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# Allocation of Scarce Resources During Mass Casualty Events

## Executive Summary

### Background

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

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

By definition, an MCE generates a level of demand for health care resources that outstrips available supply. Under those circumstances, local and regional health care providers are unable to meet victims' needs at the level normally expected of a modern health care delivery system. Because such situations are difficult to predict and can occur with little or no warning, health care systems and providers must be prepared to swiftly

### Evidence-based Practice Program

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. The EPCs systematically review the relevant scientific literature on topics assigned to them by AHRQ and conduct additional analyses when appropriate prior to developing their reports and assessments.

AHRQ expects that the 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.

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

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Evidence-Based Practice

implement contingency plans to reduce less-urgent demand for health care services; optimize the use of existing resources; and secure additional resources, if possible, from backup sources. If these measures are insufficient to meet demand, providers may be forced to shift from the traditional treatment approach, which strives to deliver optimum care to every patient, to one that seeks to do the most good for the most people with the available resources. This latter concept has come to be known as "crisis standards of care."

## Objectives

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

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

This report addresses the following Key Questions:

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

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

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

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

## Analytic Framework

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

## Methods

### Input From Stakeholders

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

### Data Sources and Selection

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

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

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

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

### Data Extraction and Quality

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

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

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

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

### Data Synthesis and Analysis

Due to the diversity of topics covered in the Key Questions, we structured our findings around several broad categories, graded by the overall strength of the evidence: (1) strategies intended to reduce or more effectively manage less-urgent demand for health care services, (2) strategies intended to optimize the use of existing resources, (3) strategies designed to augment existing resources, and (4) strategies for ethical decisionmaking regarding allocation (or reallocation) of scarce medical resources in crisis situations. Within each of these categories, we considered the weight of evidence regarding

the impact of applicable strategies on health outcomes (e.g., reduced mortality and/or morbidity, adverse events). When no evidence was found regarding the impact of the strategy on health outcomes, we looked for evidence of its impact on process measures, such as rates of use of consumable health care resources.

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

## Results

### Key Question 1: What strategies are available to policymakers to optimize the allocation of scarce resources during mass casualty events?

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

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

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

POD = point of dispensing

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

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

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

### Key Question 2: What strategies are available to providers to optimize the allocation of scarce resources during mass casualty events?

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

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

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

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

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

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

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

Several studies evaluated outcomes of strategies involving implementation of crisis standards of care during actual or simulated MCEs. Examples of the identified strategies

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

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

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

| Table B. Summary of strategies addressing Key Question 2, by category (continued) | |
|---|---|
| | **Strategies** |
| **Augment existing resources** | **Resource conversion (1 study)**<br>• Conversion between formulations of nerve agents to augment supply |
| **Crisis standards of care** | **General (1 study)**<br>**Orthopedics (1 study)**<br>• External fixation of fractures rather than definitive orthopedic care<br>**Pediatrics (1 study)**<br>• Provision of only "essential" interventions<br>**Trauma surgery (2 studies)**<br>• "Damage control" approach (e.g., for orthopedic surgery or more generally) |

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

### Key Question 3: What are the public's concerns regarding strategies to allocate scarce resources?

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

- A successful allocation system should balance the goals of ensuring the functioning of society, saving the greatest number of people, protecting at-risk populations, reducing deaths and hospitalizations, and treating people fairly and equitably.
- Participants used multiple criteria to prioritize recipients of resources during an MCE. Health care professionals, health care workers, and first responders were among the highest priority groups; politicians were among the lowest.
- Many participants accorded high priority for receipt of care to children and young adults.
- Most participants rejected prioritization criteria based on ability to pay, "first come, first served," or random selection (lottery system).
- The public showed a high degree of faith and trust in medical professionals to make appropriate allocation decisions based on their expert opinions.
- Resource allocation guidelines should be generally consistent but should allow health care institutions some degree of flexibility to make allocation decisions based on their specific demand and supply situation.

### Key Question 4: What methods are available to engage providers in developing strategies to allocate scarce resources during MCEs?

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

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

| Table C. Summary of strategies addressing Key Question 4 | |
|---|---|
| | **Strategies** |
| **Led by providers** | • Enrollment, education, training, and exercise of qualified laboratory staff for preparing biodosimetry specimens<br>• Organization of de novo regional hospital planning group<br>• Alternative planning models (decentralized regional planning, hospital-directed tiered regional planning model, third-party directed planning model)<br>• Development of consensus on appropriate pediatric crisis standards of care<br>• Development of evidence-based "reverse triage" classification system<br>• Pilot testing of local-, regional-, and national-level tabletop exercises for the Veterans Health Administration<br>• Pharmacy-led development of regional pharmaceutical preparedness policies and procedures |
| **Led or co-led by policymakers** | • Public health/business partnership for mass dispensing<br>• Development and pilot testing of tabletop exercise template for local-level governments and providers<br>• Organization of neighboring States into a voluntary disaster surge network<br>• State or local public health department planning model, including development of mutual aid agreements<br>• Incorporation of community health centers into surge plan, with training for community health centers and three event-based tests<br>• Developing proposed ethical frameworks and procedures for rationing scarce health resources within a State (2 studies)<br>• Broadly inclusive regional hospital-level planning process to identify surge beds |

### State Plans

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

## Discussion

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

### Key Findings

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

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

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

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

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

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

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

### Limitations of the Review Methods

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

### Limitations of the Evidence Base

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

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

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

## Future Research

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

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

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

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

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

- Identification of the optimal approach to rapidly distributing various biological and nonbiological countermeasures to the public. Promising and potential strategies include engaging a mix of the public sector (e.g., U.S. Postal Service letter carriers) and private sector (e.g., retail pharmacies, overnight shippers) to disperse products and services to homes or neighborhood locations that are easily accessible on foot. Studies of this sort could produce dramatic gains in a short amount of time.
- Research directed toward harnessing the capabilities of existing bidirectional communication devices, technologies, and social media for real-time disease surveillance, self-triage, community outreach, and coordination of recovery efforts.
- Better approaches to prehospital triage during MCEs.
- More widespread and substantive work, through public forums and other methods of engagement, to ascertain the public's views regarding allocation of scarce resources in MCEs. A special effort should be

made to reach beyond general public forums to elicit the views of minorities and at-risk communities.

- Development of more realistic models and exercises to develop, assess, and refine optimal approaches to respond to MCEs, including affordable simulations and "no-notice" drills to public health and health system decisionmakers to exercise key elements of national, State, and community response in challenging situations
- Rapid engagement of health care professionals, ethicists, public health officials, and community members to devise contingent strategies for allocation of scarce resources in a variety of plausible scenarios—particularly allocation strategies to be implemented under crisis standards of care.

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## Full Report

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