurements, post-exercise measurements reflected significant increases in knowledge and confidence regarding deployment of such measures.[39] The computer simulation indicated that N95 respirators provide better protection against influenza infection than do surgical masks for both droplet and airborne virus transmission, but only if compliance with their use is nearly universal.[34]

The third study in this category assessed the effectiveness of imposing restrictions on ambulatory and inpatient medical and surgical care for nonurgent cases across all 32 hospitals in the greater Toronto area during the 2003 SARS epidemic.[40] The authors showed that, while nonurgent admissions decreased significantly, high-acuity emergency department (ED) visits and interhospital transfers also decreased, suggesting that some patients may not have received needed care.

Strategies To Optimize Use of Existing Resources

We identified two studies in this category. One was of poor quality despite its providing highly applicable evidence from an actual MCE[45]; it is therefore not a robust source of evidence for this review. It described response strategies following the September 11, 2001, terrorist attacks in New York City. The study found that the absence of an enforced patient distribution system led to uneven load in three trauma centers, and attack damage to the Office of Emergency Management and disruption of cell phone and radio communications exacerbated problems with coordination and communication.

The second study documented significant reduction in patient transfer times once a coordinated regional trauma system was introduced for routine, small-scale trauma events.[44] A comparably designed system based on a regional medical operations center was able to efficiently transfer and manage evacuation patients following Hurricane Katrina and transfer at-risk patients prior to Hurricane Rita.

Strategies To Augment Existing Resources

We reviewed four studies of strategies to augment existing resources. Three of the four were intervention studies evaluating measures taken after a major hurricane. The fourth was an influenza computer simulation discussed above under strategies to reduce or manage less-urgent demand for health care services.

The hurricane-related intervention studies did not report comparable end points; therefore we cannot make valid comparisons across their different strategies. One study documented the extra patient load cared for by a mobile field hospital deployed to care for evacuees from Hurricane Katrina.[47] A second reported that an alternate care site in Dallas provided so much medical surge capacity following Hurricane Katrina that the emergency departments and trauma centers in the city saw no significant rise in patient visit rates during the two weeks postevent.[46] The third study, which was a computer simulation, concluded that “mobile servers” (augmented hospital capacity provided by Federal health care providers) reduced predicted patient mortality.[41]

One study examining the impact of mutual aid agreements allowing transshipment of antivirals during an influenza epidemic found that the policy mainly favors less densely populated counties and is only cost-effective when there is geographic variability in the epidemic.[32]

The strategies we identified for augmenting capacity during MCEs relied on data from two real events and two computer simulations. All of the strategies were tested at a single site or within a single region; however, most strategies appear to be broadly applicable across settings. Several studies within this category reported process outcomes—mainly the number of patients served—while more relevant outcomes for policymakers might involve health outcomes. While the mobile field hospital appears to be particularly useful for a broad range of MCEs, the alternate care site that was established during Hurricane Katrina may only be useful for MCEs in which victims suffer less severe injuries.

Table 3 outlines the strength of evidence for Key Question 1.

Table 3. Strength of evidence for Key Question 1

Strategies		Risk of Bias	Consistency	Directness	Precision	SOE Grade
Reduce or manage less-urgent demand for health care services	Biological counter-measures (n=12)	High	Consistent	Interventions: Indirect Simulations: Direct	Imprecise	Low/Medium
	Nonbiological counter-measures (n=3)	High	Not applicable	Two direct, one indirect	Two precise, one imprecise	Low
Optimize use of existing resources	Load sharing (n=2)	High	Not applicable	Indirect	Imprecise	Insufficient
Augment existing resources	Temporary facility (n=3)	Low	Consistent	Indirect	Imprecise	Low
	Load sharing (n=1)	Medium	Not applicable	Indirect	Imprecise	Insufficient
Crisis standards of care		NA	NA	NA	NA	NA

Tested Strategies Lacking Comparison Groups

Seven studies were included in this section of the review. One study presented the results of an exercise that tested a disaster response protocol for Super Bowl XXXVIII.[48] A second study, conducted as a simulation in Hawaii, demonstrated that prophylactic medication can be efficiently dispensed with minimal human-to-human contact using a drive-through clinic model.[49] Another simulation study, conducted in the Netherlands, examined laboratory capacity during MCEs. It found that a national diagnostic laboratory network could handle diagnostic requests from hospitals during an MCE, but it would have insufficient capacity to manage the surge of tests that could be generated by the nonhospitalized population.[50] A second study related to laboratory capacity described a customized laboratory information system to support Centers for Disease Control and Prevention (CDC) activities for rapid sample analysis and data reporting.[51]

Two studies assessed resource allocation strategies during hurricanes. Irwin et al. reported details about the successful use of a multidisciplinary treatment center in Houston to treat large numbers of evacuees for non-emergent medical concerns in the aftermath of Hurricane Katrina.[52] During the time this large facility was in operation, it substantially reduced use of local emergency departments for non-emergent problems. A related study indicated that deployable military hospitals can effectively supplement surviving local health care capabilities after disasters.[53]

One study reported outcomes of an information technology applications deployed during the height of the 2009 H1N1 pandemic—an interactive, Web-based decision-support tool to help adults with influenza-like illness self-assess their need for ED care.[54] The tool closely adhered to a diagnostic algorithm the group developed in collaboration with the CDC and subsequently validated using electronic health information collected from a large HMO in Colorado. The interactive, Web-based version of this algorithm was offered to the public via Flu.gov and a free Web site operated by Microsoft (H1N1responsecenter.org). Users accessed it approximately 800,000 times before the end of the pandemic, with no reported adverse events. Although the report suggests that the concept of a web-based self-triage for influenza-like illnesses is feasible, it could not quantify the impact of the decision support tool on surge capacity. Similar Web sites exist, including one developed by a collaboration led by the American Medical Association (www.AMAfluhelp.org).

Finally, in a study examining resource allocation under crisis standards of care, Etienne et al. described how a Multidisciplinary Healthcare Ethics Committee determined allocation of resources during the Haiti earthquake.[55] The authors found that this process enabled ethical decision making in a timely manner.

Proposed Strategies

Our systematic review identified one study that described a proposed strategy for use by policymakers to allocate resources during MCEs. In 2008, a Federal interagency working group developed the current national plan for guiding the allocation of influenza vaccines during pandemics. The guidance is intended for use by Federal, State, local, and tribal governments; communities; and the private sector.[56] Prioritizing the allocation of vaccine was accomplished by defining four categories in order of importance: (1) homeland and national security; (2) health care and community support services; (3) critical infrastructures; and (4) the general population. These target groups are further prioritized into tiers within each category, and, within tiers by the severity of the pandemic. The rationale behind the prioritization scheme is clearly elaborated in the report. For example, the highest-tier target group within homeland and national security comprises deployed and mission-critical personnel, recognizing that “these individuals are critical to protect national security” and have “a potential greater risk of infection due to geographic location and crowded living or working conditions.”

Key Question 2: What Strategies Are Available to Providers To Optimize Allocation of Scarce Resources During MCEs?

Key Points

- A wide range of provider-oriented strategies has been tested in various contexts, including actual MCEs, exercises, drills, and computer simulations. However, with the exception of pre-hospital or “field” triage during MCEs, the body of high-quality evidence addressing any individual strategy is small, usually with no more than one or two studies providing evidence in each area. There is insufficient evidence to support the use of any one strategy over another.

- Various triage systems and triage acuity scales have been used in emergency department operations for many years and have been extensively studied. But triage in the setting of MCEs is quite different, particularly triage practiced in pre-hospital settings where first responders may be required to assess large numbers of victims in a very short timeframe. Many of the studies on this topic raised significant concerns about current triage systems when used during actual MCEs. Other studies tested triage systems during exercises or drills and provided evidence with limited applicability.
- The evidence base available to assess the effectiveness of the remaining strategies identified under this Key Question is thin. Few studies that met our inclusion criteria were based on data that were collected during one or more actual MCEs. The quality of these studies was substantially lower than drill-based studies. Few studies employed a randomized design. The computer simulations we identified provided low-quality evidence.
- The majority of identified studies reported process measures (e.g., improved throughput times or triage accuracy) rather than outcomes. Studies that reported outcome data used less rigorous designs, such as comparing outcomes against historical control groups or a benchmarked performance rate, rather than a contemporaneous comparison group.
- Few of the articles we identified examined specific barriers and facilitators to the implementation of provider strategies. Those that did reported this information inconsistently.
- Evidence derived from drills and exercises did not report data on outcomes that are particularly relevant to patients and providers. The applicability of the findings beyond the immediate exercise setting is questionable.
- With few exceptions, strategies proposed by national provider organizations were vague. Many did not propose actionable steps to help health care providers make difficult decisions regarding allocation of scarce resources under crisis standards of care.

Description of Included Studies—Tested Strategies

The 55 studies included in this part of the review address tested strategies available to providers to reduce or manage less-urgent demand for health care services (3 studies[57-59]), optimize use of existing resources (48 studies[60-107]), augment existing resources (1 study[108]), and implement crisis standards of care (5 studies[77, 79, 109-111]). Two studies included strategies that were classified in multiple categories.[77, 79] To meaningfully synthesize the available evidence we further classified strategies into subcategories (Table 4).

The 55 studies comprised a diverse set of analyses. Thirty-nine studies were intervention studies, including 19 studies evaluating the outcomes of drills and 20 analyses involving actual MCEs. Of the remaining 16 studies, 7 were computer simulations, 2 were systematic reviews, 5 were validation analyses, and 2 were laboratory analyses. Seventeen of the 39 intervention studies took place in the United States, while the remaining 22 represented a range of international contexts, including Europe (8), Israel (6), Asia (3), Canada (1), Australia (1), Mexico (1), Rwanda (1), and Haiti (1).

The studies addressed a wide range of MCEs, including explosive events (9), pandemic influenza (6), natural disasters (6, all of which involved earthquakes), nuclear/radiological events (3), transportation accidents (3), chemical events (3), multiple hazards (10), other MCEs (5), and unspecified events (10). The quality ratings were at least moderately high (50 percent or more of the total possible points across the quality domains) for 41 of the 55 studies.

Among the 20 studies examining actual MCEs, 6 used a pre-post design, 13 included only post-test assessments, and only a single study used a randomized controlled trial design. Studies assessing drills included 4 randomized designs, 5 pre-post designs, and 10 post-only designs.

Eighteen of the 19 studies involving strategies tested in drills had moderately high quality, compared with 11 of the 20 analyses of strategies tested during actual MCEs. Both meta-analyses were high quality, but only 3 of the 7 computer simulations were rated as having at least moderately high quality.

Table 4. Summary of strategies addressing Key Question 2, by category

	Strategies
Reduce or manage less-urgent demand for health care services	**Biological countermeasures (2 studies)**[58,59] • Emergency mass clinic based on CDC guidelines • POD strategies (e.g., dynamic staffing) **Public information (1 study)**[57] • Automated central information distribution system for families
Optimize use of existing resources	**Case managers (1 study)**[72] • Hospital-based case managers to ensure care coordination **Decontamination (1 study)**[63] • Strategies to increase decontamination effectiveness (e.g., instructions, providing washcloths) **Health care worker prophylaxis (1 study)**[91] • Influenza prophylaxis for health care workers **Health information technology (2 studies)**[61,87] • Electronic triage tags to monitor vital signs and transmit information to first responders • Regional telemedicine hub to support delivery of specialty care **Imaging (4 studies)**[80,86,93,104] • Focused assessment of sonography for trauma (FAST) for triage • Sonographic screening for abdominal/pelvic injury or bleeding for triage • Accelerated CT protocols **Load sharing (4 studies)**[70,75,77,97] • Load-sharing protocols • Central allocation of patients to hospitals based on available resources **Medical interventions (2 studies)**[82,103] • Medical interventions for the prevention of acute renal failure in crush victims • Novel drug infusion devices **Space optimization (3 studies)**[64,105,107] • Conversion of lobbies, clinics, and other units to accommodate surge • Reverse triage to create surge capacity (e.g., early discharge, increasing use of community care options) **Training (6 studies*)**[71,73,81,88,90,99] • Hospital staff training (e.g., disaster drills, computer simulations, tabletop exercises) • Triage training (e.g., JumpSTART training program, virtual reality, podcasts, computer games) **Triage (24 studies)***[60,62,65-69,74,76,78,79,83-85,89,92,94-96,98,100-102,106] • Triage systems (e.g., START, mSTART, American College of Surgeons Committee on Trauma criteria, Radiation Injury Severity Classification, CBRN-specific system, Revised Trauma Score, Sacco triage method, SALT, Influenza-Like Illness Scoring System, TAS Triage Method, Simple Triage Scoring System, Model of Resource and Time-based Triage) • Triage strategies (e.g., combining triage categories, adding categories, one- vs. two-stage triage) • Simplified biodosimetry protocol to triage exposed victims

Table 4. Summary of strategies addressing Key Question 2, by category (continued)

	Strategies
Augment existing resources	**Resource conversion (1 study)**[108] • Conversion between formulations of nerve agent antidote to augment supply
Crisis standards of care	**General (1 study)**[109] **Orthopedics (1 study)**[111] • External fixation of fractures rather than definitive orthopedic care **Pediatrics (1 study)**[77] • Provision of only "essential" interventions **Trauma surgery (2 studies)**[79,110] • "Damage control" approach (e.g., for orthopedic surgery or more generally)

CBRN = chemical/biological/radiological/nuclear; CDC = Centers for Disease Control and Prevention; CT = computerized tomography; POD = points of dispensing; SALT = sort, assess,lLife-saving interventions, treatment/support; mSTART = modified simple triage and rapid treatment; START = simple triage and rapid treatment; TAS = Interdisciplinary Emergency Service Cooperation Course

*Includes one systematic review.

Detailed Synthesis of Tested Strategies

Strategies To Reduce or Manage Less-Urgent Demand for Health Care Services

Three studies described strategies to reduce less-urgent demand for health care services. Two studies examined techniques to rapidly dispense prophylactic medication, while the third study assessed the impact of a centralized information distribution system to support the information needs of the public. The strength of evidence provided by these studies was insufficient.

Among the two studies involving delivery of mass prophylaxis, one study demonstrated that communities can implement existing CDC mass vaccination protocols during a real MCE and achieve benchmark levels of throughput.[58] The second study used a computer simulation to demonstrate that the design of PODs may require better command and control structures to address variability in patient flow.[59] The third study showed that implementing an automated, centralized information distribution system in Israel prevented overloading of a hospital's communication lines.[57]

Although each of these studies cleared the threshold for evidence, the two simulations were of low quality. Moreover, the incident command system proposed as a solution to address bottlenecks in the operation of PODs has not been tested in an actual MCE. The study of the mass vaccination clinic used data from an actual event (an outbreak of Hepatitis A) in a community with apparently average levels of preparedness. The results may be generalizable to similar communities but may not be generalizable to other types of MCEs. Although the outcomes of the centralized public information system were assessed at a single hospital, the findings are likely to be applicable to other Israeli hospitals. However, the requirements for implementing such a system in the United States are unclear.

Strategies To Optimize Use of Existing Resources

A total of 48 studies included a test of a strategy for optimizing existing resources during an MCE. Because of the large number of studies reporting the development or implementation of triage systems, we synthesized the evidence from these studies separately from the remaining studies in this category. The strength of evidence for both the triage studies and the nontriage studies is low.

Triage Systems

The 24 studies that examined triage systems can be classified in two main groups: (1) those that examined the validity of new or existing systems, and (2) those that assessed the degree to which these systems accurately triaged patients during drills or actual MCEs. One recent systematic review of the validity of triage systems comprising 11 articles (8 triage systems) concluded that limited evidence supported their validity.[62] Among existing systems, the reviewers considered the Sacco Triage Method the most promising because it was the only system that combined estimates of patients' survival probabilities with data on available capacity at receiving hospitals. A later validation study that was not included in the review showed that the Field Triage Score predicted patient mortality comparably to the Revised Trauma Score but was easier to calculate at the scene of an MCE.[94] Collectively, these validation studies have low methodological quality. Most rely on small sample sizes, and few studies assessed the validity of the tool using prospectively collected health outcomes data from real events. In addition, few triage tools are applicable to pediatric disaster victims.

Several studies examined the implementation of triage systems during real or simulated events (Table 5). The vast majority assessed the accuracy of classifying patients into triage categories using the system's specific criteria compared to a gold standard (e.g., medical record review or "true" triage categories determined prior to a drill). Only three studies reported data on the accuracy of a specific triage system used during an MCE. The reported accuracy of triage ranged from 62 percent to 100 percent across systems.

A few studies described implementation problems associated with triage systems. For example, in a commuter rail accident, implementation of Simple Triage and Rapid Treatment (START) led to poor allocation of patients between trauma centers and community hospitals, mainly because of confusion about the meaning of each triage category.[78] Another study demonstrated that START triage categories were not sensitive to patients experiencing myocardial infarction or an asthma attack and may lead to under-triage of individuals with these conditions.[100] Some studies reported triage performance using time-based outcomes, but these outcomes had limited comparability across studies due to differences in design.

Other studies provided evidence to inform triage approaches beyond the use of specific tools. For example, one hospital-based triage approach that was found to be superior in a computer simulation used a two-stage process in which mild cases were first separated from more severely ill or injured patients, after which the critically ill patients were distinguished from urgent cases.[66] During the Sichuan earthquake of 2008, adding a resuscitation category to the standard START protocol enabled higher survival rates for a subset of victims who would have otherwise been categorized as "expectant" and not vigorously resuscitated.[67] Other promising triage protocols included modified dosimetry methods, such as using fewer metaphase spreads for dicentric chromosome assays.[60] One study demonstrated the effectiveness of a quality improvement program that was initiated in response to triage failures during a 2005 train crash and reported improvements in performance during a similar crash three years later.[95]

Although MCE triage has been examined more extensively than any other strategy, many of the studies we reviewed neither included a contemporaneous comparison group nor reported patient outcomes associated with the triage protocol. Studies tended to report throughput times or triage accuracy relative to an existing benchmark. Established standards for what constitutes acceptable triage performance are lacking, complicating efforts to infer the effectiveness of specific tools. Few studies tested triage protocols during MCEs. In general, triage accuracy rates that are measured during drills or exercises may provide evidence with limited applicability, because few drills are likely to capture the unique decision-making context imposed by a real MCE, and because results may be confounded by training that is part of the exercise.[65, 69]

Table 5. Accuracy of triage for individual triage tools reported in 10 included studies

	Under-triage	Over-Triage	Overall Accuracy	Real MCE	Drill
	Results			Study Type	
ACS Committee on Trauma criteria[84]	1%,14%, 13%*	33%	-	x	
CBRN triage system[74]	11%	2%	-		x
Influenza-like Illness Scoring system[89]	<1%	-	-	x	
London transit bombings triage method[79]	-	64%	-	x	
Radiation Injury Severity Classification[76]	-	-	0.92**		x
SALT[68]	10%	6%	83%		x
SALT[69]	4%	13%	79%		x
START[100]	-	-	70%		x
START[100]	-	-	62%***		x
mSTART[96]	3%	5%	-		x
TAS Triage method[65]	0%	0%	100%		x

ACS = American College of Surgeons; SALT = sort, assess,lLife-saving interventions, treatment/support; START = simple triage and rapid treatment; mSTART = modified simple triage and rapid treatment; TAS = Interdisciplinary Emergency Service Cooperation Course; CBRN = chemical/biological/radiological/nuclear
*Rates for critical, severe, and moderately injured.
**Kappa statistic.
***Accuracy of triage when clinical status was manipulated for 47 patients.
Note: Data from three systems were not amenable to synthesis.[83, 85, 95]

Nontriage Studies

A total of 24 studies addressed resource optimization strategies other than the use of triage systems. We describe these results by subcategory and then assess the strength of evidence and applicability across all studies.

Case Managers

The use of case managers in an Israeli hospital was found to significantly expedite the delivery of critical tests and procedures and to lower the duration of hospital stays for critically injured patients.[72]

Decontamination

A randomized trial of alternative showering strategies suggested that providing washcloths with instructions to exposed victims of a radiological MCE enhanced the effectiveness of decontamination compared to the other methods.[63]

Health Care Worker Prophylaxis

One randomized trial conducted during the 2009 H1N1 influenza epidemic demonstrated that surgical masks were as effective as more costly and less readily available N95 respirators at preventing health care workers from contracting influenza.[91]

Health Information Technology

A computer simulation showed that a regional telemedicine system could potentially reduce mortality by limiting needless ED bed use and specialty care, thereby increasing surge capacity following a simulated earthquake.[61] A second study demonstrated that triage accuracy can be enhanced through the use of electronic triage tags that monitor vital signs and permit reclassification of patients as their status evolves.[87]

Imaging

Four studies evaluated strategies involving the use of imaging to optimize triage or ED throughput. In two studies, use of imaging improved initial assessment of large numbers of trauma patients. In the first, Focused Assessment by Sonography in Trauma (FAST) exams were found to have comparable diagnostic accuracy to CT and other diagnostic techniques.[93] A second study showed that sonography was sufficiently accurate to be used as a primary triage tool during a major earthquake.[86] In two drills, ED throughput was increased through the use of accelerated multislice CT protocols[80, 104]

Load-Sharing

Four studies provided evidence that load-sharing strategies can optimize allocation of patients to trauma centers and avoid the need to adopt crisis standards of care. In one study, the use of an incident command system successfully allocated victims of a terrorist bombing to avoid overwhelming the nearest hospital.[75] A second study—also describing a terrorist event—demonstrated that centralized allocation of patients to hospitals, based on available capacity, achieved balanced allocation of patients to hospitals.[97] A third study used a computer simulation to show that a regional surge distribution strategy reduced mortality among pediatric mass casualty victims.[77] Finally, a load-sharing protocol developed in Germany for disaster situations involving mass gatherings was found to meet national standards.[70]

Medical Interventions

Two studies evaluated specific medical interventions for disaster victims and both reported favorable results. One demonstrated that many disaster victims with rhabdomyolysis from crush syndrome can avoid renal failure through vigorous fluid resuscitation.[103] In a chemical exposure drill, a novel infusion device proved to be effective at delivering antidote, which enhanced throughput and increased predicted survival rates.[82]

Space Optimization

Three studies examined space optimization strategies. Two studies examined “reverse triage” protocols. One was implemented during a major transportation accident and the other during the 2009 H1N1 influenza epidemic. In the first study, the authors report that the protocol successfully created additional surge capacity without worsening the prognosis of patients who were discharged early.[64] In the second study, the protocol failed to increase surge capacity—presumably because hospital management never formally implemented the protocol.[107] The third study demonstrated that re-appropriating hospital lobbies, subspecialty clinics, and short-stay units (in conjunction with other strategies) increased surge capacity and reduced waiting times during the 2009 H1N1 epidemic.[105]

Training

Each of the six studies of preparedness training for MCEs reported that the strategy is effective. One systematic review on training found that disaster drills were effective in improving response to MCEs, whereas evidence from computer simulations and tabletop exercises was inadequate to draw conclusions.[81] Among studies that were not included in that review, one found that a computer game-based triage exercise was more effective in improving triage accuracy than tabletop exercises.[88] A virtual reality method of teaching mass casualty triage skills reportedly improved accuracy,[73] whereas a second study indicated that it did not improve provider performance using the START protocol.[90] Another study that used podcasts and multi-manikin simulations improved triage performance by medical students.[71] A typical "JumpSTART" training session improved triage performance in a subsequent drill.[99]

Although a clear majority of studies assessing resource optimization strategies indicate that these methods are effective, the limited level of evidence within each category does not allow us to draw definitive conclusions. Only three studies used randomized designs, and many studies failed to include a robust comparison group. Rather, many studies relied on performance benchmarks from prior events—a potentially subjective standard. For example, it is unclear what an "acceptable" false negative rate might be for an accelerated imaging protocol. Outcomes of load-sharing strategies that demonstrated balanced allocation are difficult to interpret: the few studies published on this topic did not report health outcomes or adverse events associated with these strategies, three occurred outside the United States, and the remaining study was a computer simulation. Nearly all studies reported positive results, suggesting that publication bias may be a threat to the validity of these findings. Although many of these studies drew on data collected during actual MCEs, they were often limited to a single setting and relied on small sample sizes, undermining both the validity and applicability of the results.

Despite providing outcomes data with published sources or comparison groups, many of these strategies can be regarded more accurately as promising pilot tests. For example, strategies involving electronic triage tags, and technology-enhanced triage training have not been taken to scale. As a result, important details of these strategies may not yet be fully understood. Load-sharing examples developed in Israel, a compact country where emergency care utilizes a national incident command system, may not work as well in other settings. Likewise, because the effectiveness of the telemedicine system was based on simulated data only, an unknown number of implementation issues may arise when applying the strategy in practice.

Strategies To Augment Existing Resources

A single study assessed different strategies for augmenting scarce resources during an MCE. Researchers demonstrated the feasibility of augmenting supplies of nerve agent antidote by converting a more widely available intramuscular formulation of pralidoxime to enable intravenous administration—a route more suitable for treating critically ill victims of a mass nerve agent attack.[108] The strength of evidence in this category is insufficient.

Strategies for Use Under Crisis Standards of Care

Five studies evaluated outcomes of strategies for use under crisis standards of care during actual or simulated MCEs. These studies assessed a wide range of non-comparable outcomes that may have limited relevance to most providers. The strength of evidence from these studies is insufficient to support firm conclusions.

One article described the use of very early discharge from the intensive care unit (ICU) in a field hospital during the 2010 Haiti earthquake. The authors reported that this strategy enabled the hospital to treat a greater number of patients than would have otherwise been possible.[109] Two studies assessed outcomes associated with a limited approach to trauma surgery under crisis standards. The first evaluated impact of "damage control" surgery to treat the initial influx of complex trauma victims from the London transit bombings. The authors report that this strategy resulted in lower than expected mortality rates.[79] In the second study, hospitals that implemented damage control surgery in the aftermath of a major earthquake improved their operating room throughput with limited impact on patient outcomes.[110] Another study examined the impact of crisis standards of care for orthopedic surgery under battlefield conditions. It reported faster throughput, but at the cost of higher complication rates, particularly surgical infections.[111] Finally, a computer simulation study found that implementing crisis standards of care for pediatric disaster victims could reduce mortality, particularly if preceded by strategies to improve allocation of patients under surge conditions.[77] However, this study has limited use because the specific approach used to implement crisis standards of care was not defined.

Collectively, these studies present encouraging findings but not definitive evidence. Most studies were of low quality because they used study designs that did not adequately control for potential confounders. Moreover, in the studies of actual events, data collection was typically nonsystematic, and measures of effectiveness were often compared to historical benchmarks that are open to interpretation. Several studies did not measure health outcomes or even the most relevant process outcomes. Instead, most of the studies focused on measures of throughput.

Reports based on actual MCEs were generally less rigorous but provided more applicable evidence. Computer simulations and exercises provided low-quality evidence, and their findings have limited applicability to real MCEs or to other settings. Crisis standards in the studies we reviewed were implemented in very specific contexts, including an earthquake and a terrorist bombing, and likely involved different types of injuries and different protocols. Crisis standards were typically implemented on a small scale and occasionally at a single site, limiting the generalizability of those studies.

Table 6 outlines the strength of evidence for Key Question 2.

Table 6. Strength of evidence for Key Question 2

Strategies		Risk of Bias	Consistency	Directness	Precision	SOE Grade
Reduce or manage less-urgent demand for health care services		Medium	Consistent	Direct	Imprecise	Insufficient
Optimize use of existing resources	Triage	High	Inconsistent	Indirect	Imprecise	Low
	Other	Medium	Consistent	Direct	Imprecise	Low
Augment existing resources		Medium	Consistent	Direct	Imprecise	Insufficient
Crisis standards of care		High	Consistent	Indirect	Imprecise	Insufficient

Tested Strategies Lacking Comparison Groups

We identified 47 additional articles that presented evidence relevant to Key Question 2 but that did not meet the level of evidence required to be formally included in our review because they lacked a comparison group (Appendix Table C-5). Although the impact of these strategies on patient outcomes has not been conclusively demonstrated, many used novel techniques to optimize use of existing resources, augment existing capacity, and implement crisis standards of care. None of these articles addressed reducing less-urgent demand for health care services.

Some strategies are sufficiently promising to warrant consideration for future research to advance the field.

Optimizing Resource Use

Seventeen studies sought to optimize resource use through improved approaches to triage or the use of imaging to support triage decisions. Two reports from actual disaster events[112, 113] described the use of ultrasound, particularly the FAST exam, as a screening tool to support triage decisions. A third study, based on a simulation, assessed the feasibility of implementing ultrasound screening in the context of an MCE.[114] Another simulation study examined the use of a modified approach to CT scanning as an adjunctive tool for clinicians evaluating large numbers of patients with complex injuries.[115] A retrospective study described the use of three levels of triage—at disaster sites, primary health care centers, and tertiary referral centers.[116] Okumura et al.[117] described an approach that uses colored clothespins to perform color-coded triage for MCEs that require decontamination. Another drill-based study showed that a care team comprising both ambulance and hospital staff allowed timely triage for simulated disaster victims.[118]

Several exercises and simulations tested the effectiveness of information technology applications to facilitate MCE triage in the pre-hospital setting. One study employed a portable data collection tool for first responders. The authors claim that it reduced triage collection time and improved data collection accuracy in two field simulations.[119] Another simulation exercise demonstrated that it was feasible to use a prototype Radio Frequency Identification (RFID) technology in the field as part of an online triage system for MCEs.[120] A simple navigation device designed to guide walking wounded to a target destination was successfully tested in a third study.[121] A pilot test of a “Scalable Medical Alert Response Technology,” or SMART, to monitor unattended patients showed promise in several emergency departments and scenes of actual MCEs.[122] Electronic patient tracking through bar codes[123] and web-based triage tools[124] have also been shown to be promising techniques for optimizing resources.

Information technology has also been used to improve resource use inside health care facilities during MCEs. One article described the use of an electronic health information system—including patient medical records, picture archiving, and communications—that facilitated patient care in a field hospital established after the 2010 earthquake in Haiti.[125] In another study, Roth and colleagues described a web-based all-hazards electronic disaster management system designed to optimize resource use by integrating health care data from multiple sources.[126] A test of an automated call-down system demonstrated that roughly a third of personnel contacted were able to report to the facility in less than 60 minutes.[127]Another pilot study tested an educational tool that linked participants’ resource allocation decisions to patient outcomes.[128]

Augmenting Existing Resources

Twenty-nine studies in this group focused on augmenting resources by repurposing drugs or devices; opening ancillary facilities; providing additional training to providers; or modifying existing equipment, such as ventilators, to serve multiple patients simultaneously. Two studies involved simulations to test whether a single ventilator could be modified to sustain up to four individuals.[129, 130] One of the studies, conducted with four sheep, concluded that it may be possible to use this strategy during an MCE, such as a pandemic, when ventilators are in critically short supply.[130] However, the other study, based on a simulation, suggested that such an approach would sustain only four adults for a very limited period of time.[129] Another study of mechanical ventilation devised a prototype that could be quickly manufactured during an emergency.[131] Automatic gas-powered resuscitators have been proposed to augment the supply of ventilators, but questions about their capacity and usefulness remain.[132, 133] Other studies of respiratory support focused on enhancing capacity to deliver oxygen via an improvised system,[134] testing the feasibility of just-in-time training for medical students to provide bag-valve-mask ventilation,[135] and assessing the feasibility of cross-training non-respiratory therapists to assist in mechanical ventilation.[136] Both of the cross-training studies demonstrated successful competency of trainees.

Several studies examined load-sharing strategies. A descriptive study, based on an actual MCE, reported successful use of an alternate care site as a temporary burn center coupled with successful long-distance transfer of some patients.[137] Another described the implementation of a fully equipped mobile surgical hospital (MED-1) during Hurricane Katrina that succeeded in providing services to approximately 350 patients per day.[138] During the 2009 H1N1 pandemic, an alternate care site effectively expanded ED capacity by 42 percent without any adverse events.[139] Other studies reported the successful conversion of a charter plane to transport a large number of injured and ill tsunami victims back to their country of origin[140] and a successful trans-provincial mass transfer of patients following a major earthquake in China.[141] One study, conducted in a non-disaster situation, demonstrated that it is possible to implement load-sharing by transferring pediatric patients, including critically ill children, without adverse outcomes.[142] Lessons learned during the mass interstate transfer of pediatric patients during Hurricane Katrina highlight the need for improved regionalization of pediatric services prior to an MCE.[143] Trauma system structures have been tested as a mechanism for distributing victims of an MCE. For example, the Medical Alert Center in Los Angeles County has demonstrated its ability to coordinate distribution of critical casualties among area hospitals and trauma centers.[144]

Several articles in this group pointed to the role that information technology can play in augmenting health care resources. One team used a web-based application to assess surge capacity and other resources in a State disaster exercise.[145] Another used a mass-casualty tracking system to improve coordination and reduce confusion during a simulated MCE.[146] A wireless handheld device for recording and transmitting patient information between first responders and incident command has also been successfully field tested.[147] A system that uses bar-coded identifiers to represent patients, injuries, facilities, and locations has been shown to facilitate information transfer and minimize errors during a simulated MCE.[148] Two separate pilot tests demonstrated that electronic medical information tags can increase patient care capacity in the field and facilitate successful transfer of information to receiving facilities.[149] Another study described the use of “pervasive computing technology” for MCEs, using a device that would capture contextual information from individuals in a non-intrusive manner to facilitate response. However, a prototype has not been built or tested.[150]

A few studies examined other approaches to augmenting resources. One study tested a tool designed to rapidly mobilize anesthesiology staff;[151] another used a tool to estimate manpower reserve and service capacity for radiology staff.[152] Two studies focused on lab capacity and scalability, particularly for chemical and radiological disasters. One of the studies described a customized laboratory information system developed at the CDC to support emergency response laboratory activities that would be required for the rapid analysis of samples such as chemical warfare agents.[51] In another study, the Biodosimetry Laboratory in the State of Connecticut identified 30 willing and qualified labs that could perform initial biodosimetry processing should a radiological disaster occur.[153] One study demonstrated the use of a unilateral external fixation device for stabilizing musculoskeletal injuries prior to major surgery.[154] Two studies examined infectious disease control strategies within health care facilities. The first explored the feasibility of repurposing existing space to serve highly infectious patients and described the conversion of existing space within a health care facility into a temporary negative-pressure room through use of portable, HEPA-filtered forced air.[155] The second tested a cost-effective method of establishing an airborne infection isolation area using a commercially available portable filtration unit and basic hardware supplies.[156]

Crisis Standards of Care

A single study focused on crisis standards of care met our criteria for inclusion in the review. The authors applied a decision support tool previously developed for ventilator allocation during an influenza pandemic to evaluate ventilator allocation decisions during the Haitian earthquake of 2010. The study used a case study design and assessed the allocation decisions made for five pediatric victims of the earthquake.[157]

Proposed Strategies

We identified 17 additional articles that proposed strategies to help providers allocate scarce resources during MCEs. These strategies have not been tested in the context of a real event, exercise, drill, or simulation, but represent the consensus opinion of one or more national professional organizations or task forces convened by the Federal government. The proposed strategies reviewed here addressed two major activities: performance of pre-hospital (field) triage and allocation of scarce resources in the hospital setting.

Prehospital Triage

National Association of EMS Physicians Workgroup

A national workgroup convened by multiple professional societies, provider organizations, public health organizations, the CDC, and the National Highway Traffic Safety Administration (NHTSA) reviewed nine existing mass casualty triage systems with the goal of recommending a single, national standard.[158, 159] The work group used elements from existing systems to develop a new triage method known as SALT (Sort-Assess-Lifesaving Interventions-Treatment and/or Transport) that could serve as an initial all-hazards triage method. Although this work group ultimately endorsed the SALT triage system, it viewed it as “a beginning rather than final product.”

This workgroup subsequently developed the Model Uniform Core Criteria for Mass Casualty Triage to serve as a national guideline for mass casualty triage while enabling local flexibility in implementation.[160] The Core Criteria consist of four categories: general considerations, global sorting, lifesaving interventions, and individual assessment of triage categories. Examples of recommendations include withholding lifesaving interventions if the intervention is not within the provider’s scope of practice, cannot be performed quickly (i.e., in less than 1 minute), or requires the provider to stay with the patient. Criteria for individual assessment include using the “dead” triage category for any patient not breathing after one attempt to open the patient’s airway and to refrain from counting or timing vital signs during the initial assessment.

Scarce Resource Allocation in the Hospital Setting

IOM Committee on Guidance for Establishing Standards of Care for Use in Disaster Situations

The 2009 IOM Letter Report called on health care providers, organizations, government officials, and the public to approach the challenge of allocating scarce resources in MCEs in a proactive and thoughtful way.[13] The committee declared that such an effort should be grounded in the principles of fairness; equitable processes; community and provider engagement, education, and communication; and the rule of law. The committee called for the development of "consistent crisis standard of care protocols within each State," and expressed the hope that their guidance could produce "a single, national framework for responding to crises in a fair, equitable, and transparent matter." The Letter Report outlined a comprehensive framework for developing appropriate guidelines, based on an inclusive process and the best available medical evidence. However, it did not offer concrete recommendations to policymakers or providers about how they should make difficult resource allocation decisions under crisis standards of care. Our review identified no additional consensus recommendations on crisis standards of care in response to the Letter Report.

Task Force for Mass Critical Care

The task force developed a series of recommendations during the course of a summit meeting on definitive care for the critically ill during disasters. We have included three papers containing detailed recommendations. In the first paper, the Task Force developed recommendations on the use of equipment and space for creating surge capacity during MCEs.[161] It recommended the use of one mechanical ventilator per patient (rather than the use of a multiple-limb ventilator circuits)—numerous examples of which were reported in the previous section. It also produced a list of ideal characteristics for stockpiled surge mechanical ventilators, recommended equipment for surge PPV, and recommended non-respiratory medical equipment. In the event that ICUs, post-anesthesia care units, and emergency departments have reached capacity, the Task Force recommended the following treatment spaces (in order): (1) intermediate care units, step-down units, and large procedure suites; (2) telemetry units; and (3) hospital wards. The Task Force strongly discouraged the use of nonmedical facilities to serve as alternate care sites. Finally, the Task Force endorsed a collaborative team model for staffing during critical care surge.

In the second paper, the Task Force proposed a bundle of seven services that comprise emergency mass critical care (EMCC).[162] Each of these services requires inexpensive equipment and can be implemented without consuming extensive staff or hospital resources. The Task Force also developed a framework for optimizing surge capacity that includes various activities along a continuum from minimal patient need to overwhelming patient need and consists of 5 major types of activities: substitution, adaptation, conservation, reuse, and reallocation. The Task Force also adopted a multi-tiered critical care surge capacity framework that delineated specific triggers for escalation to higher tiers.

In the third paper, the Task Force presented a framework for resource allocation during MCEs that included specific inclusion criteria for the receipt of medical or palliative care.[163] The inclusion criteria recommended by the Task Force are based on those developed by Christian et al.[164] Recommended exclusion criteria take into account both the Sequential Organ Failure Assessment (SOFA) score and a patient's chronic illnesses. The Task Force proposed a SOFA score cutoff corresponding to an 80% risk of mortality, and it also enumerated the specific chronic illnesses that should be used as exclusion criteria. The Task Force recommended prioritizing patients in the order of their latest SOFA score and daily SOFA trend. Finally, the Task Force described the recommended responsibilities of the triage officer and the recommended composition of the triage team—a critical care nurse, respiratory therapist, and/or clinical pharmacist.

Pediatric Mass Critical Care Task Force

The Task Force proposed minimum resource requirements for pediatric emergency mass critical care [165] that are largely consistent with those developed by the Adult Task Force on Emergency Mass Critical Care.[161-163] The Task Force also developed specific recommendations for non-pediatric hospitals, including a recommendation that adult ICUs keep adolescent patients without consultation (and patients aged 5–8 years after consulting with pediatricians). The Task Force was unable to recommend a pediatric prognostic scoring system to guide the triage of pediatric MCE victims due to the poor performance of existing systems. Moreover, the Task Force declined to endorse exclusion criteria for the use of life support based on pre-existing conditions despite the fact that other groups have proposed such criteria. The Task Force was also unable to develop recommendations on criteria for withdrawing life support for pediatric patients during MCEs. Finally, the Task Force called for the development of a triage protocol that not only took into account a patient's likelihood of survival but also the likelihood that a patient would require a prolonged ICU stay. (This latter point is a notable difference from the adult recommendations that did not consider prolonged use of ICU resources).

Working Group on Emergency Mass Critical Care

This working group was convened by the Society of Critical Care Medicine and the Center for Biosecurity at the University of Pittsburgh Medical Center. The work group recommended that minimal requirements during crisis standards of care include: basic modes of mechanical ventilation, hemodynamic support, antibiotic or other disease-specific countermeasure therapy, and a minimum set of prophylactic interventions that can reduce the serious adverse consequences of critical illness.[166] The work group also emphasized that the goal of crisis standards was to help the greatest number of people survive the crisis, and favored the use of triage protocols rather than a first come first served model. Additional recommendations included the personnel that should be involved with emergency mass critical care, the location where care should be provided, and specific infection control practices.

Society of Critical Care Medicine Ethics Committee

The SCCM Ethics Committee recommended that resource allocation decisions for patients with otherwise equivalent prognoses should be made on a "first come, first served" basis.[167] Although the SCCM listed factors that should be considered when allocating ICU beds, such as the likelihood of a successful outcome, the patient's remaining life expectancy, and the patient's anticipated quality of life, it did not provide specific inclusion/exclusion criteria for these decisions. Ultimately, the SCCM Committee argued that "*institutions* should establish an explicit mechanism for implementing policies to allocate ICU resources."

American Thoracic Society Bioethics Task Force

The Task Force reached similar conclusions to those of the SCCM Ethics Committee[168] It emphasized that patients who continue to meet criteria for medical need and benefit should continue to receive ICU care, even if new candidates for ICU admission have an even greater potential for benefit. This task force went further and applied these same principles to all ICU services, not simply the allocation of ventilators or ICU beds.

Other Recommendations

Other recommendations, such as those by the European Society of Intensive Care Medicine, offer illustrative inclusion/exclusion ICU admission criteria but stop short of providing recommendations.[169] The Australasian Surge Strategy Working Group enumerated strategies involving the use of space, staffing, supplies and equipment, and flow to optimize the ED response to mass casualty events, but it did not specifically address crisis standards of care, noting that this effort was "beyond the scope of [their] paper."[170] Similarly, other articles specified objectives for disaster preparedness and response, but not a path to achieving them. For example, the CDC convened an interdisciplinary panel of experts to develop strategies to assure surge capacity for sudden MCEs, particularly terrorist bombings.[171] The effort culminated in the development of "surge action templates" tailored to ten distinct disciplines to address known challenges. The EMS template, for example, calls on local EMS organizations to "describe in a plan how alternative transport for 200 ambulatory patients will be initiated in the first 10 minutes after an explosion." But it does not offer guidance on how to accomplish these objectives.

Another study focused specifically on appropriate use of immunization and postexposure prophylaxis for tetanus and occupational and non-occupational exposures to bloodborne pathogens during mass casualty events.[172] However, the recommendations did not directly address altered standards of care when vaccines are in short supply. The European Society of Intensive Care Medicine's Task Force for Intensive Care Unit Triage also provided recommendations and standard operating procedures for patient and staff prophylaxis during a pandemic.[173]. Finally, In 2007, the American Medical Association and American Public Health Association jointly released a set of eight goals for expanding health system surge capacity.[174]

Key Question 3: What Are the Public's Concerns Regarding Strategies to Allocate Scarce Resources?

What are the public's key perceptions and concerns (e.g., values, equity, transparency, communication, and public input) regarding the development and implementation of strategies to allocate and manage scarce resources during both actual and potential MCEs?

Key Points

The evidence across studies is relatively consistent in supporting the following concepts:

- A successful allocation system should balance the goals of ensuring the functioning of society, saving the greatest number of people, protecting at-risk populations, reducing deaths and hospitalizations, and treating people fairly and equitably.
- Multiple criteria are used to prioritize recipients of resources during an MCE. Health care professionals, health care workers, and first responders were among the highest priority groups; politicians were among the lowest.
- High priority should be given to children and young adults for receipt of care.
- Prioritization criteria should not be based on ability to pay, "first come, first served," or random selection (lottery system).
- The public has a high degree of faith and trust in medical professionals to make appropriate allocation decisions based on their expert opinions.

- Resource allocation guidelines should be generally consistent, but should allow health care institutions some degree of flexibility to make allocation decisions based on their specific demand and supply situation.

Description of Included Studies

Our search identified ten studies that addressed this Key Question.[175-181, 182-184b] Six studies [177-180182] were conducted in seven different U.S. States (Georgia, Massachusetts, Minnesota, Nebraska, Oregon, Washington, and Louisiana); two studies were conducted in Australia,[175, 176] and one each in Canada[181] and Brazil[183]. Seven studies reported public opinions related to pandemic influenza, while three[177, 183, 184] did not involve a specific MCE context. Two basic approaches were used to solicit public opinions: (1) public engagement activities in various forms, such as deliberative meetings, community forums, and small group discussions; and (2) surveys, including web-based questionnaires, telephone surveys, and solicitation of written comments.

The number of citizens participating in the studies ranged from fewer than 10 to more than 5,000; public engagement forums (sample size 9–441) involved fewer participants in general but generated substantially more in-depth discussions among participants. As a result, public engagement activities provided substantially more detailed information than surveys, although the latter were more broad-based (sample sizes 1,030–5,220).

Detailed Synthesis

A wide range of issues were discussed regarding public opinions on policies and strategies to allocate and manage scarce medical resources during an MCE. The ten papers all addressed at least one of two main themes: development of resource allocation policy and criteria for who should receive treatment under crisis standards of care. Resource allocation policy covered the public's perceptions about allocation systems in general such as whether or not resource allocation guidelines were needed; what goals the allocation system should achieve; who should make allocation decisions; and what role the Federal and State governments should play in developing, managing, and implementing such a system. Priority criteria reflected the public's views of which groups should be considered high versus low priority for receiving scarce medical resources during an MCE.

We rated the overall strength of evidence for these studies as medium (Table 7). Because of the limited number of studies addressing the question, and because four were from outside the United States, we rated the risk of bias for the set of results as medium. The evidence from the seven forums and three surveys was remarkably consistent, and, by construction, the evidence was derived directly from the public (indirect reports of public opinion were excluded). Because much of the evidence comprised rankings and consensus opinions, we could not meaningfully evaluate the precision of the results. Key themes arising from public engagement activities are summarized below.

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[b] Doctor, 2011175. Docter SP, Street J, Braunack-Mayer AJ, et al. Public perceptions of pandemic influenza resource allocation: A deliberative forum using Grid/Group analysis. J Public Health Policy. 2011 Jan 13PMID 21228887. and Braunack-Mayer, 2010176. Braunack-Mayer AJ, Street JM, Rogers WA, et al. Including the public in pandemic planning: a deliberative approach. BMC Public Health. 2010;10:501. PMID 20718996. reported data from the same public engagement activities. Since they had slightly different focuses of the data reported, we included them both.

Allocation Guidelines

The public agreed that MCEs are highly unusual situations that require decision-making processes and protocols different from those used in normal clinical circumstances. They stressed the need to proactively establish allocation standards or guidelines that will be followed by health care facilities and other providers. Participants generally felt that it will be important to take into consideration the different capacities that each region or facility might have, as well as different service demands they might face. Thus, although they widely agreed that guidelines for crisis standards of care should be generally consistent across health care facilities, they believed that institutions should have some degree of flexibility to make allocation decisions based on their specific demand and supply situation. Participants also agreed that guidelines should be relatively simple so that they could be successfully implemented.[180]

Goals of Allocation Systems

Participants in these forums listed several goals for a successful resource allocation system: ensuring the functioning of society, saving the greatest number of people, protecting at-risk populations, reducing deaths and hospitalizations, and treating people fairly and equitably.

Some participants preferred one goal over another, but one study found that many participants showed some degree of internal conflict when weighing different goals.[181] Other participants suggested a balance of objectives.[179] When forced to choose only one goal, participants explicitly stated that they would choose ensuring the function of society in the long run.[176] To achieve the goals, most participants agreed that certain compromises might have to be made. For example, seeking to save the greatest number of people might result in lowered standards of care.[180]

Allocation Decisionmakers and the Role of Government

Across most studies, the public showed a high degree of faith and trust in medical professionals to make appropriate allocation decisions based on their expert opinions. They believed that health care professionals and experts were essential to ensure a fair and effective allocation system. Some participants preferred a joint committee consisting of a variety of experts and policymakers (but not politicians) elected by their peers.[175] The public expressed a lack of trust in elected or appointed representatives and politicians without public health qualifications to make health resource allocation decisions.

Participants in the Public Engagement Pilot Project on Pandemic Influenza study suggested that the role of the Federal government should be to provide broad guidance, while responsibilities for interpreting and implementing the guidance should remain at the State and local level.[178]

Prioritization Criteria

Although the underlying rationale of prioritization has always been to ensure the best use of limited resources without capricious discrimination, participants used mixed criteria to prioritize recipients of resources during an MCE. Given different situations, participants expressed their preferences for a range of criteria, including the individual's role in society (e.g., occupation), equity, survivability (the number of years a person would live if they are treated and survive), vulnerability, risk of exposure, and likelihood of recovery. Below, we summarize the key considerations raised by the public regarding each criterion.

“Role in Society” Criterion

A majority of participants across studies seemed to accept the criterion of ranking people based on their role in maintaining a properly functioning society. Professionals and health workers were always among the groups given highest priority to ensure an adequate workforce for providing continuous services to all people. For the same reason, first responders, essential services (e.g., power, water, electricity, gas), and military personnel were also listed as priority groups by many participants. This prioritization seemed to reflect the public’s perception that a successful allocation system should assure the functioning of society. However, one problem with this criterion, as pointed out by some other participants, was that it was not always easy to assess an individual’s “value” to society because individuals contribute to society in different ways.

“Equity” Criterion

Equity was a somewhat expected criterion, given America’s egalitarian nature and the role of equity concerns in public health in general. All participants in all studies unanimously agreed that decisions based on race, gender, culture, legal status, nationality, language, or income were unacceptable; prioritization based on age seemed to favor children and young people over the elderly. The elderly were not generally perceived as a priority group, although a small proportion of participants expressed the belief that all age groups should be equally valued and valuable.[179] Together with chronically ill and disabled people, the elderly were perceived by some participants as “not contributors to a future society” and therefore were accorded lower priority for receipt of scarce health care resources.[175] In fact, some participants in one study supported a policy that would “de-prioritize” persons more than 85 years of age.[179]

In contrast, many participants listed children and young adults as priority groups. For example, in a study from Australia, priority was given to children and young people aged 2–30, because “they *are* the future.”[176] In the United States, children and pregnant women were prioritized, although to a lesser degree than health care professionals and health workers.[180] Findings from a nationwide telephone survey conducted by the American Academy of Pediatrics highlighted the significant lack of medications for children during disasters.[177] A majority of respondents in the studies we reviewed supported giving higher priority to children who need life-saving treatment.

“Survivability” Criterion

Many participants expressed the belief that patients’ survivability should be considered and that health care providers should be the ones to make allocation decisions accordingly. They argued that allocation of significant resources to an individual with low probability of survival is a suboptimal use of limited resources, regardless of the importance of that individual’s role in society.[180]

Other Findings Related to Prioritization

Political decision makers were generally among the groups accorded the lowest priority, mainly due to lack of public trust and public suspicion that they would misuse their authority. Participants raised the issue that improving transparency of decision-making processes and funding streams and providing more information to the public could be important tools to gain the public’s trust.

A few prioritization methods were rejected by most participants. These methods included decisions based on ability to pay, “first come, first served,” and random selection via a lottery system.

Another interesting finding was that some participants changed their priority decisions when those choices were reassessed in follow-up surveys, implying that their opinions could be influenced by the process of group deliberation, as well as by exposure to public briefings by experts. Data from the King County post-forum survey showed that many participants had shifted their opinions during the time between the forum and the post-forum survey.[180] For example, the percentage of participants who considered children and pregnant women to be a high-priority group dropped from 71 percent during the forum to 40 percent after the forum.

Special Concerns of At-Risk Participants

Few studies separately reported public opinions on resource allocation regarding at-risk populations (e.g., minority groups, frail elderly). In most instances, members of these groups were actively recruited and included in the discussions. The only notable finding was from a public engagement forum in Seattle and King County, Washington, where Hispanic participants voiced much stronger opinions about prioritizing children and pregnant women than did non-Hispanic participants (70 percent indicating that children and pregnant women should be a priority vs. 27 percent of non-Hispanics). They also emphasized the needs of minorities and immigrant populations.

Other Relevant Findings

The public’s perceptions and concerns about medical resource allocation during an MCE did not always agree with those of policymakers, public health experts, or other stakeholders. Some doubted how much their concerns and perceptions would be taken into account in establishing a disaster plan. But in other cases, the public and health policymakers shared the same opinions. For example, in Australia, the priority groups selected by the public (health care workers and other functioning groups) based on the criterion of “the need to maintain functioning of critical infrastructure” corresponded to those outlined in the national pandemic plan.[176] In Minnesota, a majority of the participants agreed on the three resource rationing objectives proposed by expert panels (reduce deaths, treat people fairly, and protect public health and infrastructure).[179] However, other studies showed some nuanced differences in perspectives between the general public and experts or other stakeholders. For example, the King County study found that while the goals of prioritization were similar, experts tended to focus on maximizing resources by assessing survivability and saving the greatest number of people, and the public appeared to focus more on response capabilities by prioritizing health care workers and first responders.

It was notable that participants generally did not choose prioritization strategies that specifically favored themselves or their families. For example, the study in Canada found that participants who had children themselves did not necessarily give priority to children: Only 9.7 percent of participants who had children preferred the child-focused priority plans.[181] Similarly, in the Minnesota public engagement project, which focused on prioritization for socially vulnerable groups, members of these groups seldom chose to prioritize themselves, but rather were more likely to prioritize groups associated with critical infrastructures.[182] Fear of stigma following the implementation of such a policy was one of the main reasons cited by these representatives.

Participants acknowledged that an MCE is a difficult situation that would affect everybody. Some suggested that the number of pharmaceutical manufacturers should be increased to produce more supplies to meet the needs of an influenza pandemic. Others urged that in an MCE when medical resources were scarce and difficult allocation decisions must be made, more communication, information, education, and training would be needed to prepare the public.[178] Some participants reported that they would be willing to accept some increase in their income taxes now as a form of insurance against an inadequate response to a future disaster.[176]

Table 7. Strength of evidence for Key Question 3

Strategies	Risk of Bias	Consistency	Directness	Precision	SOE Grade
Public engagement (forums and surveys)	Medium	Consistent	Direct	N/A	Medium

Key Question 4: What Methods Are Available To Engage Providers in Developing Strategies To Allocate Scarce Resources During MCEs?

What current and proposed methods are available to engage providers in discussions regarding the development and implementation of strategies to allocate and manage scarce resources both in planning for and during an MCE? What outcomes are associated with these strategies? What factors are identified as facilitators or barriers to engaging providers in these discussions?

Key Points

- Nearly all studies described successful engagement strategies that involved multiple stakeholders and employed an inclusive, systematic, and often iterative process for reaching decisions or crafting a final plan. The articles we reviewed did not clearly identify one approach as superior to the others.
- Engagement strategies varied by type of policymaker, provider, and range and mix of participants. Engagement strategies addressed planning for scarce resource allocation at different jurisdictional levels, ranging from local to regional, State, and even interstate levels.
- Most engagement strategies were not specific to a particular type of disaster or to any single broad category of adaptive strategy for scarce resource allocation. However, only 5 of 14 studies addressed the development of strategies for implementing crisis standards of care.
- Only 2 of 14 studies described an engagement process that included the public.
- Provider engagement was led both by providers and by local or State government officials. The latter often did so in partnership with other institutions, including academic institutions.
- Technical (e.g., clinical) experts and health leaders both led and participated in provider engagement strategies, adding credibility to the engagement process and the resulting plan, protocol, framework, or strategy.

Description of Included Studies

The 14 studies included in this part of the review address a wide range of planning activities and exercises with the goal of developing resource allocation strategies for MCEs. Many engagement activities involved a combination of adaptive strategies for resource allocation, but fewer than half of the studies (5) addressed the implementation of crisis standards of care. Six studies reported the results of engagement activities led by providers, while seven studies reported on those led or co-led by policymakers. One study reviewed planning models that included both provider-led and public health department-led engagement models.

All 14 studies took place in the United States but reflected broad geographic diversity: 11 studies described local-, regional-, or State-level planning in urban or rural settings in 16 different, specified States. Two studies were carried out in multiple, unspecified locations. One study drew experts from across the country.

Nearly half of the studies (6) did not specify the type of MCE to which planning activities or exercises were oriented. Among the remaining 8 studies, 4 addressed pandemic influenza preparedness, 2 addressed all-hazards preparedness, 1 addressed biological threats of various types, and 1 addressed radiological or nuclear threats. Of the 14 included studies, 11 were largely descriptive, while 3 were intervention studies with at least one post-test measurement.

All engagement strategies involved multiple stakeholders and systematic, often iterative, consensus building to undertake planning or multi-party exercises. Different studies described planning at the local, intrastate regional or county, State, or interstate level. Nearly all studies described engagement of hospitals—often by other hospitals. State and/or local public health departments were also included in most, though not all, studies. Leaders of engagement processes, commonly in partnership, included hospitals, State or local public health departments, academic institutions, intrastate or interstate regional entities, and de novo planning entities. The range of providers who were targeted by engagement strategies included professional staff in general or specialty hospitals, clinics, community health centers, pharmacy departments, laboratories, and front-line health care workers (e.g., emergency medical technicians). Although most of the studies described well established engagement strategies, some described more novel strategies. Of note, only 2 of 14 studies included public representation as part of the engagement process.[179, 185] A summary of strategies addressing Key Question 4 is located in Table 8.

Detailed Synthesis

Nearly all studies described a successful engagement process that led to one or more desirable outcomes, including the development of resource allocation plans, training, or a commitment of resources. Synthesizing the evidence for Key Question 4 was challenging because of the nature of this question (related to provider engagement methods, rather than testing of the resource allocation strategies developed as a result of the engagement process) and the variability in study focus. However, several facilitators and barriers emerged as general themes across multiple studies.

Table 8. Summary of strategies addressing Key Question 4, by category

	Strategies
Strategies led by providers	Enrollment, education, training, and exercise of qualified laboratory staff for preparing biodosimetry specimens Organization of de novo regional hospital planning group Alternative planning models (Decentralized regional planning, Hospital-directed tiered regional planning model, Third-party directed planning model) Development of consensus on appropriate pediatric crisis standards of care Development of evidence-based "reverse triage" classification system Pilot testing of local-, regional-, and national-level tabletop exercises for the Veterans Health Administration (VHA) Pharmacy-led development of regional pharmaceutical preparedness policies and procedures
Strategies led or co-led by policymakers	Public health/business partnership for mass dispensing Development and pilot testing of tabletop exercise template for local level governments and providers Organization of neighboring States into a voluntary disaster surge network State or local public health department planning model, including development of mutual aid agreements Incorporation of community health centers into surge plan, with training for CHCs and three event-based tests Developing proposed ethical frameworks and procedures for rationing scarce health resources within a State (2 studies) Broadly inclusive regional hospital level planning process to identify surge beds

Common facilitators of provider engagement strategies included the personal relationships established, the willing commitment of actors to participate in cooperative planning, the iterative and broadly inclusive engagement of key stakeholders, and the technical excellence and credibility of partner institutions or experts. Some papers referred to barriers stemming from the differences in the organizational cultures of collaborating partners, such as public health and hospitals[186] or public health and business.[187] Other barriers related to the long time required to build critical relationships,[188] government regulations,[187, 189] the complexity of interstate agreements,[188] and the variability across facilities or other differences that impede a "one size fits all" approach.[179, 190]

We rated the overall strength of evidence for Key Question 4 as medium (Table 9). The risk of bias was medium, given the high likelihood for publication bias (unfavorable engagement strategies may be significantly less likely to be published). While the evidence on the effectiveness of the engagement models was consistently positive, it was indirect because the studies did not report how implementation of the strategies developed from the engagement process affected population health outcomes. We could not assess precision, given the qualitative nature of the evidence.

No study appeared to be highly unique to the site where it was carried out; however, the applicability of the evidence may be somewhat limited to the contexts described in each study. Most of the studies were at least moderately dependent on the scale of the MCE, such as the public health–business partnership to dispense medical countermeasures and the different approaches to optimize or augment resources through the use of existing personnel, health centers, laboratories, or pharmacy departments to provide surge medical resources. All strategies related to crisis standards of care were very dependent on scale of the MCE.

Below we summarize the key results according to whether providers or policymakers led or co-led the engagement process.

Engagement Strategies Led by Providers

Individual providers tended to engage other providers to develop highly technical or clinically oriented resource allocation strategies. For example, one study described how academic medical leaders engaged clinician and non-clinician experts to develop a 5-category classification system for "reverse triage" of hospital inpatients, based on their agreement about varying levels of risk tolerance for major medical consequences.[191] In another study, hospital pediatric leaders engaged other acute care pediatricians from across the country to develop pediatric crisis standards of care.[189]

Two studies described more novel engagement approaches. In these instances, the providers who initiated the engagement represented ancillary clinical services, such as the laboratory and pharmacy department. In one study, the State biodosimetry laboratory engaged all public and commercial laboratories in the State to assess and support development of additional capacity to prepare laboratory specimens for diagnosis of radiation exposure following a major nuclear or radiological event.[153] In the other study, the pharmacy department of a hospital helped lead development of a regional mass casualty "pharmaceutical preparedness" plan, including pharmaceutical resource sharing among regional providers.[192]

Institutional providers such as hospitals engaged other institutional providers in medical surge planning. In one study, an entirely new planning institute was created: Four unaffiliated hospitals in Brooklyn engaged the New York City Department of Health to organize the "New York Institute of All-Hazards Preparedness," which in turn engaged individual hospitals to work together to identify enough surge beds to meet national standards across the region as a whole.[193] Another study presented extant U.S. models for medical surge planning. Florida and Louisiana reflect decentralized planning models in which hospitals and the State hospital association engage other hospitals in surge planning.[186] The same study described the decentralized rural surge planning process in Oregon, in which a regional medical center engaged other hospitals in surge planning. This study also described hospital-directed tiered regional planning models in Illinois, Louisiana, and Missouri. In these States, a designated regional hospital engaged other hospitals in surge planning.

A particularly interesting model is that of the Veterans Health Administration (VHA), because it is both a very large provider (the largest integrated health care delivery system in the United States) and a Federal policymaker. One study described a series of pilot tabletop exercises for the local, regional, and national levels of the VHA system, in which the VHA engaged other local and regional providers, as well as local and State public health departments and first responders.[194]

Engagement Strategies Led or Co-Led by Policymakers

With the exception of the VHA study just noted, government-led engagement strategies were largely at the State and local government level. In most instances, State or local public health departments partnered with other institutions, such as academic medical centers, to engage other providers in planning for scarce resource allocation. Some studies described engagement strategies involving the traditional and typically large range of partners, while others described more novel partnerships. For example, the case study compilation of planning models describes the top-down county planning model with master (State-level) mutual aid agreement exemplified by California and Illinois, and the third-party-directed planning model of Missouri, where the State's health department and a designated hospital engaged other hospitals in surge planning.[186]

Another traditional example is Boston's public health department and the State primary care association. Working together, they engaged hospitals, community health centers (CHCs), and the emergency medical system in planning that added CHCs to the city's medical surge plan; the city health department then engaged the Harvard School of Public Health to provide training and exercises for CHCs. This plan was subsequently tested in three actual events: preparation for the Democratic National Convention and the public health investigation of two disease outbreaks.[190] In another study from Massachusetts, the State's public health department and a partner academic institution engaged a wide range of institutional health care providers, other health agencies, and the general public in developing consensus State-level guidelines and a decision-making protocol for crisis standards of care.[185] In 2004, RAND Corporation, in conjunction with local public health departments used tabletop exercise templates that could be locally customized to assess the strength of relationships between local public health agencies and local delivery systems when faced with a hypothetical pandemic flu emergency.[195]

Another study described a similarly inclusive planning process in Utah, in which the State health department and university medical center engaged multiple hospital and non-hospital facilities, professional associations, local public health departments, transit, EMS, and church groups in an iterative process to develop a regional medical surge plan.[196] Yet another study described the initiative of two State health departments and the regional public health preparedness center in engaging pediatric hospitals, major pediatric clinics, State public health departments, and emergency responders into a five-State voluntary pediatric surge network; in doing so, they created a network, an operational handbook, and a formal memorandum of understanding.[188]

Examples of less traditional approaches include the partnership of a State government (Minnesota), a State university, and a health care ethics center to engage local governments, experts, the general public, and a few hospitals and clinics in developing proposed ethical frameworks and procedures for rationing scarce medical resources within the State during an influenza pandemic.[179] Another study described a public health–business partnership in Georgia that engaged providers from the public and business side to refine approaches to, and expand sites for, mass dispensing of medical countermeasures.[187]

Table 9. Strength of evidence for Key Question 4

Strategies	Risk of Bias	Consistency	Directness	Precision	SOE Grade
All strategies led by providers or policymakers	Medium	Consistent	Indirect	N/A	Medium

Analysis of State Reports

The IOM Letter Report[13] called for development of "consistent crisis standards of care protocols" within each State, with neighboring States, and in collaboration with public and private sector partners. The Letter Report went on to recommend that each crisis standards of care protocol address five key elements:

1. A strong ethical grounding

2. Integrated and ongoing community and provider engagement, education, and communication
3. Assurances regarding legal authority and environment
4. Clear indicators, triggers, and lines of responsibility
5. Evidence-based clinical processes and operations.

We reviewed a set of existing State plans to identify and describe the strategies developed by States to allocate scarce resources during MCEs. The majority of these State plans, plus Guam, (N=23 States) were compiled as part of the research that contributed to the IOM Letter Report and were forwarded to us by AHRQ. However, several of the documents we received did not qualify as a formal State plan or did not directly address the issue of scarce resources. We identified two additional State plans—New York and Wisconsin—through a search of the references in the plans we received. When States had multiple plans for different MCE contexts, we synthesized their content to give the reader a sense of the totality of the State's strategies. Ultimately, we reviewed plans from 11 States and one U.S. territory. Collectively, these plans provide an important window into the current status of State planning and the specific resource allocation strategies that will be used in response to an MCE.

In general, the strategies outlined in the State plans fit into the same four categories of adaptive strategies used to guide our CER. These include (1) early actions to reduce or divert less-urgent demand for health care services; (2) steps to optimize use of existing resources; (3) efforts to augment existing resources; and finally, if and when these measures prove to be inadequate to meet demonstrable need, (4) the ability to shift rapidly from strategies designed to deliver optimal care to each patient to a modified approach calculated to do the most good for the most people with the resources at hand. In cases where strategies might be classified in multiple categories, we explain the rationale for our choice.

In the sections that follow, we qualitatively summarize how these recurring strategies and themes were addressed across States with plans, plus Guam. Table 10 displays specific elements of the various plans on a State-by-State basis.

Reduce Less-Urgent Demand for Medical Resources

The State plans we reviewed described several proposed strategies to reduce demand on the health care system during MCEs. Their strategies followed two basic approaches: keep non-critical patients out of the hospital, and, in the case of an infectious disease outbreak, urge non-ill members of the public to self-quarantine through social distancing.

Keep Noncritical Patients Out of the Hospital

The State of California, in particular, has devoted considerable attention to strategies to reduce demand for services that could be provided outside of hospital settings. The State plans indicate that all elective surgeries should be canceled so medical staff can refocus their energies and other key resources on patients who require urgent care, and to keep healthy patients away from those who may be contaminated.[197, 198] Although the cancellation of elective surgeries might alleviate demand to a limited degree, a substantial MCE will likely necessitate further measures to ensure that sufficient supplies, staff, and facilities are available to treat critically ill or injured patients. Therefore the plan argues that non-critical care (e.g., first aid, primary care) could be safely and efficiently provided in off-premises facilities, such as community clinics or temporary health care facilities to reduce the demand on hospital resources.[199-202]

Encourage the Public to Self-Quarantine (Social Distancing)

For certain infectious disease outbreaks, such as an influenza pandemic, a few States[201, 202] discussed measures to impede or delay disease transmission by encouraging the public to self-quarantine. Specific strategies included encouraging employers to allow their employees to telecommute, closing schools, and educating the public regarding easily implementable non-pharmaceutical interventions, such as wearing a facemask.

Optimize Existing Resources

Nine of the 12 plans we reviewed recommended strategies to leverage the most benefit from existing health care resources, including staff, stuff (i.e., supplies) and structure.

Repurpose Existing Resources

Several States incorporated a range of approaches to increase bed capacity in their plans, including repurposing nonpatient care space for patient care, establishing temporary health care facilities such as tent hospitals, and "freeing up" space through early discharge of stable patients. Three of 12 States suggested repurposing space by converting overflow space and non-patient care areas (e.g., waiting rooms) into patient care areas or using outpatient areas for inpatient care.[197, 199] One of the plans recommended enhancing capacity by converting single-occupancy rooms to accommodate two or three patients.[199] Another option described in one of the California State plans is to triage ventilator-dependent patients directly to step-down units.[199] Lastly, preserving bed capacity might be accomplished by canceling elective surgeries and limiting those that are done to "life or limb" situations in order to facilitate discharge.[203]

Optimize Use of Space

Several State plans recommend optimizing the use of space by establishing temporary health care facilities in non–health care settings.[198, 204] Alternatively, California and Guam plan to expand bed capacity through strategies such as "reverse triage" that either allow for early discharge of stable patients from the emergency room or the hospital or that persuade outside facilities, such as long-term care units, to accept lower-acuity patients in transfer.[197, 205] Load balancing by distributing care across a region (e.g., mutual aid) is another common approach to optimize the use of space within individual facilities. Plans in several States recognized that morgue capacity could be exceeded and call for the establishment of temporary morgues in certain scenarios.[197, 198, 205]

Use Health Care Providers and Nonmedical Staff More Efficiently

During MCEs, medical and nursing staff are likely to quickly become limited resources. State plans described five strategies involving staffing, including the shifting of duties and priorities, to accommodate potentially large and rapidly growing patient populations. Several State plans recommend increasing nursing shift duration (from 8 to 12 hours or from 12 to 16 hours) as well as increasing provider-to-patient ratios to extend the reach of available personnel.[197, 198, 205] Cross-training staff through "just-in-time" training might allow for more staffing flexibility.[205, 206] Examples of potential uses of this strategy during an influenza pandemic include training health care professionals who are not respiratory therapists to provide basic respiratory care, including ventilator management (Project XTREME), or teaching emergency medical services (EMS) personnel to administer vaccines.[198] In addition, non-health care personnel could be deputized to carry out essential non-clinical functions and free up nursing staff.[197] During a pandemic, cohorting patients having similar ailments in a single ward or facility may allow specially trained staff to provide care more efficiently and effectively.[197] Finally, relaxing the requirements for medical documentation may enable staff to focus on patient care or other higher-priority duties.[197]

Triage

Florida's prehospital triage strategy indicates that the State's hospitals are using or implementing standard triage strategies, including Simple Triage and Rapid Treatment (START).[207] JumpSTART extends the concept of a standardized triage to children. Florida's plan also mentions an alternative triage system called the START2Finish® Surge Capacity Response Model for Healthcare. This model focuses on optimizing allocation of labor, supplies, and space during an MCE.[207] In a similar vein, Utah has devised State-level Pandemic Influenza Hospital and ICU Triage Guidelines to systematically match patients to appropriate levels of resources based on their need in order to preserve bed capacity and oxygen capacity, limit or stop elective surgeries, and maximize available personnel to care for victims of a future flu pandemic.[203]

Substitute Effective Alternatives

Plans in two States, Wisconsin and Minnesota, focus on reuse or substitution methods to optimize available resources. Wisconsin, in its "Oxygen Conservation Strategies in Resource-Limited Situations" plan, recommends several detailed methods for conserving medical oxygen: (1) Discontinue high-flow applications, such as restricting the use of Simple Mask and partial rebreather to 10 Ipm; (2) decrease the number of inhalation medication applications or restrict continuous nebulization therapy; (3) maximize reuse of expendable oxygen appliances, including disinfecting via high-level procedures (bleach concentrations of 1:10; high-level chemical disinfection or irradiation if available); and (4) terminally sterilize ventilator circuits, as well as low- and high-bore tubing.[206, 208] Minnesota's State plan includes similar strategies but also recommends substituting oral or nasogastric hydration for intravenous hydration or substituting epinephrine for vasopressor if the need arises.

Strategies To Augment Existing Resources

Increase Reserves and Stockpiles

Several State plans incorporated strategies to draw on equipment, supplies, drugs, and personnel held in reserve or stockpiled for such contingencies or to secure these resources from other States or institutions that are not experiencing surge conditions. These strategies included the use of mutual aid agreements, and coordination with outside agencies, such as the American Red Cross and the Medical Reserve Corps.

One of California's plans recommends stockpiling supplies at 20 to 25 percent above conventional levels to last for at least the first 72 hours (ideally, 96 hours) of an MCE.[197] Other plans recommend inventories or plans to increase critical supplies to assess considerations for stockpiling, such as ventilators and critical medications.[199, 205] Several State plans call for accessing either drug caches (antibiotics, antivirals) or supplies from the Strategic National Stockpiles (SNS).[197, 206, 209, 210]

Mutual Aid Agreements

Mutual aid agreements are key elements of several California plans as well as one from Washington.[197, 200, 210-212] Other partnerships that can augment personnel include volunteer clinical staff, such as the California Medical Assistance Team (CalMAT), federal Disaster Medical Assistance Teams (DMATs), Emergency System for Advance Registration of Volunteer Health Professionals (ESAR VHP), Colorado's Volunteer Mobilizer (CVM) for Medical and Public Health (CDPHE), the American Red Cross, and the federal Medical Reserve Corps (MRCs).[197, 198, 200, 205]

Adopt Crisis Standards of Care

All of the State plans we reviewed addressed general parameters for the shift to crisis standards of care. Most commented on the following elements:

Define Priority Groups

The first step in defining crisis standards of care is to identify priority groups for certain types of resources. For example, several States, including Nevada, California, and North Dakota, discuss the protocol for allocating antiviral agents during a pandemic flu outbreak.[204, 209, 210] The priority groups include those at the highest risk for infection, such as medical personnel, young children, pregnant women, and the elderly.

Be Prepared To Provide Comfort Care

In the event that lifesaving resources cannot be allocated to patients who need them, either because they are unavailable or because the patient has a low probability of survival, experts agree that protocols should be put in place to ensure that these patients are made as comfortable as possible. Only a single State mentioned comfort care in the plans we reviewed. California has noted the importance of this issue in their Enhancing Surge Capacity and Partnership Effort (ESCAPE) Crisis Care Guidelines plan, developed by the University of California, Davis, Health Systems.[204]

Allocate Resources Under Crisis Standards of Care

Some State plans offer guidance on how to allocate critical resources under crisis standards of care. For example, Minnesota and New York have plans to allocate certain medical equipment and supplies by patient prognosis, using triage methods such as the Sequential Organ Failure Assessment score (SOFA) and a tool based on the recommendations of the Ontario Health Plan for an Influenza Pandemic (OHPIP).[206, 213] Many of these strategies focus on the distribution of mechanical ventilators, advocating that assignment (and in some cases reallocation) of ventilators should be directed toward those patients who are most likely to benefit. New York's draft plan for ventilator allocation was cited by several other State plans when they convened a working group to study this issue.[206] Nevertheless, although all of the State plans reference the need for crisis standards of care, few have articulated guidelines or cited published evidence to support provider decisions.

Table 10. Key elements of State Plans

	Keep Non-Critical Patients out of the Hospital Emergency Departments	Encourage the Public to Self-Quarantine	Triage	Use Health Care Providers and Non-Medical Staff More Efficiently	Balance the Load Across Different Facilities	Re-Purpose Existing Resources	Substitute Effective Alternatives	Increase Reserves and Stockpiles	Negotiate Mutual Aid Agreements	Define Priority Groups	Be Prepared to Provide Comfort Care	Adopt Crisis Standard of Care
	Strategies To Reduce Demand		*Optimize Existing Resources*				*Strategies To Augment Existing Resources*			*Crisis Standards of Care*		
Arizona									x	x		x
California	x		x	x	x	x		x	x	x	x	x
Colorado	x		x	x	x							x
Florida				x		x				x		x
Guam					x			x		x		x
Minnesota	x				x	x	x	x	x			x
Nevada		x			x			x		x		
New York												x
North Dakota								x		x		x
Utah	x					x						x
Washington		x	x		x			x	x	x		
Wisconsin							x					x

Discussion

The United States faces a wide range of threats to its health security. The tragic events of September 11, 2001, and the subsequent anthrax attacks highlight the ongoing danger of terrorism. In the decade following the September 11, 2001, attacks, the major mass-casualty events on U.S. soil involved natural disasters, such as hurricanes Katrina and Rita, and naturally emerging biological threats, such as SARS and 2009 H1N1 influenza. The recent earthquakes that claimed so many lives around the world remind us that temblors of sufficient magnitude can cause widespread loss of life, even in highly developed nations, such as Chile, New Zealand, and Japan.

The predominant belief among authorities is that it is only a matter of time before a major natural or man-made disaster outstrips the capacity of our health care system to respond. Whether the incident is local, regional, or national in scope, the common denominator is a stark imbalance between immediate needs and existing resources, such as personnel, supplies, medications, and/or equipment at the incident site. When an MCE occurs, first responders, physicians, nurses, and other health care providers will be forced to make extremely difficult decisions about the delivery of care in the most demanding of circumstances with significant clinical, legal, and ethical ramifications. Therefore, strategies to allocate and manage scarce resources in mass casualty events (MCEs) must be founded in rigorous scientific scrutiny, grounded in empirical evidence, and thoughtfully considered before they are implemented. This is the context that led the Office of the Assistant Secretary for Preparedness and Response (ASPR) to request the Agency for Healthcare Quality and Research (AHRQ) to commission this comparative effectiveness review.

Key Findings

At the current time, there is limited evidence to help policymakers select the most effective strategies to allocate scarce resources during MCEs. However, although the evidence is largely not definitive, there are some specific strategies that appear promising. It is generally accepted that rapid deployment of biological countermeasures, such as mass vaccinations, mass dispensing of antivirals, or the rapid distribution of prophylactic antibiotics, could reduce demand for health care resources in the immediate aftermath of a bioterror attack or pandemic. There is low- to medium-strength evidence that a “push” method to deliver medications, such as via U.S. Postal Service letter carriers, is more effective than conventional approaches that seek to “pull” patients to a fixed point of dispensing (POD) or a neighborhood pharmacy. However, most of these assessments used speed of distribution rather than accuracy or appropriateness as their measure of outcome.

There is low to medium strength evidence that better management of POD operations can speed throughput and therefore accelerate distribution of biological countermeasures. There is also low strength evidence that public distribution of non-biological countermeasures, such as N-95 respirators or surgical masks, can reduce demand for hospital beds, intensive care unit beds, and ventilators.

There is little evidence to support particular approaches to optimizing resource allocation and use in conditions of scarcity. There is some evidence that resource use can be optimized by better load sharing between facilities. There is also limited evidence that pressure on overburdened health care resources may be reduced by transferring patients to more distant hospitals and by opening temporary facilities, such as a mobile field hospital.

Other than these observations, there is no evidence to guide policymakers in their deliberations and recommendations regarding how to allocate scarce resources under crisis standards of care. A focused and prioritized agenda for developing policy guidelines is urgently needed.

The evidence base to guide providers on the best strategies to optimize the allocation of scarce resources during MCEs is equally limited. Numerous strategies have been proposed to help providers and health care systems respond to MCEs. Unfortunately, evidence is insufficient to favor one of them over the others. Rigorous studies are rare, and much of the evidence that exists comes from simulations, drills, and exercises, rather than empirical evidence drawn from actual events. Many of the studies we reviewed did not report outcomes that are relevant to patients or providers. In most cases, the applicability of the study's findings beyond the immediate exercise setting or particular MCE was questionable.

The only provider-oriented strategy subjected to comparative assessment to date is field triage during MCEs. Even then, the strength of evidence to support use of one approach over others is low. A systematic review of field triage systems, comprising 11 papers that evaluated eight different triage tools, found limited evidence for the validity of any existing tool.[62] Published derivation and validation studies were of relatively poor quality, in part because most were based on small sample sizes. Few existing triage tools are specifically designed for use with pediatric disaster victims.

The accuracy with which providers can apply various triage tools is also unclear. More than half of the studies of triage accuracy were based on exercises or drills, rather than on actual events. Exercise-based assessments may not accurately reflect how a triage tool will perform in an actual MCE. For example, four studies of START, a widely used prehospital triage tool, reported accuracy rates of 62 percent to 82 percent. But when one group used the tool in an actual MCE, they found that it poorly allocated patients because providers were confused about the meaning of the different triage categories. Research is urgently needed to develop a simple, reliable, and accurate method to triage casualties in an MCE.

For every other category of provider-based strategies, the evidence base was insufficient to support a conclusion at more than a low level of evidence. With the exception of the previously mentioned studies of pre-hospital triage, few strategies were evaluated in more than three studies. As a result, there is very limited evidence to guide providers on the best strategies to use to reduce demand, optimize use of resources, augment existing resources, or apply crisis standards of care in the setting of an MCE.

The addition of promising but untested strategies increased the pool of interesting and potentially promising ideas, but none of the studies in this group is backed by sufficient evidence to favor one promising idea over another. A few studies, such as those describing the emerging technique of "damage control surgery," reported highly encouraging findings. However, most of the studies we reviewed were prone to at least a medium level of bias. Therefore, we judged the strength of evidence for most of the provider-based interventions described to date as low or insufficient.

First responders, physicians, and other health care providers need evidence-based guidance on how to best manage resource use and, when all else fails, employ crisis standards of care. Unfortunately, few strategies have been examined with sufficient scientific rigor to guide practice or policy. There is a compelling need to implement a prioritized research agenda and secure sufficient support to conduct these studies.

Although the evidence base is minimal regarding public perceptions of how scarce resources should be maximized and crisis standards applied during MCEs, the few published findings are generally consistent. Firm evidence regarding public perceptions is limited. The majority of the studies we reviewed reported data collected from a single community, four of which were outside the United States. Nevertheless, because these studies were well designed and their findings are generally consistent with each other, we judged the strength of evidence as medium. Collectively, these studies indicate that citizens are interested and motivated to participate in community forums. Participants in these forums expressed the belief that a successful allocation system should balance the goals of ensuring the functioning of society, saving the greatest number of people, protecting the most vulnerable, reducing deaths and hospitalizations, and treating people fairly. Although the public wanted appropriate guidelines to be established in advance with the input of health care professionals, they believed that the guiding parameters should allow providers a degree of flexibility to make allocation decisions based on their specific demand and supply situation.

The viewpoints elicited to date should be interpreted with caution. They are drawn from a relatively small number of participants, including four groups outside the United States. More substantive public input through community engagement forums will give credence to the process and ensure the level of public confidence needed to secure citizen cooperation during future MCEs. Consequently, we recommend that more public engagement studies of the sort reported to date be conducted in a variety of communities and settings. Determining the most effective ways to engage the public and to disseminate information to policymakers and providers is a matter of urgent concern.

Promising strategies exist to engage providers in developing resource allocation strategies, including crisis standards of care, but none has been sufficiently evaluated. The 14 studies we examined indicate that it is possible to engage health care providers in productive discussions, but there was insufficient evidence to recommend one engagement strategy as superior to the others. Nonetheless, several important themes emerged from our synthesis of this work. First, inclusive processes that engage all major stakeholders work better than those that do not. Ideally, such efforts should involve representatives of the relevant provider institutions, professional associations, State and/or local government, academia, and the public. Second, systematic and iterative processes produce more robust and satisfying products—such as a critical planning framework or a consensus plan—than those that do not. Third, involving credible subject matter experts enhances participation, satisfaction, and the quality of the final product. Finally, engaging nontraditional providers or groups adds innovation and breadth. Additional research will be needed to confirm these observations.

In addition to assessing the published research literature, we also analyzed the consensus guidelines of various specialty societies and task forces and strategies outlined in existing State plans. These efforts produced two additional summary findings:

Currently, the consensus guidelines and recommendations of specialty societies and government advisory groups rest on an insufficient body of evidence. Few offer actionable guidance to policymakers, health care providers, or the public. Most of the consensus panel recommendations we reviewed are either badly dated or pitched at a level unlikely to be useful to policymakers or health care providers. This was particularly true of guidelines produced by specialty societies.

In many cases, the intent of the consensus task force was to develop principles that providers at the local level could use to derive their own protocols. This approach contradicts the recommendations of the committee that produced the IOM Letter Report, which expressed the hope that their guidance would produce “a single, national framework for responding to crises in a fair, equitable and transparent matter.”[13]

It is interesting to note that committees sponsored by the Society for Critical Care Medicine and the American Thoracic Society’s Bioethics Task Force recommended that intensive care unit resources be allocated on the basis of “first come, first served.” This position contradicts the view of the public, based on the limited number of surveys and public engagement studies published to date. The public, like the authors of the IOM letter report, want to see resource allocation decisions made in a proactive and thoughtful way that protects the core interests of society, as defined by the populace.

Some States have made progress toward adopting plans to manage and, if necessary, allocate resources under crisis standards of care. We reviewed plans from 11 States and one U.S. territory and abstracted information regarding how policymakers and providers should respond in the context of an MCE. Some plans seek to reduce less-urgent use of health care resources through such measures as mass dispensing of vaccine, prophylactic medications, and self-quarantine. Others seek to optimize use of existing resources through triage, load balancing, repurposing of facilities, more efficient use of providers, and substitution of more plentiful alternatives. Most seek to augment existing resources by tapping stockpiling and other reserves and by activating mutual aid agreements. Finally, some plans recommend that, when all else fails, crisis standards of care should be implemented based on predefined priorities, with the understanding that this means certain patients will receive comfort care rather than aggressive intervention. However, few of the plans defined detailed approaches for making these determinations that could be readily put into practice. Moreover, few plans proposed legal and operational frameworks for shifting to crisis standards of care. Although these strategies are appealing in principle, and most have a high degree of face validity, they are supported by a limited base of evidence.

Limitations of the Review Methods

As with all attempts to systematically review a vast body of literature about a complex topic, it was necessary to make a number of decisions to clearly define the scope of the review, identify and assess the key studies, and synthesize the findings. We considered each decision carefully and believe we have a strong rationale for the choices we made. In making these choices, however, some trade-offs were made that could be seen as limitations of the study.

First, we chose to keep the scope of the review quite broad. While this was useful in identifying resource allocation strategies from across the full spectrum of preparedness and response, it made it difficult to conduct targeted searches of the literature. It is possible that our more general search did not identify specialized studies that would have been found if the CER had focused on a small set of specific strategies. The use of reference mining and forward searches mitigates this possibility to some extent.

Second, because of the challenges in conducting research on MCEs, we included study designs in this CER that are normally considered to produce lower levels of evidence, including cohort, before-after, and quasi-experimental studies. In the end, we retained even studies that referenced historical performance as the comparison standard, but graded the level of evidence accordingly. To further broaden our coverage of the topic, we included studies that had some measure of feasibility or performance but lacked a comparison group. Finally, we identified consensus recommendations by specialty societies and national panels. None of these provided new evidence, but they did speak to important dimensions of Key Questions 1 and 2.

Because we included a broader range of study types in the CER, the validated instruments for assessing quality typically used in CERs were not applicable. We therefore searched for other relevant rubrics. Finding no single scale that seemed appropriate for our topic, we combined elements of several and developed our own composite scale. While the scale seemed to work well, it has not been validated. In addition, as in most rating schemes, there is some degree of subjectivity in assigning scores to each item in our quality assessment scales. To minimize the potential bias, two reviewers rated each study independently and any discrepant scores were reconciled.

We were unable to perform meta-analyses that often accompany CERs due to the wide range of topics covered, the different measures of effectiveness employed across studies, and the small number of studies focused on any one particular strategy. As such, the synthesis of the results and the grading of strength of evidence for each Key Question are primarily qualitative in nature. While the process was systematic, there is some subjectivity involved.

Although the scope of our review was broad, it did not address every aspect of the management of MCEs. For example, our review did not address clinical or logistical aspects of EMS care and transport of patients, other than the technique of field triage in the setting of MCEs. Finally, although our literature search procedures were extensive, the possibility of publication bias still exists.

Limitations of the Evidence Base

By their very nature, MCEs are uncommon and largely unanticipated. MCEs also vary widely from one another with respect to geography, cause, onset, setting, duration, scale, and many other characteristics. This high degree of unpredictability, coupled with the variability and rapid evolving nature of MCEs, make it difficult to draw generalizable inferences from any single event. The technical and ethical dimensions of disaster research are challenging as well. Unlike directors of clinical trials, researchers interested in improving response to MCEs cannot prospectively enroll and allocate their subjects into treatment groups with precisely controlled study protocols. By their nature, MCEs invite and sometimes require improvisation. This makes such basic processes as systematic data collection difficult at best.

Some research teams have attempted to model alternative interventions using computer simulation or have tested them in simulated exercises and drills. Although these approaches provide useful data, they raise significant internal and external validity concerns. It is far from clear how generalizable the findings of these studies are to actual MCEs. It is difficult for the most realistic models and drills to reproduce the demanding environment of an actual disaster or MCE. It is equally difficult to predict human behavior in such incidents, especially if the rescuers and health care providers lack prior experience.

The current evidence base is characterized by marked variability in methodologies and a relative paucity of studies that addressed any single strategy. The multiplicity of options assessed to date means that few strategies have been sufficiently evaluated to confirm their effectiveness. With the exception of prehospital (field) triage, most of the strategies we identified were assessed by no more than three studies. This limited the strength of evidence available to compare one strategy to another. As a result, it was almost impossible to reach firm conclusions regarding their comparative effectiveness.

The different measures of effectiveness employed by authors posed another limitation. Most of the articles that met our generous screening criteria for inclusion assessed the impact of a current or proposed strategy on a clinical process or some aspect of a process. Relatively few examined outcomes. When outcomes were measured, they were often secondary outcomes that served as proxies for the true outcome of interest (e.g., survival). Second, as addressed by Shekelle and colleagues (in an evidence review on assessing the quality of patient safety interventions), the outcomes of process interventions are often, if not always, inextricably linked with the specific context in which they are implemented.214 Thus, no guarantee exists that an intervention that was successfully implemented in one setting will produce the same results if it is implemented in a different setting. This challenge is dramatically amplified in the context of MCEs because the conditions on the ground can vary dramatically from one incident to another.

Opportunities for Future Research

This comparative effectiveness review (CER) spans more than two decades of preparedness research, including the decade following the September 11, 2001, attacks. Despite generous inclusion criteria, the addition of studies that lacked a control group, and even a supplemental section examining promising ideas, we determined that few strategies for allocating resources in a mass casualty event (MCE) have been sufficiently evaluated to confirm their effectiveness.

Key Challenges

Given the challenging nature of the topic and its importance to the health security of the United States, decisive action is required to quickly build the evidence base required to properly inform policies and practice. Three hurdles must be cleared to achieve such rapid progress.

Insufficient Funding

Business and health care leaders frequently complain that the "tyranny of the urgent" distracts them from issues that are more important. This is certainly true in the case of planning and preparedness for MCEs. Those who are responsible for assuring our nation's health security at the national, State, community, and tribal level must be careful to distinguish between what is urgent and what is important. Because MCEs are rare and largely unforeseeable, efforts to improve emergency preparedness, mitigation, and response often take a back seat to the day-to-day demands of managing complex public health and health care systems. But when an MCE occurs, its urgency and importance eclipse everything else. At that point, it is too late to prepare.

Prior to September 11, 2001, public health in the United States suffered through a long period of decline. In 1988 and again in 2002, the Institute of Medicine determined that our nation's public health system was in "disarray".[215, 216] In the first few years following 9/11 and the anthrax attacks, large sums of Federal money were directed toward strengthening public health and hospital emergency preparedness. However, the bulk of these resources were devoted to biodefense through such Federal programs as BioWatch, BioSense, BioShield, and the Biodefense Advanced Research and Development Authority (BARDA) and biodefense research at the National Institutes of Health (NIH) and the Centers for Disease Control and Prevention (CDC).[217] Less money was invested in restoring the core infrastructure and capabilities of public health and health care systems to respond to the full array of health security threats.

Most of the Federal money that made its way to the States and hospitals during this time was for capacity building, rather than research to determine the most effective ways to use these resources. Moreover, most of these resources were restricted to efforts directly related to biodefense. Little thought was given to creating systems and infrastructures that are capable of responding to both daily emergencies and MCEs of all types. As the decade progressed, the global economic crisis and the recession it triggered led to a sharp decline in government revenues and large cuts in Federal spending for preparedness research, core public health programs, and staff.

In light of the austere economic environment, future preparedness research activities should be tightly focused, efficient, and effective. The overarching goal of these studies should be to provide needed guidance to policymakers and providers. The approach should seek to build a solid foundation for a health care system that will be robust and responsive in day-to-day activities, as well as in any health care crisis. With proper guidance and oversight, even a limited funding stream can produce better research and more valid findings. Health crises are, by their very nature, variable in onset, cause, location, scope, duration, and other characteristics. For this reason, categorical programs are rarely adequate, because it is impossible to predict the next MCE or terror attack. Public health and health care systems and providers must be capable of flexibly responding to a wide range of threats drawing from a toolkit of capabilities and skills.

Inadequate Coordination

Recently, the RAND Corporation, with support provided by the U.S. Department of Health and Human Services Assistant Secretary for Preparedness and Response, conducted a first-ever portfolio analysis of nonclassified federally funded extramural research on public health and health systems preparedness across eight Federal research agencies: the NIH, the CDC, the Agency for Healthcare Research and Quality, the Department of Homeland Security Office of Science and Technology, Department of Defense Northern Command, the Department of Energy, the National Science Foundation, and the Veterans Health Administration.

This analysis determined that 62 percent of identified projects are focused on one or more aspects of infectious disease, foodborne illness, or pandemic influenza. Only 10 percent of funded projects addressed natural disasters. Nuclear, radiological, and explosive threats were each the focus of no more than 4 percent of research projects. More than half of all extramurally funded projects were laboratory studies; most were funded by the NIH. Only 6 percent of projects were focused on improving the performance of the health care system in disasters.[218]

The results of this CER suggest that such an ad hoc, agency-specific approach to preparedness research may not produce the findings we need to rapidly strengthen the national health security of the United States. Rather than fragmenting activity and dissipating efforts across a wide range of objectives, future research activity should be focused on the most urgent and promising issues. This will only happen if the various Federal agencies and stakeholders craft a plan to coordinate their activities. Unity of purpose, combined with a sustained stream of funding, will produce a more rapid and actionable set of advances than a much larger but poorly coordinated program of research.

Logistical Barriers

We have highlighted the inherent challenges of conducting research during an MCE. Because these events cannot be readily foreseen, research teams must be assembled and deployed on short notice. Few institutional review boards are able, much less willing, to provide the requisite approvals to allow human subjects research in a workable time frame. There are also formidable ethical and logistical obstacles to collecting data at a time when resources are scarce and large numbers of people are pleading for help. It is not only difficult to envision conducting randomized controlled trials in such circumstances; it is nearly unthinkable.

However, it can be argued that the type of research needed to rapidly advance the field does not employ the sort of study designs typically required for inclusion in a comparative effectiveness review. Many high-impact business innovations have come from “focused empiricism”—identifying what works and what does not and subsequently refining promising strategies. A similar approach undergirds the well-accepted process of continuous quality improvement. Some experts in health care innovation have argued that beyond basic determinations of therapeutic efficacy and safety, relying on serially constructed, randomized controlled trials (RCTs) to establish the comparative effectiveness of various approaches to health care operations is neither feasible nor desirable.[219]

Hospital leaders should not need the results of RCTs to convince them of the value of rapidly clearing the emergency department in the short time window between notification that a terrorist bombing has occurred and the arrival of the first wave of complex casualties.[220] Likewise, Federal and State policymakers should not need RCTs, cohort studies, or quasi-experimental trials to convince them of the value of stockpiling vital drugs and critical supplies that are likely to run short in the first few days or weeks following a major MCE. Adoption and consistent performance of simple performance improvement processes, such as routinely conducting rigorous but nonjudgmental “after-action reviews” (AARs) following each MCE could produce rapid advances in technique. This will not happen unless the findings of these AARs are systematically captured and the resulting observations are widely shared. Such an effort would go a long way toward promoting systems learning and improved performance.

AARs of large-scale events—the type that trigger a Federal response—could be dramatically strengthened by predesignating an evaluation team, with contingent approval from a national institutional review board to rapidly deploy with the lead elements of a Federal disaster response. A similar concept could be adopted by the United Nations and its member States to prospectively collect important lessons from global disasters of the scale of the Indonesian tsunami and the Haiti earthquake.[221]

At the other end of the spectrum, local planners and hospital officials should view small-scale events, near misses, as opportunities to assess and refine various elements of their community’s response plan. Federal and State governments should leverage annually recurring events, such as flu vaccination campaigns, as opportunities to test various elements of their response plans for bioterrorism and other emerging disease threats.

Planning a Prioritized Research Agenda

With adequate funding, greater levels of collaboration and coordination, and flexible approaches to various modes of evaluation and research, rapid progress could be made toward addressing the most urgent and formidable challenges to the health care system in disaster preparedness and response. Specifically, we recommend the development of a prioritized research agenda modeled along the following lines:

1. Enhance coordination across Federal research agencies. A Federal interagency working group on health security research would go a long way toward ensuring that future research portfolios minimize overlaps and address key gaps. This will only happen if agencies agree to share information and jointly allocate a portion of their resources.
2. Require federally funded researchers to prospectively categorize the projects and key findings using a standardized format. If agencies adopt a common taxonomy for categorizing disaster research, it will be much easier in the future to prospectively identify projects and index their results. This would allow agency heads, policymakers, and researchers to avoid needless duplication of effort and better target their activities toward filling critical gaps.
3. Create a centralized information center that banks all available strategic plans and pertinent discussions of current and past science and ongoing projects.
4. Encourage State officials to engage community members, health care providers, and local policymakers to ascertain their views about contingent strategies and ethical frameworks for allocating scarce resources in MCEs. Because public engagement is important, special efforts should be made to include participants from different regions, ethnic backgrounds, cultures, ages, and faith traditions.

5. At the same time, efforts should be made to fully engage provider groups, including primary care and specialty clinicians and health system administrators, along with experts in health care law, policy, and ethics, to reach a national consensus on how scarce resources should be allocated under crisis standards of care. This process should include a systematic effort to identify the most important legal or regulatory barriers that could impede or undermine optimal allocation of scarce resources under crisis conditions.
6. Because community forums and face-to-face meetings are costly to conduct, they will never reach more than a small sample of the public. For this reason, researchers should explore methods to harness the power and reach of traditional news media (e.g., print, radio, and television), new media (Internet, short message service [SMS]), and social networks, such as Facebook and Twitter. The goal of these efforts should be to determine the most effective ways to engage and inform different segments of the public so that they can take appropriate action in an unfolding MCE and the recovery phase that follows.
7. Because it will always be extremely difficult to test various strategies under actual conditions, efforts should be made to develop and refine affordable simulations, computer models, and drills, including "no-notice" exercises, to more realistically assess and improve key elements of public health and health system operations and decision making.
8. We urgently need to build on the existing evidence to identify a simple but reliable approach to field triage in the setting of MCEs. This question could be quickly answered with a focused program of research. This work might be guided by the Model Uniform Core Criteria and other consensus-based MCE triage principles and protocols.
9. Additional research devoted to understanding facilitators and barriers to the effective implementation of incident command systems might provide greater insight into the poor response to several MCEs that we observed in several studies included in our review, and might suggest opportunities to strengthen this framework moving forward.
10. Because the consequences of a bioterror attack, a highly lethal flu pandemic, or an emerging infectious disease are so great, we urgently need to build on the existing evidence to determine the most effective method or methods to rapidly deploy needed biological and/or nonbiological countermeasures to the public.
11. Considerable benefit could be achieved by quickly developing and deploying efficient and affordable IT solutions for a variety of challenges, including (1) systems capable of tracking victims through various steps in the continuum of care from the scene of an MCE to definitive care, recovery, and repatriation; (2) software to guide hospital emergency operations centers through the various phases of responding to an MCE; and (3) passive public health surveillance systems that track area hospital emergency department, inpatient bed, and intensive care unit occupancy rates and each institution's diversion status so local EMS providers can swiftly determine the best destination for casualties of daily emergencies as well as MCEs.
12. Similarly quick gains could be achieved by rapidly evaluating a variety of bidirectional communication technologies, including call centers with automated IVR and nurse advice lines, Web sites, SMS, and various forms of interactive social media to reach, inform, and engage the public in bidirectional communication. Automated algorithms, modeled on existing prototypes, could allow patients to self-triage themselves and get specific advice that is appropriate to their condition and circumstance. Bidirectional tools of this sort could be used to better match patients to available resources, reduce needless visits to hospital emergency rooms, and collect epidemic intelligence in real time.[222] Similar approaches could

be used to enable local nongovernmental organizations and community groups to match available resources and needs.

13. In addition to interactive communications, other methods and tools are needed to enhance the capacity of public health agencies, primary care providers, retail clinics, and local/regional health care systems to safely provide substantial levels of minor illness and injury care. This will allow resource-constrained hospitals to focus their staff on meeting the needs of more seriously ill and injured victims.
14. Additional work is needed to improve the methodologies used in disaster research. This might best be accomplished by an expert panel convened by the Institute of Medicine or a similar body. This group should pay particular attention to improving existing "measures of effectiveness," including appropriate measures of outcome. Measurement problems are a common source of error that weakens the value of many MCE studies. Reviewers and journal editors generally look at three main areas when considering the merits of a study: internal validity, external validity, and merit. A study has to answer a question that is meaningful to have merit. In one former editor’s words, "a difference to be a difference must make a difference."[223]
15. As noted in the discussion above, widespread institutionalization of a rigorous and objective approach to after-action reviews could produce rapid gains in knowledge through focused empiricism. To maximize the yield of this activity, the standard components of an AAR should be identified and refined so that they are uniform and helpful. A national clearinghouse should be created to distill the lessons learned from this process and widely share them with policymakers, providers, and, when appropriate, the public.
16. The U.S. government should either designate or contract with a small team of evaluators with prior security clearance and institutional review board approval to be on 24/7 call to immediately deploy, in the case of a major disaster or terrorist attack, with elements of the National Disaster Medical System. The only responsibility of this team should be to prospectively monitor, document, and report back observations of what went well and what did not over the course of the event. Although these individuals should be empowered to alert incident commanders to problems they identify, they should not have patient care responsibilities. This will enable them to focus their attention on rigorous data collection and analysis. To enable them to perform this important task, the team should granted access to every aspect of the response, including field hospitals, distribution centers, and the inner workings of the incident command center. A similar approach should be taken to large-scale global disasters by the United Nations, the World Health Organization, or another global relief group. Otherwise, we are doomed to repeat the mistakes of the past.[221]

Conclusions

Emergency preparedness and response is essential to protect our nation’s health security. Our nation faces a wide array of man-made and natural threats. The existence of these threats and others that will undoubtedly emerge in the years to come cannot be ignored or wished away. Prevention and mitigation can and should remain key elements of our approach. But, from time to time, terror groups will launch a successful strike, or natural forces will overwhelm the best-built and most thoughtfully designed structures. When that happens, our nation must be prepared and capable of responding to minimize subsequent harm and loss of life.

In light of these facts, readers of this CER should be concerned by the limited amount of high-quality, highly applicable evidence to help policymakers, health care providers, and the public determine the best course of action in planning, preparing for, and responding to MCEs. In the same way that health care providers in a disaster strive to do the most good for the most people with the resources at hand, so should officials charged with advancing the applied science of disaster response strive to generate the most useful information in the shortest possible time within existing and, hopefully, augmented resources.

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Acronyms and Abbreviations

AGPRs	automatic gas-powered resuscitators
AHRQ	Agency for Healthcare Research and Quality
ASPR	Office of the Assistant Secretary for Preparedness and Response
CalMAT	California Medical Assistance Team
CDC	Centers for Disease Control and Prevention
CDPHE	Colorado Department of Public Health and Environment
CENTRAL	Cochrane Central Register of Controlled Trials
CER	comparative effectiveness review
CHC	community health centers
CINAHL	Cumulative Index to Nursing and Allied Health Literature
CME	continuing medical education
CT	computerized tomography
CVM	Colorado’s Volunteer Mobilizer
DARE	Cochrane Database of Abstracts of Reviews of Effects
DHS	Department of Homeland Security
DHHS	Department of Health and Human Services
DMAT	Disaster Medical Assistance Team
DOD	Department of Defense
DoE	Department of Energy
ED	emergency department
EMS	emergency medical services
EPC	Evidence-based Practice Center
ESAR VHP	Emergency System for Advance Registration of Volunteer Health Professionals
ESCAPE	Enhancing Surge Capacity and Partnership Effort
FAST	Focused Assessment by Sonography in Trauma
GAO	Government Accountability Office
HHS	Health and Human Services
HMO	health maintenance organization
ICU	intensive care unit
IOM	Institute of Medicine
KQ	Key Question
LIMS	Laboratory Information System
LTC	long-term care
MAC	multi-agency coordination
MCE	mass casualty event
MRC	Medical Reserve Corps
NHSS	National Health Security Strategy
NIH	National Institutes of Health

NORTHCOM	Northern Command
NREPP	National Registry of Evidence Based Programs and Practices
NSF	National Science Foundation
OHPIP	Ontario Health Plan for an Influenza Pandemic
OHSU	Oregon Health Sciences University
OR	operating room
PAHO	Pan American Health Organization
PICOTS	populations, interventions, comparators, outcomes, timeframes, and settings
POD	point of dispensing
RCT	randomized controlled trial
SARS	severe acute respiratory syndrome
SNF	skilled nursing facility
SNS	Strategic National Stockpile
SOFA	Sequential Organ Failure Assessment
SRC	Scientific Resource Center
TEP	technical expert panel
VHA	Veterans Health Administration
WHO	World Health Organization

Appendix A. Literature Search Strategy

INITIAL SEARCHES RAN JANUARY 21, 2011, COVERING 1990-January 2011. FINAL UPDATE SEARCHES PERFORMED ON NOVEMBER 8, 2011 COVERING JANUARY 2011-NOVEMBER 2011.

SEARCH #1 (updated 11/8/2011)
DATABASE SEARCH & TIME PERIOD COVERED:
PubMed 2011-2011
SEARCH STRATEGY:
disasters[mesh] OR disaster*[tiab] OR emergencies OR emergency planning OR emergency preparedness OR mass casualt* OR ((triage[ti] OR triaging[ti]) AND disaster*) OR pandemic[ti]
AND
surge OR scarce OR scarcity OR allocat* OR ration OR mass OR (triage AND (ethic* OR protocol)) OR "emergency medical care" OR (emergency medical care services[mh] AND ration) OR remote consultation[mh] OR “crisis standards” OR “altered care” OR “adapted care” OR “crisis standards of care” OR “altered standards of care”
NOT: Letters, Case Reports, Clinical Trials
NOT: animal*NOT Human*
NOT :("human remains" OR "identifying human bodies" OR autops* OR "end of life planning" OR pig OR pigs OR porcine OR cow OR cows OR bovine OR horse OR horses OR dog OR dogs OR cat OR cats OR mice OR mouse OR hamster OR hamsters OR rat OR rats OR "identification of human bodies" OR epidemiology OR appendectomy OR “dental identification” OR "water insecurity" OR "mass gatherings" OR "dental identification" OR (food AND ration) OR clinicaltrials.gov OR "total hip replacement" OR (mass AND cancer) OR ECMO OR forensic* OR drought OR “abdominal aortic aneurysm” OR (oil AND spill) OR “global warming” OR “partner violence” OR “violence prevention”)

NUMBER OF ITEMS RETRIEVED: 223

SEARCH #2 (updated 11/8/2011)
DATABASE SEARCH & TIME PERIOD COVERED:
CINAHL – 2011-2011
(Disaster* OR emergencies OR emergency planning OR emergency preparedness OR mass casualt* OR ((TI triage OR TI triaging) AND disaster*) OR TI pandemic)
AND
(surge OR scarce OR scarcity OR allocat* OR (triage AND (ethic* OR protocol)
OR "emergency medical care" OR ("emergency medical services" AND ration) OR "remote consultation" OR "crisis standards" OR "altered care" OR "adapted care" OR "crisis standards of care" OR "altered standards of care")
And Human
Not Letters

Limiters - Date of Publication from: 20110101-20111231; Peer Reviewed; Exclude MEDLINE records; Human

NUMBER OF ITEMS RETRIEVED: 7 (1 duplicate) = 6

SEARCH #3 (updated 11/8/2011)

DATABASE SEARCH & TIME PERIOD COVERED:

Cochrane – 2011-2011

“mass casualt*” OR “disaster preparedness” OR (Triag* AND (disaster OR mass))

NUMBER OF ITEMS RETRIEVED: 6

SEARCH #4 (RUN 11/8/2011)

DATABASE SEARCH & TIME PERIOD COVERED:

Embase – 2011-2012

'mass disaster'/exp OR disaster*:ab,ti OR 'emergencies'/exp OR 'emergency'/exp AND 'planning'/exp OR 'emergency'/exp AND preparedness OR 'mass'/exp AND casualt* OR ((triage:ti OR triaging:ti)AND disaster*) OR pandemic:ti AND [embase]/lim

AND

'emergency medical care'/exp OR ('emergency medical services'/exp AND ration) OR 'remote consultation'/exp OR 'crisis standards' OR 'altered care' OR 'adapted care' OR 'crisis standards of care' OR 'altered standards of care' OR surge OR scarce OR scarcity OR allocat* OR ration OR 'mass'/exp OR ('triage'/exp AND (ethic* OR protocol)) AND [embase]/lim

AND [humans]/lim AND [1990-2011]/py

NOT

pandemic NEAR/3 vaccin*

NUMBER OF ITEMS RETRIEVED: 21 results (8 duplicates) = 13 results

SEARCH #5 (updated 11/8/2011)

DATABASE SEARCH & TIME PERIOD COVERED:

Web of Science – 2011-2011

TS=disaster* OR TS=emergencies OR TS=emergency planning OR TS=emergency preparedness OR TS=mass casualt* OR (TI=triage OR TI=triaging) AND TS=disaster*) OR TI=pandemic

AND

TS=surge OR TS=scarce OR TS=scarcity OR TS=allocat* OR TS=triage AND TS= (ethic* OR protocol) OR TS="emergency medical care" OR TS= ("emergency medical services" AND ration) OR TS="remote consultation" OR TS="emergency medical care" OR TS= ("emergency medical services" AND ration) OR TS="remote consultation" OR TS="crisis standards" OR TS="altered care" OR TS="adapted care" OR TS="crisis standards of care" OR TS="altered standards of care"

NOT: Letter

NOT :

(TS="human remains" OR TS="identifying human bodies" OR TS=autops* OR TS="end of life planning" OR TS=pig OR TS=pigs OR TS=porcine OR TS=cow OR TS=cows OR TS=bovine OR TS=horse OR TS=horses OR TS=dog OR TS=dogs OR TS=cat OR TS=cats OR TS=mice OR TS=mouse OR TS=hamster OR TS=hamsters OR TS=rat OR TS=rats OR TS="identification of human bodies" OR TS=epidemiology OR TS=appendectomy OR TS= “dental identification” OR TS="water insecurity" OR TS="mass gatherings" OR TS="dental identification" OR TS= (food AND ration) OR TS=clinicaltrials.gov OR TS="total hip replacement" OR TS= (mass AND cancer) OR TS=ECMO OR TS=forensic* OR TS=drought OR TS=“abdominal aortic aneurysm” OR TS= (oil AND spill) OR TS=“global warming” OR TS= “partner violence” OR TS= “violence prevention” OR TS=geological OR TS="clinical trial" OR TS="urban modeling" OR TS="urban simulation" OR)

Refined by: [excluding] Subject Areas=(ENGINEERING, MECHANICAL OR WATER RESOURCES OR ECOLOGY OR CONSTRUCTION & BUILDING TECHNOLOGY OR MATHEMATICS, INTERDISCIPLINARY APPLICATIONS OR ENGINEERING, GEOLOGICAL OR METEOROLOGY & ATMOSPHERIC SCIENCES OR VETERINARY SCIENCES OR ENGINEERING, OCEAN OR MEDICAL INFORMATICS OR OCEANOGRAPHY)
NUMBER OF ITEMS RETRIEVED: 273 (before deduping); 227 after de-duping

SEARCH #6 (RUN 11/10/2011)
DATABASE SEARCH & TIME PERIOD COVERED:
Global Health – 1990-2011
1 S DISASTER? OR MASS()CASUALT? OR EMERGENCY(5N)PLAN? OR EMERGENCY(5N)PREPAR? OR EMERGENCY()MEDICAL()CARE OR REMOTE()SERVICES OR EMERGENCIES OR PANDEMIC?
S2 S TRIAG?/TI AND DISASTER?
S3 S S1 OR S2
S4 S SURGE OR SCARCE OR SCARCITY OR ALLOCAT? OR RATION OR RATIONED OR RATIONING OR MASS
S5 S TRIAGE AND (ETHIC? OR PROTOCOL?)
S6 S S3 OR S4
S7 S S3 AND S6
S8 S S3 AND S4
S9 S S8 OR S5
S10 S EMERGENCY()MEDICAL()CARE()SERVICE? AND (RATION OR RATIONED OR RATIONING)
S11 S EMERGENCY()MEDICAL AND (RATION OR RATIONED OR RATIONING)
S12 S REMOTE?(2N)CONSULT?
S13 S CRISIS(2N)STANDARD? OR ALTERED()CARE OR ADAPTED()CARE
S14 S S9 OR S11 OR S12 OR S13
S15 S S14/ENG
S16 S S15/1990:2011
NUMBER OF ITEMS RETRIEVED: 137 – 51 duplicates – 86

SEARCH #7 (RUN 4/16/2011)
DATABASE SEARCH & TIME PERIOD COVERED:
SCOPUS – 1990-2011

TITLE-ABS-KEY(**disaster***) OR **emergencies** OR **{emergency planning}** OR **emergency preparedness** OR **mass casualt*** OR TITLE(**triage**) OR TITLE(**pandemic**)
AND
surge OR scarce OR scarcity OR allocat* OR ration OR mass OR (triage AND (ethic* OR protocol))
OR(**{emergency medical care}** OR **{remote consultation}**) AND **ration OR**
{crisis standards} OR **{altered care}** OR **{adapted care}** OR **{crisis standards of care}** OR **{altered standards of care}** OR **{crisis care}**

AND
PUBYEAR AFT **2011**
NOT
{human remains} OR **{identifying human bodies}** OR **autops*** OR **{end of life planning}** OR **pig** OR **pigs** OR **porcine** OR **cow** OR **cows** OR **bovine** OR **horse** OR **horses** OR **dog** OR **dogs** OR **cat** OR **cats** OR **mice** OR **mouse** OR **hamster** OR **hamsters** OR **rat** OR **rats** OR **{identification of human bodies}** OR **epidemiology** OR **appendectomy** OR **{dental identification}** OR **{water insecurity}** OR **{mass gatherings}** OR **{dental identification}** OR (**food** AND **ration**) OR **clinicaltrials.gov** OR **{total hip replacement}** OR (**mass** AND **cancer**) OR **ecmo** OR **forensic*** OR **drought** OR **{abdominal aortic aneurysm}** OR (**oil** AND **spill**) OR **{global warming}** OR **{partner violence}** OR **{violence prevention}**)
NUMBER OF ITEMS RETRIEVED: 218 -114(weeding) – 45 (deduping)= 59

SEARCH #8 (updated 11/8/2011)
DATABASE SEARCH & TIME PERIOD COVERED:
NLMLocatorPlus– 2011-2011
Mass Casualty as a phrase in Title
OR
Disaster in Title
AND
Medicine in Title

NUMBER OF ITEMS RETRIEVED: 15 titles kept 3
(these are in a separate .txt file: NLMupdatedresults.txt)

SEARCH #9 (RUN 11/14/2011)
DATABASE SEARCH & TIME PERIOD COVERED:
NYAM Grey Literature Report– 2011-
Key word: mass casualty OR disaster OR disasters
NUMBER OF ITEMS RETRIEVED: 12
(these citations are in a separate word document:
NYAM_UpdateDisaster_MassCasualty_11_2011.doc)
SEARCH #1 (RUN 1/21/2011)
DATABASE SEARCH & TIME PERIOD COVERED:
PubMed – 1990-2011
SEARCH STRATEGY:
disasters[mesh] OR disaster*[tiab] OR emergencies OR emergency planning OR emergency preparedness OR mass casualt* OR ((triage[ti] OR triaging[ti]) AND disaster*) OR pandemic[ti]
AND
surge OR scarce OR scarcity OR allocat* OR ration OR mass OR (triage AND (ethic* OR protocol)) OR "emergency medical care" OR (emergency medical care services[mh] AND ration) OR remote consultation[mh] OR “crisis standards” OR “altered care” OR “adapted care” OR “crisis standards of care” OR “altered standards of care”
NOT: Letters, Case Reports, Clinical Trials
NOT: animal*NOT Human*
NOT :("human remains" OR "identifying human bodies" OR autops* OR "end of life planning" OR pig OR pigs OR porcine OR cow OR cows OR bovine OR horse OR horses OR dog OR

dogs OR cat OR cats OR mice OR mouse OR hamster OR hamsters OR rat OR rats OR "identification of human bodies" OR epidemiology OR appendectomy OR “dental identification” OR "water insecurity" OR "mass gatherings" OR "dental identification" OR (food AND ration) OR clinicaltrials.gov OR "total hip replacement" OR (mass AND cancer) OR ECMO OR forensic* OR drought OR “abdominal aortic aneurysm” OR (oil AND spill) OR “global warming” OR “partner violence” OR “violence prevention”)
OR:
Levin D[au] AND pandemic[ti]
NUMBER OF ITEMS RETRIEVED: 2472

SEARCH #2 (RUN 1/27/2011)

DATABASE SEARCH & TIME PERIOD COVERED:

CINAHL – 1990-2011
Disaster* OR emergencies OR emergency planning OR emergency preparedness OR mass casualt* OR ((TI triage OR TI triaging) AND disaster*) OR TI pandemic
AND
surge OR scarce OR scarcity OR allocat* OR (triage AND (ethic* OR protocol)
OR "emergency medical care" OR ("emergency medical services" AND ration) OR "remote consultation" OR "crisis standards" OR "altered care" OR "adapted care" OR "crisis standards of care" OR "altered standards of care"
And Human
Not Letters
Date of Publication from: 19900101-20111231; Peer Reviewed; Exclude MEDLINE records
NUMBER OF ITEMS RETRIEVED: 83 (AFTER DEDUPING) 76

SEARCH #3 (RUN 1/27/2011)

DATABASE SEARCH & TIME PERIOD COVERED:

Cochrane – 1990-2011
“mass casualt*” OR “disaster preparedness” OR (Triag* AND (disaster OR mass))
NUMBER OF ITEMS RETRIEVED: 56

SEARCH #4 (RUN 1/27/2011)

DATABASE SEARCH & TIME PERIOD COVERED:

Embase – 1990-2011
'mass disaster'/exp OR disaster*:ab,ti OR 'emergencies'/exp OR 'emergency'/exp AND 'planning'/exp OR 'emergency'/exp AND preparedness OR 'mass'/exp AND casualt* OR ((triage:ti OR triaging:ti)AND disaster*) OR pandemic:ti AND [embase]/lim
AND
'emergency medical care'/exp OR ('emergency medical services'/exp AND ration) OR 'remote consultation'/exp OR 'crisis standards' OR 'altered care' OR 'adapted care' OR 'crisis standards of care' OR 'altered standards of care' OR surge OR scarce OR scarcity OR allocat* OR ration OR 'mass'/exp OR ('triage'/exp AND (ethic* OR protocol)) AND [embase]/lim
AND [humans]/lim AND [1990-2011]/py
NOT
pandemic NEAR/3 vaccin*
NUMBER OF ITEMS RETRIEVED: 129 results (before de-duping) 70 (after de-duping & hand removal)

SEARCH #5 (RUN 1/27/2011)
DATABASE SEARCH & TIME PERIOD COVERED:
Web of Science – 1990-2011
TS=disaster* OR TS=emergencies OR TS=emergency planning OR TS=emergency preparedness OR TS=mass casualt* OR (TI=triage OR TI=triaging) AND TS=disaster*) OR TI=pandemic
AND
TS=surge OR TS=scarce OR TS=scarcity OR TS=allocat* OR TS=triage AND TS= (ethic* OR protocol) OR TS="emergency medical care" OR TS= ("emergency medical services" AND ration) OR TS="remote consultation" OR TS="emergency medical care" OR TS= ("emergency medical services" AND ration) OR TS="remote consultation" OR TS="crisis standards" OR TS="altered care" OR TS="adapted care" OR TS="crisis standards of care" OR TS="altered standards of care"
NOT: Letter
NOT :
(TS="human remains" OR TS="identifying human bodies" OR TS=autops* OR TS="end of life planning" OR TS=pig OR TS=pigs OR TS=porcine OR TS=cow OR TS=cows OR TS=bovine OR TS=horse OR TS=horses OR TS=dog OR TS=dogs OR TS=cat OR TS=cats OR TS=mice OR TS=mouse OR TS=hamster OR TS=hamsters OR TS=rat OR TS=rats OR TS="identification of human bodies" OR TS=epidemiology OR TS=appendectomy OR TS= “dental identification” OR TS="water insecurity" OR TS="mass gatherings" OR TS="dental identification" OR TS= (food AND ration) OR TS=clinicaltrials.gov OR TS="total hip replacement" OR TS= (mass AND cancer) OR TS=ECMO OR TS=forensic* OR TS=drought OR TS=“abdominal aortic aneurysm” OR TS= (oil AND spill) OR TS=“global warming” OR TS= “partner violence” OR TS= “violence prevention” OR TS=geological OR TS="clinical trial" OR TS="urban modeling" OR TS="urban simulation" OR)

Refined by: [excluding] Subject Areas=(ENGINEERING, MECHANICAL OR WATER RESOURCES OR ECOLOGY OR CONSTRUCTION & BUILDING TECHNOLOGY OR MATHEMATICS, INTERDISCIPLINARY APPLICATIONS OR ENGINEERING, GEOLOGICAL OR METEOROLOGY & ATMOSPHERIC SCIENCES OR VETERINARY SCIENCES OR ENGINEERING, OCEAN OR MEDICAL INFORMATICS OR OCEANOGRAPHY)
NUMBER OF ITEMS RETRIEVED: 748 (before deduping); 506 after de-duping (and screening)

SEARCH #6 (RUN 2/1/2011)
DATABASE SEARCH & TIME PERIOD COVERED:
Global Health – 1990-2011
1 10670 S DISASTER? OR MASS()CASUALT? OR EMERGENCY(5N)PLAN? OR EMERGENCY(5N)PREPAR? OR EMERGENCY()MEDICAL()CARE OR REMOTE()SERVICES OR EMERGENCIES OR PANDEMIC?
S2 16 S TRIAG?/TI AND DISASTER?
S3 10670 S S1 OR S2
S4 93610 S SURGE OR SCARCE OR SCARCITY OR ALLOCAT? OR RATION OR RATIONED OR RATIONING OR MASS
S5 54 S TRIAGE AND (ETHIC? OR PROTOCOL?)
S6 103284 S S3 OR S4
S7 10670 S S3 AND S6

S8 996 S S3 AND S4
S9 1026 S S8 OR S5
S10 0 S EMERGENCY()MEDICAL()CARE()SERVICE? AND (RATION OR RATIONED OR RATIONING)
S11 1 S EMERGENCY()MEDICAL AND (RATION OR RATIONED OR RATIONING)
S12 21 S REMOTE?(2N)CONSULT?
S13 3 S CRISIS(2N)STANDARD? OR ALTERED()CARE OR ADAPTED()CARE
S14 1048 S S9 OR S11 OR S12 OR S13
S15 974 S S14/ENG
S16 930 S S15/1990:2011
NUMBER OF ITEMS RETRIEVED: 930

SEARCH #7 (RUN 4/16/2011)
DATABASE SEARCH & TIME PERIOD COVERED:
SCOPUS – 1990-2011

TITLE-ABS-KEY(**disaster***) OR **emergencies** OR **{emergency planning}** OR **emergency preparedness** OR **mass casualt*** OR TITLE(**triage**) OR TITLE(**pandemic**)
AND
surge OR scarce OR scarcity OR allocat* OR ration OR mass OR (triage AND (ethic* OR protocol))
OR(**{emergency medical care}** OR **{remote consultation}**) AND **ration OR**
{crisis standards} OR **{altered care}** OR **{adapted care}** OR **{crisis standards of care}** OR **{altered standards of care}** OR **{crisis care}**
AND
PUBYEAR AFT **1989**
NOT
{human remains} OR **{identifying human bodies}** OR **autops*** OR **{end of life planning}** OR **pig** OR **pigs** OR **porcine** OR **cow** OR **cows** OR **bovine** OR **horse** OR **horses** OR **dog** OR **dogs** OR **cat** OR **cats** OR **mice** OR **mouse** OR **hamster** OR **hamsters** OR **rat** OR **rats** OR **{identification of human bodies}** OR **epidemiology** OR **appendectomy** OR **{dental identification}** OR **{water insecurity}** OR **{mass gatherings}** OR **{dental identification}** OR (**food** AND **ration**) OR **clinicaltrials.gov** OR **{total hip replacement}** OR (**mass** AND **cancer**) OR **ecmo** OR **forensic*** OR **drought** OR **{abdominal aortic aneurysm}** OR (**oil** AND **spill**) OR **{global warming}** OR **{partner violence}** OR **{violence prevention}**)
NUMBER OF ITEMS RETRIEVED: after deduping 1270 – after weeding 428

SEARCH #8 (RUN 1/28/2011)
DATABASE SEARCH & TIME PERIOD COVERED:
NLMLocatorPlus– 1990-2011
Mass Casualty as a phrase in Title
OR
Disaster in Title
AND
Medicine in Title

NUMBER OF ITEMS RETRIEVED: 141 titles kept 42

SEARCH #9 (RUN 1/31/2011)
DATABASE SEARCH & TIME PERIOD COVERED:
NYAM Grey Literature Report– 1990-2011
Key word: mass casualty OR disaster OR disasters
NUMBER OF ITEMS RETRIEVED: 290

Appendix B. Data Abstraction Tools

Short Form

1. Is the language of the article in English?

Yes No (please specify language)
If the language of the article is in a language that you cannot read then please stop.

2. Does this study directly address a KQ?

Yes No (exclude and go to background, soft exclude, and reference mining question)

3. What type of study is this?
A. Proposed Strategy (recommendation)
If proposed strategy then is the proposed strategy based on a rigorous expert consensus process (e.g., expert panel, task force, Delphi process), or data from a real event?
Yes (included) No (exclude and go to background, soft exclude, and reference mining question

B. Tested Strategy (simulation, actual event, etc.)
☐ Prospectively tested in a real event ☐ Prospectively tested using a model, simulation, or exercise ☐ Synthesize results from multiple real events or studies ☐ None (i.e, single event AARs)

C. KQ 3 relevant
If this article contains a tested strategy or is KQ 3 relevant then this article will be **included** and you can proceed to the next article)

D. KQ 4 (only) relevant

KQ4
Is this KQ 4 (only) strategy tested or proposed?
A. KQ 4 Proposed

Is this only KQ 4 (only) proposed strategy based on a rigorous expert consensus process (e.g., national expert panel or task force using Delphi or similar process) or organized review of multiple events?

Yes No (Exclude and go to background, soft exclude, and reference mining questions)

If you answered yes then this article will be **included** and you can proceed to the next article.
If the proposed strategy is not based on a rigorous expert concensus this article will be **excluded**. If you chose to exclude it then please proceed to background, soft exclude, and reference mining questions.

B. KQ 4 Tested Strategy-Training

If the tested strategy is only KQ 4 relevant does it report changes in actual performance outcomes?
Yes No (Exclude and go to background, soft exclude, and reference mining questions)

If you answered yes then this article will be **included** and you can proceed to the next article.
If the tested strategy does not report changes then this article will be **excluded**. If you chose to exclude it then please proceed to background, soft exclude, and reference mining question

C. KQ 4 Tested Strategy-Other

4. If this study is not being included do we need to separately mine it for references?
Yes No
Please answer the background question if you have **excluded** the article

5. Is this a potential background article?
Yes No
Please only answer the background question if you have **excluded** the article on a previous question.

6. If the study is excluded should it be a soft exclude?
Yes No
Please only answer the soft exclude question if you have **excluded** the article on a previous question.

7. Is this excluded article very high yield? (Use sparingly)
Yes No
Please only answer the high yield question if you have **excluded** the article on a previous question.

Long Form: KQ1 and 2 Tested Strategies

KQ1-2 Long Form

****KQ1-2 Tested Strategy**** Mass Casualty Data Abstraction Form (Long Version)

PAPER ID# [ ] **CLASSIFICATION:**

I. Key inclusion criteria to be reconciled first

1. Which Key Question(s) are addressed? [Check all that apply – avoid selecting both KQ1, KQ2]
   - KQ1: Strategies available to *policy makers* to optimize resource allocation during MCEs
   - KQ2: Strategies available to *providers* to optimize resource allocation during MCEs
   - KQ3: Public's concerns regarding resource allocation strategies [STOP if KQ3 only. Review separately]
   - KQ4: Strategies to engage stakeholders in developing strategies to optimize resource allocation during MCEs [STOP if KQ4 only. Review separately]

Does not address a key question [STOP. Exclude]

Comments [ ]

2. Does this study describe a tested or a proposed strategy?

   Describes a *tested* strategy (i.e., tested in an actual event, exercise, or simulation. For actual events, the strategy could have been developed ex ante or during an event. Pilot tests qualify as valid tests.) [these items should pop up if "tested strategy"]

   - Does the study describe a specific, implementable strategy? [Yes/no] [If no – Stop. EXCLUDE.]
   - Does the strategy relate to scarce resources? [Yes/no] [If no – Stop. EXCLUDE.]"
   - Does the study report on relevant outcomes (may be qualitative or process measures, but they must be fairly closely related to "hard" outcomes) [Yes/no] [If no – Stop. EXCLUDE.]

- Does the study report outcomes relative to an appropriate standard (e.g., an alternative strategy or of the status quo strategy)? [Yes/no]
  [If no – Stop. EXCLUDE.]
- If exclude, should this article be considered a high-yield background article? [yes/no]

Describes a *proposed* strategy [these items should pop up if "tested strategy"]

Strategy:

#	Briefly state the strategy [see examples below]	Into which category does this strategy fit? [Use Ringel table of strategies as a guide]	Select stakeholder [check all that apply]	Modulators of the strategy's implementation and/or effectiveness outcomes
1		☐ Reduce/ manage less urgent demand ☐ Optimize use of existing resources ☐ Augment existing resources ☐ Allocation or Reallocation of resources ☐ Other (Describe) ☐ Other (Describe) ☐ Other (Describe)	In-field/On-scene ☐ Health care institution (Hospital) ☐ Health care institution (Non-Hospital)-- eg, nursing home, LTC ☐ Health care (Other) eg, private practice, vaccine clinic, pharmacy ☐ Policy setting/governmental organization (Federal) ☐ Policy setting/governmental organization (State or Local) ☐ Policy setting/governmental organization (Unspecified) ☐ Non-governmental entity ☐ Other [Please specify] ☐ Other	☐ Modulator 1 ☐ Modulator 2 ☐ Modulator 3 ☐ Modulator 4 ☐ Modulator 5

			[Please specify] ☐ Other [Please specify]	
2				
….				

- Examples of individual strategies: Use SOFA score to triage patients; Cancel elective hospital admissions; Request supplemental

STOP HERE to allow reconciliation of these four questions.

II. Study design and characteristics

Where did the study take place?

- US (specify city and state if relevant)
- Canada, Australia, New Zealand
- Western Europe
- Eastern Europe
- Israel
- Asia
- South America
- Not Reported
- Not Relevant (e.g., computer simulation)
- Other – specify (for each "other" entity)

How would you describe the study setting?

- Low population density (e.g., rural)
- Moderate population density (e.g., suburban)
- High population density (e.g., urban)
- Unclear (elaborate if necessary)
- Not relevant
- Not reported

What type of MCE is described? [Check all that apply]

- All-hazards
- Chemical
- Biological
- Radiological
- Nuclear
- Explosive
- Natural disaster – if so, what type?
- Infectious disease (if so, pandemic flu?)

- Other – specify
- Unspecified
- Don't know

What is the study design?

- Randomized controlled trial
- Observational, pre-post with comparison group [Describe comparison group]
- Observational, pre-post
- Observational, post only with comparison group [Describe comparison group]
- Proof of concept test [outcome of strategy not assessed]
- Systematic Review/Meta-analysis
- Computer Simulations
- Non-systematic Review
- Other, please specify

Where do the data supporting the strategy come from? [Check all that apply]

- Single real event [Give common name if applicable (e.g., Hurricane Katrina; Sarin Gas Attacks)]
- Multiple real events
- Exercise, drill, or training program
- Computer simulation
- Proof of concept test (e.g., alternative oxygen delivery system)
- Survey, focus group
- Other, please specify

III. Outcomes Assessment

Outcomes

#	What are the main results? {These data will be reported directly into the evidence table}	What kind of outcome is it?	To which strategy does this outcome correspond?	What is the effect size (or qualitative result)?	What is the standard error or confidence interval (if reported)?
1		Feasibility ☐ Process ☐ Health outcome ☐ Opinion ☐ Ethical ☐ Economic ☐ Other, please describe Clear Response	Strategy 1 ☐ Strategy 2 ☐ Strategy 3 ☐ Strategy 4 ☐ Strategy 5	Effect Size 1 ☐ Effect Size 2 ☐ Effect Size 3 ☐ Effect Size 4 ☐ Effect Size 5	SE/CI 1 ☐ SE/CI 2 ☐ SE/CI 3 ☐ SE/CI 4 ☐ SE/CI 5
2					
...					
10					

IV. Quality	TOTAL SCORE:

What type of study is this?

- ☐ Computer Simulations only
- ☐ Systematic Reviews only
- ☐ Proof of concept study
- ☐ All other study-types

For computer simulations only

Evidence supporting assumptions and/or data:

- ☐ Weak or no evidence to justify assumptions or data (0)
- ☐ Reasonable attempt to justify assumptions or data (1)
- ☐ Strong justification of assumptions or data (2)

Description of the strategy:

- ☐ Limited description of the strategy is presented (0)
- ☐ Comprehensive description of the strategy is presented (i.e., the strategy is presented in enough detail that it can be replicated or is described elsewhere) (1)

Assessment of generalizability of the findings (includes limitations of the strategy)

- ☐ No discussion of the generalizability of findings(0)
- ☐ At least some discussion of the generalizability of findings (1)
- ☐ Thorough discussion of the generalizability of findings (2)

Sensitivity analyses

- ☐ No sensitivity analyses performed (0)
- ☐ At least some sensitivity analyses performed (1)
- ☐ Robust sensitivity analyses of key assumptions performed (2)

Discussion of confounders:

- ☐ No discussion of confounders (0)

- ☐ At least some discussion of confounders (1)
- ☐ Thorough discussion of confounders (2)
- ☐ Not Applicable

Systematic Reviews

Was an 'a priori' design provided?

The research question and inclusion criteria should be established before the conduct of the review.

- ☐ Yes
- ☐ No
- ☐ Not Reported
- ☐ Not Applicable

Was there duplicate study selection and data extraction?

There should be at least two independent data extractors and a consensus procedure for disagreements should be in place.

- ☐ Yes
- ☐ No
- ☐ Not Reported
- ☐ Not Applicable

Was a comprehensive literature search performed?

At least two electronic sources should be searched. The report must include years and databases used (e.g. Central, EMBASE, and MEDLINE). Key words and/or MESH terms must be stated and where feasible the search strategy should be provided. All searches should be supplemented by consulting current contents, reviews, textbooks, specialized registers, or experts in the particular field of study, and by reviewing the references in the studies found.

- ☐ Yes
- ☐ No

- ☐ Not Reported
- ☐ Not Applicable

Was the status of publication (i.e. grey literature) used as an inclusion criterion?

The authors should state that they searched for reports regardless of their publication type. The authors should state whether or not they excluded any reports (from the systematic review), based on their publication status, language etc.

- ☐ Yes
- ☐ No
- ☐ Not Reported
- ☐ Not Applicable

Was a list of included studies provided?

A list of included and excluded studies should be provided.

- ☐ Yes
- ☐ No
- ☐ Not Reported
- ☐ Not Applicable

Were the characteristics of the included studies provided?

In an aggregated form such as a table, data from the original studies should be provided on the participants, interventions and outcomes. The ranges of characteristics in all the studies analyzed e.g. age, race, sex, relevant socioeconomic data, disease status, duration, severity, or other diseases should be reported.

- ☐ Yes

☐ No

☐ Not Reported

☐ Not Applicable

Was the scientific quality of the included studies assessed and documented?

'A priori' methods of assessment should be provided (e.g., for effectiveness studies if the author(s) chose to include only randomized, double-blind, placebo controlled studies, or allocation concealment as inclusion criteria); for other types of studies alternative items will be relevant.

☐ Yes

☐ No

☐ Not Reported

☐ Not Applicable

Was the scientific quality of the included studies used appropriately in formulating conclusions?

The results of the methodological rigor and scientific quality should be considered in the analysis and the conclusions of the review, and explicitly stated in formulating recommendations.

☐ Yes

☐ No

☐ Not Reported

☐ Not
Applicable

Clear Response

Were the methods used to combine the findings of studies appropriate?

For the pooled results, a test should be done to ensure the studies were combinable, to assess their homogeneity (i.e. Chi-squared test for homogeneity, I^2). If heterogeneity exists a random effects model should be used and/or the clinical appropriateness of combining should be taken into consideration (i.e. is it sensible to combine?).

- ☐ Yes
- ☐ No
- ☐ Not Reported
- ☐ Not Applicable

Was the likelihood of publication bias assessed?

An assessment of publication bias should include a combination of graphical aids (e.g., funnel plot, other available tests) and/or statistical tests (e.g., Egger regression test).

- ☐ Yes
- ☐ No
- ☐ Not Reported
- ☐ Not Applicable

Was the conflict of interest stated?

Potential sources of support should be clearly acknowledged in both the systematic review and the included studies.

- ☐ Yes
- ☐ No
- ☐ Not Reported
- ☐ Not Applicable

Proof of Concept

Data collection:

- ☐ Non-systematic data collection (0)
- ☐ Systematic, retrospective data collection (1)
- ☐ Systematic, prospective data collection (2)

Description of the strategy:

- ☐ Limited description of the strategy is presented (0)
- ☐ Comprehensive description of the strategy is presented (i.e., the strategy is presented in enough detail that it can be replicated or is described elsewhere) (1)

Assessment of generalizability of the findings (includes limitations of strategy)

- ☐ No discussion of the generalizability of findings (0)
- ☐ At least some discussion of the generalizability of findings (1)
- ☐ Thorough discussion of the generalizability of findings (2)

For all study-types other than computer simulation and systematic reviews:

Data collection:

- Non-systematic data collection (0)
- Systematic, retrospective data collection (1)
- Systematic, prospective data collection (2)

Description of the strategy:

- Limited description of the strategy is presented (0)
- Comprehensive description of the strategy is presented (i.e., the strategy is presented in enough detail that it can be replicated or is described elsewhere) (1)

Fidelity in implementing resource allocation strategy. (Note: fidelity is defined as the degree to which the strategy is implemented consistently throughout the course of the MCE whether or not a formal protocol exists):

- No data on fidelity are reported. (0)
- Quantitative or qualitative data on fidelity are reported. (1)
- Not Applicable

Assessment of generalizability

- No discussion of the generalizability of findings (0)
- At least some discussion of the generalizability of findings (1)
- Thorough discussion of the generalizability of findings (2)

Discussion of confounders:

- No discussion of confounders (0)

- At least some discussion of confounders (1)
- Thorough discussion of confounders (2)
- Not Applicable

V. Applicability

To which geographic scope is this strategy applicable? [Check all that apply]

- ☐ Local only
- ☐ Large urban or regional
- ☐ Multi-regional or larger
- ☐ Other (specified) ______

Is the strategy unique to the jurisdiction described (in terms of leadership required, populations served, stakeholders included, or availability of resources)? [Check all that apply]

- ☐ Highly unique
- ☐ Somewhat unique
- ☐ Not unique

For strategies tested outside of the U.S., are the strategies applicable in the U.S.? [Check all that apply]

- ☐ Yes
- ☐ No
- ☐ Unclear
- ☐ Not Relevant

How relevant are the outcomes to patients? [Check all that apply]

- ☐ At least somewhat relevant
- ☐ Highly relevant
- ☐ Not Applicable

To what extent is the primary strategy ready for use? [Check all that apply]

- ☐ Not ready for use because the strategy is not effective
- ☐ Not ready for use because the strategy needs additional development/testing
- ☐ Ready for use
- ☐ Unclear (elaborate if necessary)

VI. General

Are there any references that need to be checked? If so, please indicate the reference number(s).

Has the primary reviewer completed the bottom half of the long form?

- ☐ Yes
- ☐ No

Has the secondary reviewer reviewed the bottom half of the form?

- ☐ Yes
- ☐ No

Has this article been fully reconciled?

- ☐ Yes
- ☐ No

Comments on the study

KQ4 Long Form

****KQ4**** Mass Casualty Data Abstraction Form (Long Version)

PAPER ID# [ ]   **CLASSIFICATION:** EVIDENCE / PROPOSED

I. Key inclusion criteria to be reconciled first

1. Which Key Question(s) are addressed? [Check all that apply – avoid selecting both KQ1, KQ2]

- KQ1: Strategies available to *policy makers* to optimize resource allocation during MCEs
- KQ2: Strategies available to *providers* to optimize resource allocation during MCEs
- KQ3: Public's concerns regarding resource allocation strategies [STOP if KQ3 only. Review separately]
- KQ4: Strategies to engage stakeholders in developing strategies to optimize resource allocation during MCEs [STOP if KQ4 only. Review separately]

Does not address a key question [STOP. Exclude]

Comments [ ]

2. Does this study describe a tested or a proposed strategy?

- Describes a *tested* strategy (i.e., tested in an actual event, exercise, or simulation. For actual events, the strategy could have been developed ex ante or during an event. Pilot tests qualify as valid tests.) [these items should pop up if "tested strategy"]
- Does the study describe a specific, implementable strategy? [Yes/no] [If no – Stop. EXCLUDE.]
- Does the strategy relate to surge capacity? [Yes/no] [If no – Stop. EXCLUDE.]
- Does the strategy relate to at least one specific strategy (demand, optimize, augment, crisis level) scarce resources? [Yes/no] [If no – Stop. EXCLUDE.]
- Does the study report on relevant outcomes (***for KQ4 this may also include a tested plan**;* may be qualitative or process measures, but they must be fairly closely related to "hard" outcomes) [Yes/no] [If no – Stop. EXCLUDE.]

  If exclude, should this article be considered a high-yield background article? [yes/no]

- Describes a *proposed* strategy [Stop. Review separately for background section]

Strategy:

#	3.Briefly describe strategy/strategies	4. Into which category does this strategy fit? [see list below]	5a. Stakeholder(s): Who engaged others?	5b. Stakeholders: Who was engaged?	6. Modulators* of strategy implementation or outcome effectiveness
1					
2					
….					

Examples of individual strategies: Use SOFA score to triage patients; Cancel elective hospital admissions; Request supplemental resources from VA hospital.

** Modulators: refers to facilitators and/or barriers*

4. Into what category does this strategy fit?

- STR1 - Reduce/manage less urgent demand
- STR2 - Optimize use of existing resources
- STR3 - Augment existing resources
- STR4 - Allocation or reallocation of resources (crisis level, e.g., triage)
- STR5 - Surge capacity in general (not specifically one or more of the above)
- STR6 - Other – describe:

5a/5b. Select stakeholders: (a) Who engaged others? (b) Who was engaged [indicate all that apply in table above]

- STK1 - In-field / On-scene
- STK2 - Health care institution (hospital)
- STK3 - Health care institution (non-hospital) – e.g., nursing home, LTC
- STK4 - Health care (Other) e.g., private practice, vaccine clinic, pharmacy
- STK5 - Policy setting/govt agency (Federal)
- STK6 - Policy setting/govt organization (State or Local)
- STK7 - Policy setting/govt organization (Unspecified)
- STK8 - Non-governmental entity
- STK9 – Academia
- STK10 – Professional association
- STK11a, b, c, etc. -Other (specify each)

STOP HERE to allow reconciliation of these four questions.

II. Study design and characteristics

8. Where did the study take place?

- US (specify city and state if relevant)
- Canada, Australia, New Zealand
- Western Europe
- Eastern Europe
- Israel
- Not Relevant (e.g., computer simulation)
- Asia
- South America
- Not Reported
- Other – specify (for each "other" entity)

9. How would you describe the study setting?

- Low population density (e.g., rural)
- Moderate population density (e.g., suburban)
- High population density (e.g., urban)
- Unclear (elaborate if necessary)
- Not relevant
- Not reported

10. What type of MCE is described? [Check all that apply]

- All-hazards
- Chemical
- Biological
- Radiological
- Nuclear
- Explosive
- Natural disaster – if so, what type?
- Infectious disease (if so, pandemic flu?)
- Other – specify
- Unspecified
- Don't know

11. What is the study design?

- Randomized controlled trial
- Observational, pre-post with comparison group [Describe comparison group]
- Observational, pre-post
- Observational, post only with comparison group [Describe comparison group]
- Proof of concept test [outcome of strategy not assessed]
- Systematic Review/Meta-analysis
- Non-systematic Review
- Description of planning process
- Description of exercise or real event
- Other, please specify

12. Where do the data supporting the strategy come from? [Check all that apply]

- Single real event [Name if applicable]
- Multiple real events
- Exercise, drill, or training program
- Multi-stakeholder meetings, etc.
- Computer simulation
- Proof of concept test
- Survey, focus group
- Other, please specify

III. Outcomes Assessment

Outcomes

#	13. What is the outcome? [describe briefly]	14. What kind of outcome is it? *[see list below]*	15. To which strategy does this outcome correspond? *[see list below]*	16. What is the effect size (or qualitative result)?	17. Was the outcome tested?
1					
2					
…					
10					

14. What kind of outcome is it?

- OU1 - Feasibility
- OU2 - Process
- OU3 - Health outcome
- OU4- Opinion
- OU5 - Ethical
- OU6 - Economic
- OU7 – Plan or protocol
- OU8 – Surge resources (e.g., staff, space, and/or supplies)
- OU9a, b, c, etc. - Other - specify

15. To which strategy does this outcome fit? [Q3 – strategy number]

IV. Quality	TOTAL SCORE: ## / 5

18. Data collection:

- No data collection (0)
- Non-systematic data collection (1)
- Systematic data collection (2)

19. Description of the strategy:

- Limited description of the strategy is presented (0)
- Comprehensive description of the strategy is presented (i.e., the strategy is presented in enough detail that it can be replicated) (1)

20. Fidelity in implementing resource allocation strategy. (Note: fidelity is defined as the degree to which the strategy is implemented consistently throughout the course of the MCE whether or not a formal protocol exists):

- No data on fidelity are reported. (0)
- Quantitative or qualitative data on fidelity are reported. (1)

21. Assessment of generalizability

- No discussion of the generalizability of findings (0)
- Generalizability of findings discussed (1)

V. Applicability

22. To what extent is the strategy/outcome dependent on size/scale of the MCE?

- Not at all
- Somewhat
- Moderately
- Very much
- Unclear

23. Is the strategy unique to the jurisdiction described (in terms of leadership required, populations served, stakeholders included, or availability of resources)?

- highly unique
- somewhat unique
- not unique

24. For strategies tested outside of the U.S., are comparable resources available in the U.S.?

- Yes
- No
- Unclear
- Not relevant

25. How relevant are the outcomes to patients? [check all that apply]

- At least somewhat relevant
- Highly relevant
- Not applicable

26. To what extent is each strategy or outcome ready for use? [indicate for each]

Strategy or Outcome #	Strategy or Outcome	Not ready for use (e.g., needs more detail or testing before possible to use)	Ready for use	Unclear

VI. General

Are there any references that need to be checked? If so, please indicate the reference number(s)

Comments on the study

Appendix C. Evidence Tables

Appendix Table C-1a. Tested Strategies to reduce or manage less urgent demand (KQ1)

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Ablah, 2010[31]	Biological counter-measures	Nassau Co, NY	Exercise, drill, or training program	Post only with comparison group: Hybrid POD model	Infectious disease: Anthrax	Use of centralized POD model, as compared with a hybrid POD model.	Centralized POD model had slightly faster processing time than the hybrid model. Centralized and hybrid models had similar quality control outcomes overall. However, hybrid models were more likely to follow the individual steps in the protocol designed to reduce medication error. Centralized PODs were slightly more accurate in dispensing the correct medication. Centralized POD processed 0.75 patients/minute, compared with 0.48 patients per minute.	This only looked at 1st responder/receivers and family, not general population.	6/8
Arora, 2010[32]	Biological counter-measures *Also in Augment resources	Not relevant	Computer simulation	N/A	Infectious disease: Influenza	1) Determine what proportion of CDC stockpile to preallocate in response to pandemic flu outbreak. 2) Implement mutual aid agreements that allow transshipment of antivirals between counties. 3) Allocate CDC stockpile according to age group, gross attack rate, or population only. 4) Determine what proportion of CDC stockpile to use for prophylaxis vs. treatment for pandemic flu outbreak.	Postponing allocation is optimal by allowing allocation according to the infected population rather than the susceptible population. Transshipment through mutual aid agreements is an optimal policy when infection rates vary across counties and counties with small populations are affected. Allocate CDC antiviral stockpile according to gross attack rates rather than population is the optimal strategy. Age-based allocation may also be optimal. Limit use of CDC antiviral stockpile for prophylaxis when supplies are limited and focus on treatment instead.	Vaccine effectiveness is lower among the elderly	4/7

Appendix Table C-1a. Tested Strategies to reduce or manage less urgent demand (KQ1)

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Bravata, 2006[33]	Biological counter-measures	Not relevant	Computer simulation	N/A	Infectious disease: Anthrax	Comparison of broad categories of strategies, including: (1) enhancing bioterrorism event detection, (2) increasing local dispensing capacity, (3) increasing local inventories of antibiotics, and (4) increasing the amount of inventory deployed from the SNS to the site of an attack.	Surveillance strategies to enhance attack detection do not result in reduced mortality when dispensing capacity is low. Increasing local antibiotic stockpiles and instituting surveillance systems to reduce the delay in attack detection, are cost-effective only if the community can achieve a high dispensing capacity, if the probability of an attack is greater than 0.0001 per year, and if the attack is large.	N/A	7/9
Glasser, 2010[35]	Biological counter-measures	Not relevant	Computer simulation	N/A	Infectious disease: Influenza	Target pandemic flu vaccine to specific demographic groups	A strategy of vaccinating children, adolescents, and young adults reduced morbidity the most during a simulated pandemic, while a strategy of vaccinating infants, older adults, and young adults had the largest impact on reducing mortality.	N/A	2/7

Appendix Table C-1a. Tested Strategies to reduce or manage less urgent demand (KQ1)

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Koh, 2008[30]	Biological counter-measures	Boston, MA	Exercise, drill, or training program	Post only with comparison group: Implicit benchmark standard	Infectious disease: Anthrax	1) A streamlined Point of Dispensing (POD) strategy for mass distribution of antibiotics within 48 hours after an Anthrax release. 2) A push method of dispensing (via U.S. Postal Service mail carriers) for mass distribution of antibiotics within 48 hours after an Anthrax attack	Number of people served per hour via POD (relative to benchmark standard)- 1988 person/hour (about 33/hour/staff person) Number of people served per hour via mail carrier - 23,000 persons in 6 hours (120 people/hour/carrier)	Heads of household can pick up meds for all No identification requirement to register Preregistered/trained staff insufficient for probable demand Innovation in training: online and tailored to background (clinical/nonclinical) and commitment (response/leadership Neighborhood-centric strategy for selecting PODs was seen as important	6/8

Appendix Table C-1a. Tested Strategies to reduce or manage less urgent demand (KQ1)

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Lee, 2006[29]	Biological counter-measures	Atlanta, Georgia	Exercise, drill, or training program	Post only with comparison group: 7 counties not using decision support software	Infectious disease: Anthrax	Use of integrated simulation and decision-support software (RealOpt) to determine appropriate staffing for point of dispensing medical countermeasure following Anthrax release.	DeKalb County, the only county participating in the point of dispensing exercise that used RealOpt, achieved the highest throughput compared to all other participating counties. DeKalb was the only county to exceed 450 targeted households; its throughput was 50% higher than the next highest county (which processed only 71% of target households). External evaluators reported that DeKalb County produced the most efficient floor plan (with no path crossing), the most cost-effective dispensing (lowest labor/throughput value), and the smoothest operations (shortest average wait time, average queue length, and equalized utilization rate). No quantitative measures were reported for these parameters.	Computation time for a simulation required <1 minuted CPU time, compared to 5-10 hours for existing commercial software. Combined computation time (using RealOpt) for total 860,000 households was 30 minutes.	4/8
McCaw, 2008[36]	Biological counter-measures	Not relevant	Computer simulation	N/A	Infectious disease: Influenza	Optimal strategy for allocation of antivirals from the Strategic National Stockpile (SNS) during an influenza pandemic (if there ARE two effective drugs)	The two drug strategy (give a different drug to Cases versus their Contacts – i.e. use a different drug for treatment versus prophylaxis) is superior to other strategies because it produces greater delays in: a) propagation of the epidemic and b) the emergence of drug resistance (including multi-drug resistance), but when resistance does emerge, it is more likely to be multi-drug resistance.	The implications of multidrug resistance are strongly dependent on the relative fitness of mutant strains, with the potential for either reduced or extended delays to an uncontrolled outbreak. Strategies that allocate different drugs to treated cases and their close contacts are likely to be most effective at constraining the rate of resistance emergence	7/9

Appendix Table C-1a. Tested Strategies to reduce or manage less urgent demand (KQ1)

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
McVernon, 2010[37]	Biological counter-measures	Not relevant	Computer simulation	N/A	Infectious disease: Influenza	Continuous pre-exposure prophylaxis for health care workers during a influenza pandemic	Provision of continuous pre-exposure prophylaxis to 300,000 HCWs consumed 46% of the stockpile over 18 weeks. While appreciably depleting resources, such use had a negligible impact on the containment effort. Continuous distribution of antiviral prophylaxis to healthcare workers (HCWs)is considered necessary in the early phases of the pandemic response to ensure continuity of healthcare services, the finding suggest it does not compromise population disease control.	N/A	4/7
Medlock, 2009[38]	Biological counter-measures	Not relevant	Computer simulation	N/A	Infectious disease: Influenza	Model to determine optimal vaccine allocation strategy for mass prophylaxis to a novel virus	Mortality (relative to status quo strategy) and other outcomes were usually most reduced by vaccinating children 5-19 years old (highest transmission group) and child-rearing aged adults (30-39 years), but reduced mortality by 20-40% relative to current CDC recommendations.	Optimal strategy depends on which outcome gets priority (deaths averted, life years saved, etc.) Outcome depends on age-group related transmission rate Outcome depends on age-specific mortality Outcome depends on age-specific vaccine efficacy	5/9

Appendix Table C-1a. Tested Strategies to reduce or manage less urgent demand (KQ1)

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Wein, 2003[41]	Biological counter-measures (POD) *Also in Augment resources	Not relevant	Computer simulation	N/A	Infectious disease: Anthrax	1) Aggressive and rapid antibiotic distribution post Anthrax mass attack detection 2) Dramatically expanded POD & hospital surge capacity (for example by cross training, and using non-hospital volunteers to extend trained personnel, and mobile servers from other federal agencies to provide hospital surge capacity)	The Number of Deaths (relative to base case strategy of no or very delayed treatment) is a function of the speed of distribution - Mass antibiotic distribution reduces deaths to 123,000 (8.3% of base case) versus 660,000 deaths (44% of base case) if only symptomatic patients are treated Number of Deaths (relative to base case strategy) - function of hospital capacity - dramatically decreased with sufficient personnel - ten-fold or more, and mobile servers (e.g., from other federal agencies)	Antibiotic Efficacy Adherence to prophylactic regimen Adding mobile servers (to provide surge hospital care) is more effective than adding local servers because the former are typically less busy and therefore more available.	5/9
Zaric, 2008[42]	Biological counter-measures	Not relevant	Computer simulation	N/A	Infectious disease: Anthrax	Develop a model to optimize the logistical response to a bioterrorism event.	The demonstration model provides the following insights: (1) communities should focus on dispensing capacity rather than stockpiling of supplies. (2) improved surveillance can reduce mortality if adequate dispensing capacity exists. (3) the mortality from an attack is significantly affected by the number of unexposed individuals who seek prophylaxis and treatment.	N/A	3/9
Zenihana, 2010[43]	Biological counter-measures	Not relevant	Computer simulation	N/A	Infectious disease: Smallpox	A combination of mass vaccination, contact tracing and vaccination, and school closure as countermeasures to a smallpox bioterrorism attack	A combination of mass vaccination and contact tracing and vaccination can lead to lower mortality, quicker eradication, and less vaccine use than either strategy separately. School closure potentiates the effect of all strategies.	Time required to trace contacts Number of days between index patient and start of countermeasures 1-day vs. 2-day mass vaccination periods	3/7

Appendix Table C-1a. Tested Strategies to reduce or manage less urgent demand (KQ1)

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Cahill, 2008[34]	Non-biological counter-measures	Not relevant	Computer simulation	N/A	Infectious disease: Influenza	Distribute surgical masks or N95 respirators to the public to limit the spread of pandemic influenza (both droplet and airborne transmission).	Use of N95 respirators lowers the probability of infection and the percentage of the population infected compared to surgical masks. Estimated outpatient visits for the N95 mask (100% compliance) were 14,330, as compared to the surgical mask (100% compliance) with 56,200 outpatient visits. However, at 60% compliance, this range narrows to 126,640-128,070. Use of N95 respirators reduces use of hospital beds, ICU beds, and ventilators compared to surgical masks. Estimated hospitalizations for the N95 mask (100% compliance) were 300, as compared to the surgical mask (100% compliance) with 1,190 hospitalizations. However, at 60% compliance, this range narrows to 580-590. N95 respirators and surgical masks had comparable impacts on workdays lost and total economic losses at compliance levels of 60%, but respirators were superior when compliance levels were 100%.	Optimal strategy depends on attack rate and level of compliance wearing masks. Protective efficiency of mask types is based on theoretical calculations involving droplet size, not empiric evidence	2/9

Appendix Table C-1a. Tested Strategies to reduce or manage less urgent demand (KQ1)

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Savoia, 2009[39]	Non-biological counter-measures	US	Exercise, drill, or training program	Pre-post	Infectious disease: Influenza	Tabletop Exercise (and didactic session) to train Public Health officials in what steps they can legally take to limit spread in response to a pandemic	After participating in the course there was a statistically significant increase in most participants' knowledge of and level of confidence in their legal authority to take specific response actions (such as imposing quarantine) to limit pandemic spread.	Legal authority may be present, but procedures to implement that authority may still be lacking... Legal professionals gained somewhat more knowledge	4/7
Schull, 2007[40]	Non-biological counter-measures	Canada/ Australia/ New Zealand	Analysis of single real event	Pre-post with comparison group: Ottawa and London, similar but unaffected regions in Canada	Infectious disease: SARS	Restrict ambulatory and inpatient medical and surgical activity to urgent cases. Respiratory isolation rooms were expanded. Visitor access was severely restricted. A centralized system was created to screen all requests for inter-hospital patient transfers	The rate of overall and medical admissions decreased by 10%–12%; there was no change in the comparison regions. The rate of elective surgery in Toronto fell by 22% and 15% during the early and late restriction periods respectively and by 8% in the comparison regions. Decrease in high acuity ED visits and inter-hospital transfers in Toronto relative to comparison regions suggests potential unintended consequences.	N/A	4/8

Appendix Table C-1b. Tested Strategies to optimize use of existing resources (KQ1)

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Epley, 2006[44]	Load sharing	Southwest Texas	Analysis of multiple real events	Pre-post with comparison group: Routine trauma system (pre-/post-) and disaster trauma system	All-hazards, Natural Disaster: Hurricane	Use of comparable coordinated regional trauma systems for routine (Medcom) and disaster (Regional Medical Operations Center) operations to facilitate the rapid transfer of hospitalized and special needs patients following small-scale trauma events and disasters.	Pre-post- analysis of Medcom: • Pre-Medcom (10 mos.): Transfer decision time 115 +/-3 min; transfer accept time 30.5min; total transfer time 145+/-12min. • Post-Medcom (10 yrs): Transfer decision time 80+/-1min, transfer accept time 10 +/-2 min, total transfer time 91 +/-1 min Regional Medical Operations Center (RMOC) : • Post-Hurricane Katrina- transferred 6 patients/hour & 170 patients/hour from 2 incoming transports • Pre-Hurricane Rita: transferred 20 patients/hour	Medcom (routine) and RMOC (disaster) regional trauma systems are comparable, inter-related and symbiotic. Medcom is practical small-scale rehearsal for major disasters. Authors unaware of comparative data between trauma system; benchmarks would be useful.	4/8
Simon, 2001[45]	Load sharing	NYC	Analysis of single real event	Post only with comparison group: Qualitatively compared against counterfactual	Explosive, Terrorism	1) Control the distribution of urgent patients through scene or central command to limit overwhelming the nearest hospital. 2) Site emergency management centers in a low vulnerability location. 3) Use robust and interoperable emergency communications systems.	No enforced patient distribution system led to moderate and critical patients swamping the two nearest trauma centers, while a 3rd trauma center 3 miles from scene sat idle Attack damage to Office of Emergency Management (OEM) dramatically exacerbated communication and coordination efforts including patient distribution Cell phone and radio disruptions (from attack damage and post-attack overload) prevented response coordination - most patient distribution was blind to hospital resource availability	N/A	2/8

Appendix Table C-1c. Tested Strategies to augment existing resources (KQ1)

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Arora, 2010[32]	Mutual aid agreements *Also in Reduce demand	Not relevant	Computer simulation	N/A	Infectious disease: Influenza	1) Determine what proportion of CDC stockpile to preallocate in response to pandemic flu outbreak. 2) Implement mutual aid agreements that allow transshipment of antivirals between counties. 3) Allocate CDC stockpile according to age group, gross attack rate, or population only. 4) Determine what proportion of CDC stockpile to use for prophylaxis vs. treatment for pandemic flu outbreak.	Postponing allocation is optimal by allowing allocation according to the infected population rather than the susceptible population. Transshipment through mutual aid agreements is an optimal policy when infection rates vary across counties and counties with small populations are affected. Allocate CDC antiviral stockpile according to gross attack rates rather than population is the optimal strategy. Age-based allocation may also be optimal. Limit use of CDC antiviral stockpile for prophylaxis when supplies are limited and focus on treatment instead.	Vaccine effectiveness is lower among the elderly	4/7
Blackwell, 2007[47]	Temporary facilities	US	Analysis of single real event	Post only with comparison group: Qualitatively compared to implied standard of limited or no care available.	Natural Disaster: Hurricane	Deploy a mobile field hospital	7,400 patients were evaluated and treated over a 6-week period.	N/A	3/5

Appendix Table C-1c. Tested Strategies to augment existing resources (KQ1)

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Eastman, 2007[46]	Temporary facilities	Dallas, TX	Analysis of single real event	Pre-post	Natural Disaster: Hurricane	Implement alternate-site surge capacity facility during a mass casualty event	All other trauma centers/EDs in Dallas had no statistically significant increases in visit rates during the two-week period in which the alternate care site was operational compared to visit rates in the prior year. There were no incidents of safety or contamination breaches during operation of the alternate care site.	Leadership team for the alternate care site also served as medical direction team for the City of Dallas Emergency Medical Services and enhanced effectiveness through greater coordination with other agencies. Availability of space and physical structure (especially climate-controlled) Level I centers were required to provide staff and resources, and took nearly 7 days to obtain necessary equipment. Limited capabilities for surgical intervention.	4/7
Wein, 2003[41]	Temporary facilities *Also in Reduce demand	Not relevant	Computer simulation	N/A	Infectious disease: Anthrax	1) Aggressive and rapid antibiotic distribution post Anthrax mass attack detection 2) Dramatically expanded POD & hospital surge capacity (for example by cross training, and using non-hospital volunteers to extend trained personnel, and mobile servers from other federal agencies to provide hospital surge capacity)	The Number of Deaths (relative to base case strategy of no or very delayed treatment) is a function of the speed of distribution - Mass antibiotic distribution reduces deaths to 123,000 (8.3% of base case) versus 660,000 deaths (44% of base case) if only symptomatic patients are treated Number of Deaths (relative to base case strategy) - function of hospital capacity - dramatically decreased with sufficient personnel - ten-fold or more, and mobile servers (e.g., from other federal agencies)	Antibiotic Efficacy Adherence to prophylactic regimen Adding mobile servers (to provide surge hospital care) is more effective than adding local servers because the former are typically less busy and therefore more available.	5/9

Appendix Table C-2. Tested Strategies lacking comparison groups (KQ1)

Author, Year	Strategy	Mass Casualty Context	Innovation	Description	Results
Balch, 2004 [48]	Augment resources	All-hazards	Community readiness	Conducted an exercise to demonstrate community readiness and medical response to a MCE	Shadow Bowl earthquake scenario demonstrated significant strain on the healthcare system.
Irvin, 2007 [52]	Augment resources	Hurricane	Surge, alternate care site-real event	Description of a multidisciplinary Hurricane Katrina Evacuation Center	Successful non-ED alternative to address non-emergent medical concerns
van Asten, 2009 [50]	Augment resources	Infectious Disease	Load sharing	Strengthening national lab surge capacity with regard to diagnostic demand	National network of laboratories has capacity to handle diagnostic requests from hospitals, but probably insufficient for a surge generated in the non-hospitalized population (Netherlands)
Weddle, 2000 [53]	Augment resources	Hurricane	Readiness	Improve the efficiency of deployable military hospitals to supplement surviving local health care capabilities after disasters	Improve communications while requesting resources, broaden the range of available health assets, position resources regionally or in the civilian sector, and create clear indications for full-scale deployable hospitals when they are required.
Etienne, 2010 [55]	Crisis standards of care	Earthquake	Ethics committee	Multidisciplinary Healthcare Ethics Committee to determine allocation of resources	Describe guiding ethics principles for allocation of resources
Kellermann, 2010 [54]	Reduce demand	Infectious Disease	Web-based self triage	Deployment of clinical algorithm during 2009 H1N1 enabled adults with influenza-like illness to self assess need for ED versus clinic or self care	Two websites deployed and used during 2009 H1N1 pandemic; one via flu.gov. Approximately 800,000 visits nationwide, no reports of adverse outcomes. Unable to measure impact due to no follow up
Zerwekh, 2007 [49]	Reduce demand	All-hazards	Biological countermeasure	Drive-thru clinic model for dispensing SNS medication	Timely dispensing of prophylactic medications with high accuracy and minimal human to human contact

Appendix Table C-3. Proposed strategies to allocation scarce resources during mass casualty events (KQ1)

Author, Year	**Organization, Task Force, or Panel**	**Title of Report or Article**	**Proposed Strategy**
No Author, [56]	U.S. Department of Health and Human Services; U.S. Department of Homeland Security	Guidance on Allocating and Targeting Pandemic Influenza Vaccine	Guidance on the allocation and targeting of influenza vaccines during influenza pandemics for Federal, State, local and tribal governments, communities, and the private sector. According to the recommendation, pandemic vaccination target groups are prioritized into four categories by order of importance: homeland and national security, health care and community support services, critical infrastructures, and the general population. These target groups are further prioritized into tiers within each category, and prioritization by tier depends on the severity of the pandemic. For example, in the general population, highest risk groups include pregnant women then infant and toddlers whereas the lowest risk groups include healthy adults 19-64 years old. A detailed rationale for prioritization is provided.

Appendix Table C-4a. Tested Strategies to reduce or manage less urgent demand (KQ2)

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Erwin, 2009[58]	Biological counter-measures	US	Analysis of single real event	Post only with comparison group: Benchmark	Infectious disease: Smallpox	Use CDC smallpox post-exposure clinic guidelines to establish an emergency mass clinic. (The guidelines were implemented during a Hepatitis A outbreak.)	Time per patient - mean: 10 minutes for individuals and mean: 3.5 minutes for groups Immunizations (actual demand) per staff-hour - 1.45 immunizations per staff-hour (versus CDC benchmark of 1.58 immunizations per staff-hour)	N/A	4/8
Hupert, 2009[59]	Biological counter-measures	Not relevant	Computer simulation	N/A	Infectious disease: Anthrax	Account for temporal variability in patient arrivals by dynamically adjusting staffing to meet demand in point-of-dispensing stations for mass prophylaxis using Dynamic POD Simulator	For a given number of staff hours, dynamic changes in staffing in response to demand can increase the capacity (number of patients treated) of a POD station.	Ability to accurately forecast future arrivals based upon current demand might be limited	2/7
Adini, 2010[57]	Public information	Israel	Analysis of multiple real events	Pre-post	All-hazards	Use a standardized, automated central information distribution system for hospitals to help family members locate and identify MCE victims	Overload of hospital communication lines occurred frequently during MCEs, prior to deploying the central information system, but has never happened since implementing the system	N/A	4/8

Appendix Table C-4b. Tested Strategies to optimize use of existing resources (KQ2)

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Einav, 2009[72]	Case managers	Israel	Analysis of multiple real events	Pre-post	Explosive	Use of case managers in supervising patient care and transfer of care throughout an MCE.	Using case managers improved patient management and flow with similar staff and no additional resources. Reductions were observed in: the number of x-rays/patient/1st 24-hour (P < 0.001), time to performance of first chest x-ray (P = 0.015), time from first chest x-ray to arrival at the next diagnostic/treatment location (P = 0.016), time from ED arrival to surgery (P = 0.022) and hospital lengths of stay for critically injured casualties (37.1 +/- 24.7 versus 12 +/- 4.4 days, P = 0.016 for ISS > or = 25). Using case managers had no adverse impact on the health outcomes of critically injured patients. Mortality rates were similar for critically injured patients.	N/A	3/8
Amlot, 2010[63]	Decontamination	Western Europe	Exercise, drill, or training program	Randomized controlled trial	Chemical, Biological, Radiological, Nuclear	Use of instructions, washcloth and/or shower duration to increase decontamination effectiveness	Any form of showering is more effective than not showering; however, the use of a washcloth significantly improved results over showering alone, showering with instructions or showering for longer. Washcloth use led to 20% less contamination, compared to other interventions.	Showering instructions were provided before the shower, and were not available during the shower, which may have reduced effectiveness.	3/6

Appendix Table C-4b. Tested Strategies to optimize use of existing resources (KQ2)

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Loeb, 2009[91]	Health care worker prophylaxis	Canada	Analysis of single real event	Randomized controlled trial	Infectious disease: Influenza	The use of surgical masks in place of N95 respirators to protect healthcare workers against influenza.	Surgical masks were deemed noninferior to N95 respirators. The lower end of the 95% confidence interval for the reduction in incidence of influenza (N95-surgical) was greater than the established noninferiority limit of -9%.	N/A	5/6
Gao, 2007[87]	Health info technology	US	Exercise, drill, or training program	Post only with comparison group: Paper triage tags	Unspecified	Use electronic triage tags (Advanced Health and Disaster Aid Network, AID-N) to monitor vital signs and transmit information to first responders.	Time required for triage was similar in both electronic and paper triage groups. Electronic triage tags allowed first responders to re-triage patients three times more often as first responders who used paper triage tags.	Triage status indicator used LEDs that were difficult to see from a distance under bright sunlight and when the triage tag was flipped over on the patient. Patients might wander out of range or vehicles (e.g., fire trucks) might block data transmissions. Pulse oximeter readings have limited accuracy in the presence of methemoglobin, carboxyhemoglobin, nail polish, nail fungus, fluorescent light, and motion. Tags used at least eight times less energy than existing, similar devices	5/8

Appendix Table C-4b. Tested Strategies to optimize use of existing resources (KQ2)

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Xiong, 2010[61]	Health info technology	Not relevant	Computer simulation	N/A	Natural Disaster: Earthquake	Implement regional telemedicine hub to support delivery of specialty care during MCE	Use of the telemedicine hub reduced the number of deaths by 5.4%, 36.5% and 27.3% for the major, medium and minor scale earthquake scenarios respectively. Use of the telemedicine hub reduced local ED bed usage and local trauma specialist usage for medium and minor earthquakes. Use of the telemedicine hub lowered average wait times for ED beds and specialists.	Rapid availability of specialists external to the event are required Local ED resources may serve as a bottleneck and require higher rates of transfer even when the telemedicine hub is operational	2/7
Beck-Razi, 2007[93]	Imaging	Israel	Analysis of single real event Validation study	Medical record review	Explosive, Trauma: War	Use of focused assessment of sonography for trauma (FAST) in for MCE triage.	FAST results were generally consistent with the results of CT scans, laparotomy and clinical observation. Overall accuracy of FAST (compared to other methods) was 93.1% (sensitivity: 75.0%, specificity: 97.6%).	Sonography in this study was performed and interpreted by radiologists, not emergency medicine physicians/providers Type of injury varied between soldiers (open wounds and fractures) versus civilians (blast/shrapnel injuries) FAST only can detect fluid/air so can diagnose bleeding, but cannot exclude all clinically important types of abdominal injury	6/8
Korner, 2011[104]	Imaging	Western Europe	Exercise, drill, or training program	Post only with comparison group: 4-slice MDCT	MCEs involving major trauma	Use 64-slice multi-detector computerized tomography scan (vs. 4-slice MDCT) with high volume image reading capabilities to facilitate triage during MCEs	The 64-MDCT protocol reduced image processing time from an average of 9.0 minutes to 4.1 minutes.	Large volume of data led to an overload of the 3D workstation; backups workstations would be required Image quality might be a modulator but it was not assessed as part of the study	7/8

Appendix Table C-4b. Tested Strategies to optimize use of existing resources (KQ2)

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Korner, 2006[80]	Imaging	Western Europe	Exercise, drill, or training program	Pre-post with comparison group: Individually admitted patients after multiple trauma (historical)	Unspecified	Implement accelerated whole body multislice computed tomography protocol (Triage MSCT)	Use of the triage MSCT protocol allowed a throughput of 6.7 patients per hour compared to 2.4 patients per hour for the standard protocol. Triage MSCT protocol produced an average of 201 images per patient compared with 1031 images per patient for the standard protocol.	Triage MSCT patients were assumed to undergo preparation at the site of the MCE or during transport, did not undergo focused abdominal ultrasound, and were transferred directly to the CT exam room. This accounted for most of the throughput gain. To decrease image number and image calculation time, no high-resolution reformations and multiplanar reformations were calculated in the Triage MSCT group. Tube cooling problem were encountered when using the Triage MSCT protocol that required a reduction in dose for each scan and consequently the potential for lower image quality. This issue may be avoided by using newer scanners. Staff participating in the study were instructed before the simulation on how to operate the CT console with the new MSCT protocol.	5/7
Sarkisian, 1991[86]	Imaging	Eastern Europe	Analysis of single real event	Retrospective case review	Natural Disaster: Earthquake	Sonographic screening for abdominal/pelvic injury or bleeding to triage earthquake MCE casualties and screen for occult injuries	False positive rate of 0/345 (0%) among patients without true abdominal trauma. (Reviewers' calculation) False negative rate of 4/55 (7.2%) among patients with true abdominal trauma. (Reviewers' calculation) Mean exam time of 4 minutes (Range: 1-10 minutes)	N/A	4/8

Appendix Table C-4b. Tested Strategies to optimize use of existing resources (KQ2)

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Kanter, 2007[77]	Load sharing *Also in Altered standards	Not relevant	Computer simulation	N/A	Unspecified	1) Control distribution of pediatric disaster victims to avoid overcrowding near scene 2) Expand hospital capacity by altering standards of care to provide only "essential interventions"	Simulated mortality was reduced both by controlling the distribution of disaster victims and by relaxing standards of care. The greatest reduction was achieved by employing both strategies together.	Findings are based upon a variety of untested and extrapolated assumptions. Thus, "the reported results are not intended to recommend particular response strategies." A large urban center is modeled; the applicability to rural or suburban environments is unclear.	3/9
Leiba, 2006[97]	Load sharing	Israel	Analysis of single real event	Post only with comparison group: Benchmark (implied)	Explosive	1) Central allocation of patients to hospitals based on available resources 2) Central information system and local hospital information offices remote from care areas 3) Simplified field triage system - urgent (P1 & P2), non-urgent (P3), and expectant (P4) to speed scene clearance	Avoidance of individual hospital overload - 5/13, 5/13 and 3/13 urgent patients triaged to three nearest Level I trauma centers Limited diversion of medical care personnel to family/media information needs Speed of scene clearance - all 21 urgent (and 2 DOA) casualties evacuated in 25 minutes. All ambulance patients cleared within 35 minutes	N/A	2/8
Raiter, 2008[75]	Load sharing	Israel	Analysis of single real event	Post only with comparison group: Benchmark (implied)	Explosive	1) Central Incident Command System (ICS) which gathers data and assigns patients to receiving hospitals 2) Robust redundant communications channels between Command Center, Responders, and Receiving Hospitals	Optimal allocation of resources (patients to hospitals) - no overload of capacity - nearest Level I got 5/9 severe patients, Level II got 4/9, 59 mildly injured patients distributed amongst 5 hospitals Effective communication between responding entities - cell phone service overloaded/failed, radio, beeper & internet channels functioned smoothly	N/A	3/8

Appendix Table C-4b. Tested Strategies to optimize use of existing resources (KQ2)

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Wolf, 2009[70]	Load sharing	Western Europe	Exercise, drill, or training program	Post only with comparison group: Benchmark	Unspecified	New model to accommodate MCEs with >200 casualties, including on-site triage and stabilization and immediate transport of severely injured patients to modular "Initial Care Hospitals" for further stabilization and emergency treatment including surgery	Mean time from registration to entry into operating room for 10 patients needing emergency surgery was 19.5 minutes National standard was met at the designated "Initial Care Clinic": 60-minute lead time (from alert to full preparedness and maximum influx of patients)	N/A	8/8
Gunal, 2004[103]	Medical treatment	Asia	Analysis of single real event	Post only with comparison group: Benchmark (historical comparison)	Natural Disaster: Earthquake	An organized, on-site medical intervention for the prevention of acute renal failure in crush victims after a catastrophic earthquake.	Only 4 of 16 patients with rhabdomyolysis required hemodialysis. All 16 survived. This is compared to dialysis rates of 60.8% and 77% for comparable patients in two recent earthquakes, and to other reported mortality rates of 15%-40% for patients who require hemodialysis.	N/A	6/8
Vardi, 2004[82]	Medical treatment	Israel	Exercise, drill, or training program	Randomized controlled trial	Chemical	Spring-driven intraosseous infusion device to replace IV insertion in a chemical MCE where providers are in full protective gear.	Simulated survival with/without IO device use - 73.4% survival versus 3.3% survival (under the simulation rules) Total average casualty treatment time with/without device - 207 seconds versus 590 seconds	Anesthesiologists performed faster in both treatment and control groups	6/8
Satterthwaite, 2010[64]	Space optimization	Australia	Analysis of single real event	Retrospective case review	Explosive, Transportation accident	Use reverse triage to create surge capacity, including: suspension of normal elective activity, discharging patients earlier in the day, and increasing use of community care options such as respite nursing home beds and community nursing services)	Nineteen patients were discharged early (and would not have been discharged early under normal conditions). Seven patients were ultimately readmitted, however, early discharge did not increase clinical risk.	N/A	2/7

Appendix Table C-4b. Tested Strategies to optimize use of existing resources (KQ2)

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Scarfone, 2011[105]	Space optimization	Philadel-phia, PA	Analysis of single real event	Pre-post	Infectious disease: Influenza	1) Appropriate space for other uses, including: 1) converting the hospital lobby to an ED waiting room 2) using a subspecialty clinic to care for non-urgent patients, and 3) using a 24-hour short stay unit to care for ED patients. 2) Use physicians not board certified in pediatric emergency medicine and inpatient-unit medical nurses to care for ED patients. 3) Other strategies included stockpiling PPE, antiviral medication, and bed surfaces, and the use of a tiered distribution of H1N1 vaccine.	Both patients' average wait time in the ED and the rate of leaving the ED without being seen during the pandemic were less than rates measured during the peak of seasonal influenza in the prior year. The ED continued to accept all children brought by local ambulance crews, and never went on divert status.	Decision to abandon initial plan to treat all children with ILI in one or more unit	2/8
Van Cleve, 2011[107]	Space optimization	Seattle, Washington	Analysis of single real event	Pre-post	Infectious disease	Reverse triage to identify patients for release and increase inpatient surge capacity	The hospital discharged essentially the same number of patients on November 4 as on previous high-census days when the surge plan was not activated, suggesting that the surge plan did not succeed in creating excess discharges.	The hospital never declared a disaster abd never sytematically implmented reverse triage	5/8
Andreatta, 2010[90]	Training	Ann Arbor, MI	Exercise, drill, or training program	Randomized controlled trial	Explosive	Use virtual reality to teach START triage	Virtual reality-based triage performance did not lead to improved performance compared to (traditional) standardized patient triage training.	Higher up-front costs for VR development	6/6

Appendix Table C-4b. Tested Strategies to optimize use of existing resources (KQ2)

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Hsu, 2004[81]	Training	US, Western Europe, Eastern Europe, Asia	Systematic Review/Meta-analysis	N/A	All-hazards, Chemical, Biological, Radiological, Nuclear, Explosive, Transportation accident	1) Conduct hospital disaster drills to train hospital staff to respond to a mass casualty event 2) Use computer simulations to train hospital staff to respond to a mass casualty event 3) Conduct tabletop or other exercises to train hospital staff to respond to a mass casualty event	Disaster drills have the potential to identify problems with incident command, communications, triage, patient flow, materials and resources, security, and decontamination. Disaster drills usually were not designed to evaluate the effectiveness of patient care. Computer simulation was able to identify bottlenecks in patient care, electromechanical failures, crowd control issues and other security problems, and resource deficiencies. Evidence is insufficient to reach definitive conclusions regarding the effectiveness of computer simulations or tabletop exercises.	N/A	7/10
Jarvis, 2009[88]	Training	Western Europe	Exercise, drill, or training program	Randomized controlled trial	Unspecified	Use computer game method of triage training	Computer game participants achieved higher triage tagging accuracy (compared to participants in a tabletop exercise)	Providing interim feedback improves step accuracy but not accuracy of triage classification.	4/8

Appendix Table C-4b. Tested Strategies to optimize use of existing resources (KQ2)

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Sanddal, 2004[99]	Training	US	Exercise, drill, or training program	Pre-post	Explosive, Transportation accident	A 1 hour training program to improve pediatric triage performance ("JumpSTART")	The training session improved triage performance and that improvement was sustained at 3 months.	Motivation and abilities of trainees The generalizability of performance improvement to other scenarios (or to any non-drill situation) is unknown. The sustainability of performance improvement beyond 3 months is unknown. Using triage tags rather than simulating them was found to be helpful	6/8
Vincent, 2009[71]	Training	US	Exercise, drill, or training program	Pre-post	Explosive	Teach triage skills using podcasts and iterative multi-manikin simulations	Accuracy of triage, choice of intervention, and rapidity of triage all improved with training.	Performance may vary with mechanism of injury Improvement might have resulted from technical familiarity with manikins rather than improvement in triage skills.	3/5
Vincent, 2008[73]	Training	US	Exercise, drill, or training program	Pre-post	Unspecified	Teach mass casualty triage skills using an immersive 3D Virtual Reality environment.	Triage accuracy and intervention scores improved significantly after one iteration of training. Time to complete the scenario improved with each iteration.	There may have been a selection bias, with more technologically savvy learners signing up to participate in this trial Apparent performance gains could reflect familiarity with VR equipment rather than improved triage knowledge	4/7

Appendix Table C-4b. Tested Strategies to optimize use of existing resources (KQ2)

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Adeniji, 2011[92]	Triage	Western Europe	Validation study	Retrospective case review	Infectious disease: Influenza	STSS (Simple Triage Scoring System) to help triage critical care admissions during influenza pandemic	STSS had superior accuracy in predicting ICU need relative to SOFA score - the Area Under the Curve (AUC) of the Receiver Operator Characteristic (ROC) was 0.88 versus 0.77 STSS had superior accuracy in predicting need for mechanical ventilation relative to SOFA score - the Area Under the Curve (AUC) of the Receiver Operator Characteristic (ROC) was 0.91 versus 0.87	Low mortality of H1N1 patients prevented evaluation of predictive accuracy for mortality	3/6
Aylwin, 2006[79]	Triage *Also in Altered standards	Western Europe	Analysis of single real event	Retrospective case review	Explosive	1) Trained/experienced triage at scene 2) Simplified on-scene triage (urgent (P1 & P2), not urgent (P3), expectant 3) Re-triage at every stage, directed by trained/experienced providers with explicitly designated authority 4) Damage Control approach (minimize use of all critical hospital resources)	Accuracy of on-scene triage was much higher for locations where fully trained responders (versus by medically trained bystanders) performed triage (33% overtriage versus 82% overtriage of critical patients) Speed of scene clearance - Average of 27 P1 & P2 (most seriously wounded) patients per hour (= 2.2 minutes per patient) Second stage screening (at the ED Door) reduced the surge demand (by screening out over-triage and identifying under-triaged/deteriorating patients) reducing initial overtriage to 0% and undertriage to 20% of critical patients. Increase available surge capacity - created 10 ICU bed spaces and made all ORs available within 2 hours	N/A	5/8

Appendix Table C-4b. Tested Strategies to optimize use of existing resources (KQ2)

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Beyersdorf, 1996[85]	Triage	Spokane, WA	Analysis of single real event	Post only with comparison group: Benchmark (implied)	Mass shooting	Preexisting/pre-tested MCE response plan incorporating interagency cooperation, unified communications and incident command, on-scene provider triage, and allocation of casualties based on hospital resources.	A total of 2/19 patients (11%) were over-triaged and 2/19 (11%) were under-triaged. 100% survival.	Pre-hospital vehicles contained job descriptions and duties printed on small cards, and were utilized to establish a command center and chain of command at the scene Designation of a regional disaster control hospital allowed for minute-by-minute knowledge of the capabilities of area hospitals and efficient dispersion of the victims to appropriate facilities. Surgical specialists were preassigned to specific facilities thereby avoiding confusion.	2/6
Cancio, 2008[94]	Triage	Iraq	Analysis of multiple real events Validation study	Medical record review	Military/Combat	The use of the Field Triage Score (FTS07) compared to the Revised Trauma Score (RTS) in predicting mortality and massive transfusion.	FTS predicted mortality and massive transfusion nearly as well as the Revised Trauma Score (RTS), but can be calculated without computing assistance in the field.	Often, study patients already had field interventions (such as intubation) performed prior to RTS/FTS assessment	4/6

Appendix Table C-4b. Tested Strategies to optimize use of existing resources (KQ2)

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Casagrande, 2011[106]	Triage	Not relevant	Computer simulation	N/A	Nuclear	Use Model of Resource and Time-based Triage to prioritize victims with moderate life-threatening injuries over victims with severe life-threatening injuries, and to prioritize victims with different levels of radiation exposure.	First, when the victim loading is low (i.e., less than or equal to the baseline number of surgical teams and patients),a triage system that prioritizes moderately injured victims followed by severely injured victims followed by mildly injured victims (mod-sev-mild) saves 10% more lives than alternative approaches. Second, as the victim loading increases relative to the resources available (up to 10-fold more patients or 10-fold fewer surgical teams as the baseline), mod-sev-mild saves more than 3-fold more victims than a sev-mod-mild system. Delaying the care of victims with trauma and >0.7 Gy of irradiation increases the number of lives saved by 1.4-fold compared to a system in which irradiated victims are treated exactly like non-exposed victims. The mod-sev-mild triage scheme results in less demand for ICU beds than a sev-mod-mild scheme (15,000 vs. 17,000 on the first day).	N/A	6/9

Appendix Table C-4b. Tested Strategies to optimize use of existing resources (KQ2)

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Cohen, 1998[84]	Triage	Israel	Analysis of multiple real events Validation study	Retrospective case review	Explosive	Use American College of Surgeons Committee on Trauma criteria during field triage for blast MCE injuries.	Field undertriage rate - 0/26 (0%) critical patients, 4/28 (14%) severely injured, and 19/143 (13%) moderately injured patients initially classified as less severe Field overtriage rate - 12/36 (33%) minor injury patients initially classified as more severe	Experience of field triage providers	4/8
Cone, 2009[69]	Triage	US	Exercise, drill, or training program	Post only with comparison group: Benchmark	All-hazards	Use of the Sort- Assess- Lifesaving Interventions- Treatment/transport (SALT) triage protocol.	Study participants (paramedics) using SALT had a 78.8% accuracy rate. The overtriage rate was 13.5% and the undertriage rate was 3.8%. The undertriage rate is lower than the 5% the authors assert is standard in the literature. Average triage time was 15 seconds (median: 11.5 seconds; range 5-57 seconds).	Time elapsed between training on triage method and application of methodology. Training level and experience of triage provider (EMT, Paramedic, MD, etc.) may also influence accuracy	5/8
Cone, 2008[74]	Triage	New Haven, CT	Exercise, drill, or training program	Post only with comparison group: Gold standard triage category	Chemical	Use combined trauma/CBRN-specific triage method during an MCE.	Overtriage rate (1.8%, 1/56 patients) Undertriage rate (10.8%, 6/56 patients) Triage speed - 19 seconds per patient	Inaccuracy in triage mostly due to missing signs of chemical toxidrome	6/8

Appendix Table C-4b. Tested Strategies to optimize use of existing resources (KQ2)

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Cryer, 2010[95]	Triage	Los Angeles County, CA	Analysis of multiple real events	Pre-post	Transportation accident	1) Use a trauma system performance improvement program to evaluate MCE response, identify shortcomings, and change policy based upon the findings. 2) Use air transport to facilitate distribution of "immediate" patients evenly to area trauma centers. 3) Encourage EMS to distribute all victims meeting "trauma center criteria" to trauma centers rather than to non-trauma community hospitals.	Regional EMS quality improvement plan can improve the distribution of patients to appropriately resourced hospitals in mass casualty events. In the 2005 train crash only 44% (11/25) of "immediate" patients were taken to trauma centers, as compared to 89% (55/62) in 2008. In the 2005 crash, only 2 patients were transported by air; in 2008, 34 were transported by air.	N/A	5/8
Guest, 2009[102]	Triage	Western Europe	Prospective cohort study prospective data collection during conventional care conditions	N/A	Infectious disease: Influenza	Implement Christian et al.'s triage protocol during an influenza pandemic	For prioritizing ICU admission, sensitivity/specificity for "no significant organ failure" were 0.66/0.83, respectively. For the "palliative treatment only" category, sensitivity and specificity were 0.29 and 0.84, respectively. For prioritizing ongoing ICU care, sensitivity/specificity for "no significant organ failure" were 0.76/0.86, respectively. For the "palliative treatment only" category, sensitivity and specificity were 0.61 and 0.87, respectively.	N/A	5/7

Appendix Table C-4b. Tested Strategies to optimize use of existing resources (KQ2)

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Gutsch, 2006[96]	Triage	Western Europe	Exercise, drill, or training program	Post only with comparison group: Benchmark	Unspecified	Use mSTART triage algorithm	Triage time by EMTs was a median of 35 seconds each (average 41 seconds), which compares favorably with emergency physician average of ~3 minutes. EMT critical red over-triage was 5.3% and critical red under-triage was 3% (both are considered excellent). Sensitivity was 88%, and specificity was 94%.	N/A	4/4
Hirshberg, 2010[66]	Triage	Not relevant	Computer simulation	N/A	Explosive	1) Use a 2-stage triage system for large-scale MCEs 2) Use most experienced physician for the first step of triage	Single-step triage works well for small-scale incidents. When resources are overwhelmed, 2-stage triage substantially increases the "time to saturation" (point at which ED is at full capacity). If two triage providers have 70% and 90% accuracy, assigning the better provider to the first step of a sequential triage increases time to saturation by approximately 50%.	Value of 2-step procedure varies with the ratio of casualties to provider teams Model does not deal well with the possibility of under-triage in two-step process	6/9
Janousek, 1999[83]	Triage	US	Exercise, drill, or training program	Post only with comparison group: Provider groups compared against each other.	Chemical, Biological, Nuclear, Trauma: War	The use of various providers types in doing MCE triage.	Physicians had higher triage accuracy scores than other military healthcare providers (nurses, dentists and medics, using the NATO triage classification system (mean score of 54, compared to 50--denominator could not be determined). There were no statistically significant differences between emergency physicians, surgeons and general medical officers. Likewise, there were no differences between medics, nurses and dentists.	N/A	3/7

Appendix Table C-4b. Tested Strategies to optimize use of existing resources (KQ2)

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Kilner, 2010[62]	Triage	Not relevant	Systematic Review/Meta-analysis	N/A	Explosive, Natural Disaster	Field triage tools for victims of "big bang" incidents (sudden onset MCEs rather than slowly emerging MCEs).	There is limited evidence for the validity of existing triage tools. The authors identify the Sacco triage system as "the most promising" but state that further evaluation of this tool is required.	N/A	8/8
Kuniak, 2008[76]	Triage	US	Exercise, drill, or training program	Post only with comparison group: Gold standard disposition categories	Radiological	Use Radiation Injury Severity Classification (RISC) for early triage of radiation MCE casualties when dosimetry data are unavailable	Accuracy of raters' classification was approximately 95%.	Trend towards training level affecting triage accuracy (MD>RN>EMT) Hematologic component proved most difficult to score System allows for the rapid assessment of ARS severity without the availability of dose information Less complex than other systems (e.g., METROPOL) and is amenable to self-education.	6/8
Lerner, 2010[68]	Triage	Augusta, GA & Milwaukee, WI	Exercise, drill, or training program	Post only with comparison group: Benchmark (START protocol)	Explosive	Use of the Sort- Assess-Lifesaving Interventions-Treatment/transport (SALT) triage protocol	Performance using the SALT protocol was comparable to other studies using the START triage protocol. Final triage was correct 83% of the time (CI: 78-88%), compared to START studies (48-75%). 6% were overtriaged and 10% were undertriaged. Timing using the SALT protocol was comparable to other studies using the START triage protocol. Mean triage time was 28 seconds (Std dev: 22 sec), compared to 30 seconds for START. Further, this study used simulated 'patient' interference, which may have increased triage times.	N/A	5/8

Appendix Table C-4b. Tested Strategies to optimize use of existing resources (KQ2)

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Navin, 2009[98]	Triage	Not relevant	Computer simulation	N/A	Unspecified	Use Sacco triage method (vs. START triage) for patients of military age with blunt, penetrating, and blast injuries.	Simulated survivorship improves by 20-300% depending upon the distribution of injuries and resource constraints.	N/A	3/7
Nie, 2010[67]	Triage	Asia	Analysis of single real event	Post only with comparison group: Benchmark (START protocol)	Natural Disaster: Earthquake	Use field triage method that accounts for resources at the accepting institution. In this instance, a 'resuscitation' category was added.	The addition of a resuscitation group to standard (START) protocols led to lives saved within that group. 4 of 6 patients in the resuscitation group survived to discharge. These patients would have been classified as 'expectant' under START.	Strategy depends heavily on local decisions. Accuracy of triage may depend on specialty of physician who conducts initial triage.	2/8
Rehn, 2010[65]	Triage	Western Europe	Exercise, drill, or training program	Pre-post	Transportation accident	TAS Triage Method for bus crash type MCE (combines triage Sieve for adults and trauma tape for pediatric patients)	Overtriage rate before implementation of TAS: 9/74 (12.2%), versus 0/74 (0%) after implementation of TAS Undertriage rate before implementation of TAS: 9/24 (12.2%) , versus 0/24 (0%0 after implementation of TAS Scene clearance rate - mean: 22 minutes (range 15-32) before implementation of TAS, versus mean: 10 minutes (range 5-21) after implementation of TAS	Need TAS Training Need TAS Equipment Probably easier to collect accurate input data under simulation conditions than in real MCE	6/8

Appendix Table C-4b. Tested Strategies to optimize use of existing resources (KQ2)

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Rodriguez-Noriega, 2010[89]	Triage	Mexico	Analysis of single real event	Prospective case series	Infectious disease: Influenza	Use Influenza-Like Illness Scoring System to triage adults seeking care at an ED during an influenza pandemic. Patients with high scores are admitted and treated with oseltamivir. Those with intermediate scores are sent home with oseltamivir and followed up by phone daily for 10 days. Those with low scores are discharged home without treatment.	Of 1324 ambulatory patients who were discharged without receiving oseltamivir, 14 (0.8%) returned after their initial visit. Three of these patients were hospitalized and treated with oseltamivir (two of them tested positive for H1N1).	N/A	5/8
Romm, 2011[60]	Triage	US, Canada/ Australia/ New Zealand, Western Europe, Asia	Laboratory test	N/A	Radiological, Nuclear	Use fewer metaphase spreads when using the dicentric chromosome assay method of biodosimetry for mass radiological incidents.	Analyzing 50 metaphases gives reliable and accurate individual dose estimations over the dose range of 0.75 to 4.5 Gy. Most of these dose estimations are within 20% of the actual doses. Dose estimations based on analysis of only 20–30 metaphases allowed an accurate evaluation in the higher dose ranges. (Routine standard is 500-1000 metaphases)	Range of exposure doses and uniformity of exposure will impact effectiveness of strategy.	5/5
Sacco, 2007[101]	Triage	Not relevant	Computer simulation	N/A	Any MCE associated with penetrating trauma	Use Sacco Triage Method (as compared to START) for victims with penetrating trauma injuries during an MCE	Under severe resource restrictions, the Sacco Triage Method may save up to an additional 6 to 16 individuals (among 60 simulated victims); whereas the minimum survival benefit is between 0 and 7 victims. When resources are not constrained, the method saves at most 5 additional victims (out of 60).	Method requires inter-hospital coordination with respect to reporting resource availability and receiving patients Method also requires robust communication systems	5/7

Appendix Table C-4b. Tested Strategies to optimize use of existing resources (KQ2)

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Schenker, 2006[100]	Triage	New York, NY	Exercise, drill, or training program	Post only with comparison group: Benchmark	Chemical, Explosive, Transportation accident	Implement START triage algorithm during mass casualty event	A total of 88/121 patients (70%) were triaged accurately. A total of 29 of 47 patients (62%) were managed appropriately when their clinical status was altered as part of the exercise. Six patients who underwent status changes indicating a possible myocardial infarction or asthma attack were classified as over-triaged according to START but were judged to be managed appropriately by exercise staff.	N/A	6/8
Zoraster, 2007[78]	Triage	Los Angeles, CA	Analysis of single real event	Retrospective case review	Transportation accident	Use of START triage by a regional trauma network to prioritize transport of MCE patients and to distribute them among area hospitals.	Trauma centers were underutilized and community hospitals received critical patients that they were poorly equipped to handle.	Hospital capacity self-report was inaccurate START categorization scheme was imperfectly understood START triage categories differ from trauma center criteria, causing confusion	4/6

Appendix Table C-4c. Tested Strategies to augment existing resources (KQ2)

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Corvino, 2006[108]	Resource conversion	US	Laboratory experiment	N/A	Chemical	Convert Pralidoxime (2-PAM) in autoinjectors into IV form if needed to respond to nerve agent MCE	Resulting formulation is potent and stable - Greater than 90% potency at 28 day post-preparation, with no bacterial contamination or detected physical changes	N/A	6/7

Appendix Table C-4d. Tested Strategies for crisis standards of care (KQ2)

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Aylwin, 2006[79]	Trauma surgery *Also in Optimize resources	Western Europe	Analysis of single real event	Retrospective case review	Explosive	1) Trained/experienced triage at scene 2) Simplified on-scene triage (urgent (P1 & P2), not urgent (P3), expectant 3) Re-triage at every stage, directed by trained/experienced providers with explicitly designated authority 4) Damage Control approach (minimize use of all critical hospital resources)	Accuracy of on-scene triage was much higher for locations where fully trained responders (versus by medically trained bystanders) performed triage (33% overtriage versus 82% overtriage of critical patients) Speed of scene clearance - Average of 27 P1 & P2 (most seriously wounded) patients per hour (= 2.2 minutes per patient) Second stage screening (at the ED Door) reduced the surge demand (by screening out over-triage and identifying under-triaged/deteriorating patients) reducing initial overtriage to 0% and undertriage to 20% of critical patients. Increase available surge capacity - created 10 ICU bed spaces and made all ORs available within 2 hours	N/A	5/8

Appendix Table C-4d. Tested Strategies for crisis standards of care (KQ2)

Author, Year	Sub-category	Study Location	Study Type	Study Design	Relevant type of mass casualty event	Strategy	Findings	Outcome Modulators	Quality score
Dhar, 2008[110]	Trauma surgery	Asia	Analysis of single real event	Post only with comparison group: Comprehensive care (implied)	Natural Disaster: Earthquake	"Damage control" surgery for the orthopedic injuries of MCE polytrauma patients if referral to hospital is delayed or comprehensive care resources unavailable	Acceptable outcome at 1 year compared with comprehensive care = 49/62 (79%) "excellent" or "good" outcomes; only 3 non-unions (unhealed fractures) Mortality - 0% Operating Room Time (relative to definitive repair) - mean: 38.5 minutes for external fixation (37% of internal fixation time)	Results inferior for intra-articular (joint involved) fractures	5/8
Kanter, 2007[77]	Pediatrics *Also in Optimize resources	Not relevant	Computer simulation	N/A	Unspecified	1) Control distribution of pediatric disaster victims to avoid overcrowding near scene 2) Expand hospital capacity by altering standards of care to provide only "essential interventions"	Simulated mortality was reduced both by controlling the distribution of disaster victims and by relaxing standards of care. The greatest reduction was achieved by employing both strategies together.	Findings are based upon a variety of untested and extrapolated assumptions. Thus, "the reported results are not intended to recommend particular response strategies." A large urban center is modeled; the applicability to rural or suburban environments is unclear.	3/9
Labeeu, 1996[111]	Orthopedics	Rwanda	Analysis of single real event	Post only with comparison group: Standard care (implied)	Trauma: War	External fixation of fractures rather than definitive orthopedic care	External fixation used for 1,129 fractures. Average time of placement was 30 minutes. Numerous complications, not quantified. Authors consider this to be the best compromise between nonoperative methods and definitive care.	N/A	1/6
Merin, 2010[109]	General	Haiti	Analysis of single real event	Post only with comparison group: Standard care (implied)	Natural Disaster: Earthquake	Altered standards of care, and allocation of resources towards patients most likely to benefit.	Authors assert that they treated more patients than they would have if they had not relaxed standards of care or had they not allocated resources with the goal of maximizing the number of lives saved.	N/A	1/6

Appendix Table C-5. Tested Strategies Lacking Comparisons Groups (KQ2)

Author, Year	Strategy	Mass Casualty Context	Innovation	Description	Results
Bouman, 2000[123]	Optimize resource use	All-hazards	Information technology	Register patients using a bar code to facilitate patient flow	The patient bar system has been in effect in the Netherlands since the late 90s. It has had positive effects on the Major Incident Management Plan and has reduced registration errors.
Curtis, 2008[122]	Optimize resource use	All hazards	Information technology	Use of the SMART (Scalable Medical Alert Response Technology) to monitor unattended patients (exercise)	An initial evaluation in the ED via a pilot and a city-wide disaster drill showed promise. Future plans include modification of algorithms to reduce number of false positives and increasing integration of the system within the ED.
Dan, 2009[112]	Optimize resource use	Earthquake	Imaging	Use ultrasonography as a key triage tool (actual event)	Ultrasonography was used during the Wenchuan Earthquake. It played an important role in the triage of earthquake victims, provided accurate and timely diagnosis of closed injury, bedside examination of severe cases, and interventional treatments.
Gunawan, 2009[121]	Optimize resource use	All-hazards	Information technology	Use of a simple navigation aid for the walking wounded (simulation)	Use of an arrow-pointing prototype device provides sufficient guidance for the walking wounded to reach the targeted destination, sparing first responders as escorts.
Jokela, 2008[120]	Optimize resource use	All-hazards	Information technology	Use of Radio Frequency Identification (RFID) technology to provide online triage system for mass casualty	A simulation exercise demonstrated that use of RFID is feasible for use in the field.
Körner, 2009[115]	Optimize resource use	All-hazards	Imaging	Use of a CT triage protocol for MCIs (simulation)	Results from 2 large scale exercises demonstrated that a CT triage protocol was feasible and produced similar findings among the exercises conducted.
Levy, 2010[125]	Optimize resource use	All-hazards	Information technology	IT- hospital administration system, EMR, picture archiving and communication system	IT, including EMR, is feasible in a field hospital operation.
Ma, 2007[114]	Optimize resource use	All-hazards	Imaging	Utilization of ultrasound as a triage tool to aid clinicians in rapid screening (simulation)	Ultrasound imaging is feasible and may be applied to MCIs.
Malik, 2004[116]	Optimize resource use	Trauma	Triage tool	Use of multiple scoring systems in the triage process	Triage effectively accomplished at 3 levels using 3 different scoring systems (e.g. on site "Triage sieve", at the primary health care center "field categories of trauma patients", tertiary referral center "Advanced Trauma Life Support" (ATLS) secondary survey").
Mazur, 2009[113]	Optimize resource use	Hurricane	Imaging	Use of ultrasound by DMATs as a MCI triage adjunct (Actual event)	US is feasible to use in MCI and can assist in triage decisions.
Nilsson, 2008[128]	Optimize resource use	All-hazards	Training	Educational tool that links resource allocation decisions to patient outcomes	Pilot study conducted as part of a national training program.
Okumura, 2007[117]	Optimize resource use	Chemical	Triage tool	Triage and decontamination with colored clothes pegs (CCP) (simulation)	Effective use of CCP for triage and decontamination in a drill.
Probst, 2008[118]	Optimize resource use	Cemical, explosive	Provider coordination	Medical Rescue Task Force that combines hospital rescue and ambulance staff to support care at an initial care hospital	In the course of three separate exercises, the protocol was shown to be highly efficient.
Roth, 2009[126]	Optimize resource use	All-hazards	Information technology	Web based healthcare related all hazards electronic disaster manangement system (simulation)	Describes the tool and its potential uses.

Appendix Table C-5. Tested Strategies Lacking Comparisons Groups (KQ2)

Author, Year	Strategy	Mass Casualty Context	Innovation	Description	Results
Urban, 2007[127]	Optimize resource use	All-hazards	Information technology	Automated call-down system to mobilize staff during MCE	In two tests, up to 50% of all workers could be reached (up to 18% could report in under 30 minutes; up to 32% could report within 60 minutes). Among trauma room team members, up to 53% could be reached (up to 21% could report in under 30 minutes; up to 36% could report within 60 minutes).
Young, 2006[124]	Optimize resource use	Infectious disease	Information technology	Web-based triage tool for bioterror or ID outbreak (simulation)	Safely reduces the number of clinical positions in managing the Point-of-Dispensing (POD).
Zhao, 2006[119]	Optimize resource use	All-hazards	Information technology	Use of a portable tool by first responders in documenting and communicating triage of victims (e.g. TACIT software) (simulation)	Two field trials verified that a portable tool could efficiently work in prehospital response e.g. reduced triage collection time, improved collection accuracy.
Albanese, 2007[153]	Augment resources	Radiological	Load sharing	Establisment of a Biodosimetry Laboratory in Connecticut for surge capacity	Identified 30 of 32 labs qualified and willing to perform initial biodosimetry processing. Additionally a functional exercise involving a subset of these labs and their technicians was conducted with promising feedback.
Baldwin, 2006[143]	Augment resources	Hurricane	Mass transfer	Can the mass interstate transfer of pediatric patients be accomplished during a hurricane? (acutal event)	Despite successful interstate transfer of pediatric patients, there remains a need for planned regionalization of children's services.
Barillo, 2010[137]	Augment resources	Burns	Response teams	Use of Special Medical Augmentation Response Teams-Burn for rapid ICU expansion (actual event)	Description of a method for and lessons learned from creating a temporary burn center
Björnsson, 2008[140]	Augment resources	Tsunami	Mass transfer	Conversion of a charter plane to mass transport patients (actual event)	Alterations of a Boeing 757-300 in 2 days to accommodate 18 patients on stretchers and 78 seated passengers was deemed a success with regard to safe transport from Thailand to Sweden.
Chen, 2009[141]	Augment resources	Earthquake	Mass transfer	Trans-province transfer of patients (China - actual event)	Successful trans-province transfer of 10,373 patients (no casualties)
Chung, 2011[139]	Augment resources	All-hazards	Load sharing	Use of pediatric alternate care site during 2009 H1N1 pandemic	On the days the ASC was open, the mean ED volume was 42% greater than the baseline rate for the same period in the prior year. There were no adverse reports concerning the ASC filed, and none of the patients who returned for evaluation within 72 hours were admitted to the hospital.
Cryer, 2009[144]	Augment resources	All-hazards	Load sharing	Use of a trauma system structure during multicasualty events (actual events)	The Medical Alert Center for Los Angeles County can coordinate the distribution of casualties among the hospitals serving the region (e.g. most critical patients triaged to level 1 centers)
ECRI Institute, 2009[132]	Augment resources	All-hazards	Mechanical ventilation	Use of automatic gas-powered resuscitators (AGPRs) for respiratory support in MCI as an alternative to ventilators	AGPRs do not have all features needed for full respiratory support. Usefulness and limitations of APGRS discussed
ECRI Institute,2008[133]	Augment resources	All-hazards	Mechanical ventilation	Use of automatic gas-powered resuscitators (AGPRs)for respiratory support in MCI as an alternative to ventilators (simulation)	Conclude that the respiratory needs of most pt in a MCI will exceed what AGPRs can provide.

Appendix Table C-5. Tested Strategies Lacking Comparisons Groups (KQ2)

Author, Year	Strategy	Mass Casualty Context	Innovation	Description	Results
Epstein, 2010[151]	Augment resources	All-hazards	Communications	Text messages for staff recall (simulation)	Successful test of system to rapidly mobilize staff. Text messaging is simple, inexpensive, and easy to implement
Fuzak, 2010[142]	Augment resources	All-hazards	Mass transfer	Mass inpatient pediatric transfer using parallel circuits - actual event (nondisaster)	Successful transfer of 111 pediatric pts (64 critical) with no adverse outcomes. Describe pediatric considerations and equipment, lessons learned
Gao, 2008[149]	Augment resources	All-hazards	Information technology	Use of miTag (medical information tag) to track patients throughout the disaster response process (simulation)	Two separate pilots demonstrated feasibility of the miTag in terms of increasing patient care capacity in the field as well as successful transfer of information within radio-interference-rich settings.
Hamilton, 2003[146]	Augment resources	All-hazards	Information technology	Institute a Web based tool - a mass casualty tracking system- to help reduce the amount of confusion at a MCI (simulation)	The alpha test of the Emergency Patient Tracking System (EPTS) demonstrated that it is possible to coordinate efforts and reduce confusion during MCIs.
Hammer, 1996[154]	Augment resources	All-hazards	Devices	Use of unilateral external fixation device for stabilization prior to major surgery	The device allowed soft tissue recovery in nearly all cases.
Hanley, 2008[136]	Augment resources	All-hazards	Mechanical ventilation and cross-training	Implementing a program that trains non-respiratory therapists to assist in providing mechanical ventilation (Project XTREME (Cross-training Respiratory Extenders for Medical Emergencies))	Pilot testing of Project XTREME demonstrated that evaluated individuals could successfully complete training based on cognitive and performance scores.
Jacobs, 2006[145]	Augment resources	Explosive	Information technology	Web application designed to be the primary communication and resource management tool during a terrorist event or public health emergency (simulation)	State of CT participated in a DHS exercise. The web application was successfully implemented to assess surge capacity and other resources.
Killeen, 2006[147]	Augment resources	All-hazards	Information technology	Wireless handheld device with an electronic medical record (EMR) for use by rescuers responding to MCEs (simulation)	Records real-time data electronically for simultaneous access by providers and incident command.
Körner, 2010[152]	Augment resources	All-hazards	Communications	Use of electronic call down system for radiology staff during an MCE	Successul test of system. Automated alarm procedure might be helpful and testing allows for estimation of the manpower reserve and calculation of maximum service capacities.
Lin, 2009[135]	Augment resources	All-hazards	Mechanical ventilation and cross-training	Bag-valve-mask technique training for medical students ias an alternative to mechanical ventilation	The majority of students (93%) knew proper head positioning technique in non-trauma cases after a 30 minute didactic session. All 31 students completed and passed the competency checklist.
Little, 2009[134]	Augment resources	Infectious Disease	Oxygen delivery	Method of providing an improvised oxygen delivery system (simulation)	An improvised system to deliver oxygen in the event of a disaster can be easily assembled and is both feasible and functional.
Lucas da Silva, 2008[150]	Augment resources	All-hazards	Information technology	Use of pervasive computing technology to non-obtrusively capture contextual information	Describes the concept of the technology, but prototype has not been built or tested.
Mead, 2004[156]	Augment resources	Infectious Disease	Infection control	Method to establish airborne infection isolation areas using a	The best-performing designs showed no measurable source migration out of the inner isolation zone. The cost of constructing the filtration unit was

Appendix Table C-5. Tested Strategies Lacking Comparisons Groups (KQ2)

Author, Year	Strategy	Mass Casualty Context	Innovation	Description	Results
				commercially available portable filtration unit and common hardware supplies	less than US$2,300 and required fewer than 3 person-hours to construct.
Neyman, 2006[129]	Augment resources	All-hazards	Mechanical ventilation	Simulation study to determine if one ventilator could be modified to provide mechanical ventialtion for four adults simultaneously (simulation)	Single ventilator could sustain four 70-kg individuals for a limited duration.
Noordergraaf, 1996[148]	Augment resources	All-hazards	Information technology	Use barcoded identifiers to represent patients, injuries, facilities, and locations (simulation)	Minimized errors and made exchange of data possible. The system communicates with the permanent hospital information system. Extensive training to use the tool was shown to be unnecessary.
Paladino, 2008[130]	Augment resources	All-hazards	Mechanical ventilation	4-limbed ventilator circuit connected in parallel (simulation)	Successful oxygenation and ventilation of 4 sheep with a single vent.
Rosenbaum, 2004[155]	Augment resources	Infectious disease	Re-purpose space	Conversion of existing space to create a negative-pressure room for respiratory isolation (simulation)	Use of portable HEPA filtered forced air was successful in establishing an operational negative-pressure room.
Sandlin, 2009[51]	Augment resources	Chemical	Information technology	Use of a customized laboratory information system (LIMS), the Emergency Response Management System (ERMS), at the Centers for Disease Control and Prevention (CDC) for rapid analysis of clinical samples (e.g. chemical warfare agents) and reporting of this data	A customized LIMS was developed to support emergency response laboratory activities at the CDC among all users.
Voelker, 2006[138]	Augment resources	All-hazards	Capacity augmentation	Fully equipped mobile surgical hospital (MED-1)	The hospital treated 350 patients per day during Hurricane Katrina.
Williams, 2010[131]	Augment resources	Infectious Disease	Mechanical ventilation	Use of a low oxygen consumption pneumatic ventilator for emergency construction (simulation)	Three prototypes demonstrated acceptable performance in a test lung model with regard to compliance and rate settings.
Ytzhak, 2012[157]	Crisis standards of care	Infectious disease	Triage tool	Application of a decision support tool previously developed for ventilator allocation during an influenza pandemic to evaluate ventilator allocation decisions during the Haitian Earthquake of 2010.	Decision support tool appeared to be a useful tool in the allocation of ventilators by basing decisions on three dimensions.

Appendix Table C-6. Proposed strategies to allocate scarce resources during mass casualty events (KQ2)

Author, Year	Organization, Task Force, or Panel	Title of Report or Article	Proposed Strategy
Altevogt, 2009[13]	Institute of Medicine	Guidance for Establishing Crisis Standards of Care for Use in Disaster Situations: A Letter Report	The IOM committee was convened to develop guidance that state and local public health officials and health-sector agencies and institutions can use to establish and implement standards of care to be applied in disaster situations. The committee recommended the development of consistent state crisis standards of care protocols with five key elements: 1) A strong ethical grounding; 2) Integrated and ongoing community and provider engagement, education, and communication; 3) Assurances regarding legal authority and environment; 4) Clear indicators, triggers, and lines of responsibility; and 5) Evidence-based clinical processes and operations. Recommendations on specific implementation strategies included: 1) Using "clinical care committees," "triage teams," and a state-level "disaster medical advisory committee" that will evaluate evidence-based, peer-reviewed critical care and other decision tools and recommend and implement decision-making algorithms to be used when specific life-sustaining resources become scarce; 2) Providing palliative care services for all patients; 3) Mobilizing mental health resources to help communities and providers; 4) Developing specific response measures for vulnerable populations and those with medical special needs; and 5) Implementing robust situational awareness capabilities to allow for real-time information sharing.
ATS Board of Directors, 1997[168]	American Thoracic Society Bioethics Task Force	Fair allocation of intensive care unit resources	One of the aims of the task force was to provide guidelines defining ethically appropriate and inappropriate criteria for admitting and discharging ICU patients and for the use of scarce resources in the ICU. The Task Force determined that patients meeting thresholds for medical need and benefit should be admitted on a first-come, first-served basis. Similarly, patients who continue to meet criteria for medical need and benefit should continue to receive ICU care. They should not be discharged prematurely with medical care inadequate for their needs in order to make room for a new ICU admission with even greater potential benefit. The Task Force considered it an error to use ICU prognostic systems *alone* to deny ICU admission. Criteria for use and discontinuation of a specific scarce resource were analogous to those for ICU admission and discharge based on thresholds of sufficient medical need and potential benefit and should be offered on a first-come, first-served basis.
Bone, 1994[167]	Society of Critical Care Medicine Ethics Committee	Consensus statement on the triage of critically ill patients	In general, patients with good prognoses for recovery have priority over patients with poor prognoses. While uncertainty of prognosis is a crucial problem in critical care, providers should utilize predictive instruments with a full understanding of their strengths and limitations. Decisions to be made between patients with equivalent prognoses should be made on a first come, first served basis. Factors that should be considered are: 1) likelihood of a successful outcome; 2) patient's life expectancy due to disease(s); 3) anticipated quality of life of the patient; 4) wishes of the patient and/or surrogate; 5) burdens for those affected, including financial and psychological costs and missed opportunities to treat other patients; 6) health and other needs of the community; and 7) individual and institutional moral and religious values.
Bradt, 2009[170]	Australasian College for Emergency Medicine Disaster Medicine Subcommittee	Emergency Department Surge Capacity: Recommendations of the Australasian Surge Strategy Working Group	Proposed strategies to guide surge management in the Emergency Department (ED). Proposed strategies include dealing with space, staffing, supplies and equipment, and flow both preceding and during surge conditions. For example, recommendations relating to actual surge conditions in each category include: maximizing cohort care and minimizing one-on-one care (space), requesting surgical and critical care liaison points in ED (staffing); having a team member dedicated to restocking supplies in main cohort areas, allowing staff in these areas to maintain clinical roles (supplies and equipment), and considering the use of Focused Assessment with Sonogram in Trauma (FAST) to assist early disposition. A total of 22 specific strategies are proposed to optimize the use of resources prior to a mass casualty event, and 10 specific strategies are proposed for implementation during a mass casualty event.
Chapman, 2008[172]	Center for Disease Control and Prevention	Post-exposure interventions to prevent infection with HBV, HCV, or HIV, and tetanus in people wounded during	Recommendations on the use of immunization and post-exposure prophylaxis for tetanus and occupational and nonoccupational exposures to bloodborne pathogens in mass casualty events. Pathogens considered include Hepatitis B virus, Hepatitis C virus, and HIV. Recommended interventions are tailored to risk category (penetrating injuries vs. mucous membrane exposure vs. superficial exposure). Recommendations do not directly address altered standards of care when vaccines are in short supply. Local authorities are directed to rely on local and state health departments, mutual aid agreements, and commercial vendors, and if necessary work with CDC to make up for shortfalls

Appendix Table C-6. Proposed strategies to allocate scarce resources during mass casualty events (KQ2)

Author, Year	Organization, Task Force, or Panel	Title of Report or Article	Proposed Strategy
		bombings and other mass casualty events	
Christian, 2011[165]	Task Force for Pediatric Emergency Mass Critical Care	Treatment and Triage recommendations for pediatric emergency mass critical care	The Task Force proposed minimum resource requirements for pediatric emergency mass critical care (PEMCC), which are largely consistent with those developed by the adult task force on emergency mass critical care[161-163]. The Task Force also developed specific recommendations for non-pediatric hospitals, including a recommendation that adult ICUs should keep adolescent patients without consultation (and patients aged 5-8 years following after consulting with pediatrics). The Task Force was unable to recommend a pediatric prognostic scoring system to triage pediatric victims of MCEs due to the poor performance of existing systems. Moreover, the Task Force declined to endorse exclusion criteria for the use of life support based on patients' pre-existing conditions despite the fact that other groups have proposed such criteria. The Task Force was also unable to develop recommendations on criteria for withdrawing life support for pediatric patients during MCEs. Finally, the Task Force called for the development of a triage protocol that not only took into account a patient's likelihood of survival but also the likelihood that a patient would require a prolonged ICU stay. (This latter point is a notable difference from the adult recommendations that did not consider prolonged use of ICU resources).
Christian, 2010[169]	European Society of Intensive Care Medicine's Task Force for Intensive Care Unit Triage during an Influenza Epidemic or Mass Disaster	Chapter 7. Critical care triage	Proposed elements of a standard operating procedure for providing critical care services during a mass casualty events, including: implementation of central triage committee integrated within incident management structure, clear lines of authority for all relevant actors, allocation of ICU care by triage officers according to inclusion/exclusion criteria, basis on which to reassess triage categories, medical record documentation criteria, and recommended components of triage officer training.
Devereaux, 2008[163]	Task Force for Mass Critical Care Working Group	Definitive Care for the Critically Ill During a Disaster: A Framework for Allocation of Scarce Resources in Mass Critical Care	The Task Force presents a framework for resource allocation during MCEs that included inclusion criteria for the receipt of medical or palliative care. The inclusion criteria recommended by the Task Force are based on those developed by Christian et al.[164], and recommended exclusion criteria take into account both the Sequential Organ Failure Assessment (SOFA) score and a patient's chronic illnesses. The Task Force proposed a SOFA score cutoff that correspond to an 80% risk of mortality. The Task Force enumerated the chronic illnesses that should be used as exclusion criteria. The Task Force recommends prioritizing patients in the order of their latest SOFA score and daily SOFA trend. The Task Force describes the recommended responsibilities of the triage officer and the recommended composition of the triage team (a critical care nurse, respiratory therapist, and/or clinical pharmacist).
Lerner, 2011[160]	Work group convened by the National Association of EMS Physicians (2006), and subsequently augmented	Mass Casualty Triage: An Evaluation of the Science and Refinement of a National Guideline	Aside from recommending conventional triage categories, the workgroup proposed criteria for the use of lifesaving interventions, defined as: controlling life-threatening external hemorrhage, opening the airway using basic maneuvers (for an apneic child, consider 2 rescue breaths), performing chest decompression, and providing autoinjector antidotes. The workgroup determined that lifesaving interventions should be performed only if the equipment is readily available, the intervention is within the provider's scope of practice, the intervention can be performed quickly (ie, in less than 1 min), and the intervention does not require the provider to stay with the patient. The workgroup also made recommendations for individual assessment during field triage, including: 1) refraining from the use of counting or timing vital signs and instead using yes–or-no criteria; 2) avoiding the use of diagnostic equipment for initial assessment; 3) refraining from the use of capillary refill as a sole indicator of peripheral perfusion; and 4) classifying patients who are not breathing after 1 attempt to open their airway (in children, 2 rescue breaths may also be given) as dead and visually identifying them as such. The workgroup also delineated specific criteria for each of 5 triage categories.
Lyznicki, 2007[174]	American Medical Association and American Public Health Association	Improving health system preparedness for terrorism and mass casualty events.	One of eight priority areas dealt with expanding health system surge capacity. Specific recommendations included: funding IOM to conduct additional studies and to make recommendations; development and dissemination of model plans and strategies; development of inventories of community surge capacity assets; stimulate growth of volunteer emergency response teams; and ensuring that local emergency response plans provide appropriate distribution of patients across facilities.

Appendix Table C-6. Proposed strategies to allocate scarce resources during mass casualty events (KQ2)

Author, Year	Organization, Task Force, or Panel	Title of Report or Article	Proposed Strategy
		Recommendations for action	
No Author, 2010[171]	Centers for Disease Control and Prevention	In A Moment's Notice: Surge Capacity for Terrorist Bombings	Proposed strategies to accommodate surge following terrorist activities using templates tailored to disciplines to address known challenges associated with surge capacity. Templates were created for EMS, ED Departments, Surgical Departments, ICU, Radiology, blood banks, hospitalists, administration, pharmaceuticals, and nursing care.
No Author, 2008[158] Lerner, 2008[159]	American College of Emergency Physicians, American Trauma Society, State and Territorial Injury Prevention Directors Association	Mass Casualty Triage: An evaluation of the Data and Development of a Proposed National Guideline	Proposed triage strategy known as SALT (Sort-Assess-Lifesaving Interventions-Treatment and/or transport), to serve as national all-hazards mass casualty initial triage standard for all patients. SALT begins with a global sorting of patients for prioritization of treatment based on ability to walk, follow commands or move. The next stage, assess, involves limited life-saving interventions such as controlling hemorrhages or opening airways. Patients are then prioritized for treatment and/or transport based on an assignment to one of 5 categories: immediate, expectant, delayed, minimal and dead. The prioritization process is dynamic and condition-specific.
Rubinson, 2008[162]	Task Force for Mass Critical Care Working Group	Definitive Care for the Critically Ill During a Disaster: A Framework for Optimizing Critical Care Surge Capacity	The Task Force proposed a bundle of 7 services that comprise emergency mass critical care (EMCC). Each of these services does not require expensive equipment and can be implemented without consuming extensive staff or hospital resources. The Task Force also developed a framework for optimizing surge capacity that includes various activites along a continuum from minimal patient need to overwhelming patient need and consists of 5 major types of activities: substitution, adaptation, conservation, reuse, and reallocation. The Task Force provided examples of each. The Task Force also adopted a multi-tiered critical care surge capacity framework that delineated specific triggers for escalation to higher tiers.
Rubinson, 2008[161]	Task Force for Mass Critical Care Working Group	Definitive Care for the Critically Ill During a Disaster: Medical Resources for Surge Capacity	The Task Force developed recommendations on the use of equipment and space for creating surge capacity during MCEs. Specifically, the Task Force recommends the use of one mechanical ventilator per patient (rather than the use of a multiple-limb ventilator circuit). It also produced a list of ideal characteristics for stockpiled surge mechanical ventilators, recommended equipment for surge PPV, and recommended non-respiratory medical equipment. The Task Force also recommended (in order) the following treatment spaces after ICUs, post-anesthesia care units, and emergency departments have reached capacity: 1) intermediate care units, step-down units, and large procedure suites; 2) telemetry units; and 3) hospital wards. The Task Force strongly discouraged the use of nonmedical facilities to serve as alternate care sites. Finally, the Task Force endorsed a collaborative team model for staffing during critical care surge.
Rubinson, 2005[166]	Working group on Emergency Mass Critical Care	Augmentation of hospital critical care capacity after bioterrorist attacks or epidemics	The Work group recommends that triage decisions regarding the provision of critical care should be guided by the principle of seeking to help the greatest number of people survive the crisis. This would include patients already receiving ICU care who are not casualties of an attack.
Taylor, 2010[173]	European Society of Intensive Care Medicine's Task Force for Intensive Care Unit Triage	Chapter 6. Protection of patients and staff during a pandemic	Recommendations and standard operating procedures to protect patients and staff during a pandemic or mass casualty event. Key recommendations include (1) preparing infection control and occupational health policies for clinical risks relating to potential disease transmission; (2) decreasing clinical risks and provide adequate facilities through advanced planning to maximize capacity by increasing essential equipment, drugs, supplies and encouraging staff availability; (3) creating robust systems to maintain staff confidence and safety by minimizing non-clinical risks and maintaining or escalating essential services; (4) preparing formal reassurance plans for legal protection; (5) providing assistance to staff working outside their normal domains.

Appendix Table C-7. Public perceptions and concerns about allocating scarce resources during mass casualty events (KQ3)

Author, Year	Type of Study	Objective *(Type of MCE)*	Study Location	Population Characteristics (n = sample size)	Key Findings	Quality Score (of 7)
Bailey, 2011 [181]	Web-based survey	To investigate the views of students and staff at the university on the allocation of scarce resources during an influenza pandemic *(pandemic influenza)*	Edmonton, Canada	Students and staff at University of Alberta; 70% females (n = 5,220)	*Resource Allocation Policy:* 1. The goals of the allocation system include: save the most lives, follow a ranking system, and save those most likely to die, with most respondents supporting "save the most lives". *Priority Criteria:* 1. Most respondents gave the highest priority to health care workers and emergency workers , followed by children; 2. Lower priority was given to politicians; 3. "First come, first served" was least preferred.	5
Braunack-Mayer, 2010 [176]	Deliberative forum	To elucidate informed community perspectives on the allocation of scarce pharmaceuticals in a pandemic *(pandemic influenza)*	Adelaide, Australia	6 females (n = 9)	*Resource Allocation Policy:* 1. Preserving society in the long run, rather than saving the most lives, was the goal if forced to choose between the two. *Priority Criteria:* 1. Priorities should be given to the following potential recipients in the order of: health care workers, researchers and laboratory staff dealing with pandemic influenza, essential services (water, power, waste, etc.), and military; 2. The elderly and the chronically ill were explicitly excluded from the list of potential recipients.	3
de Carvalho Fortes, 2002[183]	Interview-based survey	To explore the public's views regarding priorities for allocating scarce resources during surge/emergencies	São Paulo, Brazil	Persons visiting patients in one public hospital n=395; 147 male, 248 female	Majority of survey respondents accept social values driving decisions regarding allocation of scarce resources, largely based on justice, equity, and priority for the most vulnerable Examples: In hypothetical scenarios, majority favored scarce resources for a 7-yr old over 65-yr old; 7-yr old over 1-yr old; 65-yr old over 25-yr old males; mother of more children over mother of fewer children; married female over single female; out-of-town male over male resident; poor female over rich female; unemployed over employed person	5

Appendix Table C-7. Public perceptions and concerns about allocating scarce resources during mass casualty events (KQ3)

Author, Year	Type of Study	Objective *(Type of MCE)*	Study Location	Population Characteristics (n = sample size)	Key Findings	Quality Score (of 7)
Docter, 2011 [175]	Deliberative forum	To test how the resource allocation plan of the Australian government (for antiviral drugs and vaccines) corresponds with community views about the priority groups in a severe pandemic *(pandemic influenza)*	Adelaide, Australia	Participants in the age group 20 - 29 were absent; oversampling of female members (n < 12)	*Resource Allocation Policy:* 1. A committee consisting of a variety of experts and policy makers, but not politicians, should make allocation decisions. They are essential for the fair and effective allocation of scarce resources. *Priority Criteria:* 1. Both antiviral drugs and vaccines were allocated to groups in the following order: primary health-care workers, viral and vaccine researchers and workers, essential workers and military; 2. Lowest priority groups include: political decision makers; elderly, chronically ill and disabled people were excluded.	4
Poll, 2010 [177]	Telephone survey	To understand the public's opinion about prioritizing children's needs in disaster planning and response *(disaster – unspecified)*	United States	U.S. residents (n = 1,030)	*Resource Allocation Policy:* 1. The same medical treatments currently available for adults should also be readily available for children . *Priority Criteria:* 1. If resources are limited and tough decisions must be made, children should be given a higher priority for life-saving treatments rather than adults with the same medical condition.	2
PEPPPI, 2005 [178]	Deliberation meeting and feedback session	To pilot test a new model for engaging citizens on vaccine related policy decisions when supplies of vaccine are limited and scarce resources need to be allocated efficiently in a severe pandemic *(pandemic influenza)*	GA (Atlanta), MA, NE, OR	Adults aged 18-78; a larger proportion of participants aged 55-64; more females, more participants with higher education (n = 250)	*Resource Allocation Policy:* 1. The goals of the allocation system should be 1) assuring the functioning of society using the minimum number of vaccine doses, and 2) reducing the individual deaths and hospitalizations due to influenza (protecting those who are vulnerable and at risk); 2. Transparency and open communication are key to ensure the fairness and trust essential to the plan's success; 3. The federal government role should be providing broad guidance; responsibility for more specific interpretation and implementation should remain with state and local health authorities; 4. Public health experts rather than political appointees should make the vaccine priority decisions. *Priority Criteria:* 1. Top priorities should be given to society's caretakers and persons at high risk; 2. Little support for giving priorities to young people, using a lottery system, or "first come, first served".	5

Appendix Table C-7. Public perceptions and concerns about allocating scarce resources during mass casualty events (KQ3)

Author, Year	**Type of Study**	**Objective *(Type of MCE)***	**Study Location**	**Population Characteristics (n = sample size)**	**Key Findings**	**Quality Score (of 7)**
Public Engagement Project, 2009 [180]	Public engagement forum	To better understand the public's values and priorities regarding the delivery of medical services during a severe influenza pandemic *(pandemic influenza)*	WA (Seattle / King County)	70% females; 2/3 Whites; diverse age span and education level; large number of participants living near poverty line (n = 123)	*Resource Allocation Policy:* 1. Altered decision-making processes and protocols will be required to determine allocation of scarce medical resources during an influenza pandemic; 2. The system should be relatively simple to support successful implementation and administration but should be consistent at state or national level; 3. Guidelines should allow some flexibility to facilities; 4. The goals of the allocation decisions should be 1) treat as many people as possible even if it means compromised standard of care; 2) The prioritization system should be fair and accessible to all people. *Priority Criteria:* 1. Priority treatment should be given to health care providers and first responders; 2. Children and pregnant women should receive some priority when all other factors are equal; 3. Survivability is a priority treatment consideration; 4. Strategies rejected: "first come, first served", randomization, ability to pay, strategies that discriminate according to race, gender, culture, legal status, nationality, or language. *Other:* 1. Decisions for withdrawing life-saving care should be made by the patient or patient's family with input from a doctor or health care provider.	5

Appendix Table C-7. Public perceptions and concerns about allocating scarce resources during mass casualty events (KQ3)

Author, Year	**Type of Study**	**Objective *(Type of MCE)***	**Study Location**	**Population Characteristics (n = sample size)**	**Key Findings**	**Quality Score (of 7)**
SSA Consultants, 2011[184]	Deliberative forum with exercises and consensus development	To better understand the public's values, beliefs, and opinions regarding the implementation of crisis standards of care	Baton Rouge, LA and Shreveport, LA	Age 20-69; 68% female; 63% Caucasian, 33% African-American	Highest priorities: 1. First responders (fire fighters, police, ambulance workers) should have priority for medical care because they are important to everyone's safety. 2. Saving the greatest number of people, even if it means that some people aren't going to be treated and will die. 3. Give priority for medical care to patients with the best chance of survival. Otherwise, it's not the best use of resources. 4. Doctors, nurses, and medical workers should have priority for medical care because they can help everyone else when they recover. 5. It's a better use of medical resources to help the most people even if we can't give the same level of care as we could in non-emergencies. Lowest priorities: 1. People without transportation should be given priority for medical care. It may take them a lot longer just to get to the hospital and then they will be at the end of the line. 2. People who do not speak English very well have greater difficulty accessing the health care system so they should be given priority for medical care. 3. People should be given medical care on a first come, first serve basis. People should be treated in the order they arrive in the hospital. 4. People who can afford to pay should be given priority for medical care. 5. Patients should be randomly selected for medical care because it is too difficult to figure out a way to give anyone priority. Findings were remarkably similar to similar exercises performed in Seattle, particularly: • Providing treatment to the most numbers of people • Survivability criterion • Prioritization of first responders • Rejection of first come, first served, randomization, ability to pay.	2
Vawter, 2011[182]	Community forum, small group discussion, solicitation of written comments	To solicit broader public input on rationing scarce health resources in Minnesota in a severe influenza pandemic, with a particular focus on attending to the needs of the socially vulnerable when rationing resources	Minnesota, United States	Not stated. Referred to other document for details	Resource allocation policy: • Ensure that health disparities are not exacerbated. • Protect the population's health • Protect public safety and social order Rationing: • Do not ration on the basis of race, ethnicity, income, geography, or first-come first-served. • Do not prioritize based on differences in social vulnerability.	3

Appendix Table C-7. Public perceptions and concerns about allocating scarce resources during mass casualty events (KQ3)

Author, Year	**Type of Study**	**Objective** ***(Type of MCE)***	**Study Location**	**Population Characteristics (n = sample size)**	**Key Findings**	**Quality Score (of 7)**
Vawter, 2010 [179]	Community forum, small group discussion, solicitation of written comments	To solicit broader public input on rationing scarce health resources in Minnesota in a severe influenza pandemic *(pandemic influenza)*	MN	66% females, 9% Hispanic/Latino, 82% White (n = 441)	*Resource Allocation Policy:* 1. Three objectives should be balanced when rationing health care resources allocation: 1) reduce deaths, 2) treat people fairly, and 3) protect public health and infrastructure; 2. Transparency and public education are important to ensure fairness. *Priority Criteria:* 1. Priority rationing should not be based on gender, race, ability to pay, or first-come first served; 2. A large majority supported age-based rationing and prioritized children and young adults before seniors; seniors over age 85 were de-prioritized by some; 3. It is important to pay attention to the needs of vulnerable populations.	3

Appendix Table C-8. Strategies to engage providers in allocating scarce resources during mass casualty events (KQ4)

Author, Year	Leader of Engagement	Study Location	Study design	Type of mass casualty event	Engagement Strategy	Who Engaged Whom	Findings (Outcome)	Outcome Modulators (Facilitators or Barriers)	Quality score (of 4)
Albanese, 2007[153]	Providers	CT (state level)	Observational, 2 post-tests	Radiological, nuclear	Enrollment, education, training and exercise of qualified laboratory staff for preparing biodosimetry specimens (to test radiation exposure)	State biodosimetry laboratory *engaged* hospital and commercial laboratories statewide	Augmentation of critical laboratory capacity, skills retained 6 months after training (functional drill): 30 of 33 labs were qualified; Staff in 30 labs were trained 22 of 30 labs volunteered to participate in surge network 79 personnel trained to date in 19 of these labs 37 participated in drill: (a) every specimen met standards; (b) average turnaround time (specimen preparation) = 199 minutes	*Facilitators:* most laboratories were already qualified because of existing equipment; education allayed safety concerns *Barrier:* Many laboratories had safety concerns (before training)	4
Dayton, 2008[193]	Providers	Central Brooklyn, NY	Descriptive – surge plan development	All-hazards	Organization of de novo regional hospital planning group and cooperative hospital level surge planning for central Brooklyn	Hospitals *engaged* city PH to develop planning group; new hospital consortium organization *engaged* individual hospitals	De novo planning group created; surge space/beds designated at each hospital to meet regional needs (+22% beds: 987 baseline to 1207 surge); protocol for notification and plan activation developed	*Facilitators:* Willingness of hospitals to plan cooperatively; national standards provided planning target	4

Appendix Table C-8. Strategies to engage providers in allocating scarce resources during mass casualty events (KQ4)

Author, Year	Leader of Engagement	Study Location	Study design	Type of mass casualty event	Engagement Strategy	Who Engaged Whom	Findings (Outcome)	Outcome Modulators (Facilitators or Barriers)	Quality score (of 4)
Grier, 2006[186]	Providers, Policy makers	CA, FL, IL, OR, LA, MO (state level in each)	Case studies – planning process	Unspecified	1. Top-down county planning model, master Mutual Aid Agreement (CA, IL) 2. Decentralized regional planning (FL, LA) 3. Decentralized rural planning (OR) 4. Hospital-directed tiered regional planning model (IL, LA, MO) 5. Third-party directed planning model (MO)	1. State PH *engaged* local PH, hospitals 2. Hospitals, state hospital association *engaged* hospitals 3. Regional medical center *engaged* hospitals 4. Designated regional hospital *engaged* hospitals 5. State PH and designated hospital *engaged* hospitals	Multiple surge capacity planning models based on plans in 8 localities in 6 different US states	*Facilitators:* Planning centered on hospitals (no major mix of organizational cultures); third-party-directed planning model minimized competition among hospitals *Barriers:* Culture differences between PH and hospitals, competition among hospitals	4
Kanter, 2009[189]	Providers	US (experts drawn from different states)	Descriptive – planning process	Unspecified	Systematic development of consensus on appropriate pediatric crisis standards of care through modified Delphi process involving hospital pediatricians	Hospital pediatric leaders *engaged* other acute care hospital-based pediatricians	Consensus on non-ICU interventions but not on ICU interventions	*Facilitators:* Structured process, conducted via email (cheap, efficient), anonymity of experts, flexible approach, use of established scoring system as endpoints *Barriers:* No face-to-face discussion among experts, no full consensus on some elements, need to coordinate with government regulations potentially over-rides expert consensus	3
Kelen, 2006[191]	Providers	MD	Descriptive – planning process	Unspecified	Development of evidence-based “reverse triage” classification system through systematic expert consensus process using formally-defined real-time anonymous virtual network	Academic medical center leaders *engaged* 39 clinician and non-clinician experts	Evidence-based 5-category patient classification system based on agreed-upon risk tolerance levels	*Barriers:* absence of evidence that expert opinion-based system would result in safe practice; did not include experts from broad range of hospital types	4

Appendix Table C-8. Strategies to engage providers in allocating scarce resources during mass casualty events (KQ4)

Author, Year	Leader of Engagement	Study Location	Study design	Type of mass casualty event	Engagement Strategy	Who Engaged Whom	Findings (Outcome)	Outcome Modulators (Facilitators or Barriers)	Quality score (of 4)
Lurie, 2008[194]	Providers	2 US localities and 3 regions (not specified)	Tabletop exercises	Pandemic influenza	Pilot testing of local, regional and national level tabletop exercises for the Veterans Health Administration (VHA)	Central federal health provider agency (VHA) *engaged* local and regional VA hospitals and non-hospital facilities, local hospitals, state and local PH and local first responders	Tested tabletop exercise templates for local and regional use by VA system, engaging government and public and private providers	*Facilitators:* ability to share and use exercise templates across VA system nationwide, VA engagement with local communities, mutual respect between local VA providers and their communities, integrated VA health system with electronic health records and hotlines enable patient flow management Barriers: unclear who decides on resource sharing between VA and local facilities, different levels of care between VA and local hospitals, organizational culture differences between VA and local providers (command vs. collaboration)	4
Terriff, 2001[192]	Providers	Spokane, WA (regional level)	Descriptive – planning, tabletop exercise	Biological	Pharmacy-led development of regional pharmaceutical preparedness policies and procedures (protocol) for response to BT event -- pre-911	Hospital pharmacy department, county EMS and Army *engaged* first responders, hospitals, non-hospital facilities, FEMA, USPHS, FBI, and state PH	Technical documentation & city-wide policy and protocol for medical management of BT (obtaining antidotes), including plan for local stockpiles, resource sharing across region (city)	*Facilitator:* Initiative of pharmacy department in one hospital and interest of all participants in city-wide planning	4

Appendix Table C-8. Strategies to engage providers in allocating scarce resources during mass casualty events (KQ4)

Author, Year	Leader of Engagement	Study Location	Study design	Type of mass casualty event	Engagement Strategy	Who Engaged Whom	Findings (Outcome)	Outcome Modulators (Facilitators or Barriers)	Quality score (of 4)
Buehler, 2006[187]	Policy makers	GA (metro-politan level)	Descriptive -- case study of operational partnership	Unspecified	Public health-business partnership for mass dispensing	State and local PH and voluntary business coalition *engaged* local PH, schools, businesses	1200 business volunteers participated in 3 mass dispensing drills at public and business sites	*Facilitators:* Personal relationships, business commitment to service, strategic engagement by senior business and government officials, business model, conceptual link between business and community continuity, links to multiple government agencies *Barriers:* government procurement regulations; potential shifts in government priorities; different management styles; occasional government disorganization; confidentiality of proprietary information; liability; ongoing differences in perspective	4
Dausey, 2006[195]	Policy makers	Three US metropolitan areas (not specified)	Tabletop exercises	Pandemic influenza	Development and pilot testing of tabletop exercise template for local level governments and providers	State PH and RAND *engaged* local PH & elected officials, hospitals and private practitioners, law enforcement	Tested tabletop exercise template applicable to localities across the U.S.	*Facilitators:* Excellence of technical partner, willingness of participants	4
Ginter, 2010[188]	Policy makers	AL, MI, FL, LA, TN	Descriptive – planning process	All-hazards (“natural and manmade”)	Organization of five neighboring states into a voluntary disaster pediatric surge network	2 state PH and regional PH preparedness center *engaged* pediatric hospitals and major clinics, state PH, and emergency responders	Established pediatric surge network, operational handbook, formal MOU	*Facilitators:* “Highly-reliable organization” model previously established and adaptable to surge network development *Barriers:* Planning process is time-consuming (5 yrs), inter-state agreements are more complicated than intra-state ones	4

Appendix Table C-8. Strategies to engage providers in allocating scarce resources during mass casualty events (KQ4)

Author, Year	Leader of Engagement	Study Location	Study design	Type of mass casualty event	Engagement Strategy	Who Engaged Whom	Findings (Outcome)	Outcome Modulators (Facilitators or Barriers)	Quality score (of 4)
Koh, 2006[190]	Policy makers	Boston, MA	Descriptive – surge plan development, observational testing	Unspecified	Incorporation of CHCs into surge plan, with training for CHCs and three event-based tests	City PH & state primary care association *engaged* hospitals, CHCs, EMS in planning; City PH, EMS & academia *engaged* CHCs in training and first responders, hospitals and CHCs in tests of plan	Surge-related roles and responsibilities for CHCs delineated in plan; plan tested in city-wide preparation for Democratic National Convention and 2 outbreak investigations (e.g., screened 1500 persons for TB in one investigation)	*Facilitators:* CHCs were willing to participate and some were already integrated with nearby hospital; excellent academic partner provided high quality technical assistance *Barriers:* Variability in CHC sizes and resources precluded "one size fits all" approach; CHC staff had limited time & resources for training, testing	4
Levin, 2009[185]	Policy makers	MA (state level)	Descriptive – planning process	Pandemic influenza	State level planning to establish framework and ethical principles to guide development of altered standards of care protocols	State PH and academia *engaged* local PH, hospitals, non-hospital healthcare facilities, other health agencies, non-government entity, general public	Consensus state-level framework (guidelines) and decision making protocol for altered standards of care (ASC); 4 goals, 7 principles – decision-making protocol to determine ASC	*Facilitators:* Excellence of academic institution; involvement of ethicists, legal counsel, and broad stakeholder base	3
Moser, 2005[196]	Policy makers	Utah (regional level)	Descriptive – planning process	Unspecified	Broadly inclusive regional hospital level planning process to identify 1250 additional (surge) beds state-wide; regional approach to be replicated throughout state	State PH and state university medical center *engaged* multiple hospital and non-hospital facilities, professional associations, state and local PH, transit, EMS and church groups	State coordinating group identified broad range of public and private sector task force members and created regional surge plan through systematic iterative process	*Facilitators:* Broadly inclusive and iterative process; begin with small group; identify key personnel early; use prominent players for credibility; central planning office	3
Vawter, 2010[179]	Policy makers	MN (state level)	Descriptive – planning process	Pandemic influenza	Developing proposed ethical frameworks and procedures for rationing scarce health resources within a state	State government, university and health care ethics center *engaged* local governments, experts, general public and a few (not many) health care providers (hospital, non-hospital, other)	Decision tools – ethics guidance: Multiple ethical frameworks for setting rationing priorities (for vaccine, N95 respirators, surgical masks, antiviral drugs for prophylaxis and for treatment, mechanical ventilators) -- principles, objectives, general strategies	*Facilitators:* involvement of ethicists, extensive public input, specific resource items *Barriers:* resulted in decision tool (not plan); one size does not fit all; very few providers were reported as involved	3

Appendix D. Excluded Studies

Short Form Rejects

No Key Questions Addressed (N=692)

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