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Number XX

Allocation of Scarce Resources during Mass Casualty Events (MCEs)

Prepared for:
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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 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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Comparative Effectiveness Review on the Allocation of Scarce Resources during Mass Casualty Events (MCEs)

Structured Abstract

Objectives: In the immediate aftermath of a natural disaster or a catastrophic health event, demand for medical care typically outstrips the available supply. This systematic review was performed to provide policymakers, healthcare systems, providers, and the public with the best available evidence regarding strategies to allocate scarce resources during mass casualty events (MCEs).

Data Sources: We searched Medline, Scopus, EMBASE, CINAHL, 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/papers by nongovernmental organizations, and practice guidelines published by relevant specialty societies. Both English and foreign language studies were included.

Review Methods: Because evaluating strategies to optimize the allocation or management of health care resources during MCEs is not amenable to randomized controlled clinical trials, our comparative effectiveness review included studies that evaluated tested strategies in real world MCEs, relative to historical or contemporaneous controls, as well as strategies tested in drills, exercises, or simulations that included a comparison group. Studies that lacked a comparison group, and those that proposed promising strategies were reviewed separately. We also identified consensus recommendations developed by professional societies or government panels. Existing state plans were reviewed to examine the current state of planning for scarce resource allocation during MCEs. A minimum of two investigators independently reviewed each article, abstracted data, and assessed study quality.

Results: 4,441 reports were considered for this comparative effectiveness review. Ultimately, 147 met selection criteria, including 23 studies that focused on policymakers, 101 that addressed the decisions of providers, 7 that considered the perspectives of the public, and 16 that addressed engagement of providers in developing strategies to optimize the allocation and management of scarce resources. Our CER identified a moderate number of studies that provided evidence on triage that suggest that commonly used triage systems do not perform consistently in actual MCEs. Another group of studies examined various ways to distribute biological countermeasures more efficiently during a bioterror attack or influenza pandemic. They provide modest evidence that the way these systems are organized influences the speed of distribution. Although we reviewed a substantial number of additional articles on a wide range of current or proposed strategies, the number of high-quality studies addressing any single strategy was insufficient to support confident conclusions about its effectiveness relative to other strategies. Broadly considered, these findings indicate that the consensus guidelines and state plans currently embraced by policymakers and providers rest on a limited body of high-quality evidence. Studies of public engagement consistently find that 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, reducing deaths and hospitalizations, and treating people fairly and equitably.

Conclusions: To adequately prepare and respond to an MCE, communities, states and our nation must implement effective measures to allocate and manage scarce resources. Scientific research to identify the most effective strategies is an emerging area, and as such, it remains unclear which of the many options available to policy makers and providers will be most effective in achieving these goals. 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.

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Comparative Effectiveness Review on the Allocation of Scarce Resources during Mass Casualty Events (MCEs)

Executive Summary

The Effective Health Program was initiated in 2005 to provide valid evidence about the comparative effectiveness of different medical interventions. The object is to help consumers, health care providers, and others in making informed choices among treatment alternatives. Through its Comparative Effectiveness Reviews, the program supports systematic appraisals of existing scientific evidence regarding treatments for high-priority health conditions. It also promotes and generates new scientific evidence by identifying gaps in existing scientific evidence and supporting new research. The program puts special emphasis on translating findings into a variety of useful formats for different stakeholders including consumers.

The full report and this summary are available at www.effectivehealthcare.ahrq.gov. Ahrq.gov/reports/final.cfm

Background

Most experts define a mass casualty event (MCE) as a natural (e.g., earthquake, pandemic) or man-made (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 the demand for medical care resources has the potential to vastly outstrip the ability of a healthcare 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 a MCE can severely challenge the most highly experienced and well-equipped healthcare providers and systems.[4]

By definition, an MCE generates a level of demand for healthcare resources that outstrips available supply. When that happens, 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 unpredictable and can occur with little or no warning, healthcare systems and providers must be prepared to swiftly implement contingency plans to reduce less urgent

demand, 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 approach to treatment, which strives to deliver optimum care to every patient, to one that seeks to save the most lives with the resources at hand. This latter concept has come to be known as "crisis standards of care."

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 that recommended that healthcare 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 AHRQ reviews by conducting a thorough review of the evidence regarding allocation of scarce medical resources in MCEs.

Objectives

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

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

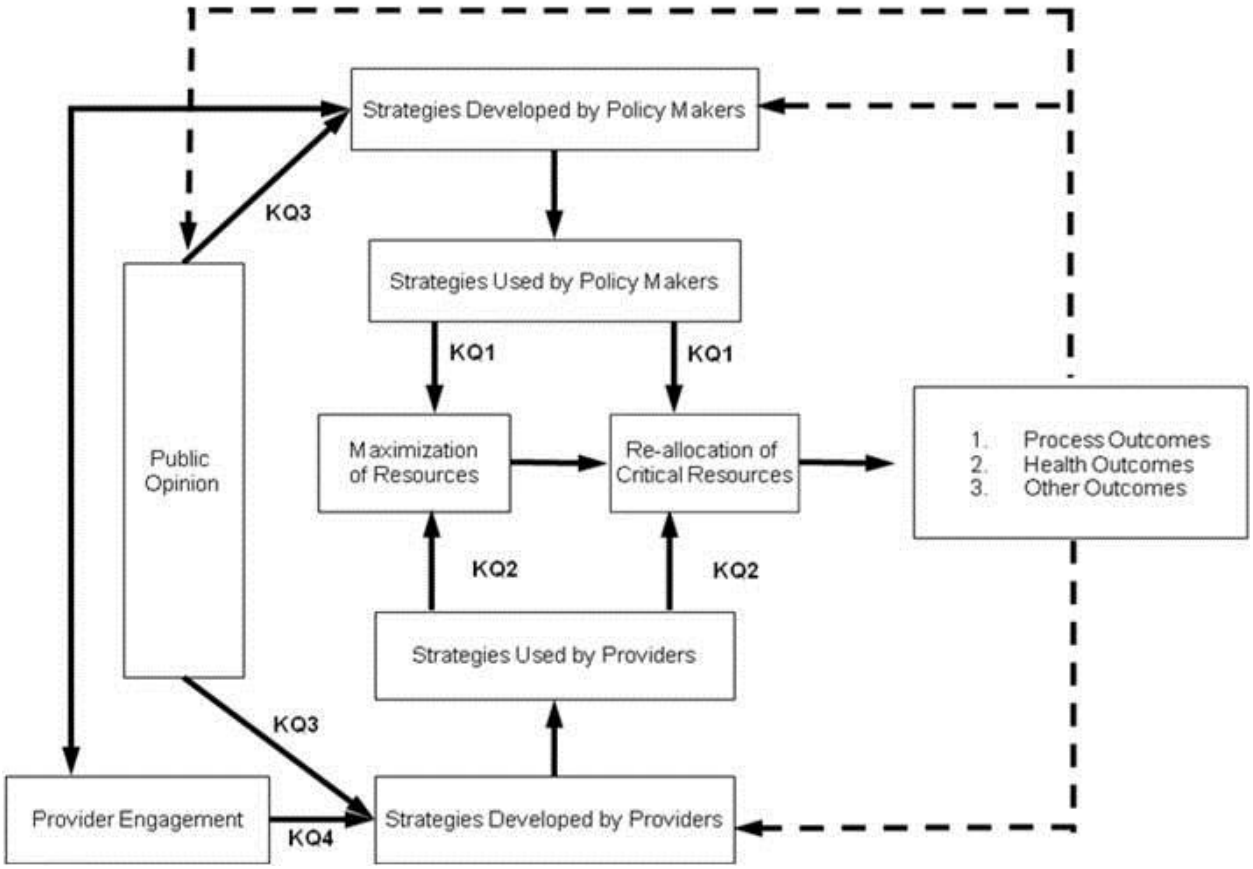
Key Question 3. What are the public's key perceptions and concerns (e.g., values, equity, transparency, communication, and public input) regarding the development and implementation of strategies to allocate and manage scarce resources during both actual and potential mass casualty events (MCEs)?

Key Question 4. What current or proposed strategies 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?

Conceptual Framework

The conceptual framework for our evidence review is depicted in Figure A. It shows how strategies to allocate and manage scarce resources are developed and used by policymakers and healthcare providers, and how the thinking and actions of both groups are modified by public opinion.

Figure A. Conceptual framework for allocating and managing scarce medical resources during a mass casualty event (MCE)



The conceptual framework reflects the development and use of strategies by policymakers and providers to ensure that patients receive the best care possible under the difficult and sometimes overwhelming circumstances of an MCE. Policy makers and providers develop strategies and implement strategies using an escalating series of contingent actions, based on the nature, magnitude, scope and duration of the MCE:

1. Maximize the use of existing resources by:
    a) Managing/reducing demand for non-essential health care services
    b) Optimizing the use of existing resources
    c) Augmenting, to the degree possible, available resources
2. Allocate scarce resources using "crisis standards of care".

Ultimately, the actions of policymakers and providers influence individual and population outcomes through the process of care and the outcomes this produces (health outcomes and other outcomes). Dashed lines represent feedback loops in which the outcomes of each strategy shape the refinement or development of new strategies. For example, outcomes of strategies, particularly adverse outcomes, might provoke strong reaction from the public. Providers or policy makers may then integrate the expressed preferences of the general public into new or updated strategies. Provider engagement activities might inform the strategies developed by

policy makers, while at the same time, the planning efforts of policy makers might also serve as a catalyst for providers to engage in efforts to develop strategies to respond to mass casualty events.

As we prepared our review, the research team and our Technical Expert Panel agreed that the first step in maximizing the allocation and use of scarce resources is to reduce less urgent demand. The second is to optimize use of existing resources to maintain generally accepted standards of care. Many of the "resource maximization" strategies that fall under this rubric are aimed at extending use and making management of resources more efficient in order to forestall development of resource shortages.

If these measures prove to be inadequate, health care facilities may begin operating at "contingency capacity" (excessive but manageable) while efforts are made to augment existing resources by tapping stockpiles, invoking mutual aid agreements and pursuing other options. If these contingency measures are inadequate to meet demand, the facility and its associated providers may find themselves operating at "crisis capacity" (extremely excessive demand that is unmanageable with normal standards of care).[6]

At that point, the involved institution and its providers should shift their approach from optimizing care of each individual to allocating and managing resources in a manner that seeks to do the greatest good for the largest number of people. Typically, these strategies will not be employed unless every effort to maximize available resources has reached its limit.

During a prolonged mass casualty event, a health care system may shift in 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 conceptual framework we adopted distinguishes between strategies that have been tested and formally evaluated by policymakers and/or providers in actual MCEs, drills, exercises, or simulations from those that have been merely envisioned or pilot-tested using less rigorous evaluation designs. The distinction is important. Because large-scale MCEs are rare in the United States, we did not expect to find many field-validated strategies that have been subject to the rigorous standards of evidence typically required in a CER. Therefore our review encompassed a wider array of studies, although only tested strategies were subjected to rigorous systematic review. Key Questions 1 and 2 focus on strategies developed or implemented by policymakers and providers, respectively. Question 3 focuses on public perceptions and concerns. Question 4 focuses on strategies designed to engage providers in developing and implementing strategies for allocating and managing scarce medical resources in an MCE.

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 timeframes and settings as the analytic framework for the review.

Methods

The methods for this systematic review followed the ARHQ's *Methods Guide for Effectiveness and Comparative Effectiveness Reviews* (available at http://www.effectivehealthcare.ahrq.gov/methodsguide.cfm). We followed the elements of the protocol established for a typical CER. Our methods map to the PRISMA checklist.[7] The AHRQ's Scientific Resource Center (SRC) and its co-sponsoring agency, the Office of Assistant Secretary for Preparedness and Response (ASPR), developed the research topic and its four key questions. Investigators at the Southern California Evidence Practice Center then refined the questions in consultation with two subject matter experts who are 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, healthcare ethics, military medicine, risk communication, and public engagement.

Our search strategy leveraged all existing reviews of the literature, particularly the IOM's Letter Report and Summary on Crisis Standards of Care[5, 6] and the AHRQ/ASPR's Community Planning Guide on Providing Mass Medical Care with Scarce Resources.[8] 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. Our subsequent literature search comprised four parts: (1) a formal search using multiple research databases, (2) a scan of the "grey" literature, (3) a review of current State plans, and (4) consultation with our TEP for any additional sources. Our team benefitted from the services of a professional research librarian with special skills in health information and an expert librarian at the National Institutes of Health (NIH) who previously conducted literature searches on this topic for the Assistant Secretary for Preparedness and Response (ASPR).

Searched databases included: PubMed, Scopus, EMBASE, CINAHL, 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. This set of databases was finalized through consultation with our TEP. After we constructed search algorithms for each database, we executed the search, downloaded the results into individual EndNote libraries, combined the libraries resulting from each search, and deleted duplicate references. These standard database searches were supplemented 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. We did not pursue additional searches of grey literature sources (e.g., Lexis-Nexis) because we were concerned that these sources might not provide the high quality evidence needed to satisfy our inclusion/exclusion criteria.

As a final check of comprehensiveness, individual members of the TEP identified relevant studies that were conducted and organizations that sponsored research or issued guidance on proposed strategies for allocating resources during MCEs. Examples included the Centers for Disease Control and Prevention, the Veterans' Health Administration (VHA), professional society guidelines, and non-governmental organizations such as Trust for America's Health. We compiled a list of these sources, and used scans of relevant, related websites to extend our search.

An additional element of this project was a review of state plans for allocating scarce healthcare resources in the setting of a MCE. To identify these plans, we worked closely with our federal partners, particularly officials at ASPR. Ultimately, we received one or more planning documents from 11 states and the territory of Guam. Because there is no central national repository for this information, this list may be incomplete.

Prior to conducting our search, we framed each of the four key questions along six dimensions that are commonly used in CERs: populations, interventions, comparators, outcomes timeframes and settings (PICOTS). In general, for all four Key Questions, we included articles found in the peer-reviewed and grey literatures, including but not limited to empirical studies, state and Federal government reports, state plans, peer-reviewed reports/papers by nongovernmental organizations, policy and procedure documents, and clinical care guidelines developed by specialty societies. Both U.S. and international (English and non-English language) sources were considered. We included studies utilizing randomized controlled trials, observational studies reporting data from real events, drills, exercises, or computer simulations (when a comparison group was used). Studies that generated data but lacked a control group were included but analyzed separately. We also considered strategies proposed by national provider groups, task forces or work groups convened by or comprising representatives of the federal government. For Key Question 3, we included studies reporting the outcomes of systematic data collection efforts (e.g., focus groups) that document patients' perspectives on resource allocation during MCEs. For all four key questions, we included previous systematic reviews of strategies to allocate resources during an MCE. General exclusion criteria included articles published prior to 1990, publications that presented only conceptual frameworks, non-systematic reviews, and studies that did not consider strategies in the specific context of an MCE (an example of the latter would be a study of EMS or emergency department triage in the context of routine operations rather than a MCE).

For Key Question 1, the populations of interest are patients who require treatment after an MCE and the policymakers who are responsible for implementing strategies to optimize allocation of scarce resources during an MCE. For Key Question 2, the populations of interest are patients as well as the health care providers (pre-hospital and institutional) charged with the responsibility for their care. For Key Question 3, the population of interest is the public, and for Key Question 4 it is healthcare providers. For all 4 key questions, the principal interventions of interest are strategies to optimize management and allocation of scare resources in an MCE. The range of options considered was broad. The outcomes of interest were equally broad, and included relevant process measures (e.g., throughput or resource consumption), as well as defined health outcomes such as the rate of survival. Timing was limited to preparedness and response to MCEs. For example, we did not include strategies intended to facilitate long-term

recovery (e.g., community resilience). Finally, we considered all settings in which patient care might be delivered, including but not limited to the community, pre-hospital settings, hospital emergency departments, inpatient settings, community health centers and other alternate care facilities.

After conducting our 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/ exclusion according to pre-determined 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 a 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 reviewed the abstract and reconciled the difference.

To further pare down articles, two researchers independently reviewed full-text articles and excluded those that: 1) failed to address a key question; 2) proposed strategies that did not meet our evidence threshold; or 3) related to training but did not report changes in actual performance outcomes. Disagreement was resolved by consensus to third party reconciliation. We maintained a list of studies that were excluded at the full-text review stage with the reason(s) for exclusion (Appendix D).

Our data extraction approach was tailored to each key question. Because of the volume of studies describing tested strategies that were relevant to KQ1 and 2, we developed an electronic data collection form using DistillerSR (Appendix B) to capture the necessary data elements. For KQ3 and 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 KQ4, we used a paper-based data collection form (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. For KQ4, we also noted the types of stakeholders participating in the engagement strategy. Studies comprising the two lower-evidence tiers for KQs1 and 2, (i.e., studies lacking comparison groups and proposed strategies), and all information from state plans were abstracted using a paper-based method. Abstraction involved a smaller set of data elements--the specific strategy, the relevant MCE context, and the principal findings (if relevant).

A total of nine reviewers performed data extraction. At least two reviewers, all of whom received formal orientation to the review process, abstracted each article that met one or more KQ inclusion criteria. One reviewer took the lead for reviewing each 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 edited and manipulated to generate evidence tables (Appendix C). Evidence tables for KQ1 and 2 are organized according to one of four broad classes of strategy: (1) strategies intended to reduce less urgent demand for health care services or manage demand in alternate settings, (2) strategies

intended to maximize efficient use of existing resources, (3) strategies designed to augment resources from a variety of sources, and (4) strategies designed to enable effective and ethical allocation (or reallocation) of scarce medical resources during crisis situations. Strategies were further grouped into sub-categories, (e.g., biological countermeasures, triage etc.). Within each sub-category, the newer studies are presented first.

Given the relative rarity and unpredictable nature of MCEs, we anticipated that few, if any, studies of the topic would be randomized controlled trials for which validated instruments to assess the quality of studies exist and are widely used.[9] Given the diversity in research methodologies and outcomes we expected to encounter, we determined that a more generic quality rating system would allow for greater comparability across 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 Substance Abuse and Mental Health Services Administration's (SAMHSA's) National Registry of Evidence Based Programs and Practices (NREPP) quality assessment scale and two other scales commonly used to appraise the quality of qualitative research.[10-12]

Using this composite approach, we appraised the quality of studies addressing KQ1, 2, and 4. The five individual items of our composite scale assessed the following aspects of each study: 1) the level of detail used to describe the resource allocation strategy, 2) whether or not data collection was systematic (and if so, whether it was retrospective or prospective), 3) whether or not the study's fidelity (defined as the degree to which the strategy was implemented consistently) was measured or could be inferred from the data provided, 4) whether or not the generalizability of the study's findings was assessed, and 5) whether or not the authors discussed potential confounders to the strategy's effectiveness. Reviewers could allocate up to two points for each item except the fidelity and strategy description items, for which only one point was possible. All quality scores are presented as the total number of points allocated relative to the total number of points possible (e.g., "6 of 8 points").

For two types of study designs—computer simulations and systematic reviews—we deviated from this approach because more tailored quality items were appropriate or because previously validated scales were available. In our environmental scan, we identified one study[13] which offered recommendations for modeling disaster responses in public health. We identified several key aspects of model quality from this study and modified our quality instrument accordingly. We eliminated the data collection and fidelity items and replaced them with two items that assessed model assumptions and sensitivity analyses. Specifically, we assessed the degree to which the authors justified their model assumptions and/or data inputs, and whether or not sensitivity analyses were performed (and if so, whether or not they were robust). For systematic reviews, we used the AMSTAR instrument,[14] an 11-item scale that measures features such 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 KQ3 we elected to develop our own quality scale that reflected key differences in methodology we observed across the small number of included studies. Using seven binary items, the scale assessed whether studies used a systematic data collection process, recruited a

representative sample, disclosed funding sources or sponsors, discussed limitations and generalizability, and were evaluated by an independent third party organization.

Given the complex and challenging nature of the study topic—mass-casualty events—we did not anticipate identifying many studies that would enable us to conduct a quantitative synthesis. This proved to be true. In fact, much the data we compiled were qualitative in nature. When outcomes were reported, they were generally described in broad terms such as actual versus historic (or predicted) rates of mortality, levels of resource consumption, or qualitative estimates of impact. Thus, the body of evidence is currently insufficient to attempt quantitative synthesis using statistical techniques such as meta-analysis.

In light of these limitations, we structured our findings around several broad themes and observations, graded by the overall strength of the evidence: (1) strategies intended to reduce less urgent demand for health care services or manage it in alternate settings, (2) strategies intended to maximize efficient use of existing resources, (3) strategies designed to augment resources from a variety of sources, and (4) strategies for ethical decision making 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 healthcare resources.

Whenever and wherever possible, we highlighted differences in outcomes across patient subgroups to the extent these data were reported in individual studies. After finishing our review, we drew conclusions to the degree supported by the evidence. Where the evidence was not clear-cut, we summarized the strength of existing evidence and highlighted where additional research would be beneficial.

For the sake of comprehensiveness, we compiled, in separate pools, studies that have demonstrated the technical feasibility of a novel idea, technique, or technology, and a subset of strategies that have been used during real events. The defining characteristic of these studies is that none of them included a comparison group, a necessary element to estimate the incremental impact of the strategy. Although none of these studies would normally qualify for inclusion in a CER, we summarized them in a separate group to highlight promising ideas that may warrant further exploration.

We used the approach for grading the strength of evidence outlined in the Methods Guide for Effectiveness and Comparative Effectiveness Reviews.[15] It requires assessment in four domains: risk of bias, consistency, directness, and precision. After making assessments in these four domains, the strength of the evidence was graded, 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.[15]

Given the diversity of strategies used to allocate scarce resources, we rated the strength of evidence within each of the four broad categories of strategy, i.e., those intended to reduce or

manage less urgent demand; those designed to optimize use of existing resources; those designed to augment existing resources and those that implement altered standards of care. Where possible, we also rated the strength of evidence within subcategories, such as triage. For KQ3, however, we rated the strength of evidence across all studies, regardless of whether the information was derived from stakeholder forums, interviews or surveys. A single reviewer graded the strength of evidence for each dimension, which was then reviewed by a second reviewer. Differences were reconciled through discussion. Overall strength of evidence grades were determined in an analogous manner using a qualitative assessment of the scores for each dimension. Strength of evidence grades are summarized in the Results section.

In the course of our work, we considered the applicability of the evidence presented by each article. 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 is "ready for use." For strategies tested outside of the U.S., we also assessed the degree to which the strategy is applicable in the U.S.

This approach assured that the articles that were included are applicable to the relevant populations, interventions, comparators, and outcomes. The process we used to determine each article's applicability was the same as that employed for extracting data, (i.e., 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.

Results

Key Question 1:

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 the implementation or effectiveness of strategies to optimize the allocation and management of scarce resources in MCEs?

There are 15 papers included in this review that address tested strategies for policy makers to reduce or manage less urgent demand (11 studies), optimize use of existing resources (one study), or augment existing resources (four studies); one study is included in two of these categories. No policymaker study that met inclusion criteria addressed development or implementation of crisis standards of care. The specific strategies are summarized in Table A. It is important to note that the number of studies in an area is not necessarily equal to the number of studies because (1) some strategies are included in multiple studies and (2) some studies include multiple strategies.

Table A. Summary of Strategies Addressing Key Question 1, by category

	Strategies
Reduce or manage less urgent demand	• 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 antivirals from stockpiles (e.g., level of pre-allocation, level of tailoring to population needs, amount for prophylaxis vs. treatment) • Mutual aid agreements that allow transshipment of antivirals between counties • Mass vaccination, contact tracing, and school closure • Mass distribution of antibiotics using postal carriers • Simulation models to optimize logistics of response • Activating mobile provider units from other federal agencies to provide hospital surge capacity • Training public health officials in their legal authority to implement strategies • Distribution of surgical masks or N95 respirators to the public
Optimize use of existing resources	• Central command structure to optimize distribution of urgent patients to hospitals • Establishment of site emergency management centers in low vulnerability locations • Robust and interoperable emergency communications systems
Augment existing resources	• Coordinated regional trauma systems to facilitate the rapid transfer of hospitalized and special needs patients • Mobile field hospitals • Alternate-site surge capacity facilities
Crisis standards of care	None

There is low to medium strength of evidence to favor a “push” method to deliver medications, such as via US 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 non-biological countermeasures, such as N-95 respirators or surgical masks, will reduce demand for hospital beds, ICU beds and ventilators.

There is little rigorously-generated evidence to enable policymakers to favor one strategy for optimizing resource allocation and use over another. The number of publications addressing any single strategy was inadequate to support a firm conclusion regarding its effectiveness. There is, however, minimal evidence, based on few publications, that resource use can be optimized through better load sharing between facilities. There is also limited evidence that health care resources may be augmented by transferring patients to more distant hospitals or by opening temporary facilities, such as a mobile field hospital. There was insufficient evidence to draw firm conclusions about facilitators or barriers to the implementation of effective strategies.

Key Question 2

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

In contrast to the small number of studies relevant to Key Question 1, we found numerous studies that provide evidence on a range of strategies intended to help providers optimize resource allocation during MCEs. A total of 47 studies met our criteria for full-text review (Table 3).

Three of these studies described strategies to reduce or manage less urgent demand that might be better served in other settings. A total of 39 studies addressed strategies to optimize use of existing resources. The majority of them (25) assessed triage systems, including validation studies of existing triage systems, tests of triage systems used in actual MCEs, and comparative analyses of alternative triage strategies and training programs. The other studies were thinly spread over a broad range of promising strategies. Only three studies examined strategies to augment existing resources. Six studies assessed the impact of altered standards of care. The specific strategies are summarized 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 pre-hospital or “field” triage during MCEs, the body of high-quality evidence addressing any single individual 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.

Table B. Summary of Strategies Addressing Key Question 2, by category

	Strategies
Reduce or manage less urgent demand	• Emergency mass clinic based on CDC guidelines • Points of Dispensing strategies (e.g., dynamic staffing) • Regional telemedicine hub to support delivery of specialty care
Optimize use of existing resources	• Hospital-based case managers to ensure care coordination • Strategies to increase decontamination effectiveness (e.g., instructions, providing washcloths, etc.) • Electronic triage tags to monitor vital signs and transmit information to first responders • Focused assessment of sonography for trauma (FAST) for triage • Sonographic screening for abdominal/pelvic injury or bleeding for triage • Robust redundant communications channels between command center, responders, and receiving hospitals • Central allocation of patients to hospitals based on available resources • Medical interventions for the prevention of acute renal failure in crush victims • Novel drug infusion devices • Automated central information distribution system for families • Hospital staff training (e.g., disaster drills, computer simulations, tabletop exercises) • Simplified biodosimetry protocol • Quality improvement program to improve response • Triage training (e.g., JumpSTART training program, virtual reality, podcasts, computer games) • Triage systems (e.g., START, 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) • Triage strategies (e.g., combining triage categories, adding categories, one- vs. two-stage triage)
Augment existing resources	• Influenza prophylaxis for healthcare workers • Conversion between formulations of nerve agents to augment supply • Reverse triage to create surge capacity (e.g., suspension of normal elective activity, early discharge, increasing use of community care options)
Crisis standards of care	• Accelerated whole body multislice computed tomography protocol • External fixation of fractures rather than definitive orthopedic care • Provision of only "essential" interventions • "Damage control" approach (e.g., for orthopedic surgery or more generally)

Triage systems and explicit triage acuity scales have been used in emergency department s 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 the performance of current triage systems during actual MCEs. Studies that tested triage systems during exercises or drills provided evidence with limited applicability. The evidence base for the remaining strategies identified under this key question is quite thin. Few of the studies that met our inclusion criteria are based on data that were prospectively collected during one or more actual MCEs. Randomized designs were rarely used. The computer simulations we identified tended to provide low-quality evidence.

Collecting precise data in a systematic manner in the midst of an actual MCE poses obvious challenges. Most of the studies we identified reported process measures (e.g., throughput times and triage accuracy) rather than outcomes. Studies that reported health outcome data used less-

systematic data collection processes than those typically required for inclusion in a systematic review. Many of the studies we identified used relatively weak designs and compared outcomes against a historical control group or a benchmark performance rate rather than a contemporaneous comparison group.

A few articles examined specific barriers and facilitators to the implementation of provider strategies. However, those that did inconsistently reported the information. Typically, evidence derived from drills and exercises does not include data on outcomes that are relevant to patients and providers. As a result, the applicability of the findings, beyond the immediate exercise setting, is questionable. With few exceptions, strategies proposed by national provider organizations were vague. Most did not propose actionable steps to help providers make difficult decisions regarding allocation of scarce resources under altered standards of care.

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 mass casualty events (MCEs)?

Although the current evidence base is thin, there is sufficient information to support some tentative conclusions. First, the few reports of public perceptions regarding how scarce resources should be allocated and managed during MCEs published to date are generally consistent. All but one of the six studies we reviewed reported data collected from a single community. Also, the forums we identified mostly dealt with resource allocation in the setting of a hypothetical severe influenza pandemic rather than other forms of MCE. Nevertheless, because the studies relevant to KQ3 were relatively well-designed and their findings were generally consistent with each other, we judged the strength of evidence they presented on this topic to be medium. Collectively, they indicate that citizens are both interested and motivated to participate in community forums. Participants in these studies and surveys recognized the inherent difficulty of making prioritization decisions during an MCE. To create a fair, equitable, and well-managed system, they believe that appropriate guidelines and criteria should be established in advance. Participants expressed substantial trust that health care professionals to make the right decisions, based on such criteria as societal role, age and likelihood of recovery. They rejected the notion that scare healthcare resources, such as ICU beds, should be allocated on the basis of "first come, first served" or a lottery.

Key Question 4

What current and proposed strategies 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?

The 16 studies reviewed for this key question employed a wide array of engagement strategies. They largely focus on planning and exercises, yet they addressed a diverse range of relevant planning scenarios, resource allocation issues, and stakeholders. Collectively, these 16

reports addressed engagement of providers across the full range of severity in surge medical capacity preparedness, including: reducing or managing less urgent demand (one report); optimizing use of scarce resources (five papers); augmenting resources (four papers); adopting crisis level of care (three reports) and comprehensive approaches that address more than one of the 4 broad strategies (three reports). The specific strategies are summarized in Table C.

Although the evidence they provided did not identify one approach as clearly superior to the others, several important themes emerged. First, inclusive processes that engage all major stakeholders are important. This 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 a non-traditional 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 16 studies were generally consistent in their findings, we graded the strength of evidence as medium.

Table C. Summary of Strategies Addressing Key Question 4, by category

	Strategies
Reduce or manage less urgent demand	• Public health-business partnership for mass dispensing
Optimize use of existing resources	• Organization of de novo regional hospital planning group • Incorporation of community health centers into surge plan, with training for CHCs and three event-based tests • Broadly inclusive regional hospital level planning process to identify surge beds • Training and drills to assess performance in using JumpSTART triage algorithm
Augment existing resources	• Organization of neighboring states into a voluntary disaster surge network • Enrollment, education, training, and exercise of qualified laboratory staff for preparing biodosimetry specimens • Development of evidence-based “reverse triage” classification system • Pharmacy-led development of regional pharmaceutical preparedness policies and procedures
Crisis standards of care	• Developing proposed ethical frameworks and procedures for rationing scarce health resources within a state • Development of consensus on appropriate pediatric crisis standards of care
Combined strategies	• Alternative planning models (Top-down county planning model, Decentralized regional planning, Hospital-directed tiered regional planning model, Third-party directed planning model) • Pilot testing of local, regional and national level tabletop exercises for the Veterans Health Administration (VHA) • Development and pilot testing of tabletop exercise template for local level governments and providers

Discussion

We found broad agreement in the published literature, in consensus reviews and in the 11 state plans we identified that strategies to allocate and manage scarce resources during MCEs broadly fall into one or more of four domains: (1) reduce less urgent demand for health care services or manage it in alternate settings, (2) optimize use of existing resources, (3) augment resources when possible from other sources, and (4) allocate scarce resources under crisis

standards of care. There is also broad agreement, as well as some evidence, regarding the value of mass dispensing of biological countermeasures, triage, load sharing through inter-facility transfer, resource augmentation from stockpiles and when health care resources are in very short supply, of the appropriateness of allocating scarce resources using crisis standards of care. Unfortunately, given the difficulty of conducting prospective research on MCEs and the relative lack of funding for studies of this sort, the number of studies that provide high-quality evidence to support one of these practices over another is very limited.

Despite casting a wide net for relevant studies, using generous inclusion criteria, accepting papers that might not meet the quality standards of traditional comparative effectiveness reviews, and even including studies (analyzed separately) that lacked comparison groups, we found insufficient evidence that many well-known strategies, such as pre-hospital triage, can be endorsed with anything more than a low level of confidence. This is not a reflection of the researchers or agencies that support their work, but rather, of the inherent difficulty of conducting high-quality studies in the setting of an MCE.

There are several compelling why this CER differs from others. First, in contrast to comparative effectiveness reviews that examine a particular treatment, optional management of MCEs is not approachable through quantitative analysis of data derived from previous randomized controlled trials. Fortunately, mass casualty events are rare, and generally unanticipated. Also, MCEs vary widely from each other with respect to cause, onset, setting, duration, scale and many other characteristics. This makes it difficult to draw inferences from one MCE that can readily apply across the range of potential events. Second, it is very challenging, if not impossible, to rigorously collect data in the middle of an MCE. Furthermore, it is ethically challenging to employ randomized designs to evaluate different MCE strategies during an actual event. The one exception to this rule appears to be studies of infection control and the dispensing of biological countermeasures, where the time frame for action and the pace of response are more amenable to randomization. Some research teams have tried to circumvent this challenge by modeling various interventions with computer simulations, or testing them in exercises or drills. The generalizability of these findings to actual MCEs is uncertain at best. Perhaps most formidable challenge to approaching this topic is its breadth. In the course of our review, we identified a wide array of current and potential strategies for optimizing scarce healthcare resources and allocating those that exist in the most effective manner. An inevitable byproduct of this multiplicity of options is that few strategies have been sufficiently evaluated to assess their effectiveness. When a particular intervention has been assessed only two or three times by different groups using non-comparable methods and measures, it is impossible to reach a firm conclusion regarding its effectiveness. Given the importance of MCE preparedness for national health security, the visibility of this topic in the eyes of the public, and the need to strengthen preparedness for a wide array of biological and non-biological threats, the limited amount of high-quality, highly applicable evidence poses significant barrier to effective planning.

Every review has limitations. Ours is no exception. Our literature search procedures were extensive and meticulous. They included canvassing experts to identify studies we may have missed. Nevertheless, the possibility of publication bias still exists. Although each paper was independently reviewed by at least two trained data abstractors, it is possible that our team

misclassified some information or assigned a paper to a category that was less germane than another.

Future Research

Our review has clear implications for future research on this question. After conducting this comparative effectiveness review, it is evident that no strategy, even those that are widely accepted by the field, has been researched in sufficient detail to conclusively demonstrate its effectiveness. Our review spanned more than two decades of preparedness research, including the decade following 9/11. Nevertheless, we determined that many strategies have not have not been examined by more than three studies that meet the typical threshold for inclusion in a CER.

We recognize that ASPR and other federal research agencies, private foundations, and academic researchers are actively engaged in efforts to improve the evidence base in this area, To this end, we recommend that these stakeholders and others come together to devise and implement a coordinated agenda of applied research to systematically assess the most pressing issues confronting policymakers and providers charged with the responsibility to allocate and manage scarce resources in future pandemics, terror attacks, and large scale disasters. This is unlikely to occur without conscious effort.

It may be argued that operational research of the sort needed to guide improvements in resource optimization and resource augmentation in the setting of MCEs does not require study designs of the sort generally required to qualify for inclusion in a comparative effectiveness review. Many business innovations, including marked advances in supply chain management, error reduction, and organizational structure, have come from focused empiricism – identifying what works and what doesn't, refining it, and seeking continuous improvement. Some assert that beyond determining basic efficacy and safety, dependence on individually designed, serially constructed, prospective studies to establish relative effectiveness is impractical for many interventions[16] in health system operations. This may be particularly true in the setting of disasters and other types of MCEs. For example, hospital leaders do not need a randomized controlled trial to recognize the value of rapidly clearing their emergency department in the short time window between notification that a terrorist bombing has occurred, and the arrival of the first wave of casualties.[17] Nor do we need sophisticated cohort studies to underscore the importance of stockpiling sufficient resources to support up-tempo hospital operations during the first days following a disaster, when supply chain disruptions are common. But it is equally clear that EMS systems, hospitals and health systems would benefit from practical assessments of useful techniques, technologies and tools to enhance field and ER triage, interagency and inter-facility communications, patient tracking, public information, load sharing, and rapid augmentation of "staff" (professionals and lay volunteers), "stuff" (equipment and supplies), and "structure" (physical space, systems for incident command and control). Because the opportunities to test these strategies are few and far between, it will be important to develop and implement more realistic exercises, including no-notice drills, to determine how various elements of the healthcare system respond when challenged.

A process as basic as systematically holding a rigorous but non-judgmental "after-action review" (AAR) following each major MCE could go a long way towards institutionalizing systems learning and routinizing performance improvement in disaster response. The same

approach should be adopted by the global community to foster rapid learning and performance improvement following multi-national responses to global disasters.[18] It might also be worthwhile to use smaller disasters, d, near-miss incidents, and predictable annual events such as flu vaccination campaigns to refine and test key elements of the public's and healthcare systems' response to MCEs.

Two of the major strategies addressed by this CER—demand reduction and allocation of resources under altered standards of care—could be rapidly advanced through a focused agenda of federally-sponsored research. Efforts are already being directed towards improving the management of our nation's strategic national stockpile and speeding the delivery and mass dispensing of biological countermeasures. Beyond that, policymakers and public health officials have limited evidence regarding the best methods and tools to effectively engage the public and non-hospital based healthcare providers to reduce less urgent demand for hospital services during a MCE. A focused program of research aimed at harnessing traditional (e.g., print, radio and television) and new media (Web, SMS, smartphones) could produce valuable insights on how to effectively inform the public about what to do prior to or during a MCE (such as sheltering-in-place or securing a biological countermeasure from the closest point of dispensing).

Substantial benefit may be realized by exploring how bi-directional communication technologies, such as call centers, nurse advice lines, and the internet, can be used to reach and inform the public. Fully automated, bidirectional decision support systems such as automated call centers, web sites and SMS could provide millions with practical guidance that is tailored to their specific condition or circumstance. Systems like these could also be used to collect epidemic intelligence in real time for situational awareness. Likewise, proactive engagement of community health care providers, coupled with provision of timely guidance and a cache of supplies, might draw a substantial volume of minor illness and injury care out of hospital emergency rooms (ERs), so hospital-based providers can focus on the most seriously ill and injured. Hand-held technologies and software such as global positioning may be used to link non-governmental organizations and private sector players together to swiftly match resources to need. This could be particularly important in the early days of a disaster before outside assistance arrives.

Finally, additional research is needed to confirm the optimal approach or approaches to the rapidly distributing biological and non-biological countermeasures to the public. Promising and potential strategies include engaging a mix of public (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.

At the other end of the MCE response spectrum, there is a pressing need to develop the evidence base about when and how to implement altered standards of care. The aspirational guidance provided through the IOM Letter report is an important start, but operationalizing the Committee's recommendations will be the difficult part.[5] Determining what clinical and social criteria to apply to resource allocation decisions is less a technical matter than a moral, ethical and political one. The type of research we considered for Key Questions 3 and 4 is particularly germane to this topic. The few public engagement papers we identified suggest that the public's

thinking about this matter may be better developed than many policymakers and practitioners realize. It is interesting to note, for example, that the somewhat dated recommendations of two committees representing major critical care societies endorsed the concept of "first come, first served" for allocation of ICU resources. However, the participants in the community forums and surveys published to date largely reject this approach.

Because the existing reports of public engagement are drawn from a small range of participants, they should be interpreted with caution. Diligent efforts should be made to expand the currently modest base of evidence regarding public engagement by reaching out to a wider cross-section of the United States, including individuals from different regions, ethnic backgrounds, cultures, ages, and faith traditions. Likewise, more active engagement of provider groups, including clinicians, health system administrators and experts in health care law, policy and ethics is needed to reach a practical consensus on how best to address these issues. In the course of these discussions, it will be important to identify and address the legal or political barriers that may impede effective allocation of resources under crisis conditions. Otherwise, healthcare providers, hospitals and healthcare systems may be unable or unwilling to act in ways that will do the most good for the most people.

Business analysts and pop psychologists write about the "tyranny of the urgent" and the value of distinguishing between what's urgent and what's important. Because the timing of the next mass casualty event is unknown (and generally unknowable), resource investments in improving emergency preparedness and response often take a back seat to day-to-day urgency of EMS and health system operations and the far larger (and longer-term) investments in biomedical research. But when an MCE happens, its urgency *and* its importance trump everything else. 9/11, the Anthrax attacks that followed, and Hurricane Katrina are but three of the many examples.

This review has determined that many of the fundamental principles of resource management and allocation in MCEs currently rest on limited evidence. Although the number of high quality studies in this area has grown over the past decade, more research is needed to support critical resource decisions and practices. Significantly more progress can be made in a short amount of time by coordination and prioritization of the work that must be done.

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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 (GAO) in 2008.[1, 2] The GAO'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 (EMS), hospital-based emergency departments, inpatient wards, and intensive care units (ICUs), are 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 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, the Department 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, <u>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</u>." [Emphasis added]
> NHSS, page 1.

To achieve national health security, which the Department of Health and Human Services (DHHS) describes as "…a state when the Nation and its people are prepared for, protected from, respond effectively to, and [are] able to recover from incidents with potentially negative health consequences," the NHSS establishes two overarching goals: 1) Build community resilience. 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 below, the two overarching goals of the NHSS are supported by ten strategic objectives. The third of these ten objectives, "Integrated, scalable health care systems" and the tenth, "Science evaluation, quality improvement," are the focus of this comparative effectiveness review.

Figure 1. Achieving National Health Security

Above figure taken from the U.S. Department of Health And Human Services website.[6]

Definition of Terms

For the purposes of this report, we employed and provide the following definitions:

"Policy makers"

Policy makers are defined to be government officials and agencies at the federal, state, regional, and local level that have authority to develop and enforce policies and protocols that drive decision making; policy makers include, for example:

- Federal departments and agencies (e.g., HHS, DHS)
- 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., WHO, PAHO)

"Providers"

Providers are defined to be individuals who are licensed to provide healthcare services under state/tribal law, international standards, or laws of their country, and healthcare organizations/institutions that provide patient care; providers include, for example:

- Licensed individuals such as physicians, nurses, social workers, pharmacists, paramedics

- Healthcare organizations such as health maintenance organizations (HMO), private practices, home care agencies, community health centers, emergency medical services organizations, non-governmental organizations
- Healthcare facilities/institutions such as acute care hospitals, skilled nursing facilities, long-term care institutions, psychiatric care facilities
- Health responder teams to catastrophic events (e.g. international, NGOs, military).

"Public"

The public is defined to include all community members and individuals not addressed as policy makers or healthcare providers, regardless of gender, race, ethnicity, sexual orientation, age, disability, setting, health status or other defining characteristics.

"Mass Casualty Events" (MCEs)

A MCE is defined as a natural (e.g., earthquake, pandemic) or man-made (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 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 within established standards of care.

A mass casualty event can occur suddenly, as is typically the case with an earthquake, tornado or terrorist bombing,[7] or it may evolve over hours to days, as frequently happens in a hurricane, flood, disease outbreak,[8] or a bioterror attack.[9] Regardless of its rate of onset, the scope and complexity of a MCE can severely challenge even highly experienced and well-equipped healthcare providers and system.[10] 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 healthcare, 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 (TEP) 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 EPC 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.[11] 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 healthcare 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 healthcare providers, organizations, government officials and the public approach this challenge in a thoughtful and proactive way.[11] 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, healthcare 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 multi-faceted 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 multi-disciplinary 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 non-governmental reviews, including important studies performed by the Assistant Secretary for Preparedness and Response (ASPR), a literature review conducted by the Agency for Healthcare Research and Quality (AHRQ) in 2007, a 2008 literature review performed by Koenig and colleagues for the State of California,[12] and the IOM's Letter Report on Crisis Standards of Care.[11] Collectively, these reviews provided our team with a conceptual framework for approaching and evaluating the extant literature on this topic. Our report builds on this framework by identifying existing and proposed allocation strategies, describing various ways groups have engaged providers and the public, and identifying key concerns of the public regarding implementation of crisis standards of care. In the sections that follow, we describe the level of evidence currently available to address each of these topics. By highlighting strengths and gaps in the existing evidence base, we hope to inform a research agenda that will quickly improve our nation's capacity to prepare, mitigate, respond, and quickly recover from large-scale health emergencies.

Scope of the Review

This comparative effectiveness review (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 AHRQ and the Office of the Assistant Secretary for Preparedness and Response (OASPR) provide state governments, as well as planning and provider communities, the information they need to clarify processes and/or make difficult but necessary decisions in the setting of mass casualty events (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.

This CER was requested because of growing concern that a large-scale natural disaster, pandemic, terrorist attack, or other mass casualty event could impose such heavy demands that our nation's emergency care system would be unable to meet the population's needs. This situation clearly occurred in parts of New Orleans in the aftermath of the flooding triggered by Hurricane Katrina, and it would certainly have happened if the 2009 H1N1 influenza virus had triggered a flu pandemic as deadly as the one that swept the world in 1918-19. In the absence of widely accepted, evidence-based guidelines and recommendations, healthcare providers and systems would be hard-pressed to determine how best to allocate scarce resources to relieve suffering and minimize morbidity and mortality in the affected population.

Although the need for clearer guidance is obvious, the subject itself is highly challenging. First, unlike many questions addressed by CERs, the sorts of strategies, tactics, techniques, and equipment that might be employed to more effectively allocate resources following a mass casualty event cannot be evaluated through the "gold standard" of CER – the double-blind, randomized controlled trial. First, events of this sort are, fortunately, rare. Second, randomization of interventions in the setting of an MCE is neither technically feasible nor ethically appropriate. And third, the challenges of data collection during an actual MCE make objective assessment of

the effects of a given strategy or intervention highly challenging. Had the authors applied the typical standards of a CER to this evaluation, our report would be very short, indeed.

An additional challenge is that consideration of strategies to allocate scarce healthcare 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 healthcare providers, family members, entire communities, and minority groups and other special 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.

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) healthcare providers who may be faced with the need to allocate scare 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 advisory panel refined each of the key questions. The populations, interventions, comparators, outcomes, timeframes, and settings (PICOTS) considered for each key question are described in the Methods section.

Key Question 1 (KQ1)

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 the implementation or effectiveness of strategies to optimize the allocation and management of scarce resources in MCEs?

Key Question 2 (KQ2)

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

Key Question 3 (KQ3)

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 mass casualty events (MCEs)?

Key Question 4 (KQ4)

What current and proposed strategies 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 a mass casualty event (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 appendices. 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 distinct section from the studies that underwent our full review. 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 attempted to secure as many state plans as possible, and reviewed them for common themes, features, and gaps. Our objective is to provide readers a comprehensive view of the current evidence regarding allocation of scarce resources in MCEs, and propose options for strengthening the evidence base going forward.

Methods

Overview

The methods for this systematic review follow the methods suggested in the ARHQ *Methods Guide for Effectiveness and Comparative Effectiveness Reviews* (available at http://www.effectivehealthcare.ahrq.gov/methodsguide.cfm). The main sections in this chapter reflect the elements of the protocol established for the CER; certain methods map to the PRISMA checklist.[13] To the degree feasible, our methods and analyses were determined a priori. In this section of the report, we describe how the systematic review was conducted. Subsections summarize the populations, interventions, controls, outcomes, timeframes, and settings (PICOTS) that guided our literature search strategy; inclusion and exclusion criteria; study selection process; data extraction procedures; quality assessment procedure; and approach to data synthesis. Because it is neither technically nor ethically feasible to conduct randomized controlled trials of resource allocations strategies or techniques in the midst of a MCE, we expected to find few, if any studies of this sort. In fact, most of the reports we identified, even those with historical or contemporaneous comparison groups, were descriptive in nature. For this reason, and given the widely disparate nature of MCEs, we did not subject our findings to complex statistical analyses or attempt to calculate a "number needed to treat" using the wide variety of strategies and interventions we identified. At the end of this section, we grade strength of the existing evidence, its applicability to the key questions, potential directions for future research, and the process that will be followed for peer review and public commentary.

Topic Refinement and Review Protocol

The AHRQ's Scientific Resource Center (SRC) and its co-sponsoring agency, the Office of Assistant Secretary for Preparedness and Response (ASPR), developed the research topic and its four key questions. Investigators at the Southern California Evidence Practice Center then refined the questions in consultation with a Technical Expert Panel (TEP) appointed by AHRQ.

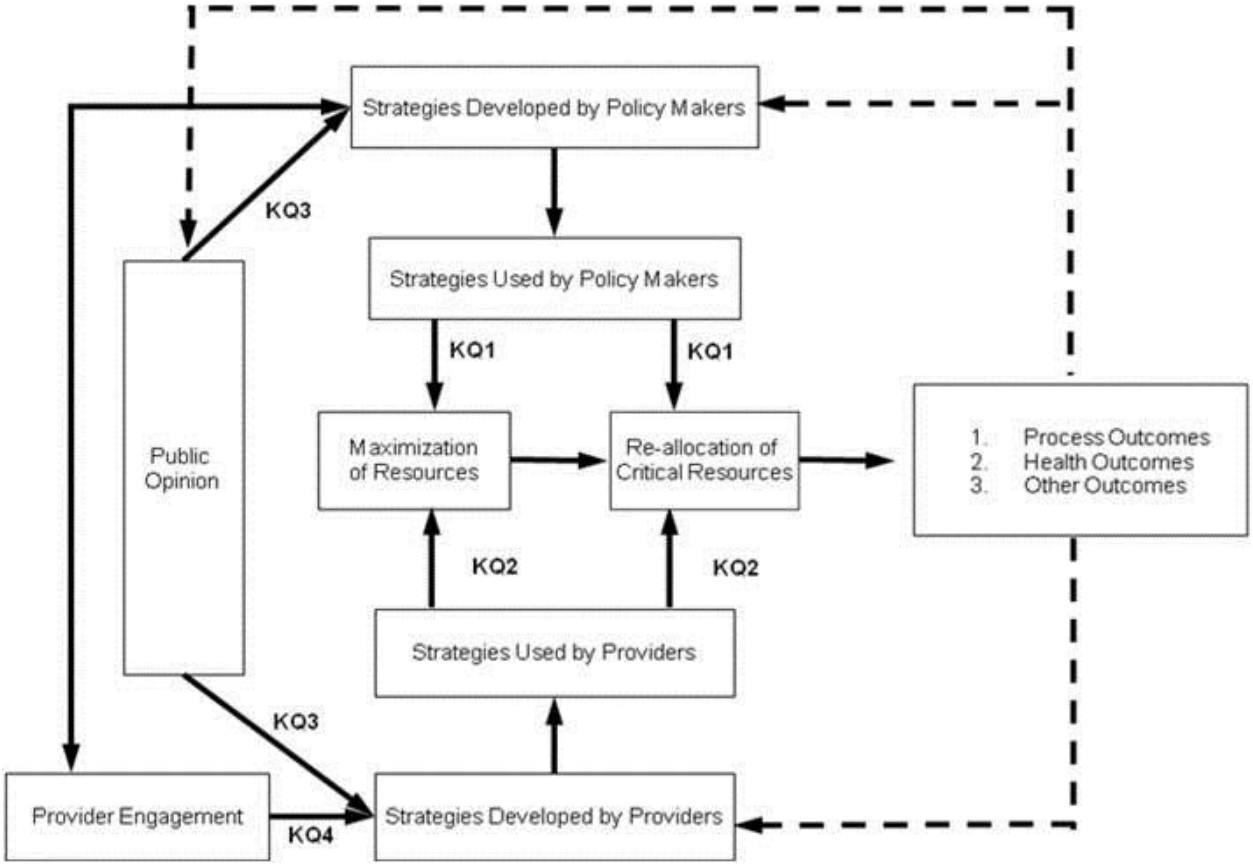
Technical Expert Panel (TEP)

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, healthcare ethics, military medicine, risk communication, and public engagement. Our two subject matter experts both of whom are nationally-recognized experts in disaster medicine and health system preparedness were drawn from the private (academic) and public sector, respectively.

Conceptual Framework

The conceptual framework for our evidence review is depicted in Figure 2. It depicts how strategies to allocate and manage scarce resources are developed and used by policymakers and healthcare providers, and how the thinking and actions of both groups are modified by public opinion.

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



The conceptual framework reflects the development and use of strategies by policymakers and providers to ensure that patients receive the best care possible under the difficult and sometimes overwhelming circumstances of an MCE. Policy makers and providers develop strategies and implement strategies using an escalating series of contingent actions, based on the nature, magnitude, scope and duration of the MCE:

1. Maximize the use of existing resources by:
    a) Managing/reducing demand for non-essential health care services
    b) Optimizing the use of existing resources
    c) Augmenting, to the degree possible, available resources
2. Allocate scarce resources using "crisis standards of care".

Ultimately, the actions of policymakers and providers influence individual and population outcomes through the process of care and the outcomes this produces (health outcomes and other outcomes). Dashed lines represent feedback loops in which the outcomes of each strategy shape the refinement or development of new strategies. For example, outcomes of strategies, particularly adverse outcomes, might provoke strong reaction from the public. Providers or policy makers may then integrate the expressed preferences of the general public into new or updated strategies. Provider engagement activities might inform the strategies developed by policy makers, while at the same time, the planning efforts of policy makers might also serve as a catalyst for providers to engage in efforts to develop strategies to respond to mass casualty events.

As we prepared our review, the research team and our Technical Advisory Panel agreed that the first step in maximizing distribution of scarce resources is to reducing less urgent demand for resources. The second is to optimize use of the resources that exist in order to maintain generally accepted standards of care. Many of the "resource maximization" strategies that fall under this rubric are aimed at extending use and making management of resources more efficient to forestall development of serious shortages.

If these measures prove to be inadequate, health care facilities may begin operating at "contingency capacity" (excessive but manageable) while efforts are made to augment existing resources by tapping stockpiles, invoking mutual aid agreements and exercising other options. If these contingency measures are inadequate to meet demand, the institution may be forced to operate at "crisis capacity" (extremely excessive demand that is unmanageable with normal standards of care).

At that point, institutions and providers should shift their approach to allocating and managing resources from one designed to maximize the outcome of each individual patient to one that seeks to do the greatest good for the largest number of people. Typically, these strategies are not employed unless every effort to maximize available resources has reached its limit or failed. During a prolonged mass casualty event, the health care system may shift in 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.

Our conceptual framework distinguishes between strategies that have been tested and formally evaluated by policymakers and/or providers in actual MCEs, drills, exercises, or simulations, and those that have been merely envisioned or pilot-tested using less rigorous evaluation designs. The distinction is important. Because large-scale MCEs are rare in the United States, we expected to find few field-validated strategies that have been subject to the rigorous standards of evidence typically required in a CER. Therefore our review encompasses both sets of strategies, although only tested strategies were subjected to rigorous systematic review. Key Questions 1 and 2 focus on strategies developed or implemented by policymakers and providers, respectively. Question 3 focuses on public perceptions and concerns. Question 4 focuses on strategies designed to engage providers in developing and implementing strategies for allocating and managing scarce medical resources in an MCE.

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 timeframes and settings as the analytic framework for the review.

Search Strategy

Our search strategy leveraged existing reviews of the literature, including but not limited to those considered in the IOM's Letter Report and Summary on Crisis Standards of Care[11, 14] and AHRQ/ASPR's Community Planning Guide on Providing Mass Medical Care with Scarce Resources.[15] 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, (3) a review of current State plans, 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 has previously conducted literature searches on this topic for the Assistant Secretary for Preparedness and Response (ASPR).

Due to the cross-disciplinary nature of this topic, our formal literature search used research databases beyond those covering the biomedical literature. We considered the following databases: PubMed, Scopus, EMBASE, CINAHL, Global Health, Web of Science®, and the Cochrane Database of Systematic Reviews, searching from 1990 through 2011. We also searched online library catalogs, such as the National Library of Medicine's LocatorPlus to identify relevant books. The set of databases to be searched was finalized through consultation with our TEP. Then, we constructed search algorithms for each database, executed the search, downloaded the results into individual EndNote libraries, combined the libraries resulting 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 included a search of the New York Academy of Medicine's Grey Literature Report, which helped identify reports from research and advocacy organizations, including non-peer-reviewed reports. We did not pursue additional searches of grey literature sources (e.g., Lexis-Nexis), out of concern that these sources might not provide the high quality evidence needed to satisfy our inclusion/exclusion criteria.

Individual members of the TEP identified relevant studies that were conducted and organizations that sponsored research or issued guidance on proposed strategies for allocating resources during MCEs. Examples included the Centers for Disease Control and Prevention, the Veterans' Health Administration (VHA), professional society guidelines, and non-governmental organizations such as Trust for America's Health. We compiled a list of these sources, and used scans of relevant, related websites to broaden our search.

An additional element of this project was a review of state plans for allocating scarce healthcare resources in the setting of a MCE. We worked closely with our federal partners, particularly officials at ASPR, to identify a current set of state plans. Ultimately, we received one or more planning documents from 11 states and the territory of Guam. Because there is no central national repository for this information, this list is probably not be exhaustive.

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 timeframes and settings (PICOTS). This section describes these dimensions and the resulting inclusion/exclusion criteria for each of the key questions, as well as general inclusion/exclusion criteria.

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/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 (whether or not a comparison group was used).
  - 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 non-systematic reviews.
- Exclude studies that do not consider these strategies in the context of an MCE.

Key Question 1: Strategies available to *policy makers* to optimize allocation of resources during MCEs

PICOTS Framework for Key Question 1

Population: 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 mass casualty event, and those with unrelated, but urgent, medical needs (e.g., treatment for heart attacks, stroke, kidney failure, or cancer). We will also address behavioral health needs in the setting of MCEs, including acute stress, grief, psychosis, and panic reactions. The affected population also includes policymakers charged with responsibility for crafting and implementing strategies to optimize allocation of resources during MCEs.

Interventions: Strategies used by policymakers to optimize resource management. These include actions to reduce or redirect less urgent demand for emergency health care services, to increase the supply of needed medical resources, and when these actions are inadequate, to ethically allocate scarce medical resources in an optimal manner. 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 in order 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.[11]
- 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, the intervention (use of a strategy) was compared to no intervention (i.e., no change in the approach to resource allocation or management). We also considered studies that compared an intervention to one or more alternative interventions. Studies that described an interesting idea, technique or technology and demonstrated its feasibility in a laboratory or simulated setting with a limited number of subjects were not included in the full CER if they did not include a comparison group. However, because these studies offered evidence of feasibility, we summarize them in a separate section. These studies may represent a useful pool of ideas for future research and field evaluation.

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, but we did not examine strategies specifically addressing long-term recovery from MCEs (e.g., community resilience).

Settings: All settings in which patient care might be directed/managed and delivered, including but not limited to: pre-hospital triage locations (e.g., on-scene, in transport), emergency department triage and care, inpatient settings (e.g., operating room (OR), intensive care unit (ICU), 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/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 (above) 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 or comprising representatives of 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 or comprising representatives of the federal government, or does not describe the consensus development process.

Key Question 2: Strategies available to *providers* to optimize allocation of resources during MCEs

PICOTS Framework for Key Question 2

Population: People who require medical treatment after a mass casualty event. This group includes those who are physically injured and/or ill as a direct or indirect result of the mass casualty event, and those with unrelated but urgent, medical needs (e.g., treatment for heart attacks, stroke, kidney failure, or cancer). We also addressed behavioral health needs in the setting of MCEs, including acute stress, grief, psychosis, and panic reactions. The affected population also includes healthcare providers who hold responsibility for making difficult decisions about how to optimize allocation of resources during MCEs.

Interventions: Strategies used by providers to maximize or allocate scarce medical resources. 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 non-clinical 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, the intervention (use of a strategy) was compared to no intervention (i.e., no change in the approach to resource allocation or management), or when specified, to one or more alternative interventions. Studies that described an interesting idea, technique, or technology and demonstrated its feasibility in a laboratory or simulated setting with a limited number of participants were not included in the full CER, but are summarized and cited separately. These "proof of concept' studies may represent a useful pool of ideas for future research and field evaluation.

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 mass casualty events. We considered strategies that address the triggers or timing for returning to normal operations, but we did not examine strategies specifically addressing long-term recovery from MCEs (e.g., community resilience).

Settings: All settings in which patient care might be delivered, including but not limited to pre-hospital triage locations (e.g., on-scene, in transport), emergency department triage and care, inpatient settings (e.g., OR, ICU, 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/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 or comprising representatives of 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 or comprising representatives of 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: Public concerns regarding resource allocation strategies

PICOTS Framework for Key Question 3

Population: The general public, with special attention paid to members of vulnerable 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 in a 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 in MCEs, including but not limited to values, priorities, preferred methods of communication 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 did not examine strategies specifically addressing long-term recovery from MCEs (e.g., community resilience)

Settings: No exclusions.

Inclusion/Exclusion Criteria

- Include studies that use a systematic data collection method (e.g., surveys, focus groups, etc.) to describe public opinion regarding the implementation of strategies for allocating scarce resources during an MCE.
- Studies can consider the general population or sub-populations 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: Strategies 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.

Interventions: 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).
- Educate or train providers on key issues or capabilities related to MCEs (e.g., through continuing medical education (CME) activities and conferences).
- 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, discussion groups).
- Encourage provider participation in collaborative activities (e.g., voluntary cooperative planning).

Comparators: For this key question, the only comparators were post-test assessments on a few of the studies reviewed. For example, some studies could compare outcomes (including knowledge, attitudes, and self-reported or observed performance) over time (e.g., before and one

or more times after an intervention), as well as the impact of provider engagement upon collaborative efforts at the local/regional, State, and national levels.

Outcomes: Combination of:

- 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: No restrictions on timing.

Settings: 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, but we did not examine strategies specifically addressing long-term recovery from MCEs (community resilience).

Inclusion/Exclusion Criteria

- Include studies that describe processes and outcomes of strategies used to engage providers in the development of strategies for addressing surge capacity or the allocation of scarce resources; for example, planning efforts to develop altered 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 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.
- See our definitions section for detailed description of providers.

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/ exclusion according to pre-determined 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 a 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.

To further pare down articles selected for potential inclusion during the abstract stage, two researchers independently reviewed full-text articles and excluded thosethat: 1) failed to address a key question; 2) proposed strategies (for KQ1, 2, and 4) that did not meet our evidence threshold; or 3) related to training 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 KQ1 and especially KQ2, we developed an electronic data collection form using DistillerSR (Appendix B) to capture the necessary data elements. For KQ3 and for our analysis of state MCE plans, data were abstracted directly into spreadsheets because of the relatively small number of data elements required for each review. For KQ4, 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, details of the strategy, outcomes reported, and implementation facilitators and/or barriers. For KQ4, we were also concerned with the types of stakeholders participating in the engagement strategy. Studies comprising the two lower-evidence tiers for KQs1 and 2, (i.e., studies lacking comparison groups and proposed strategies), and all information from state plans were abstracted using a paper-based method. Abstraction involved a much smaller set of data elements--the specific strategy, the relevant MCE context, and the principal findings (if relevant).

A total of nine reviewers performed data extraction. At least two reviewers, all of whom received formal orientation to the review process, abstracted each article that met one or more KQ 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 edited and manipulated to generate evidence tables (Appendix C). Evidence tables for KQ 1 and 2 are organized according to one of four broad classes of strategy: (1) strategies intended to reduce less urgent demand for health care services or manage demand in alternate settings, (2) strategies intended to maximize efficient use of existing resources, (3) strategies designed to augment resources from a variety of sources, and (4) strategies designed to enable effective and ethical allocation (or reallocation) of scarce medical resources during crisis situations. These categories are described in greater detail later. Strategies were further grouped into sub-categories, (e.g., points of dispensing studies, studies assessing alternative care sites, etc.). Within each sub-category, the newest studies are presented first.

Quality (Rick of Bias) Assessment of Individual Studies

Given the relative rarity and unpredictability of MCEs, we anticipated that few, if any, studies of the topic would involve randomized controlled trials, where validated instruments to assess the quality of studies exist and are widely used.[16] Given the diversity in methodologies 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. We therefore conducted an environmental scan of existing rubrics. Finding no single scale that seemed appropriate for

our topic, we developed our own assessment scale that drew heavily on the Substance Abuse and Mental Health Services Administration's (SAMHSA's) National Registry of Evidence Based Programs and Practices (NREPP) quality assessment scale and two other scales commonly used to appraise the quality of qualitative research.[17-19]

We used this composite scale to appraise the quality of studies addressing KQ1, 2, and 4. The five individual items for this scale assessed the following: 1) the level of detail used to describe the resource allocation strategy, 2) whether or not data collection was systematic (and if so, whether it was retrospective or prospective), 3) whether or not fidelity (defined as the degree to which the strategy was implemented consistently) was measured or could be inferred from the data provided, 4) whether or not the generalizability of the findings was assessed, and 5) whether or not the authors discussed potential confounders to the strategy's effectiveness. For KQ4, 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").

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 or because valid scales were available, respectively. In our environmental scan, we identified one study[20] which offered recommendations for modeling disaster responses in public health. We identified several key aspects of model quality from this study and modified our quality instrument accordingly. We eliminated the data collection and fidelity items and replaced them with two items that assessed model assumptions and sensitivity analyses. Specifically, we assessed the degree to which the authors justified their model assumptions and/or data inputs, and whether or not sensitivity analyses were performed (and if so, whether or not they were robust). For systematic reviews, we used the AMSTAR instrument,[21] an 11-item scale that measures features such 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 KQ3 we elected to develop our own quality scale that reflected key differences in methodology we observed across the small number of included studies. Using seven binary items, our scale assessed whether 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 were evaluated by an independent third party organization.

Data Synthesis

Given the study topic—mass-casualty events—we did not anticipate that we would identify many studies that would meet criteria for quantitative synthesis to produce valid and generalizable findings. First of all, MCEs are relatively rare, and few can be anticipated in time to design and mount a rigorous prospective trial. Second, the logistical, technical, and ethical barriers to randomly allocating an intervention to survivors and rigorously collecting the resulting data are too formidable to be an option in most MCEs. For these reasons, nearly all of the data compiled to date are descriptive, and most are qualitative. When outcomes were reported, they were generally described in broad terms such as actual versus historic (or predicted) rates of mortality, levels of resource consumption, or qualitative estimates of impact. Thus, the body of evidence compiled to date is insufficient to support quantitative synthesis using statistical techniques such as meta-analysis.

For these reasons, we chose to structure our findings around several broad themes and observations, graded by the overall strength of the evidence. A priori, we postulated four broad categories of adaptive strategies, which we reviewed with the TEP: (1) strategies intended to reduce less urgent demand for health care services or manage it in alternate settings, (2) strategies intended to maximize efficient use of existing resources, (3) strategies designed to augment resources from a variety of sources, and (4) strategies for ethical decision making regarding allocation (or reallocation) of scarce medical resources in crisis situations (See Figure 2, analytical framework, in Chapter 1). 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). Where no evidence was found for the impact of the strategy on health outcomes, we present evidence of its impact on process measures, such as rates of use of consumable healthcare resources.

Whenever and wherever possible, we highlighted differences in outcomes across patient subgroups to the extent these data were reported in individual studies. After finishing our review, we drew conclusions where clear evidence existed. Where the evidence was not clear-cut (e.g., results from included studies are conflicting), we have summarized the strength of the evidence and highlighted where additional research would be beneficial. For the sake of comprehensiveness, we compiled, in a separate pool, studies that have demonstrated the technical feasibility of a novel idea, technique, or technology, as well as a subset of strategies that have been used during real events. The defining characteristic of this set of studies is that none included a comparison group that would be necessary to estimate the impact of the strategy on health or process outcomes. While none of these studies reached the level of evidence that would normally qualify them for inclusion in a CER, we summarize them to highlight promising pilot tests of strategies that deserve further exploration in the future.

Strength of the Evidence

We used the approach for grading the strength of evidence outlined in the Methods Guide for Effectiveness and Comparative Effectiveness Reviews.[22] 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; cores in this domain were denoted 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. After taking into account the various outcomes and different outcomes The evidence in this category was designated as consistent or inconsistent after looking across all effect sizes. Directness refers to the degree to which the strategies have an impact on health outcomes rather than intermediate outcomes. In this domain the evidence was deemed either direct or indirect. Finally, precision refers to the level of certainty surrounding the set of effect estimates. For this domain, the evidence was rated as precise or imprecise. After making assessments in the four domains, the strength of the evidence was graded, using the four point scale (i.e., high, moderate, low, or insufficient), for the selected strategy categories and outcomes within each of the four key questions. 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.[22]

Whether our team assessed the strength of evidence for an entire key question or by sub-categories depended on the nature of the question. Given the diversity of strategies used to allocate scarce resources, we rated the strength of evidence within each of the four broad

categories, i.e., those intended to reduce or manage less urgent demand; those designed to optimize use of existing resources; those designed to augment existing resources and those that implement altered standards of care. Within these broad categories, we also rated the strength of evidence for particular subcategories, such as triage.

For KQ3, we rated the strength of evidence across all studies, regardless of whether the information was derived from stakeholder forums, interviews or surveys. The paucity of studies addressing this KQ precluded analysis by subcategories. A single reviewer graded the strength of evidence for each dimension, which was then reviewed by a second reviewer. Differences were reconciled through discussion. Overall strength of evidence grades were determined in an analogous manner using a qualitative assessment of the scores for each dimension. Strength of evidence grades are summarized 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 included studies are generalizable to the populations, practice settings, and disaster contexts, that are most relevant to them. We conducted qualitative assessments[23] of the applicability of evidence for each KQ using both the PICOTS framework for each KQ (see Key Questions, above) and through the abstraction of 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 U.S., we also assessed the degree to which the strategy was applicable in the U.S.

This approach assured that the articles that were included were clearly applicable to the relevant populations, interventions, comparators, and outcomes. The process we used to determine each article's applicability was the same as that employed for extracting data, (i.e., 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 will be invited to provide external peer review of this systematic review. The AHRQ Effective Healthcare Program Scientific Resource Center (SRC) located at Oregon Health Sciences University (OHSU) will oversee the peer review process. Peer reviewers are charged with commenting on the content, structure, and format of the evidence report and encouraged to suggest any relevant studies we may have missed. AHRQ and the SRC also requests review from its own staff. The SRC will place the draft report on the AHRQ website (http://effectivehealthcare.ahrq.gov/) for public comment and compiled the comments for our review. We will also request review from each member of our Technical Expert Panel (TEP). We will compile all comments and address each one individually, revising the text as appropriate. All changes will be documented in a "disposition of comments report" that will be made available three months after the Agency posts the final review on the AHRQ website.

Results

Literature Search

The peer-reviewed literature searches identified a total of 4101 potentially relevant citations. A search of the grey literature yielded 286 citations, and an additional 43 titles were suggested by our Technical Expert Panel. Reference mining contributed an additional 11 citations. All 4441 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 2232 relevant and unduplicated titles for abstract review (Figure 2). During abstract review, 990 articles were excluded because either the abstract did not appear to answer a key question (662 articles) or the abstract did not indicate a quantitative or qualitative data analysis (328 articles). Following abstract review, 1242 full-text articles were available for further review.

Screening these articles with the aid of a short form led to the exclusion of 882 additional articles. Reasons for exclusion included at least one of the following: 1) the article did not answer a key question (583 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 (268 articles for KQ1 and KQ2; 17 articles for KQ4).

A total of 360 articles were considered for data abstraction. Ultimately, 147 met selection criteria, including 23 studies that focused on policymakers, 101 that addressed the decisions of providers, 7 that considered the perspectives of the public, and 16 that addressed engagement of providers in developing strategies to optimize the allocation and management of scarce resources.

A total of49 articles were considered for KQ1. Fifteen articles that describing tested strategies were included. Seven additional articles were included in a separate group because they lacked a comparison population. One additional article was included that described a proposed strategy with adequate consensus. The major reasons for exclusion at the data abstraction stage for KQ1 included insufficient evidence or inadequate consensus.

For KQ2, 289 articles considered for data abstraction. Ultimately, 47 articles describing tested strategies were included. An additional 42 articles were included in a separate group because they lacked a comparison population. Twelve articles that described a proposed strategy with adequate consensus were included in a third group. Reasons for exclusion included either insufficient evidence or inadequate consensus.

For KQ3, a total of 31 articles were identified, of which 7 were included in the review. Reasons for exclusion included either failure to address resource allocation or failure to assess the public's opinions directly.

For KQ4, 16 articles were identified. All were included in the report.

The data abstraction tools used by reviewers are provided in Appendix B. Data abstracted from the included studies are presented in evidence tables located in Appendix C.A list of citations that were excluded from the review, along with the reason for exclusion, is located in Appendix D. In Figure 3 we depict the literature flow, showing the breakdown of included and excluded studies at each screening level.

Figure 3. Literature Flow

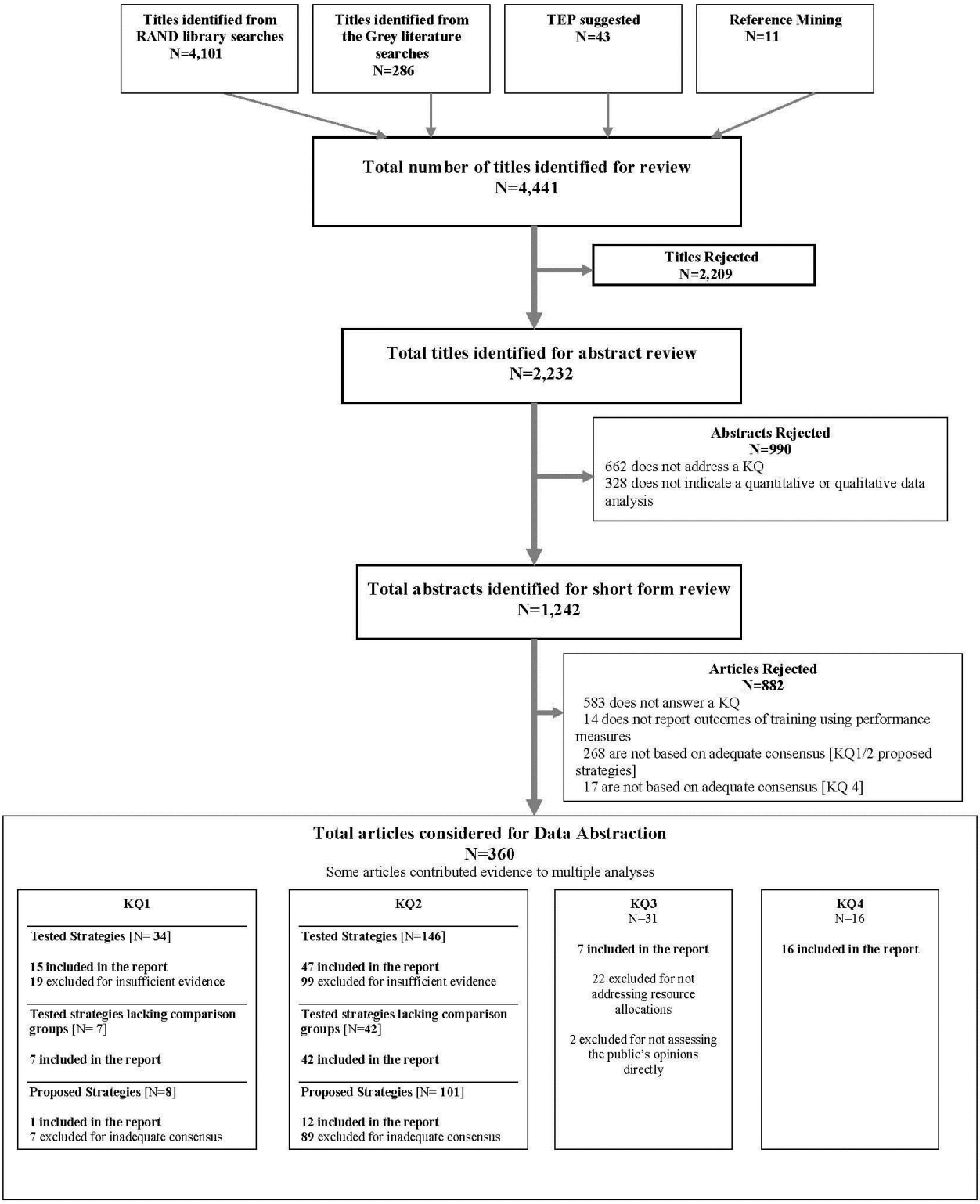


Figure Notes: TEP=Technical Expert Panel; KQ=Key Question

Key Question 1: Strategies for Policy Makers to Optimize Scarce Resource Allocation in Mass Casualty Events

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 the implementation or effectiveness of strategies to optimize the allocation and management of scarce resources in MCEs?

Key Points

- Three observational studies examined the throughput that might be expected 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.[24] A "push" strategy employing U.S. mail carriers produced even higher throughput than administration through fixed sites.[25]
- Each computer simulation was distinctly different from the others. Thus, their results cannot be meaningfully compared across studies.
- Similarly, results could not be compared for 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.
- The small number of studies that met inclusion criteria (n = 15), and the marked variability in design, focus and content for this Key Question provide a relatively weak evidence base to inform policymakers. Slightly more than half of the articles were observational in nature, and only a few of these examined similar scenarios using similar endpoints. Nearly half of the reports involved computer simulations, which depend on assumptions rather than empirical observations to generate findings.

Description of Included Studies – Tested Strategies

All mass casualty event (MCE) interventions are ultimately operationalized at the level of healthcare providers and their patients. This category includes strategies aimed at reducing or managing less urgent hospital demand, those focused at optimizing use of health care resources, those directed towards augmenting health care resources, and finally those put in place to guide application of crisis standards of care.

Table 1. Summary of Strategies Addressing Key Question 1, by category

	Strategies
Reduce or manage less urgent demand	• 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 antivirals from stockpiles (e.g., level of pre-allocation, level of tailoring to population needs, amount for prophylaxis vs. treatment) • Mutual aid agreements that allow transshipment of antivirals between counties • Mass vaccination, contact tracing, and school closure • Mass distribution of antibiotics using postal carriers • Simulation models to optimize logistics of response • Activating mobile provider units from other federal agencies to provide hospital surge capacity • Training public health officials in their legal authority to implement strategies • Distribution of surgical masks or N95 respirators to the public
Optimize use of existing resources	• Central command structure to optimize distribution of urgent patients to hospitals • Establishment of site emergency management centers in low vulnerability locations • Robust and interoperable emergency communications systems
Augment existing resources	• Coordinated regional trauma systems to facilitate the rapid transfer of hospitalized and special needs patients • Mobile field hospitals • Alternate-site surge capacity facilities
Crisis standards of care	None

Detailed Synthesis

Policy makers – governments at all levels from local to national – play a key role in providing policy and operational guidance for scarce resource allocation in mass casualty events. Many of the studies in our review describe adequately-tested interventions that involve both policy makers and health service providers. The response to KQ1 reflects studies that principally relate to policy makers and met the eligibility criteria described in Chapter 2 (Methods). The first section below addresses the 15 studies with adequately tested strategies. The following section describes eight additional studies that provided some evidence but lacked a suitable comparison group. These latter studies are included as a potential pool of interesting and possibly promising ideas worthy of future exploration. This section is followed, in turn, by a third section that describes a small set of "Proposed Strategies" – consensus documents and recommendations by national specialty societies and other bodies that are germane to the key question but do not present tested evidence.

The 15 papers included in this review address tested strategies for policy makers to reduce or manage less urgent demand (11 studies), optimize use of existing resources (one study), or augment existing resources (four studies); one study is included in two of these categories. No policymaker study that met inclusion criteria addressed development or implementation of crisis standards of care. Nine studies were conducted in the U.S., one was conducted in Asia, and the study location for five was not specified or not relevant. Eight studies reflected observational designs – a drill or an actual event. Seven were based on computer simulations. In principle, results based on actual events or drills are more credible than computer simulations, because they are more empirical than theoretical in nature.

Ten studies addressed biological threats (five anthrax, three pandemic influenza, one smallpox, and one pandemic influenza or SARS); three addressed natural disasters (all hurricane, including Hurricane Katrina), and one addressed an explosive event (one of the September 11 attacks). All seven computer simulation studies addressed biological threats, including anthrax, smallpox, pandemic influenza, and unspecified infectious diseases.

Of the eight observational studies, three had a pre-test/post-test design, and five had post-test design with a comparison group. The quality ratings were at least moderately high (50 percent or more of the total possible points across the quality domains) for all four of the observational studies related to reducing or managing less urgent demand and for all three observational studies related to augmenting existing resources (see Appendix Table C-1). The quality of the single study (observational design) in the optimizing resource use category was rated as two out of a possible eight points. Four of the seven computer simulation studies were judged to be of at least moderate quality (a score of at least four of eight), and three were of lower quality.

Strategies to Reduce or Manage Less Urgent Demand

Nine of the 11 studies reviewed under the broad category of strategies to reduce or manage less urgent demand pertained to biological countermeasures. The specific strategies included modeling stockpile allocation, exercising stockpile dispensing, and mass distribution of antibiotics using mail carriers. The other two studies pertained to non-biological countermeasures. The strategies included modeling the impact of physical barriers to disease transmission and an exercise to raise awareness of legally acceptable intervention measures.

Biological Countermeasures

The nine studies in this group included three observational studies and six computer simulations.

The three observational 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 1). 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.[26] 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.[25] 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[26] were more efficient than those in the second,[25] 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 in 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.[24]

Table 2. Comparison of Different Point of Dispensing (POD) Strategies

Intervention and Comparison Groups	Findings	Source
Centralized POD model vs. Hybrid model	Centralized: 0.75 patients/minute → 45 patients/hour Hybrid: 0.48 patients/minute → to 28.8 patients/hour	Ablah, 2010[26]
(Centralized) POD dispensing vs. "push" method using mail carriers	Centralized: 1988 persons/hour, or 33/hour/staff person Push: 3,833 persons/hour, or 120/hour/staff person	Koh, 2008[25]
1 county using RealOpt software vs. 7 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 Non-users: No county reached 450 targeted households; best one achieved 71% of target	Lee, 2006[24]

The six computer simulations relevant to Key Question 1 were more varied in focus. Three addressed pandemic influenza, two addressed anthrax, and one addressed smallpox. Each of the influenza simulations examined different questions and thus, were not particularly comparable to one another. One study looked at the use of the same or different drugs for treatment and prophylaxis,[27] one looked at allocation of the single stockpiled antiviral drug, including its use for treatment or prophylaxis,[28] and the third examined optimal vaccination-targeting strategies.[29] The results of the influenza simulation judged to be of highest quality suggested that a two-drug strategy for pandemic influenza (one drug for prophylaxis, 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 use of a single drug for both prophylaxis and treatment.[27] However, the simulation also indicated that the two-drug model is more likely to result in multi-drug resistance than resistance to a single drug, which is a significant drawback.

Another simulation, also of high quality, reflects the importance of young children in influenza transmission and indicates 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.[29] The third influenza simulation also provides useful, albeit somewhat less compelling, evidence. It notes that allocation of an antiviral stockpile should not be determined in advance and should be based instead 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.[28]

One of the anthrax simulations examined rapid mass distribution of prophylactic drugs versus treatment only of symptomatic persons. As expected, it found that the former strategy prevents significantly more deaths than the latter.[30] That study also showed the significant impact of adequate hospital surge capacity on reducing patient deaths. The other anthrax simulation was judged to be of poor quality and therefore does not provide persuasive evidence to support its rather general findings.[31]

The results of the smallpox simulation suggested 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.[32]

Several of the studies that tested strategies for implementing Points of Dispensing, involved relatively large-scale exercises that were conducted in different geographic regions. This evidence appears to be generalizable across locations and settings. Computer simulations may not provide highly applicable evidence to specific MCE contexts if their conclusions rely heavily

on assumptions or model parameters that are contextually inappropriate. The applicability of the evidence generated from these studies is exceedingly hard to assess. 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. However, few rigorous designs exist to provide relevant evidence for certain policy maker strategies such as the use of quarantine. Taken together, these studies provide reasonably applicable evidence.

Non-Biological Countermeasures

The two studies that examined non-biological countermeasures dealt with influenza—one is an observational study and one a computer simulation. Because they addressed entirely different issues, they were not comparable. The observational study was a tabletop exercise addressing measures that policy makers could legally take in 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. [31] 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.[33]

Strategies to Optimize Use of Existing Resources

We identified only one study in this category and judged it to be of poor quality despite providing highly applicable evidence from a real mass casualty event.[34] Thus it is not a confident source of evidence for this review. It described response strategies following the September 11, 2001, terrorist attacks in New York City and found that 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.

Strategies to Augment Existing Resources

We reviewed four studies of strategies to augment existing resources. Three of the four were observational studies addressing measures taken after a major hurricane. The fourth is an anthrax computer simulation discussed above under strategies to reduce or manage less urgent demand. The hurricane-related observational studies did not report comparable end-points and therefore do not permit valid comparisons across their different strategies. However, one study documented significant reduction in patient transfer times once a coordinated regional trauma system was introduced for routine, small-scale trauma events; 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 vulnerable patients prior to Hurricane Rita.[35] Another study documented the extra patient load cared for by a mobile field hospital deployed to care for evacuees from Hurricane Katrina.[36] The third study 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 post-event.[37] The computer simulation study indicated the significant favorable impact of "mobile servers" (augmented hospital capacity provided by federal health care providers) on predicted mortality.[30]

The strategies we identified for augmenting capacity during MCEs relied on data from real events with the exception of a single computer simulation. While all strategies were tested at a single site or within a single region, 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 policy makers 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. Strength of Evidence for Key Question 1

Strategies		Risk of Bias	Consistency	Directness	Precision	SOE Grade
Reduce or manage less urgent demand	Biological countermeasures (n=9)	High	Consistent	Observational: Indirect Simulations: Direct	Imprecise	Low/Medium
	Non-biological countermeasures (n=2)	High	Not applicable	One direct, one indirect	One precise, one imprecise	Low
Optimize use of existing resources	Load sharing (n=1)	High	Not applicable	Indirect	Imprecise	Low
Augment existing resources	Temporary facility (n=3)	Low	Consistent	Indirect	Imprecise	Low
	Load sharing (n=1)	Medium	Not applicable	Indirect	Imprecise	Low
Crisis standards of care		NA	NA	NA	NA	NA

Tested Strategies Lacking Control Groups

In the course of this project, the study investigators identified 46 additional articles that presented evidence related to the first and second Key Questions but did not meet the level of evidence required to be formally included in our CER because they lacked a comparison group. (Appendix Table C-2)

Although the impact of these strategies on patient outcomes has not been conclusively demonstrated, a number of them incorporated innovative techniques to reduce demand, increase efficient use of resources, and/or augment capacity during a MCE. Some showed sufficient promise to be worthy of consideration for future research to advance the field.

Six studies in this group addressed strategies that have the potential to inform policy making (KQ1). For example, one 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.[38] Another simulation study, conducted in the Netherlands, examined diagnostic demands with regard to laboratory capacity.[39] It indicated 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 non-hospitalized population. An additional study related to laboratory capacity discussed a

customized laboratory information system to support the activities of the Centers for Disease Control and Prevention (CDC) for rapid sample analysis and data reporting.[40]

The other three studies reported information collected during actual MCEs. At the height the 2009 H1N1 pandemic, a volunteer group of interdisciplinary experts from around the country collaboratively developed and deployed an interactive, Web-based decision-support tool to help adults with influenza-like illness self-asses their need for emergency department care.[41] The tool closely adhered to a diagnostic algorithm the group developed in collaboration with the CDC and validated using electronic health information collected from a large health maintenance organization in Colorado. The interactive, Web-based version of this algorithm was offered to the public via Flu.gov and a free Website operated by Microsoft. 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.

In an unrelated study examining resource allocation under crisis standards of care, Etienne et al described how a Multi-disciplinary Healthcare Ethics Committee determined allocation of resources during the Haiti earthquake.[42] They found this process enabled ethical decision making in a timely manner. Irwin et al. reported details about the successful use of a multi-disciplinary treatment center in Houston to treat large numbers of evacuees for non-emergent medical concerns in the aftermath of Hurricane Katrina.[43] During the time this large facility was in operation, it substantially reduced use of local Emergency Departments for non-emergent problems.

Proposed Strategies

Our systematic review identified one study that described a proposed strategy for use by policy makers to allocate resources during MCEs. This study met our strict criteria for defining "consensus" strategies—those resulting from the deliberations of one or more national professional organizations or those produced by task forces convened by the federal government. 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.[44] 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 prioritization by tier depends on 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 individual 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: Strategies for Providers to Optimize Scarce Resource Allocation during Mass Casualty Events

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 (Table 3). 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 prospectively collected during one or more actual MCEs. Fewer still 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-systematic data collection processes than are generally required for inclusion in systematic reviews. This is not surprising given the inherent difficulty of systematically collecting precise data in the midst of an actual MCE. As a result, most of the studies we identified used relatively weak designs and compared their 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 inconsistently reported this information.
- 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. Most did not propose actionable steps to help health care providers make difficult decisions regarding allocation of scarce resources under altered standards of care.

Introduction

Key Question 2 sought to identify strategies that were available to providers to optimize the allocation of scarce resources during MCEs. Our review comprised strategies that were tested in some way, either through actual implementation during an MCE, or through an exercise, drill, or computer simulation. All studies included in the review compared the effectiveness of one or

more strategies using a contemporaneous or historical comparison group or another performance benchmark, and all studies provided some measure of effectiveness, in the form of process outcomes or health outcomes.

In this section, we summarize the effectiveness of these provider-oriented strategies, as well as the facilitators and barriers to their implementation. Because the evidence base is limited in this area, we supplemented our review with a brief summary of studies that did not meet the evidence threshold for inclusion in the review. These studies included tests of strategies without the use of a comparison group. These study designs do not allow meaningful conclusions to be drawn regarding the effectiveness of each strategy. Nevertheless, this group of studies represents a potentially promising pool of ideas for more focused research in the future. In addition, we summarize strategies that relied on consensus levels of evidence from national provider organizations or panels convened by the federal government. Because these three groups of articles represent distinct sources and levels of evidence, we summarize them in separate subsections below. Data abstracted from studies forming the primary body of evidence are found in Appendix Table C-4. Evidence tables for strategies that did not undergo rigorous tests and recommended strategies are found in Appendix Table C-5 and C-6, respectively.

Description of Included Studies

In contrast to the small number of studies relevant to Key Question 1, we found numerous studies that provide evidence on a range of strategies intended to help providers optimize resource allocation during MCEs. A total of 47 studies met our criteria for full-text review (Table 3).

Three of these studies described strategies to reduce or manage less urgent demand that might be better served in other settings. These strategies included those relating to dispensing biological countermeasures, such as mass vaccination protocols and the use of points of dispensing, and telemedicine strategies to reduce demand for acute or highly specialized care at receiving hospitals.

A total of 39 studies addressed strategies to optimize use of existing resources. The majority of them (25) assessed triage systems, including validation studies of existing triage systems, tests of triage systems used in actual MCEs, and comparative analyses of alternative triage strategies and training programs. The other studies were thinly spread over a broad range of promising strategies. Three studies assessed ways to optimize triage in trauma MCEs by using imaging equipment such as focused ultrasonography or computerized tomography (CT) scanning to assist with patient assessment. Three studies described load-sharing systems between hospitals. Other studies evaluated the effectiveness of case managers, alternative decontamination protocols, health IT and telemedicine interventions to facilitate triage and delivery of specialty care, public information strategies that maximize providers' time spent delivering care as opposed to providing information, and medical care interventions, such as one intended to improve outcomes of victims of crush injury and another intended to facilitate delivery of antidotes following exposure to nerve agents.

Only three studies examined strategies to augment existing resources. Specific ideas tested included using "reverse triage" to facilitate discharge of less seriously ill or injured patients in order to increase hospital surge capacity; using more readily available forms of personal protective equipment to protect health care workers, and augmenting the supply of a particular antidote for nerve agents by converting an intramuscular form of the medication to a form amenable to IV administration.

Six studies assessed the impact of altered standards of care. Two were studies of trauma surgery protocols commonly referred to as "damage control surgery." Two other studies each described a modified approach to imaging and an orthopedic surgery protocol, respectively. Two studies assessed general strategies of implementing crisis standards of care—one specifically for pediatric patients, based on a disaster simulation; the other for all patients that was implemented during a natural disaster.

Table 4. Number of included studies by provider strategy category and sub-category

Provider Strategy Category	Sub-category	Number of studies
Reduce demand	Biological countermeasures	2
	Telemedicine	1
Optimize resource use	Case managers	1
	Decontamination	1
	Health information technology	1
	Imaging	3
	Load sharing	3
	Medical care	2
	Public information	1
	Telemedicine	1
	Triage	20*
	Training	6*
Augment resources	Reduce health care worker attrition	1
	Resource conversion	1
	Reverse triage	1
Crisis standards of care	General	1
	Imaging	1
	Orthopedics	1
	Pediatrics	1
	Trauma surgery	2
Total number of studies		**47****

*Includes one systematic review.
**Individual studies may be classified into multiple provider strategy categories.

Table 5. Summary of Strategies Addressing Key Question 2, by category

	Strategies
Reduce or manage less urgent demand	• Emergency mass clinic based on CDC guidelines • Points of Dispensing strategies (e.g., dynamic staffing) • Regional telemedicine hub to support delivery of specialty care
Optimize use of existing resources	• Hospital-based case managers to ensure care coordination • Strategies to increase decontamination effectiveness (e.g., instructions, providing washcloths, etc.) • Electronic triage tags to monitor vital signs and transmit information to first responders • Focused assessment of sonography for trauma (FAST) for triage • Sonographic screening for abdominal/pelvic injury or bleeding for triage • Robust redundant communications channels between command center, responders, and receiving hospitals • Central allocation of patients to hospitals based on available resources • Medical interventions for the prevention of acute renal failure in crush victims • Novel drug infusion devices • Automated central information distribution system for families • Hospital staff training (e.g., disaster drills, computer simulations, tabletop exercises) • Simplified biodosimetry protocol • Quality improvement program to improve response • Triage training (e.g., JumpSTART training program, virtual reality, podcasts, computer games) • Triage systems (e.g., START, 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) • Triage strategies (e.g., combining triage categories, adding categories, one- vs. two-stage triage)
Augment existing resources	• Influenza prophylaxis for healthcare workers • Conversion between formulations of nerve agents to augment supply • Reverse triage to create surge capacity (e.g., suspension of normal elective activity, early discharge, increasing use of community care options)
Crisis standards of care	• Accelerated whole body multislice computed tomography protocol • External fixation of fractures rather than definitive orthopedic care • Provision of only "essential" interventions • "Damage control" approach (e.g., for orthopedic surgery or more generally)

Detailed Synthesis of Tested Strategies

We noted significant heterogeneity within the four broad categories of resource allocation strategies: 1) reduce demand; 2) optimize use of existing resources; 3) augment existing resources, and 4) allocate scarce resources under crisis standards of care. Since no sub-category other than triage was the subject of more than three provider-oriented studies, we confined our synthesis of the evidence to the broad categories, rather than sub-categories. Our assessment of the strength of evidence for Key Question 2 is found in Table 5.

Reduce demand

Three studies described strategies to reduce demand. Two studies examined techniques to rapidly dispense prophylactic medication. The third study considered the potential of telemedicine to reduce demand on emergency departments and trauma centers during a hypothetical MCE. We rated the strength of evidence provided by these studies as **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.[45] A second study used computer simulation to model the throughput of a "Point of Dispensing" (POD). It indicated that POD designs may require better command and control structures to address variability in patient flow.[46]

The third study, also based on a computer simulation, examined the theoretical impact of telemedicine-based delivery of specialty care. It concluded that, following a simulated earthquake, improved rates of survival are possible, largely by freeing up emergency department (ED) beds and trauma specialty care for patients in greater need.[47]

Although each of these studies cleared the threshold for evidence and are therefore germane to a review of strategies intended to reduce health system demand, both simulations were rated as having 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. Likewise, because the effectiveness of the telemedicine system was based on simulated data only, an unknown number of implementation issues may arise when applying it in practice. The study of the mass vaccination clinic used data from an actual event (an outbreak of Hepatitis A) to derive its conclusions. Because it was conducted in a typical community, its findings may be applicable to similar communities elsewhere.

Optimize resource use

A total of 39 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 tools, we synthesized evidence on these strategies separately from the remaining optimization strategies. The strength of evidence for the set of triage studies is **low.** The strength of evidence for the non-triage studies is also **low**.

Triage Tools

Of the studies that examined triage systems, a number examined their validity, whereas, others assessed the accuracy with which these systems can be applied during drills or actual MCEs. One recent systematic review of triage systems, comprising 11 articles that reported on 8 different triage tools,[48] concluded that limited evidence supported the validity of widely used triage tools. Among existing systems, the Sacco Triage Method was considered the most promising by the reviewers because it was the only tool that combined estimates of patients' survival probabilities with data on available capacity at receiving hospitals. Another derivation study (not included in the prior systematic review) showed that the Field Triage Score predicted patient mortality comparably to the Revised Trauma Score, but was easier to calculate on the scene of an MCE.[49] Collectively, these derivation studies have low methodological quality, most analyses rely on small sample sizes, and few studies actually assess the validity of the tool using health outcomes data from real events in which the triage tool was used. Few triage tools are applicable to pediatric disaster victims.

Several studies examined the implementation of triage tools during real events or simulated events (Table 4). The vast majority assessed the accuracy of classifying patients into triage categories using the tool'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 different tools. A few studies described

implementation problems. For example, in a commuter rail accident, implementation of START led to poor allocation of patients between trauma centers and community hospitals, mainly because of confusion about the meaning of each triage category.[50] Another study demonstrated that START triage categories are not sensitive to patients experiencing myocardial infarction or an asthma attack, and may lead to undertriage of individuals with these conditions.[51] Triage accuracy rates that are measured during drills or exercises may provide evidence with limited applicability, because few drills may 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.[52, 53] Some studies reported 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.[54] During the Sichuan earthquake of 2008, the addition of 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.[55] Other promising triage protocols included modified dosimetry methods, such as using fewer metaphase spreads for dicentric chromosome assays.[56] 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.[57]

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. Few studies tested triage protocols during MCEs and therefore tend to report typically on benchmark throughput times or accuracy rates during an exercise, which may have little applicability to real disaster situations. Established standards for what constitutes acceptable triage performance are lacking, complicating efforts to infer effectiveness of specific tools. As a result, we rated the overall strength of evidence from these studies as low.

Table 6. Accuracy of triage for individual triage tools reported in nine included studies

	Under-triage	Over-triage	Overall Accuracy	Real MCE	Drill/ Exercise
	Results			Study Type	
ACS Committee on Trauma criteria[58]	1%,14%, 13%*	33%	-	x	
CBRN triage system[59]	11%	2%	-		x
Influenza-like Illness Scoring system[60]	<1%	-	-	x	
London transit bombings triage method[61]	-	64%	-	x	
Radiation Injury Severity Classification[62]	-	-	0.92**		x
SALT[63]	10%	6%	83%		x
SALT[53]	4%	13%	79%		x
START[51]	-	-	70%		x
START[51]	-	-	62%***		x
TAS Triage method[52]	0%	0%	100%		x

*Rates for critical, severe, and moderately injured
**Kappa statistic
***Accuracy of triage when clinical status was manipulated for 47 patients.

SALT=Sort, Assess, Life-saving Interventions, Treatment/Support; TAS=Interdisciplinary Emergency Service Cooperation Course; CBRN=Chemical/Biological/Radiological/Nuclear.

Other Strategies

Nineteen studies addressed strategies other than the use of triage tools. A variety of strategies focused on increasing ED throughput, including use of a triage-oriented multislice CT protocol[64] and use of case managers to expedite delivery of critical tests and procedures.[65] A randomized trial of showering strategies suggested that providing washcloths with instructions enhanced the effectiveness of decontamination compared to other methods.[66] In two studies, initial assessment of large numbers of trauma patients was improved by imaging. In the first, Focused Assessment by Sonography in Trauma (FAST) exams were found to have comparable diagnostic accuracy to CT and other diagnostic techniques.[67] A second study showed that sonography was sufficiently accurate to be used as a primary triage tool during a major earthquake.[68] Another study indicated 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.[69]

Three 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, use of an incident command system successfully allocated victims of a terrorist bombing to avoid overwhelming the nearest hospital.[70] Centralized allocation of patients to hospitals, based on available capacity was also shown to achieve balanced allocation following another terrorist incident.[71] In a third study, based on a computer simulation, optimizing allocation of pediatric mass casualty victims through a regional surge distribution mechanism reduced mortality from a disaster.[72]

Other approaches to load sharing may also be beneficial. 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.[47] Another showed that implementing an automated, centralized information distribution system prevented overloading of a hospital's communication lines.[73]

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 if they receive vigorous fluid resuscitation.[74] In a chemical exposure drill, a novel infusion device was reported to be effective at delivering antidote, which sped throughput and increased predicted survival rates.[75]

Six studies of preparedness training for MCEs each reported that this strategy is effective. One systematic review on training found that disaster drills are effective in improving response to MCEs, whereas evidence from computer simulations and tabletop exercises is inadequate to draw conclusions.[76] 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.[77] A virtual reality method of teaching mass casualty triage skills reportedly improved accuracy,[78] whereas a second study indicated that this technique did not improve provider performance using the START protocol.[79] Another study that used podcasts and multi-manikin simulations improved triage performance by medical students.[80] A typical "JumpSTART" training session improved triage performance in a subsequent drill.[81]

Although a clear majority of studies of resource optimization strategies indicate that these methods are effective, the limited level of evidence within each category 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. For example, it is unclear what an "acceptable" false negative rate is for an accelerated imaging protocol. Outcomes of load sharing strategies that indicate balanced allocation are difficult to interpret since the few studies published on this topic did not report health outcomes or adverse events associated with these strategies.

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. Publication bias is often a problem when only a few articles comment on any particular intervention. 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.

Augment resources

Three studies tested different strategies for augmenting scarce resources during an MCE. We rated the strength of evidence from these studies as **insufficient**.

One study examined a "reverse triage" protocol that was implemented during a major transportation accident. The authors report that it successfully created additional surge capacity without worsening the prognosis of patients who were discharged early.[82] A randomized trial conducted during the 2009 H1N1 influenza epidemic determined that surgical masks were as effective as more costly and less readily available N95 respirators at preventing healthcare workers from contracting influenza, thereby remaining healthy and able to work.[83] In the third study, 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.[84]

The paucity of studies in this category limits our ability to draw firm conclusions about their effectiveness. Only two were tested in real MCEs, one of which used a rigorous, randomized design. That study provides evidence that a more readily available non-biological countermeasure, surgical masks, can be used to protect health care workers during an influenza pandemic. This study's use of a randomized design and relevant outcome measures (health care worker infection rates) and its implementation during an actual pandemic significantly enhance the applicability of the evidence for possible future implementation. The conversion of nerve agent antidotes from intramuscular forms into IV forms is a relatively simple intervention that appears replicable and generalizable across settings but may be applicable only to a singular threat. It is unclear to what extent evidence from the single reverse triage study we reviewed is applicable to other settings because the study lacked detail on the practice context.

Crisis standards of care

Six studies evaluated outcomes of strategies involving implementation of altered standards of care during actual or simulated mass casualty events. These studies used a wide range of non-comparable outcomes that may have limited relevance to most providers. We judged the strength of evidence from these studies to be insufficient to support firm conclusions.

One article described the use of very early discharge decisions by a triage committee to allocate ICU care 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.[85] 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.[61] 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.[86] Another study examined the impact of altered standards of care for orthopedic surgery under battlefield conditions. It reported faster throughput, but at the cost of higher complication rates, particularly surgical infections.[87] Because the context for this study was battlefield medicine, its findings may not be applicable to the broader range of MCEs. A triage CT protocol applied during a disaster drill was found to increase imaging throughput, but would potentially produce lower quality images. The impact this might have on clinical outcomes was not assessed.[64]

Finally, a computer simulation study found that the implementation of altered standards of care for pediatric disaster victims could reduce mortality, particularly if preceded by strategies to improve allocation of patients under surge conditions.[72] However, the specific approach used to implement crisis standards of care was not defined.

Collectively, these studies present encouraging findings. However, most were judged to be of low quality due to use of study designs that did not adequately control for potential confounders. Moreover, in the studies of actual events, data collection was typically non-systematic 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.

Despite these limitations, studies of actual events in which crisis standards are implemented provide encouraging, although not-definitive, evidence. Reports based on actual MCEs were generally less rigorous but provided more applicable evidence; computer simulations and exercises provided low quality evidence, and its applicability to real MCEs or to settings outside of which they were studied is limited. Crisis standards in the studies we reviewed were implemented in very specific contexts, including an earthquake and a terrorist bombing, and likely involve different types of injuries and may require different protocols. Crisis standards were typically implemented on a small scale and occasionally at a single site, limiting the generalizability of their findings.

Tested Strategies Lacking Control Groups

In the course of this project, we identified 42 additional articles that presented evidence relevant to Key Question 2, but 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 employed novel techniques to reduce demand, optimize use of existing resources, and augment existing capacity during an MCE. None of these articles addressed reducing demand or implementing crisis standards of care. Some strategies are sufficiently promising to warrant consideration for future research to advance the field.

Optimizing resource use

Fifteen of these studies sought to optimize resource use through improved approaches to triage or use of imaging to support triage decisions. Two reports from actual disaster events[88, 89] 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.[90] 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.[91] A retrospective study described the use of three levels of triage—one at the disaster site, the second at primary health care centers, and the third at the tertiary referral center.[92] Okumura et al.[93] described an approach that uses colored clothes pins to perform color-coded triage for MCEs that require decontamination.

Information technology to facilitate MCE triage has been tested in several exercises and simulations. One such 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.[94] During another simulation exercise, a prototype Radio Frequency Identification (RFID) technology was found to be feasible for use in the field as part of an online triage system for MCEs.[95] A simple navigation device designed to guide walking wounded to a target destination was successfully tested in another study.[96] 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.[97] Electronic patient tracking through bar codes[98] and a web-based triage tool[99] have also been shown in simulations to be promising techniques to optimize use of resources.

Information technology has also been used to improve resource use inside healthcare facilities in mass casualty scenarios. 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 following the 2010 earthquake in Haiti.[100] Roth et al.[101] described a web-based all-hazards electronic disaster management system designed to optimize resource use by integrating healthcare data from multiple sources. Another pilot study tested an educational tool that linked participants' resource allocation decisions to patient outcomes.[102]

Augment existing resources

Twenty-seven 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.[103, 104] One of the studies[104], 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. However, the other study,[103] based on a simulation, suggested that such an approach would sustain only four adults for a limited period of time. Another study of mechanical ventilation devised a prototype that could be quickly manufactured during an emergency.[105] Automatic gas-powered resuscitators (AGPRs) have been proposed to augment the supply of ventilators, but questions about their capacity and usefulness remain.[106, 107] Other studies of respiratory support include one focused on enhancing capacity to deliver oxygen via an improvised system,[108], another that tested the feasibility of just-in-time training for medical students to provide bag-valve-mask ventilation,[109] and a third that assessed the feasibility of

cross-training non-respiratory therapists to assist in mechanical ventilation.[110] Both of the cross-training studies demonstrated successful competency of trainees through testing.

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.[111] 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.[112] Others 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[113] and a successful trans-provincial mass transfer of patients following a major earthquake in China.[114] Another 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.[115] 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.[116] 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.[117]

Several articles in this group pointed to the role information technology can play in augmenting healthcare resources. One team used a web-based application to assess surge capacity and other resources in a state disaster exercise.[118] Another used a mass-casualty tracking system to improve coordination and reduce confusion during a simulated MCE.[119] A wireless handheld device for recording and transmitting patient information between first responders and incident command has also been successfully field tested.[120] 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.[121] In two separate pilot tests, electronic medical information tags were found to increase patient care capacity in the field and facilitate successful transfer of information to receiving facilities.[122] Another study described the use of pervasive computing technology for MCEs, employing 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.[123]

A few studies examined other approaches to augmenting resources. One study tested a tool designed to rapidly mobilize anesthesiology staff;[124] another used a tool to estimate manpower reserve and service capacity for radiology staff.[125] Two studies focused on lab capacity and scalability, particularly for chemical and radiological disasters. One of the two studies described a customized laboratory information system (LIMS) that was developed at the CDC to support emergency response laboratory activities that would be required for the rapid analysis of samples like chemical warfare agents.[40] In another study, the establishment of 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.[126] One study demonstrated the use of a unilateral external fixation device for stabilizing musculoskeletal injuries prior to major surgery.[127] Finally, one study examined the feasibility of re-purposing existing space to serve highly infectious patients, and described the conversion of existing space within a healthcare facility into a temporary negative-pressure room through use of portable, HEPA-filtered forced air.[128]

Proposed Strategies

We identified 12 additional articles that proposed strategies to help providers allocate scarce resources during mass casualty events. 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 a task force convened by the federal government. The group of proposed strategies reviewed here addressed two major activities: performance of pre-hospital (field) triage and allocation of scarce resources in the setting of an MCE.

A national work group convened by multiple professional societies, provider organizations, public health organizations, the CDC, and NHTSA reviewed nine existing mass casualty triage systems with the goal of recommending a single, national standard. 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."

The remaining articles described strategies proposed by professional societies to optimize allocation of resources in hospital settings. One set of recommendations, from the Australasian Surge Strategy Working Group,[129] enumerated strategies involving the use of space, staffing, supplies and equipment, and flow to optimize the ED response to mass casualty events. However, the work group did not specifically address crisis standards of care, noting that this effort was "beyond the scope of [their] paper."

Two specialty society committees have proposed strategies for allocating resources that are clearly in short supply. Both the Society of Critical Care Medicine Ethics Committee[130] and the American Thoracic Society Bioethics Task Force,[131] as part of rather dated guidance, recommended that resource allocation decisions for patients with otherwise equivalent prognoses should be made on a "first come, first served" basis. 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." The American Thoracic Society's Bioethics Task Force reached similar conclusions. 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, such as those by the European Society of Intensive Care Medicine, offer illustrative inclusion/exclusion ICU admission criteria, but stop short of providing recommendations.[132] 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.[133] The effort culminated in the development of "surge action templates" tailored to 10 distinct disciplines to address known challenges associated with surge capacity. 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 this objective.

The 2009 Letter Report by the IOM Committee on Guidance for Establishing Standards of Care for Use in Disaster Situations called on healthcare providers, organizations, government

officials and the public to approach the challenge of allocating scarce resources in MCEs in a proactive and thoughtful way.[11] 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.

Table 7. Strength of Evidence for Key Question 2

Strategies		Risk of Bias	Consistency	Directness	Precision	SOE Grade
Reduce or manage less urgent demand		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

Key Question 3: Public Perceptions and Concerns about Mass-casualty Scarce Resource Allocation Strategies

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 mass casualty events (MCEs)?

Key Points

Based on the limited evidence compiled to date, the public generally agrees with the following concepts:

- MCEs are unusual situations, which require altered decision-making processes and protocols different from those used under normal circumstances.
- Resource allocation guidelines should be generally consistent, but allow health care institutions some degree of flexibility to make allocation decisions based on their specific demand and supply situation.

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

Because of the very limited number of studies related to Key Question 3 (N = 7, of which three are from outside the United States), we rated the risk of bias for each of the above points as medium. The evidence from the five forums and two large scale surveys was consistent. The results of the seven studies are indirect (related to eliciting public views, rather than directly contributing to a desired health outcome). Because the studies addressed a wide range of issues and views, we could not rate their precision. Thus, given the articles' overall quality scores, we considered the strength of evidence for each key point to be medium (Table 6).

Description of Included Studies

Our search identified seven studies that addressed this question.[134-140a] Four studies [136-139] were conducted in five different U.S. states (Massachusetts, Minnesota, Nebraska, Oregon, and Washington); two [134, 135] in Australia, and one [140] in Canada. All but one study reported public opinions related to pandemic influenza.[136] 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, with public engagement forums (sample size 9 – 441) involving fewer participants in general but generating 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

Whereas Key Questions 1 and 2 addressed evidence for specific resource allocation strategies, Key Question 3 addresses public perceptions and concerns related to such strategies.

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 seven papers all addressed 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

[a] Doctor, 2011 and Braunack-Mayer, 2010 reported data from the same public engagement activities. Since they had slightly different focuses of the data reported, we included them both.

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 a large-scale MCE.

Allocation Guidelines

The public agreed that MCEs are highly unusual situations that require altered decision-making processes and protocols different from those under 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 believe 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 to enable their successful implementation.[139]

Goals of Allocation Systems

Participants in these forums listed a few goals for a successful resource allocation system: ensuring the functioning of society, saving the greatest number of people, protecting the most vulnerable, 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.[140] Other participants suggested a balance of objectives.[138] When forced to choose only one goal, participants explicitly expressed that they would choose ensuring the function of society in the long run.[135] 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.[139]

Allocation Decision Makers and the Role of Government

Across all seven 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 policy makers (but not politicians) elected by their peers.[134] 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 PEPPPI study suggested that the role of the federal government should be to provide broad guidance, whereas responsibilities of specific interpretation and implementation of this guidance should remain at the state and local level.[137]

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 regarding 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.

"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, etc.), 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. While all participants in all studies unanimously agreed that decisions based on race, gender, culture, legal status, nationality, or language 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 [138]. Together with chronically ill and disabled people, the elderly were perceived by some participants as "not contributors to a future society"[134] and therefore were accorded lower priority for receipt of scarce healthcare resources. In fact, some participants in one study, supported a policy that would "de-prioritize" persons more than 85 years of age.[138]

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."[135] In the U.S., children and pregnant women were prioritized, although to a lesser degree than health care professionals and health workers.[139] Findings from a nationwide telephone survey conducted by the American Academy of Pediatrics highlighted the significant lack of medications for children during disasters.[136] A majority of respondents in the studies we reviewed support giving higher priority to children who need life-saving treatment.

"Survivability" Criterion

Some participants expressed the belief that patients' survivability should be considered and that health care providers should be the ones to make that allocation decision. They argued that allocation of significant resources to an individual with low probability of survival is a sub-optimal use of limited resources, regardless of the importance of that individual's role in

society.[139] According to this criterion, young people should be ranked higher than other vulnerable populations.

Other Findings Related to Prioritization

Political decision makers were among the lowest priority groups in general, 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 some sort of lottery system.

Another interesting finding was that some participants changed their priority decisions during the 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 shifted their opinions during the post-forum survey.[139] 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 Disadvantaged Participants

Few studies separately reported perceptions/concerns of disadvantaged 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, WA, 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 on medical resource allocation during an MCE did not always agree with those of policy makers, 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 what was outlined in the national pandemic plan.[135] 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).[138] 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, stakeholders 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.[140]

Participants acknowledged that an MCE is a difficult situation that would affect everybody. Some suggested the number of pharmaceutical manufacturers should be increased to produce more supplies to meet the needs of an influenza pandemic. Others urged that under an MCE when medical resources were scarce and difficult allocation decisions must be made, more communication, information, education, and training are needed to prepare the public. [137] 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. future.[135]

Table 8. Strength of Evidence for Key Question 3

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

Key Question 4: Strategies to Engage Providers in Scarce Resource Allocation in Mass Casualty Events

What current and proposed strategies 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

- Studies included in this review described a broad range of provider engagement strategies, including both traditional and more novel approaches that ranged from reducing demand to crisis standards of care.
- Engagement strategies varied by type of policy leaders, providers, range and mix of participants, and type of strategy applied. Most engagement strategies were not specific to a particular type of disaster or to the broad category of medical surge planning: reducing or managing less urgent demand, optimizing use of resources, augmenting resources, or crisis standards of care.
- Engagement strategies addressed planning for scarce resource allocation at different jurisdictional levels, ranging from local to regional, state, and even inter-state levels.
- Provider engagement was led by both providers and by local or state government officials. The latter often did so in partnership with other institutions, including academic institutions.
- 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.

- 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.
- Effective strategies for engaging providers in medical surge planning and implementation vary widely. The articles that met inclusion criteria did not clearly identify one approach as superior to the others.

In contrast to the first two questions in this review, which relate to resource allocation strategies for policy makers and providers, or the third, which relates to public views and concerns, Key Question 4 aims to assess strategies to engage providers in planning for and implementing scarce resource allocation in mass casualty events. As noted earlier, the term "providers" refers to institutions or persons that provide direct medical care (e.g., hospitals, outpatient health facilities, clinicians), and for this section, it also includes providers of related services, such as laboratory diagnosis and pharmacy departments.

Description of Included Studies

The initial inclusion criteria for Key Question 4 were the same as those described for Key Questions 1, 2, and 3. However, these inclusion criteria were modified slightly for Key Question 4 to permit inclusion of reports of studies that described engagement of providers and resulted in at least a concrete plan, protocol, or strategy even if that product was not tested. Consequently, the requirements for both study design and endpoint were less stringent than those for Key Questions 1 and 2. Specifically, papers retained for Key Question 4 needed to reflect a strategy to engage providers in planning or implementing approaches for at least one level of resource allocation (reducing demand, optimizing use of existing resources, augmenting resources, or crisis standards of care). The strategy was considered "tested" if it included a rigorous engagement process that was described in sufficient detail to be replicable and led to a concrete outcome. For Key Question 4, a plan, strategy, framework, or protocol resulting from a systematic engagement process was included as a relevant outcome. Of 16 included studies, 11 were largely descriptive; two described exercises or drills; and three were observational with at least one post-test measurement.

Table 9. Summary of Strategies Addressing Key Question 4, by category

	Strategies
Reduce or manage less urgent demand	• Public health-business partnership for mass dispensing
Optimize use of existing resources	• Organization of de novo regional hospital planning group • Incorporation of community health centers into surge plan, with training for CHCs and three event-based tests • Broadly inclusive regional hospital level planning process to identify surge beds • Training and drills to assess performance in using JumpSTART triage algorithm
Augment existing resources	• Organization of neighboring states into a voluntary disaster surge network • Enrollment, education, training, and exercise of qualified laboratory staff for preparing biodosimetry specimens • Development of evidence-based "reverse triage" classification system • Pharmacy-led development of regional pharmaceutical preparedness policies and procedures
Crisis standards of care	• Developing proposed ethical frameworks and procedures for rationing scarce health resources within a state • Development of consensus on appropriate pediatric crisis standards of care
Combined strategies	• Alternative planning models (Top-down county planning model, Decentralized regional planning, Hospital-directed tiered regional planning model, Third-party directed planning model) • Pilot testing of local, regional and national level tabletop exercises for the Veterans Health Administration (VHA) • Development and pilot testing of tabletop exercise template for local level governments and providers

Detailed Synthesis

The 16 published reports with relevant evidence largely focus on planning and exercises, yet they addressed a diverse range of relevant planning scenarios, resource allocation issues, and stakeholders (see Appendix Table C-8). Collectively, these 16 reports addressed engagement of providers across the full range of severity in surge medical capacity preparedness, including: reducing or managing less urgent demand (one report); optimizing use of scarce resources (five papers); augmenting resources (four papers); adopting crisis level of care (three reports) and comprehensive approaches that address more than one of the 4 broad strategies (three reports). Half of the studies (eight) did not specify the type of mass casualty event, four addressed pandemic influenza preparedness, two addressed all-hazards preparedness, one addressed biological threats of various types, and one addressed radiological or nuclear threats. Fifteen studies were from the United States; one was from Germany. The U.S. studies reflected broad geographic diversity: 12 described local, regional, or state level planning in urban or rural settings in 19 different specified states. Two U.S. studies were carried out in multiple unspecified locations. One study drew experts from across the country.

Engagement Strategies

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, intra-state regional or county, state, or inter-state level. Nearly all studies described engagement of, often by, hospitals. State and/or local public health departments were also included in most, though not all, studies. *Actors that engaged others*, commonly in partnership, included hospitals, state or local public health departments, academic institutions, intra-state or inter-state regional entities, and de novo planning entities. The range of *providers engaged* 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). In some studies, the term "providers" referred to health care professionals (e.g., clinicians, emergency medical technicians), whereas in others, the term referred to institutions (e.g., hospitals, clinics). Although most of the studies described well-established engagement strategies, some described more novel strategies.

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.[141] In another study, hospital pediatric leaders engaged other acute care pediatricians from across the country to develop pediatric crisis standards of care.[142] In yet another, expert clinical personnel and their respective professional organizations engaged other clinical staff in three selected U.S. states to quantitatively test a pediatric triage algorithm.[81]

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.[126] 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.[143]

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.[144] 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.[145] 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 (VA), because it is both a very large provider (the largest integrated health care delivery system in the United States) and a federal policy maker. One study described a series of pilot tabletop exercises for the local, regional and national levels of the VA system, in which the VA engaged other local and regional providers as well as local and state public health departments and first responders.[146]

Engagement strategies led or co-led by government

With the exception of the VA study just noted, government-led engagement strategies are largely at the state and local government level. In most instances, state or local public health departments partner 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.[145] 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.[147] 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 altered standards of care.[148] 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.[149] 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.[150]

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.[138] 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.[151]

Facilitators and Barriers to Different Engagement Strategies

Several facilitators and barriers emerged as general themes across multiple studies. 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 [145] or public health and business.[151] Other barriers related to the long time required to build critical relationships,[150] government regulations,[142, 151] the complexity of inter-state agreements,[150] and the variability across facilities or other differences that impede a "one size fits all" approach.[138, 147]

Table 10. Strength of Evidence for Key Question 4

Strategies	Risk of Bias	Consistency	Directness	Precision	SOE Grade
Reduce or manage less urgent demand	Medium	Consistent	Indirect	Imprecise	Medium
Optimize use of existing resources	Medium	Consistent	Indirect	Imprecise	Medium
Augment existing resources	Low	Consistent	Indirect	Imprecise	Medium
Crisis standards of care	Low	Consistent	Indirect	Precise	Medium

Assessment of the strength of evidence for Key Question 4 was challenging because of the nature of this question (related to provider engagement strategies, rather than testing of the strategies themselves), the relatively small number of studies in each category, the variability in focus of the studies, and the conceptual distance between intervention and health outcome. Key Questions 2, for example, included far more studies and addressed quantifiable strategies that are more directly related to health outcomes. For Key Question 4, we rated the risk of bias as low to medium, the evidence related to engagement strategies as consistent (positive outcomes related to the engagement itself), the results as indirect (related to creating and evaluating engagement strategies themselves rather than leading directly to a desirable health outcome) although mostly imprecise, because of the nature of the key question (Table 7).

Analysis of State Reports

Introduction

The IOM Letter Report 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 state crisis standards of care documents 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; and
5. Evidence-based clinical processes and operations. [emphasis added]

In provision in the contract to conduct this CER called for the Southern California EPC to review and assess existing state plans regarding the allocation of scarce resources during a mass casualty event (MCE). The majority of these state plans, plus Guam, (N=23 states) were compiled as part of the work on the IOM Letter report and forwarded to us by AHRQ. However, several of these documents did not qualify as a formal state plan. For instance, a few states, such as Alaska provided a short e-mail; some were produced by a third party (e.g. the Kansas Health Institute), and others did not directly address the issue of scarce resources. Therefore, we did

additional searching on our own and supplemented the portfolio with plans from two other states: New York and Wisconsin.

Ultimately, we reviewed -plans from 11 states and one US territory. Collectively, these plans provide an important window into the current status of state planning for implementing crisis standards of care. It is important to note that some states had multiple plans for different scenarios. In these cases, we synthesized their content to give the reader a sense of the totality of a given state's strategies regarding scarce resource allocation during MCEs.

In general, the state plans we reviewed followed the same path of contingent actions our researchers identified, a priori, to guide our CER. These include: a) early actions to reduce or divert less urgent demand; b) steps to optimize use of existing resources; c) efforts to augment existing resources, and finally, if and when these measures prove to be inadequate to meet demonstrable need, d) 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. Although we did our best to categorize each of the sub-strategies, some were fluid and a case can be made for fitting several concepts under parent grouping. In these instances, we made a judgment call and explained our rationale.

In the sections that follow, we qualitatively summarize how these recurring strategies and themes were addressed across states with plans, plus Guam. This is followed by a summary table that outlines 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 healthcare 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 Non-Critical Patients out of the Hospital

The State of California, in particular, has given considerable thought to strategies to reduce demand for services that could be provided outside of hospital settings if the need arose. At a fundamental level, all elective surgeries should be canceled so medical staff can re-focus their energies and other key resources on patients who require urgent care.[152, 153] This move also keeps a relatively healthy population of patients away from those who may be contaminated, preventing further increases in demand for critical resources. Although the cancellation of elective surgeries would likely 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. Non-critical care (e.g., first aid, primary care) could be safely and efficiently provided in off-premises, such as community clinics or temporary healthcare facilities.[154-157] This could alleviate constraints on a variety of resources, including medical specialists, hospital beds, etc.

Encourage the Public to Self-Quarantine (Social Distancing)

In an infectious disease outbreak or an epidemic, the best strategy for reducing demand for scarce healthcare resources is to prevent people from becoming ill with the disease. For certain infectious disease outbreaks such as an influenza pandemic, a few states[156, 157] discussed measures to impede or delay disease transmission by encouraging the public to self-quarantine. Specific strategies in these plans include encouraging employers to allow their employees to

telecommute, closing schools, and educating the public regarding easily implementable non-pharmaceutical interventions, such as wearing a face mask.

Re-Purpose Existing Resources

During a surge, hospital space is at a premium. There are several methods by which states' plans incorporated approaches to increase bed capacity including re-purposing non-patient care space for patient care, establishing temporary healthcare facilities such as a tent hospital, and "freeing-up" space through early discharge of stable patients. Three out of 12 of the state plans suggested re-purposing/re-appropriating 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.[152, 154] One of the plans suggests that additional, bed capacity could be optimized by converting single-occupancy rooms to double or triple occupancy.[154] Critical care beds easily become a limited commodity during a MCE, and expanding their capacity becomes a priority. As outlined in one of the California state plans, one option is to triage ventilator-dependent patients directly to step-down units.[154] Lastly, preserving bed capacity could be accomplished by canceling elective surgeries and limiting those that are done to life or limb-threatening problems and procedures that can facilitate discharge.[158]

Optimize Existing Resources

Optimization of existing resources entails utilizing various methods and techniques to leverage the most benefit from existing health care resources. Because these resources – staff, stuff and structure - are already at hand, it makes sense to use them as efficiently as possible. Hence, nine of the 12 plans we reviewed recommend this strategy. Ideas include:

Balance the Load Across Different Facilities

Load balancing by distributing care across a region (e.g., mutual aid) is a popular strategy. Several state plans recommend to optimize use of space or establish temporary healthcare facilities at non-healthcare settings.[153, 159] Alternatively, bed capacity can be expanded through strategies, such as "reverse triage" that either allow for early discharge of stable patients from the emergency room or the hospital (freeing up spaces) or by persuading outside facilities, such as long-term care (LTC) units to accept lower acuity patients in transfer, as outlined by plans from California and Guam.[152, 160]

Space needs must also be considered in instances when mass fatalities occur. Several states' plans recognized that morgue capacity could be exceeded. In this instance, temporary morgues may be required to hold the remains of the dead.[152, 153, 160]

Use Health care providers and non-medical staff more efficiently

During a MCE, medical and nursing staff are likely to quickly become the rate-limited resource. In this instance, their duties and priorities may need to shift in order to optimize care for a large and rapidly growing patient population. Five strategies surfaced among states' plans that speak to staffing. Several state plans recommend increasing nursing shift duration (from eight to 12 hours or from 12 to 16 hours) as well as increasing provider-to-patient ratios to extend the reach of available personnel.[152, 153, 160] Cross-training staff through "just-in-time" training could allow for more staffing flexibility while optimizing available human resources.[160, 161] Examples of the use of this strategy in a pandemic include training healthcare 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.[153] In addition, non-healthcare personnel could be deputized to carry out essential non-clinical functions and free up nursing staff.[152] During a pandemic, cohorting patients (like patient types) in a single ward or facility may allow specially trained staff to provide care more efficiently and effectively.[152] Last, relaxing the requirements for medical documentation may enable staff to free up time to focus on patient care or other higher priority duties.[152]

Triage

Another major strategy commonly applied to optimize use of existing resources is triaging of Florida's pre-hospital triage strategy indicates that the state's hospitals are using or implementing standard triage strategies, including "Simple Triage and Rapid Treatment" (START).[162] "JumpSTART" extends the concept of a standardized triage to children. Florida's plan also mentions a propriety extension of these triage systems, called the "START2Finish® Surge Capacity Response Model for Healthcare". This model focuses on optimizing allocation of labor, supplies, and space during an MCE.[162] In a similar vein, Utah has devised a state-level Pandemic Influenza Hospital and ICU Triage Guidelines to determine which patients during a flu pandemic require what level of resources. The goal is to preserve bed capacity, oxygen capacity, limit or stop elective surgeries, and maximize available personnel to care for victims of a future flu pandemic.[158]

Substitute Effective Alternatives

Two states' plans, Wisconsin and Minnesota, focus on re-use or substitute methods to optimize available resources. For instance, the state of 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) re-use 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 sterilizing ventilator circuits as well as low and high bore tubing.[161, 163] Minnesota's state plan echoes Wisconsin's oxygen conservation 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

Augmenting resources involves drawing upon equipment, supplies, drugs and personnel held in reserve or stockpiled for such contingencies, or alternative, securing such resources from other institution that are not contending with the MCE. Several state plans incorporated strategies to augment existing resources such as stockpiling with regard to drugs and vaccines as well as leveraging personnel from other facilities (through mutual aid agreements) or from outside agencies, such as the American Red Cross or the Medical Reserve Corps.

One of California's state plans recommends stockpiling supplies at a level 20-25 percent above normal to last for at least the first 72 hours (ideally, 96 hours) of an MCE.[152] Other plans recommend inventories or plans to increase critical supplies to assess considerations for

stockpiling such as ventilators and critical medications.[154, 160] Several state plans call for accessing either drug caches (antibiotics, antivirals) or the Strategic National Stockpiles (SNS) as options for resource augmenting.[152, 161, 164, 165]

Mutual Aid Agreements

Mutual aid agreements/partnerships commonly appear in state plans as a useful way to augment existing resources. Recommended agreements for mutual aid appear in several California plans, as well as in one Washington state plan.[152, 155, 165-167] Other partnerships that can be augment personnel include volunteer clinical staff such as the California Medical Assistance Team (CalMAT), federal Disaster Medical Assistance Team (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).[152, 153, 155, 160]

Adopt Crisis Standards of Care

Although there are many proposed strategies in state plans to prevent or delay the development of critical resource shortages, in a massive MCE it is quite likely that healthcare institutions and providers will be forced to shift to crisis standards of care. At this stage, decisions must be made as to how to do the most good for the most people, even if this means denying or withdrawing resources from some. In this extreme contingency, crisis standards of care are generally defined as a substantial change in usual health care operations necessitated by a pervasive (e.g., pandemic influenza) or catastrophic (e.g., earthquake, hurricane) disaster. In these state plans, the change to crisis standards is justified by specific circumstances. The shift to crisis standards will not be made on a hospital-by-hospital basis, but triggered through a formal declaration by the state's governor that crisis operations will be in effect for an indefinite, but potentially lengthy period of time. This formal declaration enables specific legal/regulatory powers and legal protections for healthcare providers in the state to take effect, so they pursue the difficult but necessary task of allocating and using scarce resources and implementing "alternative care facility operations."

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 crisis standards of care is to define priority groups for certain resources. For example, several states including Nevada, California, and North Dakota discuss the protocol for allocating anti-viral agents during a pandemic flu outbreak.[159, 164, 165] 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 the patient will likely die regardless of the revision of treatment, plans must be put in place to ensure they are made as comfortable as possible as death approaches. 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.[159]

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 like the Sequential Organ Failure Assessment score (SOFA) and a tool based on the recommendations of the Ontario Health Plan for an Influenza Pandemic (OHPIP).[161, 168] Many of these strategies focus on the distribution of mechanical ventilators, advocating that assignment (and in some cases re-allocation) of ventilators should be directed towards 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.[161] 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.

Applicability of Evidence for KQ4

Most of the studies reviewed were at least moderately dependent on the scale of the MCE and also highly relevant to patient outcomes, such as the public health-business partnership to dispense medical countermeasures, and the different approaches to optimize or augment resources through 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 and highly relevant to patient outcomes. No study appeared to be unique to the site where it was carried out.

Conclusion

The state plans we reviewed proposed various strategies to decrease less urgent demand, optimize use of existing resources, and augment existing resources when possible. Most tilted heavily towards 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 healthcare resources.

Discussion

We conducted an extensive literature search, data abstraction, and synthesis to assess the comparative effectiveness of a wide variety of strategies to manage, and if necessary, allocate scarce health care resources during MCEs. In this chapter, we describe the limitations of our systematic review and present our conclusions. We also discuss the implications of our findings for future research.

Limitations

Most comparative effectiveness reviews address a fairly narrowly defined topic, such as the comparative effectiveness of bariatric surgery in patients with metabolic conditions and BMI of at least 30 but less than 35, or the latest research on the off-label use of atypical antipsychotic medications. This review covered a much broader topic – studies addressing the comparative effectiveness of a wide range of strategies to allocate scarce health care resources in mass casualty events.

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 in an effort to clearly define, and in some cases, modify, the scope of this evidence review. Whereas the RCT is typically considered the preferred, if not the only, study design for inclusion in systematic reviews, it is rarely feasible, either technically or ethically, to use this approach to evaluate strategies to allocate resources during MCEs. We noted very few studies of this type, and most were based on exercises or simulations, rather than actual events. This lack of RCTs required us to consider studies that are normally regarded as a lower level of evidence, including cohort, before-after, and quasi-experimental designs. In the end, we retained even studies that referenced historical performance as the comparison standard to their measure of process or outcome, but graded the level of evidence accordingly.

To provide the most comprehensive coverage of this topic possible, we extended our review further by capturing studies that included some measure of feasibility or performance but lacked a comparison group. Because these studies lacked evidence to confirm their impact on outcomes, we addressed them in a separate section of each key question and summarized these articles in a separate appendix. To further assure broad coverage of the topic, we identified and summarized consensus recommendations by specialty societies and national panels. None of these provided new evidence, but spoke to important dimensions of Key Questions 1 and 2.

The heterogeneous nature of the articles we identified posed another challenge. Much of the literature could not, in fact, be considered reports of studies. Instead, it presented the results of simulations, exercises, or descriptions of interventions aimed at modifying certain processes such as triage or information exchange, with little or no evidence of impact. The paucity of rigorous quantitative findings, coupled with the non-comparability of studies that addressed any particular strategy, precluded us from performing any meta-analyses. With rare exceptions, study heterogeneity precluded us from even considering certain groups of studies together.

The multiple ways MCEs affect populations, policymakers, providers, and individual patients made it difficult, at various points, to precisely define the population of interest for a given intervention. On the one hand, individual casualties of an MCE (the injured and ill who require treatment after a MCE) are the target of all interventions, models, and guidelines. On the other hand, Key Question 1 was explicitly focused on the perspective of policymakers; Key Question 2 focused on providers (mainly acting as individuals, although it could be interpreted to include

institutional providers); Key Question 3 focused on attitudes of the public at large; and Key Question 4 focused on outreach to providers in groups.

The different measures of effectiveness employed by these studies is a major limitation. Most of the articles that met criteria for inclusion in our review assessed the impact of a current or proposed strategy on a clinical process, or some aspect of a process. This focus on process change has several implications for the kinds of conclusions we can draw. First, the outcomes that can be measured are often secondary outcomes and may not be the true outcomes of interest. 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. Thus, no guarantee exists that an intervention implemented successfully in one setting would have the same successful outcomes in a slightly different setting. The challenge of setting-to-setting variability is dramatically amplified in MCEs, which vary dramatically from one another in terms of onset, magnitude, cause, location, duration, and scale.

The most formidable limitation to this review is the paucity of evidence regarding the effectiveness of any single strategy. With the exception of pre-hospital (field) triage, most of the strategies we identified have been the subjected to few independent assessments beyond the descriptive reports of their developers. This lack of rigorous assessment limits the strength of evidence available regarding most of the strategies we identified. Finally, although our literature search procedures were extensive and included canvassing experts regarding studies we may have missed, the possibility of publication bias still exists.

Conclusions

To date, there is limited evidence to help policymakers select the most effective strategies to optimize allocation and management of scarce resources during MCEs. It is generally accepted that quick deployment of biological countermeasures, such as mass vaccinations or mass dispensing of prophylactic antivirals or antibiotics, could significantly reduce demand for healthcare resources immediately after a bioterror attack with Anthrax or an influenza pandemic. Low- to medium-strength evidence favors a “push” method to deliver medications, such as via US Postal Service letter carriers, over conventional approaches that “pull” patients to a fixed point of dispensing (POD). Evidence that better management of POD operations can speed throughput and therefore more rapidly distribute biological countermeasures is also low to medium. There is low strength of evidence that public distribution of non-biological countermeasures, such as N-95 respirators or surgical masks, will reduce demand for hospital beds, ICU beds and ventilators.

There is less evidence to support other policies to optimize resource allocation and use. For example, evidence is minimal, based on few publications, that resource use can be optimized through better load sharing between facilities. Evidence is also limited that health care resources may be augmented by transferring patients to more distant hospitals and by opening temporary facilities, such as a mobile field hospital.

The evidence base to guide providers on the best strategy or strategies to optimize management and allocation of resources during MCEs is equally limited. A substantial number of strategies have been proposed to help providers and health care systems respond to mass casualty events. Unfortunately, evidence is insufficient to favor certain strategies over others. Rigorous evaluations are rare, and much of the evidence that exists comes from drills,

exercises, and simulations rather than actual events. Many of the studies we reviewed did not report outcomes that are relevant to patients and providers. In most cases, the applicability of a study's findings beyond the immediate exercise setting, or a particular MCE, is questionable.

The only provider-oriented strategy that has been subjected to comparative assessment is triage. Even then, the strength of evidence favoring one triage system over another is low. A systematic review of such systems, comprising 11 papers that reported on eight different triage tools, found limited evidence for the validity of existing triage tools. Published derivation and validation studies are of rather poor quality, in part because most of them are based on relatively small sample sizes. Few of these tools were 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 we reviewed are based on exercises or drills, rather than actual events. Exercise-based assessments may not accurately reflect how a triage tool will perform in a MCE. For example, four studies of START, a widely used pre-hospital 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 resulted in poor allocation of patients because providers were confused about the meaning of different triage categories. More research is needed to identify the most efficient and reliable strategy to triage casualties in an MCE.

For every other category of provider-based strategies, the evidence base was insufficient to support a confident conclusion. With the exception of the previously mentioned studies of pre-hospital triage, no strategy was assessed by more than three studies, whether it involved efforts to reduce demand, optimize use of resources, augment existing resources, or apply crisis standards of care. Addition of promising but untested strategies increased the pool of interesting and potentially promising ideas, but none are backed by sufficiently compelling evidence to warrant their use over other, equally promising ideas. Although the few studies published to date on any specific topic reported generally encouraging findings, most were judged to be prone to at least a medium level of reporting bias. Therefore, the strength of evidence to judge these interventions is insufficient or low.

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. Firm evidence regarding public perceptions about the allocation and management of scare resources in MCEs is limited. Moreover, all but one of the six studies we reviewed reported data collected from a single community. Nevertheless, because these studies were well-designed and their findings are generally consistent with each other, we judged the strength of evidence on this topic to be medium. Collectively, these studies indicate that citizens are both 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. Although they want appropriate guidelines to be established in advance, they think these recommendations should allow facilities a degree of flexibility to make allocation decisions based on their specific demand and supply situation.

Promising strategies to engage providers in discussions regarding the development and implementation of strategies to allocate and manage scarce resources in MCEs exist, but none of these strategies have been evaluated in detail. The studies we examined did not point to a specific engagement strategy as being superior to the others. Nonetheless, several important

themes emerged from a qualitative synthesis of this work. First, inclusive processes that engage all major stakeholders appear to 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 often iterative processes produce 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, satisfaction, and quality of the final product. Finally, initiative taken by a non-traditional provider or group added innovation and breadth to the range of engagement strategies to enhance medical surge capacity.

Current consensus guidelines and recommendations from specialty societies and government advisory groups rest on an insufficient body of evidence. Few provide guidance that is sufficiently actionable to be useful to policymakers, health care providers, or the public. Most of the consensus panel recommendations we reviewed were either dated or aimed at a level that may not be useful to policymakers or providers. This limitation was particularly true of guidelines produced by specialty societies. In many cases, the intent of the task force was to develop principles from which providers at the local level can subsequently derive their own consensus-based protocols. This intent contradicts the recommendations of the authors of the IOM Letter Report, which expressed the hope that their guidance would eventually produce "a single, national framework for responding to crises in a fair, equitable and transparent matter."[11] The recommendations of the committees sponsored by the Society for Critical Care Medicine and the American Thoracic Society's Bioethics Task Force, which recommend allocation of intensive care on the basis of "first come, first served," contradict the wishes of the public, based on the limited number of studies published to date. The public, like the authors of the IOM letter report, wants to see resource allocation decisions under crisis standards of care addressed in a thoughtful and proactive way that protects the core interests of society.

Some states have made progress towards adopting plans to manage and if necessary allocate resources under crisis standards of care. Our review identified 11 states and one U.S. territory that have drafted guidance regarding how policymakers and providers should respond in the context of a MCE such as a large scale disaster, bioterror attack or a severe pandemic of influenza. Most, but not all, describe strategies that fit into one or more of four overarching domains: 1) reduce less urgent use of healthcare 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 stockpiling and other reserves and activate mutual aid agreements, and 4) implement crisis standards of care, at which time treatment will be allocated based on pre-defined priorities, and some patients will receive comfort care rather than aggressive intervention. Although all of these strategies are appealing in principle, most are supported by relatively limited evidence from rigorous studies. No state plan embraces all of the basic strategies.

Future Research

Our review has clear implications for future research on this topic. Even with generous inclusion criteria, including assessment of studies that lacked a control group and those that describe only promising concepts, it is clear that few strategies for allocating scarce resources in an MCE are currently supported by rigorous evidence. Many topics of importance have not been examined by more than three studies that met our threshold for inclusion in this CER.

Our review spanned more than two decades of preparedness research, including the decade following 9/11. Given that several federal research agencies, private foundations, and academic researchers are actively engaged in research to strengthen the evidence base in this area, we recommend that these , stakeholders come together to devise a coordinated agenda of applied research to systematically assess the most pressing issues confronting policymakers and health care providers charged with the responsibility to allocate and manage scarce resources in future MCEs, whether they are caused by a pandemic, terrorist attack, or a large scale natural disaster. Given the state of the art for preparedness research, it seems unlikely that rapid progress will be made without a goal is unlikely to be conscious effort to coordinate and prioritize efforts.

It may be argued that operational research of the sort needed to guide rapid improvements in resource optimization and resource augmentation in the setting of MCEs does not require study designs of the sort typically required to qualify for inclusion in a comparative effectiveness review. Many business innovations, including marked advances in supply chain management, error reduction, and organizational structure, have come from "focused empiricism" – identifying what works and what doesn't, refining promising strategies, and seeking continuous improvement. Some have asserted that beyond determinations of basic efficacy and safety, relying on individually designed, serially constructed, prospective studies to establish comparative effectiveness is impractical for many interventions in health system operations.[169] This may be particularly true in the setting of disasters and other types of MCEs. For example, hospital leaders do not need a randomized controlled trial to recognize the value of rapidly clearing their 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.[170] Likewise, policymakers do not need sophisticated cohort or quasi-experimental studies to establish the importance of stockpiling sufficient resources to support up-tempo hospital operations during the first days following a disaster, when supply chain disruptions are common. But it is likely that EMS systems, hospitals, and health systems will benefit from practical assessments of promising techniques, technologies and tools to enhance field and ER triage, interagency and inter-facility communications, patient tracking, public information, load sharing, as well as innovative approaches to rapidly augment "staff" (professionals and lay volunteers), "stuff" (equipment and supplies), and "structure" (physical space, systems for incident command and control). It will be equally important to develop and implement more realistic approaches to conducting drills and exercises, including greater reliance on no-notice events, to determine how various elements of the healthcare system respond when challenged.

Simple processes, such as holding rigorous but non-judgmental "after-action reviews" (AARs) after each major MCE could go a long way towards institutionalizing systems learning and performance improvement in disaster response. The same approach should be adopted by the global community to foster rapid learning and performance improvement after each multi-national response to a global disaster such as the Indonesian Tsunami or the Haiti earthquake.[171] It would also be worthwhile to view modestly scaled disasters, near-miss incidents, and annually

recurring events such as flu vaccination campaigns to test and refine various elements of a national, state, community or healthcare systems' response to MCEs.

Two major strategies addressed by this CER—demand reduction and allocation of resources under altered standards of care—could be rapidly advanced through a focused agenda of federally-sponsored research. Some effort has been directed towards improving the management of our nation's strategic national stockpile and speeding the delivery and mass dispensing of biological countermeasures. But beyond that, policymakers and public health officials have limited evidence about the best methods and tools to effectively engage the public and non-hospital based healthcare providers to reduce less urgent demand for hospital-based services during a MCE. A focused program of research aimed at harnessing the power and reach of traditional (e.g., print, radio, and television) and new media could produce valuable insights on how to effectively inform and engage the public about what to do in an impending event and what actions they should take in its immediate aftermath (such as sheltering-in-place or accessing an effective biological countermeasure at the closest point of dispensing).

Substantial benefits may be realized by exploring the potential for bi-directional communication technologies, such as call centers, nurse advice lines, and the internet to reach and inform the public. Fully automated, bidirectional decision support systems such as automated call centers, web sites, and SMS could provide millions with practical guidance that is tailored to their specific condition or circumstance. Systems like these could also be used to collect epidemic intelligence in real time for situational awareness. Likewise, proactive engagement of community health care providers, coupled with provision of timely guidance and a cache of supplies, might pull a substantial volume of minor illness and injury care out of hospital emergency rooms, so hospital-based providers could focus on the more seriously ill and injured. Hand-held technologies and software such as global positioning could be used to link non-governmental organizations and private sector players together to swiftly match resources to need. This virtual linkage may be particularly important in the early days of a disaster, before outside assistance arrives. Finally, additional research is needed to confirm the optimal approach (or approaches) to rapidly distributing biological and non-biological countermeasures to the public. Promising and potential strategies include engaging a mix of public (e.g., U.S. postal service letter carriers) and private sector (e.g., retail pharmacies, overnight shippers) resources to disperse products and services to homes or neighborhood locations that are easily accessible on foot. Research studies of this sort could produce dramatic gains in a short amount of time.

At the other end of the MCE response spectrum, there is an equally pressing need to develop the evidence base about when and how to implement altered standards of care. The aspirational guidance provided through the IOM Letter report is an important start, but operationalizing the Committee's recommendations will be the difficult part.[11] Determining what clinical and social criteria to apply to resource allocation decisions is less a technical matter than a moral, ethical, and political one. The type of research we considered for Key Questions 3 and 4 is particularly germane to this topic. The few public engagement studies we identified suggest that the public's thinking about this matter may be better developed than many policymakers and practitioners realize. It is interesting to note, for example, that the now dated recommendations of two critical care societies endorse the concept of "first come, first served" for allocation of ICU resources, while participants in the community forums and surveys generally reject this approach.

The viewpoints elicited from public engagement efforts conducted to date should be interpreted with caution, as they are drawn from a narrow range of participants, including several groups outside the U. S. For this reason, diligent efforts should be made to build on this currently

modest base of evidence regarding public engagement by reaching out to a wider cross-section of the nation, including individuals from different regions, ethnic backgrounds, cultures, ages, and faith traditions. Likewise, more active engagement of provider groups, including clinicians, health system administrators, and experts in health care law, policy, and ethics are needed to reach a practical consensus on these issues. In the course of the ensuing discussions, it will be important to identify legal or political barriers that may impede effective allocation of resources under crisis conditions. Otherwise, healthcare providers, hospitals, and healthcare systems may be unable or unwilling to act in ways that do the most good for the most people.

Currently, the bulk of extramurally-funded federal preparedness research is focused on other priorities. Recently, the RAND Corporation, with support provided by the Assistant Secretary for Preparedness and Response, HHS, conducted a first-ever portfolio analysis of non-classified federally funded extramural research on public health and health systems preparedness research across eight federal research agencies: the National Institutes of Health (NIH); the CDC, AHRQ, the Department of Homeland Security (DHS) Office of Science and Technology; the Department of Energy (DoE), the National Science Foundation (NSF), the VA, and the Department of Defense (DoD) Northcom. It 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 the focus of four, four and three percent of projects, respectively. More than half of all projects were focused on laboratory research, mainly at the NIH. Only six percent of funded projects focused on improving the performance of the healthcare system.[172]

Business analysts and psychologists frequently write about the "tyranny of the urgent" and the value of distinguishing between what is urgent and what is important. Because no one knows when the next mass casualty event will occur, resource investments in improving emergency preparedness and response often take a back seat to day-to-day urgency of EMS and health system operations and large scale investments in biomedical research. But when an MCE happens, its urgency *and* importance trump everything else. The tragedy of 9/11, the Anthrax attacks that soon followed, Hurricane Katrina and the Haiti earthquake are four examples of this phenomenon. There will be more such events in the future. We simply don't know when or where they will occur.

This review has identified that many of the fundamental principles of resource management and allocation in MCEs rest on limited evidence. While the number of high quality, rigorous studies in this area has grown over the past decade, progress can be accelerated by coordinating and prioritizing the work that must be done.

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Acronyms and Abbreviations

AGPRs	Automatic gas-powered resuscitators
AHRQ	Agency for Healthcare Research and Quality
ASPR	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
DHSS	Department of Health and Social Services
DMAT	Disaster Medical Assistance Team
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
NGO	Non-governmental Organization
NHSS	National Health Security Strategy
NIH	National Institutes of Health

NREPP	National Registry of Evidence Based Programs and Practices
NSF	National Science Foundation
OASPR	Office of the Assistant Secretary for Preparedness and Response
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
RCTs	Randomized Controlled Trials
SAMHSA	Substance Abuse and Mental Health Services Administration's
SNF	Skilled Nursing Facilities
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