



Rapid Evidence Product
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Resource Allocation and Pandemic Response: An Evidence Synthesis To Inform Decision Making



Main Points

- When decision makers need to make difficult choices regarding the allocation of scarce resources and pandemic response, potential strategies include:
 - Reduction of demand for healthcare services through medical countermeasures (e.g., mass vaccination) or nonpharmaceutical interventions (e.g., social distancing);
 - Optimization of existing resources (e.g., central command structure);
 - Augmenting resources (e.g., adding temporary facilities or personnel); and
 - Implementation of crisis standards of care.
- We identified 201 studies from January 2011 through May 2020 evaluating resource allocation and pandemic response strategies addressed in infectious disease threats, natural disasters, terrorism, and other mass casualty events for decision makers. Research designs were observational and critical appraisal results varied.
- Most research exists to reduce care demand (n=149); higher quality studies reported benefits of contact tracing, school closures, travel restrictions, port of entry screening, and mass vaccination. We identified 28 evaluations of strategies to augment resources; higher quality studies reported the effectiveness of establishing temporary facilities, using volunteers, and using decision support software. Strategies to optimize existing resources have been assessed in 23 studies; higher quality studies reported successfully expanding scope of work and building on existing agreements between agencies. Few studies have evaluated crisis standards of care strategies. Coronavirus disease 2019 (COVID-19) research is emerging; four higher quality studies evaluated combinations of interventions; one reported the benefit of communitywide mask policies.
- Most existing research is based on simulations, and future research is needed to test strategies in practice.



Background and Purpose

In a pandemic, such as COVID-19, the need for medical resources, including staff, stuff (e.g., supplies and equipment), and space or structure (e.g., physical location), can quickly outstrip the available resources. Policymakers need information and tested strategies to inform key decisions about how to respond and make the best use of scarce resources. Potential strategies seek to increase the overall quantity of resources, stretch existing resources, and when needed offer guidance about how to determine which patients receive those resources. These strategies focused on the healthcare delivery system are complemented by population-based strategies that seek to reduce the spread of the disease and therefore the demand for health care services.

There is a wealth of guidance developed by the Assistant Secretary for Preparedness and Response (ASPR) and the National Academy of Medicine (NAM) about the allocation of scarce resources. The degree to which these guidelines are implemented as policies or affect outcomes at the population level is harder to examine. A 2012 AHRQ review¹ identified the existing evidence on outcomes of strategies for allocating medical resources in mass casualty events. That review defined resource allocation broadly, and included pandemic response such as mitigation and community strategies that were useful to policymakers. In this rapid evidence review, we updated the search for studies about outcomes of strategies regarding allocations of scarce resources (including mitigation and community strategies) that would be of interest to a broad array of decision makers, and updated terminology to reflect the current scope.

Key Question

What strategies are available to policymakers to optimize allocation of scarce resources during mass casualty events, especially pandemics?

Methods

We searched the databases PubMed, Web of Science, and Cochrane Database of Systematic Reviews on May 4, 2020. The search strategy is documented in Appendix A. We included empirical studies and simulations evaluating strategies for policymakers to allocate scarce resources. Studies had to address the allocation of scarce resources (broadly defined, as described above and in the appendix), and interventions had to be aimed at policymakers such as local public health officials rather than individual clinicians. The detailed eligibility criteria are documented in the appendix. For the update, literature reviewers screened citations and full-text articles in duplicate, one reviewer abstracted and appraised the data, and a systematic reviewer checked the work using online data abstraction software. The screening process is outlined in Appendix B.

We documented the included studies in an evidence table (Appendix C). We used the same critical appraisal used in the previous report. For the synthesis, studies were stratified by strategy category and higher quality studies (critical appraisal score of ≥ 4 out of a possible 8; Appendix D has more information) were qualitatively synthesized in the text. No formal strength of evidence assessment was undertaken, but we used a summary of findings table to document the evidence

base across studies. COVID-19 studies were a prespecified subgroup. The review protocol can be found on the AHRQ Effective Health Care website (<https://effectivehealthcare.ahrq.gov/products/allocation-scarce-resources/protocol>).

Results

The update identified 2,795 citations, increasing total citations to 8,511. Of these, 1,911 were obtained as full text. In total, 201 studies met inclusion criteria.²⁻²⁰² Study flow is shown in Appendix B, and project details are documented in the Systematic Review Data Repository.²⁰³

The 2012 AHRQ report differentiated four general categories of strategies for policymakers: reduce or manage demand for healthcare services (n=149 studies); augment existing resources (n=28 studies); optimize use of existing resources (n=23 studies), and implement crisis standards of care guidance (n=1 study).

Within the category to reduce or manage demand, we grouped strategies as medical, nonpharmaceutical interventions, or combined countermeasures. Medical countermeasures^{204, 205} are FDA-regulated products (biologics, drugs, and devices) that are used in the event of public health emergencies such as a biological, chemical, or radiological attack or an emerging disease. This term updates our 2012 definition of “biological countermeasure.” Nonpharmaceutical interventions are defined as those that can be used by public health officials to control the spread of disease and help mitigate negative health effects in their community.²⁰⁶ This definition updates the “nonbiological countermeasure” term that we used in 2012. Combined strategies are studies those that incorporate both approaches.

Identified studies evaluated the response to mass casualty events, drills, and simulations. Studies addressed infectious disease threats (anthrax disease, chikungunya disease, COVID-19, dengue fever, Ebola virus disease, pandemic influenza, smallpox, SARS (Severe Acute Respiratory Syndrome), Zika virus disease, bioterrorism, and pandemics in general), natural disasters (hurricanes Sandy, Katrina, and Rita; earthquakes), terrorism (September 11 attacks and truck attack in Nice, France), or general mass casualty events not further specified. Half were conducted in the United States. Each addressed unique questions and scenarios.

The summary of findings table (Table 1) shows all of the identified research supporting the strategies across the mass casualty events including COVID-19.

Table 1. Summary of findings: General strategies and identified evidence informing the strategies

Category of Strategy	Specific Strategy and Evidence Base
Reduce or manage less urgent demand for healthcare services	<p>Nonpharmaceutical Interventions (83 studies)^{4-7, 9, 10, 13, 14, 16, 19, 21, 24, 27-29, 35, 37, 38, 41, 43, 44, 50, 52, 56, 58, 60-64, 78, 82, 83, 88, 90, 93-95, 97, 99, 101, 103, 104, 106, 108-110, 115, 117, 119, 120, 122, 124-126, 137, 139, 140, 142, 143, 149-151, 153-155, 157, 158, 164, 165, 171, 173-176, 179, 183-185, 189, 198, 199, 201}</p> <ul style="list-style-type: none"> • Mass screening, testing • Contact tracing • Quarantine, isolation • Information campaign, collaboration with media • Social distancing, contact reducing, protective behavior recommendations • Canceling public events, closing entertainment venues • Facemask wearing, distribution of protective kits • School closure, work restrictions • State coordination to close schools • Movement restriction, travel restrictions • Airport screening • Vector control • National stockpile distribution • Deploying self-diagnosis tools • Restricting nonurgent demand for hospital care (e.g., elective surgery) • Training for public health officials on legal authorities <p>Medical countermeasures (33 studies)^{2, 18, 25, 30, 32, 40, 47, 67, 80, 85, 98, 102, 111, 112, 116, 118, 127-130, 134, 135, 141, 146, 147, 152, 160, 161, 177, 178, 192, 195, 197}</p> <ul style="list-style-type: none"> • National and state stockpiles • Vaccine uptake promotion • Mass vaccination campaigns (e.g., by mail) • Strategies for allocating vaccines, ring vaccination, community vaccination, push vs. pull-based allocation • Point of dispensing strategies for preventive measures • Drive-through vaccination clinics, ad hoc clinics <p>Combined medical and nonpharmaceutical countermeasures (33 studies)^{8, 23, 31, 39, 45, 46, 54, 69, 73, 76, 77, 79, 86, 92, 96, 114, 121, 123, 131, 136, 145, 156, 162, 163, 168, 182, 186-188, 190, 191, 193, 196}</p> <ul style="list-style-type: none"> • Screening • Mass vaccination and household prophylaxis • Vaccine distribution models, ring vaccination • Antiviral treatment, distribution models • National vaccine stockpile • Quarantine and isolation • School closure, work closure, cancelling large events • Social distancing, facemask policies • Travel restrictions • Educational programs
Optimize use of existing resources	<p>Load and information sharing (15 studies)^{12, 26, 42, 53, 55, 68, 81, 91, 133, 144, 159, 167, 169, 170, 202}</p> <ul style="list-style-type: none"> • Central command structure to optimize distribution of patients to hospitals • Site emergency management centers in low-vulnerability locations • Robust and interoperable emergency communications systems • Statewide coordination of medical countermeasure distribution • Collaboration of laboratories, interregional blood transfer system coordinating regionally • Use home health agencies as point of dispensing, use of disaster medical assistance teams to carry out evacuations, using local health work force • Increase inventory visibility and information sharing <p>Optimize equipment and supplies (8 studies)^{20, 36, 49, 70, 132, 138, 194, 200}</p> <ul style="list-style-type: none"> • Automated drug distribution cabinet • Strategies to optimally dispense antivirals • Installation of local extraction fans to achieve ventilator performance

Category of Strategy	Specific Strategy and Evidence Base
Augment resources	<p>Temporary facilities or workforce (14 studies)^{15, 22, 33, 51, 59, 65, 71, 87, 100, 105, 107, 148, 180, 181}</p> <ul style="list-style-type: none"> • Alternate site surge capacity facilities • Mobile field hospitals • Activating mobile provider units • Medical Reserve Corps volunteers • Emergency task force • Cross training and using nonhospital volunteers <p>Equipment and supplies (11 studies)^{3, 17, 34, 48, 66, 72, 75, 84, 89, 113, 172}</p> <ul style="list-style-type: none"> • Decision support • Models for predictions and supporting allocations • National ventilator stockpile • National antiviral stockpile • Disaster call center <p>Mutual aid agreements and community support (3 studies)^{11, 74, 166}</p> <ul style="list-style-type: none"> • Mutual aid agreements • Community partnerships
Implementation of crisis standards of care	<p>Consensus guideline (1 study)⁵⁷</p> <ul style="list-style-type: none"> • Decision support

Note: N=201 studies

The narrative synthesis below focuses on studies with higher critical appraisal scores, specifically, those at or above our prespecified threshold of 4, as described in Appendix D; the findings of all 201 studies meeting inclusion criteria are summarized in Appendix C.

Strategies To Reduce or Manage Less Urgent Demand for Healthcare Services

The largest group of studies (n=149) assessed strategies aiming to reduce demand for healthcare services, primarily through preventive measures. Studies evaluated medical and nonpharmaceutical intervention countermeasures, alone or in combination. Of these, 39 met our critical appraisal threshold and are described below in more detail.

Nonpharmaceutical Interventions (21 higher quality studies)

Studies of nonpharmaceutical interventions, (n=83) included stockpiling personal protective equipment, distributing protective kits to the public, restricting movement, raising awareness of legally acceptable intervention measures to stop the spread of pandemic influenza, deploying self-diagnosis tools, controlling vectors carrying diseases, contact tracing, social distancing, mass screening, and implementing restrictions on elective surgery.

One of the higher quality studies tested the capacity for and accuracy of mass screening and reported varying implementation success.¹⁰³ A study deployed an interactive, Web-based decision-support tool during the 2009 H1N1 influenza pandemic to help adults with influenza-like illness self-assess need for emergency department visits and the study reported 800,000 site visits.⁹⁵ Another higher quality study, similar to the large number of other identified simulation studies, addressed contact tracing. The simulation targeted Ebola virus disease, specifically, and suggested that the method is a useful tool in containing epidemics, but also highlighted that 5 to 10 contacts per index patient need to be traced to influence the epidemic's behavior.⁶ A

simulation also indicated that contact tracing could have considerable impact in overcoming limited antiviral efficacy.¹⁵⁸

Several studies addressed social distancing and one of the higher quality studies demonstrated that the adherence to these measures is likely a key factor for success. The study used a survey to determine whether protective behavior recommendations to stop the spread of influenza during a large gathering were adhered to; 77 percent of respondents indicated the use of some protective behavior, but 41 percent reported respiratory illness within a week of the event.¹⁴ One study assessed school closure, voluntary home quarantine of index patient and contacts, and an information campaign, and concluded that compliance was higher in households that understood what needed to be done.⁹³ A further identified study on influenza was a simulation that suggested that school closure based on student absenteeism could be highly effective in mitigating influenza spread.⁴¹ Similarly, a study evaluating school dismissal policies in New York City reported an effect on reducing the percentage of reported influenza-like illness.⁵² A simulation indicated that school closures could decrease the number of infected students at peak, but are less effective in decreasing total number of infected students.⁹⁴ A subsequent simulation indicates how complex the interplay is between infectious disease characteristics and effects of school closures, in particular when studies address not only health outcomes but also costs and cost-effectiveness.¹⁴² One study reported positive effects of school closures, but highlighted that an instruction to avoid school friends during the closure period is necessary to strengthen the effect.¹⁷⁵ Lastly, another simulation concluded that school closure could have a moderate impact on an epidemic's scope, but disruption to society imposes a potentially great cost in productivity from parents' work absenteeism.¹⁸⁹

Other studies addressed travel restrictions and point-of-entry screening. A higher quality study reported that the total number of cases in Japanese districts was negatively correlated with the percentage of cases with airport quarantine inspection.⁶⁰ A simulation concluded that early on in the 2009 H1N1 influenza pandemic in Mexico, screening at eight airports could have stopped spread by 90 percent.⁹⁷ However, the success of interventions depends on the employed method and its purpose. A study reporting on airport health screenings based on passenger's self-identification indicated that the approach was not successful in identifying the 2009 H1N1 influenza pandemic.⁷⁸ An airport fever screening program concluded that the approach is promising (it detected 45% of the confirmed imported cases of dengue fever with a high corresponding negative predictive value).¹⁰⁸ However, a subsequent study indicated that fever screening alone is not the best method for screening for influenza and that the sensitivity of the infrared thermoscanners varied.¹⁴³ Similarly, an evaluation of a temperature-sensing camera in an airport indicated that during a seasonal epidemic of predominantly influenza type B, the proportion of influenza-infected travelers who were febrile was low and the system was not much better than chance at identifying travelers likely to be infected with influenza.¹⁵⁴ One study reported that self-reporting surveys did not prove to be effective for screening for influenza, as nonsymptomatic people overreported and those who were sick underreported symptoms.¹⁵⁵

Assessing the success of training sessions for public health officials, a study reported increased confidence to take specific actions such as imposing quarantine.¹⁶⁴ One study assessed the effectiveness of imposing restrictions on ambulatory and inpatient medical and surgical care for nonurgent cases across all hospitals in the greater Toronto area during the 2003 SARS epidemic.¹⁶⁵ The authors reported that, while nonurgent admissions decreased significantly, high acuity emergency department visits and interhospital transfers also decreased, suggesting that some patients may not have received needed care.

Medical Countermeasures (14 higher quality studies)

The 33 identified studies evaluating medical countermeasures included a large number of simulations, such as models for distributing newly developed vaccines once they become available after a novel virus strain threatens public health.

A higher quality study modeling inventory visibility concluded that the presence of information on vaccine inventory would decrease not only the amount of leftover inventory but also help decrease the influenza infection rate.¹¹⁸ Model assumptions typically included that supply is limited and that policymakers need to distribute resources strategically. One simulation documented a threshold at which a one-dose influenza vaccine administered to many individuals would be superior to a two-dose approach for half as many individuals.¹²⁸ One simulation addressing Ebola virus disease documented conditions for which a ring vaccination policy (immunizing close contacts of infected individuals) rather than a community vaccination policy (vaccination in the community independent of their connection to an infected person) would be appropriate.⁴⁰

Other simulations assessed strategies for populations. One simulation concluded that vaccinating children aged 5 to 19 and their parents (ages 30 to 39) would be particularly effective, since children are often vectors of transmission to others.¹³⁵ Another simulation reported that prioritizing prophylaxis for healthcare workers would be an effective use of a national antiviral stockpile and does not have a deleterious effect on disease control in the population.¹³⁴ A subsequent simulation indicated that the most effective targeting strategy may depend on a policymaker's objective:⁶⁷ children, adolescents, and young adults should be targeted to minimize population morbidity; in contrast, infants, young adults, and older adults should be targeted to minimize mortality. One simulation outlined the interdependency of parameters; for example, surveillance strategies to enhance anthrax bioterrorism attack detection would not result in reduced mortality when dispensing capacity is low.²⁵

Another question addressed was whether a “pull” or “push” strategy is the better for dispensing medical countermeasures. One study reported that a centralized “pull” system (in which individuals come to a fixed site) provided slightly faster and more accurate processing than a hybrid model that combined the centralized pull approach and a push approach (in which supplies are delivered to some people at their work site).² One study compared the standard centralized pull model with a push model that used U.S. Postal Service mail carriers to deliver prophylactic antibiotics in an anthrax attack exercise. The push approach in that study served more people per hour per provider than the fixed dispensing sites.¹⁰²

Other identified studies assessed the throughput that can be achieved in mass vaccination exercises. A study evaluating drive-through vaccination clinics determined that between 200 and 361 people per hour can be vaccinated when adults as well as children are targeted.¹⁸ One study reported that in 2 hours, a total of 622 people were processed in their vehicles in an exercise of dispensing State stockpile supplies, and that although patient services were reduced in comparison to walk-in clinic models, the public was able to receive prophylactic medication in a timely manner with a high rate of accuracy and minimal human-to-human contact (the drive-through area included a registration site, a triage area, and evaluations for contraindications).¹⁹⁷ Other studies evaluated equity, including a study evaluating H1N1 influenza vaccine point-of-dispensing efforts that found racial disparities in vaccination rates and average distance traveled to the dispensing point.¹⁶⁰ One study documented challenges in influencing uptake, for example through a telephone intervention to enhance vaccination uptake in neighborhoods with lower

coverage rates.⁴⁷ One study concluded that community efforts are needed to reach economically disadvantaged individuals.⁸⁰

Combined Medical and Nonpharmaceutical Countermeasures (four higher quality studies)

Some studies (n=33) evaluated the comparative effectiveness of competing individual policies or assessed effects of combined strategies. The majority were computer simulations and assessed a variety of policies, including screening, different vaccination models, school closures, and other social distancing measures.

One of the higher quality studies explored the effects of travel restrictions and vaccinations and concluded that the simulation suggested preferentially vaccinating urban locations was the single most effective strategy, but travel restrictions delayed the peak of the epidemic.⁵⁴ An influenza simulation assessed the cost-effectiveness of individual and combined interventions and concluded that for severe pandemics, the combination of antiviral use for treatment or prophylaxis, school closures for an extended duration, and social distancing to reduce contacts in the community would reduce the total costs of the influenza pandemic the most.²⁰⁷ A smallpox simulation suggested that it is advisable to carry out mass vaccination, or both traced vaccination (patients are traced and people who came into contact with those patients are vaccinated) and mass vaccination, simultaneously with school closures.¹⁹⁶ An influenza simulation tested seven interventions (e.g., social distancing); the authors concluded that with implementing all seven, the illness attack rate would be around 8 percent and with no intervention it would be 54 percent.¹⁶³

The COVID-19 studies are described in the subgroup analysis, and all other included studies are shown in Appendix C.

Strategies To Optimize Use of Existing Resources

The identified 23 studies evaluated load sharing and information sharing between agencies and counties as well as optimizing the use of existing equipment and supplies.

Load and Information Sharing (5 higher quality studies)

This evidence base included a study describing a successful partnership between the Centers for Disease Control and Prevention, State public health laboratories, and community commercial laboratories for Zika virus testing in Florida by developing an algorithm for triaging and testing specimens, such as low-risk patient samples being processed in commercial laboratories.⁸¹ A study reported successful medication distribution by enlisting the help of agencies assisting people with functional needs.²⁰² An evaluation of pediatric disaster services and regional systems of care after a tornado concluded that no preventable adverse events were identified, but also highlighted that the established communication channels between hospitals in the region facilitated the integration of services.⁹¹ Another study reported a reduction in patient transfer times once a coordinated regional trauma system was used for routine, small-scale trauma events following Hurricane Katrina.⁵⁵ One study evaluating the response to the September 11 attacks in New York concluded that the absence of an enforced patient distribution system led to uneven load in trauma centers and disruption of cell phone and radio communications exacerbated problems with coordination and communication.¹⁶⁹

Optimize Equipment and Supplies (1 higher quality study)

Other studies addressed optimizing strategies to contain infectious diseases: one higher quality simulation found that a two-drug regimen (one for prophylaxis and a different drug for treatment) would be more effective in delaying the propagation of disease during an influenza pandemic than the use of a single drug for both prophylaxis and treatment, but the strategy would also be more likely to result in multidrug resistance.¹³²

The results of the remaining studies, predominantly simulations and evaluations of responses to earthquakes, are documented in Appendix C. All COVID-19 studies are documented in the subgroup analysis below.

Strategies To Augment Existing Resources

The 28 included studies evaluating strategies to augment existing resources assessed temporary facilities and temporary workforce, additional resources gained through mutual aid agreements or community collaboration, and the addition of supplies and equipment such as software that supports decision making.

Temporary Workforce and Temporary Facilities (7 higher quality studies)

A study evaluating the use of volunteers to reach medically fragile individuals after Hurricane Sandy concluded that the volunteers helped fill gaps in reaching vulnerable populations but noted that the effect was far from what would have been required in the situation.¹⁰⁷ An exercise using Medical Reserve Corps volunteers in a response to an influenza outbreak reported that medical staff had high satisfaction with the work of the volunteers.⁶⁵ An alternate care site provided so much medical surge capacity following Hurricane Katrina that emergency departments and trauma centers in the region saw no significant rise in patient visit rates during the 2 weeks post-event.⁵¹ An anthrax simulation that examined expanding point of distribution and hospital surge capacity (i.e., by cross training and using nonhospital volunteers to extend trained personnel and mobile servers from other Federal agencies) concluded that deaths would dramatically decrease with sufficient personnel (10-fold or more), and that rapid mass distribution of prophylactic drugs compared with treatment of symptomatic persons would prevent more deaths.¹⁸¹ An exercise for mass medication distribution increased the throughput rate at the point of dispensing site.⁵⁹ Testing rapid dispensing of medication through a school-based point of dispensing model showed that medication can be dispensed in 50 minutes to 10 percent of the local population (totaling approximately 21,000 people) and that the school notification system worked well to distribute information to parents.¹⁰⁰ A simulation using a Japanese shopping street as the site for food distribution and evacuation shelter concluded that the setting would provide many advantages over no intervention after an earthquake incident.¹⁰⁵

Equipment and Supplies (3 higher quality studies)

One study evaluated the use of a computer simulation model that allocates resources for a point of distribution site; the study reported a more efficient use of time for a group responding to a bioterrorism threat when supported by the model.⁶⁶ Another study evaluated counties using decision support software to determine staffing for point of dispensing medical supplies following a hypothetical anthrax release; the study concluded that the tool helped achieve the highest throughput, reach more households, produce the most efficient floor plan, dispense cost-

effectively, and report the shortest average wait times.¹¹³ An evaluation of disaster call centers concluded that this service was highly used, with spikes in calls after hurricanes Katrina and Rita, indicating that other services did not meet the need.¹⁷

Mutual Aid Agreements and Community Support (2 higher quality studies)

One higher quality study reported good results for establishing community partnerships that, among other advantages, resulted in a high vaccination rate compared with other jurisdictions.⁷⁴ A computer simulation highlighted the potential importance of establishing mutual aid agreements between counties and pointed to the need for a greater understanding of the logistics and supply chain aspects of pandemic planning and management.¹¹

The remaining studies not meeting the critical appraisal threshold addressed a range of health care entry points and services and are documented in Appendix C. Two identified COVID-19 studies are described in the subgroup section.

Implementation of Crisis Standards of Care Guidance

Crisis standards of care are the last resort in the continuum of care ranging from conventional, through contingency, to crisis standards. One higher quality study examined resource allocation under crisis standards of care and described how a multidisciplinary health care ethics committee determined allocation of resources during the Haiti earthquake and concluded that this process enabled ethical decision making in a timely manner.⁵⁷

COVID-19 Studies

Some included studies evaluated strategies to address COVID-19, specifically. All 16 studies had been published in early 2020, and the critical appraisal results were generally low with the exception of five higher quality studies.

Of the five studies meeting the critical appraisal threshold, three assessed the effect of nonpharmaceutical interventions. A Chinese study modeled the best timing for physical distancing policies to maximize impact on number of infections, using data from the Wuhan community.¹⁵³ A contact tracing study conducted in Taiwan highlighted the high transmissibility of COVID-19 before and immediately after symptom onset and concluded that finding and isolating symptomatic patients alone may not suffice to contain the epidemic; more generalized measures such as social distancing may be required.³⁷ An international analysis of the effect of face mask wearing across countries to date found that incidence of COVID-19 was lower in countries that had implemented the strategy compared with countries without communitywide mask policies.³⁸ One study documented multiple interventions, including pharmaceutical and nonpharmaceutical measures aiming to reduce the demand for healthcare (travel restrictions, mask wearing, social distancing, self-quarantine/stay-at-home policies, antiviral treatment or prophylaxis, and screening), that had been implemented in China and concluded that these policies improved control of the novel coronavirus outbreak.¹⁴⁵ Another higher quality study employing a strategy in the “optimizing use of existing resource” category reported positive experiences with “Internet hospitals,” an approach to outpatient healthcare that provides health services via Internet technologies in China. Apart from providing medical support, the authors indicated that this optimization approach likely reduced social panic, promoted social distancing, and helped navigate care seeking.⁶⁸

The other identified COVID-19 studies included two resource augmentation approaches. An Italian study described success with establishing an emergency task force formed by government and local health authorities.⁷¹ Another study documenting experiences with creating an intermediary treatment facility in South Korea concluded that implementation reduced the number of patients needing hospital beds.¹⁴⁸

All other studies addressed countermeasures aiming to reduce healthcare demand. One study included an evaluation of mobility restriction policies in China; the authors concluded that travel restrictions are useful in early stages of an outbreak when the infection is confined to a specific area.¹⁰⁶ Another study analyzed the impact of the policy response in Wuhan. The shutdown slowed spread by an estimated 2.91 days to outside areas, and other cities that implemented control measures preemptively reported 33 percent fewer cases in the first week of their outbreaks compared with cities that implemented control measures later. The authors concluded that suspending intracity public transport, closing entertainment venues, and banning public gatherings were the most impactful initiatives.¹⁷³

The remaining studies were simulations assessing the potential effects of countermeasures. A simulation that assessed the potential effect of a range of medical and nonpharmaceutical countermeasures on the spread of the infection in China concluded that without nonpharmaceutical interventions, the number of COVID-19 cases could have been up to 67 times higher.¹⁰⁹ The remaining simulations addressed different nonpharmaceutical countermeasures. A U.S. simulation highlighted that school closures come with many tradeoffs, and suggested that the use of school closures to prevent disease transmission needs to be carefully weighed against the potential loss of healthcare workers from the standpoint of reducing cumulative mortality due to COVID-19.¹⁹ A Korean simulation modeled the effect of delayed school opening and emphasized the potential impact of nonpharmaceutical interventions to mitigate the effect of disease spread.⁹⁹ A modeling study conducted in Singapore concluded that immediate quarantining, workplace distancing, and school closure may be warranted if local secondary transmission is confirmed, while at an early stage, quarantine and workplace distancing should have priority over school closure.¹⁰⁴ A U.S. simulation emphasized the importance of social distancing, which could curtail the burden of COVID-19. The simulation suggested that using face masks in public spaces (including both surgical and cloth face masks) would be useful in minimizing community transmission, provided that the level of mask use is high. The simulation also suggested that the need for mask use decreases if it is combined with a strict social distancing strategy.¹⁴⁰ An Italian simulation concluded that a combination of social distancing, widespread testing, and contact tracing would be necessary to reduce transmission.⁶⁴ Another simulation stressed that very high adherence to community quarantine (total stay-home policy) would be necessary for curbing a hypothetical outbreak in a locked-down town.¹⁷¹ Study details are shown in Appendix C.



Discussion and Limitations

We conducted a rapid update of a portion of a very comprehensive systematic review on the allocation of scarce resources in mass casualty events, and we focused the synthesis on literature applicable to decision makers. We used a broad definition of resource allocation that included other pandemic management responses such as community and nonpharmaceutical mitigation strategies. Of particular interest were evaluations of possible responses to the current COVID-19

pandemic. The update used abbreviated methods to ensure a rapid turnaround, and there may have been studies, in particular outside of journal articles, which are missing from the review. In addition, the evidence base, in particular for COVID-19 research, is rapidly evolving and the review covered only research up to early May 2020.

We applied relevant critical appraisal criteria for all included studies and focused the narrative synthesis on studies meeting a basic methodological threshold. However, the evidence base does not include robust study designs such as randomized controlled trials that allow strong evidence statements, and no formal strength of evidence assessment was undertaken. The identified studies represent tested strategies that can inform decision makers rather than strong evidence suggesting clear evidence-based solutions. In addition, there is a wealth of published guidance for policymakers that is based on expert consensus.²⁰⁸

Furthermore, there are practical as well as many ethical and legal questions that this review does not address, including planning for the needs of at-risk populations, such as older adults and people with disabilities. Decision makers need to carefully weigh alternatives to ensure that patients receive the best possible care under the given challenging circumstances. In addition, despite the research volume, the evidence base is insufficient to meaningfully inform decision makers on several important issues such as ventilator and supply line issues.²⁰⁹ Future high-quality studies should address these important strategies. Decision makers need more information about the comparative effectiveness of the competing strategies that have been suggested to address scarce resources. Most importantly, research should test promising strategies developed by simulation in practice.



Implications and Conclusions

The COVID-19 pandemic illustrates the need to use established best practices and evidence-based approaches to optimally allocate healthcare resources when demands on the national disaster response system resources may outpace supply. In some U.S. regions, the strains on intensive care unit capacity, personal protective equipment supplies, and nursing care, compounded by supply chain disruptions, social distancing measures, and restrictions on the availability of healthcare workers, has led to inadequate resources to meet demands. Important guidance documents developed by HHS, ASPR, and NAM^{210, 211} and others, such as the Crisis Standards of Care workgroup,²¹² provide much needed guidance for decision makers about available options and resources. In addition, there are platforms for sharing COVID specific tools and resources, such as ASPR TRACIE Information Exchange.²¹³

This review complements current guidance and other resources by outlining the existing evidence about strategies applicable to allocating scarce resources. This review identified a number of strategies reported to be successful, ranging from preventing the need for healthcare to optimizing and augmenting resources and adopting crisis standards of care. It documents the evaluations and outcomes of various models that decision makers can leverage in order to make informed decisions about which strategy is best suited to their present need.

The review identified more than 200 relevant research studies. Despite the research volume on the allocation of scarce resources, few definitive evidence statements can be drawn because the research studies addressed a variety of unique question and event scenarios. Most research is available for strategies aiming to reduce the demand for healthcare. Mass vaccination to contain pandemics has been assessed in several empirical evaluations and computer simulations and was often found to be one of the most effective strategies, in particular when combined with other

community mitigation strategies. However, vaccines are not immediately available after an outbreak of a novel virus strain, and the different suggested strategies for how to best distribute a vaccine can only be executed once it is developed, deemed safe and effective, and available en masse. Simulations and exercises can inform distribution models, for example, to determine when push or pull models or ring or random vaccination strategies are most effective, and which strategies minimize population morbidity versus mortality.

A nonpharmaceutical intervention that has received substantial research attention is contact tracing (i.e., identifying people an infected person has come in contact with), and the research indicates that while it is a useful tool, a substantial number of contacts need to be traced to maximize effectiveness. Social distancing, in particular achieved through school closures, showed effects on delaying peaks of pandemics, creating often valuable time that can be used to care for infected patients and develop vaccines. The literature on travel restrictions is mainly based on simulations and empirical evaluations estimating how effective the intervention was in preventing the spread of a disease. The research also shows that the success varies considerably by method and by disease (e.g., temperature scanning in airports is successful only for selected applications). Other interventions that have been evaluated include imposing restrictions on ambulatory and inpatient medical and surgical care for nonurgent procedures. However, the experiences also showed unintended consequences suggesting that some patients may not have received needed care.

Generally, strategies to augment existing resources reported positive results for the use of temporary facilities and using established distribution systems for medication and information such as through schools. Studies testing the use of volunteers to temporarily boost the available workforce also reported positive experiences. However, most studies conducted one-time exercises, and the sustainability of the strategies is unclear, in particular in the case of pandemics that may outlast volunteers' enthusiasm. Positive results also were reported for adding decision tools, albeit in training exercises rather than real events. Strategies to optimize use of existing resources described positive effects of expanding the scope of work, for example involving community laboratories to share the workload. Other studies reported positive results after sudden mass casualty events but noted that the success was likely only possible because of existing communication channels and established collaboration agreements between agencies.

The evidence base is growing for COVID-19, including research relevant to policymakers. However, the currently available research consists primarily of studies retrospectively (or in simulations) evaluating combination of interventions, which makes it difficult to isolate the effect of individual strategies. An international analysis indicated that incidence of COVID-19 was lower in countries that had implemented communitywide mask policies compared to countries without these policies.³⁷

Decision makers also need to take the characteristics of the individual mass casualty event or infectious disease outbreak into account. For example, a pandemic creates unique challenges, and, in contrast to other events, such as a bomb blast, pandemics build up slowly as cases spread and require medical treatment, last many months, and potentially affect all geographic areas. These characteristics inform the applicability of strategies useful for decision makers in a pandemic. The extended demand for pandemic-related healthcare creates a need for strategies to ensure that routine health care needs (both acute and chronic) are met and not substantially delayed (e.g., delaying cancer care and routine childhood vaccinations), as doing so may result in worse outcomes in the long term.

Many of the strategies included in this review have been implemented or discussed at various levels across States. Many hospitals have canceled elective procedures and transitioned to a telemedicine platform to minimize patient exposure risk (thus boosting the supply of available providers despite social distancing restrictions). Coordination of regional trauma systems varies widely by county and State, and it will be important to observe any relationship between coordination of trauma systems and outcomes. Many States have set up alternate care sites to augment their surge capacity facilities and mobile field hospitals to accommodate incoming COVID-19 positive patients. Hospitals and other agencies have begun to review and revise their crisis standards of care to respond to this unprecedented surge in demand for certain resources in the face of supply limitations. As the pandemic unfolds, health systems must be strategic to ensure the allocation of scarce resources will provide the most benefit to the greatest number of patients.

Through this experience, there will be many lessons learned about implementation of scarce resource strategies. The COVID-19 outbreak will also offer opportunities for research in assessing the effectiveness of the suggested strategies as the current evidence base is still very limited and lacks robust research studies. Modeling and simulation findings need to be applied and evaluated to offer insight into how implementation of different strategies affects public health outcomes. Decision makers and healthcare delivery organizations will need to ensure that research findings and lessons learned are incorporated into their crisis of care standards and disaster plans.

Healthcare systems need to swiftly implement contingency plans when COVID-19 outbreaks or other incidents start to overwhelm the regional healthcare system. Strategies may include reducing demand for healthcare services; optimizing the use of existing resources; and securing additional resources, if possible, from backup sources. If these measures are insufficient to meet demand, healthcare providers may be forced to shift from the traditional treatment approach, which strives to deliver optimum care to every patient, to crisis standards of care, i.e., an approach that seeks to do the most good for the most people with the available resources.

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Afterword

Recognized for excellence in conducting comprehensive systematic reviews, the Agency for Healthcare Research and Quality (AHRQ) Evidence-based Practice Center (EPC) program is developing a range of rapid evidence products to assist end-users in making specific decisions in a limited timeframe.

To shorten timelines, reviewers make strategic choices about which review processes to abridge. However, the adaptations made for expediency may limit the certainty and generalizability of the findings from the review, particularly in areas with a large literature base. Transparent reporting of the methods used and the resulting limitations of the evidence synthesis are extremely important.

AHRQ expects that these rapid evidence products will be helpful to health plans, providers, purchasers, government programs, and the healthcare system as a whole. Transparency and stakeholder input are essential to the Effective Health Care Program.

If you have comments on this report, they may be sent by mail to the Task Order Officer named below at: Agency for Healthcare Research and Quality, 5600 Fishers Lane, Rockville, MD 20857, or by email to epc@ahrq.hhs.gov.

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Appendixes

APPENDIX A. Methods

Search Strategy

PubMed (Legacy Platform)

Limits: 2011 – present; English

Search Run: 4 May 2020

(disasters[mesh] OR disaster*[tiab] OR "emergency planning" OR "emergency preparedness" OR mass casualty* OR pandemic OR epidemic OR disease outbreak[mesh])

AND

(mass[tiab] AND (test*[tiab] OR screen*[tiab]))

AND

governing[tiab] OR organization*[tiab] OR agency[tiab] OR agencies[tiab] OR health official*[tiab] OR government[tiab] OR agency[tiab] OR agencies[tiab] OR tribal official*[tiab] OR "health and human services"[tiab] OR HHS[tiab] OR "department of homeland security"[tiab] OR "world health organization"[tiab] OR "Pan American health organization"[tiab] OR ("emergency management"[tiab] AND official*[tiab]) OR state official*[tiab] OR local official*[tiab] OR county supervisor*[tiab] OR mayor*[tiab] OR "city council"[tiab] OR "county council"[tiab] OR lawmaker*[tiab] OR legislature[tiab] OR governor*[tiab] OR federal official*[tiab]

Results: 101

Limits: 2011 – present; English

Search Run: 4 May 2020

(disasters[mesh] OR disaster*[tiab] OR "emergency planning" OR "emergency preparedness" OR mass casualty* OR pandemic OR epidemic OR disease outbreak[mesh])

AND

"social distancing"[tiab] OR school closure*[tiab] OR travel restriction*[tiab] OR travel ban*[tiab] OR stockpile*[tiab] OR "load sharing"[tiab] OR mutual aid agreement*[tiab] OR "contact tracing"[tiab]

AND

(protocol[tiab] OR strategy*[tiab] OR policy[tiab] OR policies[tiab] OR plan*[tiab] OR distribution*[tiab])

NOT

Clinical Trial[ptyp] OR Clinical Conference[ptyp]

AND

(humans[mh] OR inprocess[sb] OR publisher[sb] OR pubmednotmedline [sb])

Results: 116

Limits: 2011 – present; English

Search Run: 6 April 2020

(disasters[mesh] OR disaster*[tiab] OR "emergency planning" OR "emergency preparedness" OR mass casualty* OR pandemic OR epidemic OR disease outbreak[mesh])

AND

((surge OR scarce OR scarcity OR allocation* OR ration OR rations OR rationing) OR (mass[tiab] AND (vaccine*[tiab] OR distribution*[tiab])) OR (triage AND (ethic* OR protocol[tiab])) OR ("altered care" OR "adapted care" OR "crisis care") OR ((altered[tiab] OR crisis[tiab] OR adapted[tiab]) AND ("standard of care"[tiab] OR "standards of care"[tiab])) OR ((augment*[tiab] OR optimize*[tiab]) AND resources[tiab]) OR (countermeasure* OR "emergency medical care"))

AND

(protocol[tiab] OR strategy*[tiab] OR policy[tiab] OR policies[tiab] OR plan*[tiab] OR distribution*[tiab])

NOT

Clinical Trial[ptyp] OR Clinical Conference[ptyp]

AND

(humans[mh] OR inprocess[sb] OR publisher[sb] OR pubmednotmedline [sb])
Results: 1599

Web of Science

Limits: 2011 – present; English

Indexes: SSCI; SCI; A&H I

Included Document Types: ARTICLE OR EARLY ACCESS OR REVIEW OR BOOK CHAPTER OR DATA PAPER OR EDITORIAL MATERIAL

Refined by (chosen from the top 100): WEB OF SCIENCE CATEGORIES: (PUBLIC ENVIRONMENTAL OCCUPATIONAL HEALTH OR MEDICAL INFORMATICS OR INFECTIOUS DISEASES OR PHARMACOLOGY PHARMACY OR MEDICAL ETHICS OR MULTIDISCIPLINARY SCIENCES OR EMERGENCY MEDICINE OR IMMUNOLOGY OR CRITICAL CARE MEDICINE OR RESPIRATORY SYSTEM OR PSYCHIATRY OR MEDICINE RESEARCH EXPERIMENTAL OR ORTHOPEDICS OR HEALTH CARE SCIENCES SERVICES OR NURSING OR SURGERY OR ONCOLOGY OR HEALTH POLICY SERVICES OR TROPICAL MEDICINE OR MEDICINE LEGAL OR DERMATOLOGY)

Search Run: 6 April 2020

TS=(disaster* OR "emergency planning" OR "emergency preparedness" OR "mass casualty*" OR pandemic OR epidemic OR "disease outbreak*")

AND

((TS=(surge OR scarce OR scarcity OR allocat* OR ration OR rations OR rationing)) OR (TS=(mass) AND TS=(vaccin* OR distribut*)) OR (TS=(triage) AND TS=(ethic* OR protocol)) OR TS=("altered care" OR "adapted care" OR "crisis care") OR (TS=(altered OR crisis OR adapted) AND TS=("standard of care" OR "standards of care")) OR (TS=(augment* OR optimi*) AND TS=(resources)) OR (TS=(countermeasure* OR "emergency medical care"))))

AND

TS=(protocol OR strateg* OR policy OR policies OR plan* OR distribut*))

NOT

(TS=("clinical trial"))

Results: 1347 (automated duplicates removed) = 571

Limits: 2011 – present; English

Indexes: SSCI; SCI; A&H I

Search Run: 4 May 2020

TS=(disaster* OR "emergency planning" OR "emergency preparedness" OR "mass casualty*" OR pandemic OR epidemic OR "disease outbreak*")

AND

TS=(mass AND (test* OR screen*))

AND

TS=(governing OR organization* OR agency OR agencies OR health official* OR government OR tribal official* OR "health and human services" OR HHS OR "department of homeland security" OR "world health organization" OR "Pan American health organization" OR state official* OR local official* OR county supervisor* OR mayor* OR "city council" OR "county council" OR lawmaker* OR legislature OR governor* OR federal official*) OR TS=("emergency management" AND official*)

Results: 116

Web of Science Limits: 2011 – present; English

Indexes: SSCI; SCI; A&H I Included Document Types: ARTICLE OR EARLY ACCESS OR REVIEW OR BOOK CHAPTER OR DATA PAPER OR EDITORIAL MATERIAL

Refined by (EXCLUDE: veterinary sciences)

Search Run: 4 May 2020

TS=(disaster* OR "emergency planning" OR "emergency preparedness" OR "mass casualty*" OR pandemic OR epidemic OR "disease outbreak*") AND TS=("social distancing" OR school closure* OR travel restriction* OR travel ban* OR stockpil* OR "load sharing" OR mutual aid agreement* OR "contact tracing") AND TS=(protocol OR strateg* OR policy OR policies OR plan* OR distribut*) NOT (TS=("clinical trial"))

Results: 473

CDSR

Limits: 2011-present

Search Run: 6 April 2020

((disaster* OR "emergency planning" OR "emergency preparedness" OR "mass casualt*" OR pandemic OR epidemic OR "disease outbreak*")):ti,ab,kw OR MeSH descriptor: [Disasters] explode all trees OR MeSH descriptor: [Disease Outbreaks] explode all trees

AND

((surge OR scarce OR scarcity OR allocat* OR ration OR rations OR rationing) OR (mass AND (vaccin* OR distribut*)) OR (triage AND (ethic* OR protocol)) OR ("altered care" OR "adapted care" OR "crisis care") OR ((altered OR crisis OR adapted) AND ("standard of care" OR "standards of care")) OR ((augment* OR optimi*) AND resources) OR (countermeasure* OR "emergency medical care")):ti,ab,kw

AND

(protocol OR strateg* OR policy OR policies OR plan* OR distribut*):ti,ab,kw

Results: 6 – duplicates = 5

Limits: 2011-present

Search Run: 4 May 2020

((disaster* OR "emergency planning" OR "emergency preparedness" OR "mass casualt*" OR pandemic OR epidemic OR "disease outbreak*")):ti,ab,kw OR MeSH descriptor: [Disasters] explode all trees OR MeSH descriptor: [Disease Outbreaks] explode all trees

AND

((surge OR scarce OR scarcity OR allocat* OR ration OR rations OR rationing) OR (mass AND (vaccin* OR distribut*)) OR (triage AND (ethic* OR protocol)) OR ("altered care" OR "adapted care" OR "crisis care") OR ((altered OR crisis OR adapted) AND ("standard of care" OR "standards of care")) OR ((augment* OR optimi*) AND resources) OR (countermeasure* OR "emergency medical care")):ti,ab,kw OR ("social distancing" OR school closure* OR travel restriction* OR travel ban* OR stockpil* OR "load sharing" OR mutual aid agreement* OR "contact tracing"):ti,ab,kw

AND

(protocol OR strateg* OR policy OR policies OR plan* OR distribut*):ti,ab,kw

((disaster* OR "emergency planning" OR "emergency preparedness" OR "mass casualt*" OR pandemic OR epidemic OR "disease outbreak*")):ti,ab,kw OR MeSH descriptor: [Disasters] explode all trees OR MeSH descriptor: [Disease Outbreaks] explode all trees

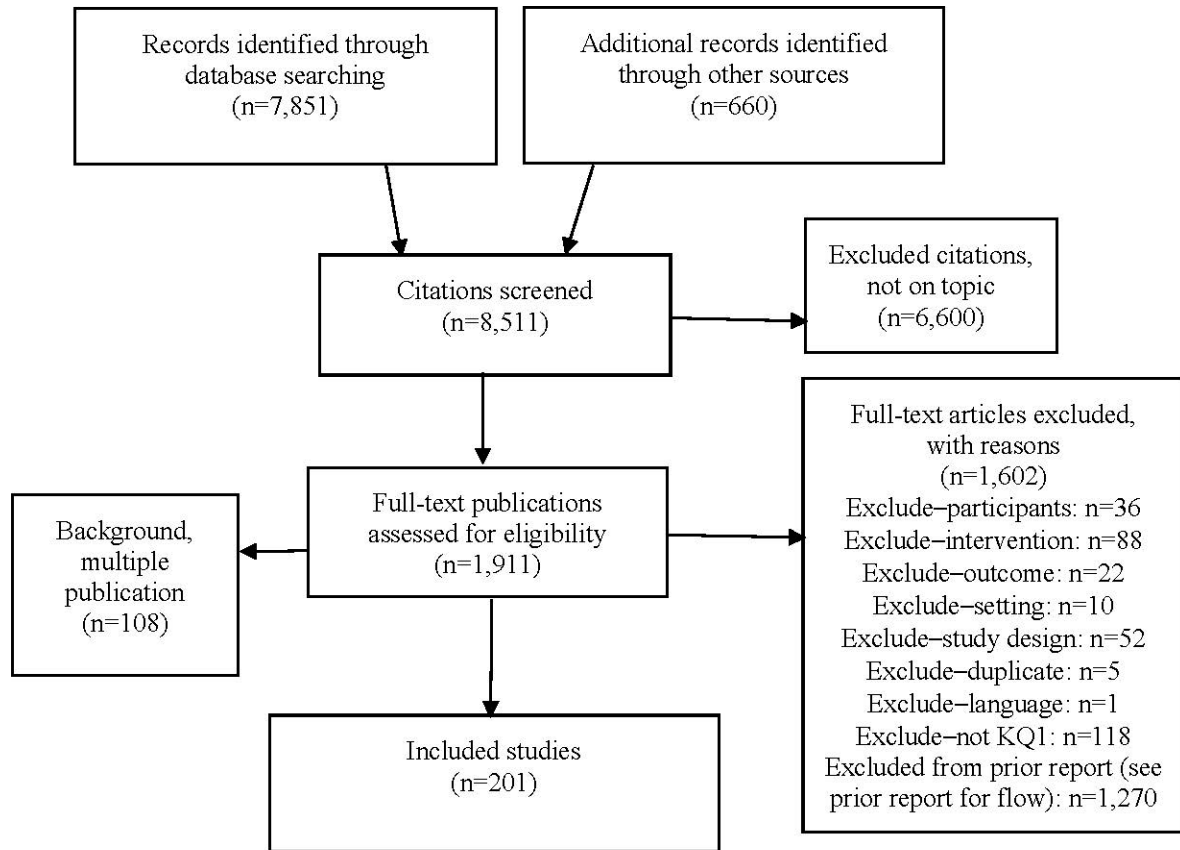
AND ((surge OR scarce OR scarcity OR allocat* OR ration OR rations OR rationing) OR (mass AND (vaccin* OR distribut*)) OR (triage AND (ethic* OR protocol)) OR ("altered care" OR "adapted care" OR "crisis care") OR ((altered OR crisis OR adapted) AND ("standard of care" OR "standards of care")) OR ((augment* OR optimi*) AND resources) OR (countermeasure* OR "emergency medical care")):ti,ab,kw OR ("social distancing" OR school closure* OR travel restriction* OR travel ban* OR stockpil* OR "load sharing" OR mutual aid agreement* OR "contact tracing"):ti,ab,kw AND (protocol OR strateg* OR policy OR policies OR plan* OR distribut*):ti,ab,kw

Eligibility Criteria

- Population: Decision makers charged with responsibility for developing and implementing strategies to allocate resources in healthcare.
 - Decision makers were defined as Federal departments and agencies (e.g., HHS, Department of Homeland Security); State and local public health officials; State governing officials (e.g., governor, State legislature); local governing officials (e.g., mayor, city council, county supervisors); State and local emergency management officials; tribal officials; and international health officials (e.g., World Health Organization, Pan American Health Organization). The affected population includes people who require medical or psychological treatment.
- Interventions and comparators: Strategies used by decision makers to maximize scarce resources regardless of the comparator:
 - Strategies focused on single or multiple components of the health system such as emergency medical services and dispatch and provider payment policies; actions taken in advance to prepare for large-scale public health (e.g., stockpiling); adaptive strategies that ensure effective incident command, control, intelligence gathering, and communication systems; actions taken to maximize resources to avoid the need to shift to crisis standards of care (e.g., 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); actions taken to reduce or manage less-urgent demand for healthcare services (e.g., activating call centers or websites that provide information about when and where to seek treatment and how to adequately care for oneself or family members at home); and 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"). Studies that do not specify the strategy or give no information on the intervention and models not primarily evaluating the effect of a strategy or not referring to strategies for decision makers were excluded.
- Outcomes: Empirical studies evaluating strategies with structured data collection and reporting on process (e.g., throughput), health (e.g., decreased infection rate), or other effect outcomes (e.g., unintended consequences). Analyses of actual events as well as simulations were eligible.
- Study design: Individual strategies for decision makers as well as full models, frameworks, and guidelines proposed by a task force convened by the Federal Government or based on formal consensus exercises with strategies fully or partially addressing decision makers were eligible.
- Timing: Preparedness and response to pandemics, strategies that address the triggers or timing for returning to normal operations, and long-term recovery (e.g., community resilience) if these strategies were implemented during the course of the pandemic.
- Settings: All settings in which patient care might be directed/managed and delivered.
- Other limiters: Non-English-language studies and reports published in abbreviated form were excluded.

Appendix B. Literature Flow

Figure B-1. Literature flow diagram



APPENDIX C. Evidence Table

Author, Year Location Critical Appraisal score*	Strategy Category	Study Type Study Design Study Description	Mass Casualty Event	Strategies	Findings
Agarwal, 2012 ⁴ India 1	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Computer simulation N/A Used modeling to look at contact tracing and quarantine and their effects on disease spread between different subpopulations in India.	Infectious disease: Influenza	Contact tracing Quarantine	Maximum quarantine and maximum contact tracing strategies have the most impact.
Ajelli, 2012 ⁵ US 1	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Computer simulation N/A Estimated transmission potential and develop model to assess the effectiveness of social distancing measures.	Infectious disease: Marburg hemorrhagic fever	Isolation of infective cases Social distancing	Epidemics can be contained with early isolation. Social distancing measures can help contain or mitigate an emerging infectious disease outbreak.
Ajelli, 2015 ⁷ Sierra Leone, Pujehun 3	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Analysis of single real event Post-only Evaluation of interventions during 2014 Ebola virus disease outbreak in Sierra Leone.	Infectious disease: Ebola	Contact tracing	Contact tracing helped to detect 43% of cases, and number of hospital beds available for treatment was a key indicator of success in stopping spread.
Ajelli, 2016 ⁶ Guinea 4	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Computer simulation N/A Agent based model, pulling on demographic data and simulating interventions including contact tracing, hospital treatments, and safe burials.	Infectious disease: Ebola	Contact tracing	Contact tracing proved to be a major component in addressing the epidemic's behavior, with emphasis on obtaining at least 5-10 contacts per person.
Araz, 2012 ⁹ US 2	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Computer simulation N/A Developed model to analyze the impact of school closures on transmission and estimate the cost effectiveness of the intervention.	Infectious disease: Influenza	School closure	The cost effectiveness of strategies is highly dependent on the severity. For severe pandemics, the preferred strategy couples the earliest closure trigger with the longest duration closure (24 weeks) considered. For milder pandemics, the preferred strategies also involve the earliest closure trigger, but are shorter duration (12 weeks for low transmission rates and variable length for high transmission rates).

Author, Year Location Critical Appraisal score*	Strategy Category	Study Type Study Design Study Description	Mass Casualty Event	Strategies	Findings
Araz, 2013 ¹⁰ US, Arizona 3	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Exercise, drill, training program Post-only Used a model on school closures in a simulated decision-making exercise.	Infectious disease: Influenza	School closure Agreement of authority and state coordination to close schools	School closure with a clear decision rule made the biggest impact in terms of reducing spread and reducing educational losses.
Bajardi, 2011 ¹³ Mexico 2	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Computer simulation N/A The Global Epidemic and Mobility model was utilized to observe the effect of travel restrictions on an emerging pandemic.	Infectious disease: 2009 H1N1 influenza pandemic	Travel restrictions	Travel restrictions are largely ineffective for containing an emerging pandemic due to large heterogeneity of human mobility patterns.
Balaban, 2012 ¹⁴ US 6	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Analysis of single real event Post-only Conducted survey to evaluate effect of behavioral interventions for travelers attending a large mass gathering to mitigate influenza illness.	Infectious disease: Influenza	Protective behavior recommendation s	77.4% reported use of protective behaviors (67.2% hand hygiene, 48.9% face covering, 46.2% cough etiquette, 34.4% social distancing, 24.2% contact avoidance). 41.3% of visitors reported respiratory illness during the Hajj and/or in the first 7 days after. Hand hygiene, social distancing, and contact avoidance were associated with reduced risk of respiratory illness.
Ball, 2015 ¹⁶ UK 3	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Computer simulation N/A Contact tracing under less than ideal circumstances (i.e., delayed reporting)	Infectious disease: Influenza, any	Contact tracing	The distribution of delays in reporting and "latent periods" impacts the spread of the epidemic.
Bayham, 2020 ¹⁹ US 3	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Computer simulation N/A Estimated child care needs caused by school closure and analyze mortality associated with a decrease in the number of health care workers.	Infectious disease: COVID-19	School closure	28.8% of health care workers require care for children ages 3-12 years. School closures could reduce the healthcare labor force and result in increased mortality.

Author, Year Location Critical Appraisal score*	Strategy Category	Study Type Study Design Study Description	Mass Casualty Event	Strategies	Findings
Berge, 2018 ²¹ South Africa 1	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Computer simulation N/A Developed model to analyze effect of contact racing, quarantine, and isolation on transmission of Ebola virus disease.	Infectious disease: Ebola	Contact tracing Quarantine Isolation/hospital ization	Combination of high contact tracing and isolation provides greatest reduction in transmission of Ebola virus disease.
Boni, 2013 ²⁴ Vietnam 3	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Computer simulation N/A Model of disease spread, as well as different types of social distancing impacts.	Infectious disease: 2009 H5N1 influenza pandemic, Influenza A	Social distancing	Social distancing would bring case fatalities down from 6.0 to 4.5%.
Brown, 2011 ²⁷ US 3	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Computer simulation N/A Developed economic model to simulate costs associated with school closure to reduce spread of influenza.	Infectious disease: Influenza	School closure	As length of closure increased, the cost due to school closure increased. Closing schools during the 2009 H1N1 influenza pandemic could have resulted in substantial costs to society as the potential costs of lost productivity and childcare could have far outweighed the cost savings in preventing influenza cases

Author, Year Location Critical Appraisal score*	Strategy Category	Study Type Study Design Study Description	Mass Casualty Event	Strategies	Findings
Cahill, 2008 ²⁸ 0	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Computer simulation N/A	Infectious disease: Influenza	Distribute surgical masks or N95 respirators to the public to limit the spread of pandemic influenza (both droplet and airborne transmission)	Use of N95 respirators lowers the probability of infection and the percentage of the population infected compared to surgical masks. Estimated outpatient visits for the N95 mask (100% compliance) were 14,330, as compared to the surgical mask (100% compliance) with 56,200 outpatient visits. However, at 60% compliance, this range narrows to 126,640-128,070. Use of N95 respirators reduces use of hospital beds, ICU beds, and ventilators compared to surgical masks. Estimated hospitalizations for the N95 mask (100% compliance) were 300, as compared to the surgical mask (100% compliance) with 1,190 hospitalizations. However, at 60% compliance, this range narrows to 580-590. N95 respirators and surgical masks had comparable impacts on workdays lost and total economic losses at compliance levels of 60%, but respirators were superior when compliance levels were 100%.
Cauchemez, 2014 ²⁹ Global 3	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Analysis of single real event Post-only School closure experiences in 12 countries evaluated.	Infectious disease: Influenza	School closures	Heterogeneity of school closure policies in different countries could not establish potential benefits compared to high economic and social costs.
Chen, 2016 ³⁵ China 1	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Analysis of multiple real events N/A Described interventions for Norovirus outbreak in resource-limited setting.	Infectious diseases: Norovirus	School closure Hand hygiene	School closure was not effective as a control measure for a waterborne norovirus.

Author, Year Location Critical Appraisal score*	Strategy Category	Study Type Study Design Study Description	Mass Casualty Event	Strategies	Findings
Cheng, 2020 ³⁷ Steinbrook, 2020 ²¹⁴ Taiwan 5	Reduce/ manage less urgent demand for health care services: Non-pharmaceutical counter-measures	Analysis of single real event Post-only Conducted a prospective, case-ascertained study	Infectious disease: COVID-19	Contact tracing	2761 close contacts identified for 100 cases. High transmissibility of COVID-19 before and immediately after symptom onset suggests that finding and isolating symptomatic patients alone may not suffice to contain the epidemic, and more generalized measures may be required, such as social distancing.
Cheng, 2020 ³⁸ Hong Kong 5	Reduce/ manage less urgent demand for health care services: Non-pharmaceutical counter-measures	Analysis of single real event Post-only Described the epidemiology of COVID-19 in the first 100 days. Analyzed the incidence of COVID-19 in areas that implemented community-wide mask use compared to areas that did not. Determined mask-on or mask-off settings.	Infectious disease: COVID-19	Mask wearing	3.4% of persons did not wear a mask with compliance ranging from 95.7-97.2% for three consecutive days. 11 clusters with 113 infections identified including 8 in recreational mask-off setting (102 persons) and 3 in workplace mask-on settings (11 persons). Incidence of COVID-19 was lower compared to countries without community-wide mask use.
Ciavarella, 2016 ⁴¹ Italy 4	Reduce/ manage less urgent demand for health care services: Non-pharmaceutical counter-measures	Computer simulation N/A A simulation was utilized to assess the effectiveness of school closure on mitigating influenza.	Infectious disease: H1N1 influenza	School closure	Reactive school closure based on student absenteeism can be highly effective in mitigating influenza spread in case of pandemics similar to 2009 H1N1 influenza pandemic.
Cooley, 2011 ⁴³ US 2	Reduce/ manage less urgent demand for health care services: Non-pharmaceutical counter-measures	Computer simulation N/A An agent-based model simulation was utilized to analyze the influence of subway riders on disease transmission.	Infectious disease: Influenza	Contact-reducing policies (hand washing, microbial use, and mask wearing) on subways Contact-reducing policies (hand washing, microbial use, and mask wearing) in the community	High level of subway ridership can influence disease spread but interventions aimed at subway riders provide limited benefits; an 100% effectiveness targeting all subway riders will only reduce cumulative incidence by 12.5%.

Author, Year Location Critical Appraisal score*	Strategy Category	Study Type Study Design Study Description	Mass Casualty Event	Strategies	Findings
Cooley, 2016 ⁴⁴ US 2	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Computer simulation N/A Models were utilized to assess whether including weekend effects is offset by increases in weekend contact patterns and if implementing 3-day weekends dampens disease transmission enough to warrant its use as a containment strategy.	Infectious disease: H1N1 influenza	Social distancing Weekend extension	Extended weekends could have a significant effect on reducing peak attack rates and societal costs. Using a 3- day weekend as an intervention strategy could be effective for mild epidemics similar in severity to the H1N1 epidemic with a concentration in school-aged children.
Earn, 2012 ⁵⁰ Canada 3	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Computer simulation N/A A model was utilized to examine the effects of school closures and weather changes on H1N1 transmission.	Infectious disease: H1N1 influenza	School closure	School closure reduced transmission in school-age children which substantially reduced incidence of influenza.
Egger, 2012 ⁵² US 5	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Analysis of single real event Post-only The effects of school dismissal on influenza transmission were studied.	Infectious disease: H1N1 influenza	Individual school dismissal policy	Selective school dismissal in New York City had a small but significant effect on reducing the percentage of reported influenza-like illness.
Espana, 2018 ⁵⁶ Colombia 2	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Computer simulation N/A Developed agent-based simulation model in predicting effects of mitigation strategies for Chikungunya outbreaks.	Infectious disease: Chikungunya	Vector control	Delays in the initiation of vector control exponentially reduced the effectiveness of the intervention ; the duration of the intervention improved effectiveness up to 22%; the recruitment rate showed a steep improvement with a plateau was reached at a recruitment rate of ~1% neighborhoods/day; participation rate affected effectiveness linearly.
Farrahi, 2014 ⁵⁸ US 2	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Computer simulation N/A A model was utilized to observe the effects of contact tracing on infectious disease.	Infectious disease: unspecified	Contact tracing	Contact tracing is greatly beneficial when an epidemic is starting but not as the epidemic grows.

Author, Year Location Critical Appraisal score*	Strategy Category	Study Type Study Design Study Description	Mass Casualty Event	Strategies	Findings
Fujita, 2011 ⁶⁰ Japan 4	Reduce/ manage less urgent demand for health care services: Non-pharmaceutical counter-measures	Analysis of single real event Post only with comparison Travelers in a Japanese airport who had traveled through North America went through quarantine inspections.	Infectious disease: H1N1	Airport quarantine inspections	The total number of cases in each district was negatively correlated with the percentage of cases with airport quarantine inspection.
Fumanelli, 2016 ⁶¹ UK 0	Reduce/ manage less urgent demand for health care services: Non-pharmaceutical counter-measures	Computer simulation N/A A simulation model was used to assess the impact of different school closure interventions.	Infectious disease: Influenza	School closure	Optimal implementations generally required short closures of 1 week each, separated by timeouts of variable duration; gradual closure and closure of all schools within the same county of a school where excess absenteeism occurs may be considered more diffusely when responding to influenza pandemic, along with reactive and proactive closures.
Fung, 2012 ⁶² US 3	Reduce/ manage less urgent demand for health care services: Non-pharmaceutical counter-measures	Computer simulation N/A A model was utilized to determine the optimal time to trigger an intervention and to study a scenario where school closure was utilized as an intervention.	Infectious disease: Influenza	School closure	Interventions that can be maintained should be advocated early and those that are costly to maintain should be implemented later during the outbreak. For school closure where only children-to-children transmission was interrupted, reduction in outbreak was mainly in children and there was little impact on outbreak in adults; efficacy had to be higher to achieve a similar optimal outcome compared to reduction of all transmission routes.
Germann, 2019 ⁶³ US 3	Reduce/ manage less urgent demand for health care services: Non-pharmaceutical counter-measures	Computer simulation N/A A simulation was utilized to evaluate the effects of school dismissal on pandemic influenza.	Infectious disease: Influenza	School dismissal	Before vaccines are widely available, school dismissals are effective in delaying epidemic peak by 4-6 days for each additional dismissal week. In early stages, pre-emptive school dismissals of 4 weeks or more implemented simultaneously on a wider geographic scale has most impact.

Author, Year Location Critical Appraisal score*	Strategy Category	Study Type Study Design Study Description	Mass Casualty Event	Strategies	Findings
Giordano, 2020 ⁶⁴ Italy 2	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Computer simulation N/A Model read epidemiologic data and the effect of the implementation of counter- measures on transmission.	Infectious disease: COVID-19	Social distancing Population-wide testing Contact tracing	Combination of social distancing, widespread testing, and contact tracing are necessary to reduce transmission.
Hale, 2012 ⁷⁸ New Zealand, Auckland 5	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Analysis of single real event Post-only Analysis of airport health screening.	Infectious disease: A(H1N1)pdm 09	Airport health screening based on passenger's self identification	Screening only detected 4 cases, but surveillance data suggested about 69 cases should have come through the airport.
Ho, 2017 ⁸² Taiwan 1	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Analysis of multiple real events Post-only Taiwan's disease surveillance activities at designated points of entry and travel and border health measures in response to Zika are discussed.	Infectious disease: Zika virus	Border entry screening	Border entry screening is useful in border disease detection, especially when laboratory examination is included in the procedure. Travel and border health measures require cooperation and coordination with multiple groups, including tourism industry, airlines, and international partners.
House, 2011 ⁸³ UK 3	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Computer simulation N/A Simulated the impact of school closures on demands for intensive care unit beds.	Infectious disease: Influenza	School closures	Short-duration school closures (1-4 weeks) may reduce peak incidence by 30- 70% based on duration and epidemiological assumptions. Reduction in peak could reduce demand for intensive care unit beds. Peak incidence in children was impacted to a greater degree by school closures than in adults.
Jacobson, 2016 ⁸⁸ US 1	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Computer simulation N/A Evaluated two policies for screening at airports using cost analysis. CDC policy - signs and symptoms, exposure levels, and body temperature. Alternative policy - CDC model plus social contact tracing (SCT) risk.	Infectious disease: Ebola	Monitoring and movement restriction policy	Costs per patients for alternative policy and CDC policy are similar at low and medium social contact tracing risk, costs are higher for high risk due to collection of additional passenger information.

Author, Year Location Critical Appraisal score*	Strategy Category	Study Type Study Design Study Description	Mass Casualty Event	Strategies	Findings
Jones, 2013 ⁹⁰ US 1	Reduce/ manage less urgent demand for health care services: Non-pharmaceutical counter-measures	Computer simulation N/A Developed model of disease transmission incorporation interventions and simulate financial and social costs.	Infectious disease: Influenza	Social distancing (e.g., closure of schools or of public transportation) Wearing masks or respirators (N95 filtering face piece available commercially to the public)	Total number of infections was minimized by maximum compliance with combined interventions. Total costs decrease with increasing compliance.
Kavanagh, 2011 ⁹³ Australia 4	Reduce/ manage less urgent demand for health care services: Non-pharmaceutical counter-measures	Analysis of single real event Post-only Conducted a cross-sectional survey to determine understanding of requirements during quarantine, sources of information, and usefulness of information.	Infectious disease: Influenza	School closure Voluntary home quarantine of index patients and contacts Information campaign	Full compliance with quarantine was 53% with higher rates in households that understood what was needed to do.
Kawano, 2015 ⁹⁴ Japan 4	Reduce/ manage less urgent demand for health care services: Non-pharmaceutical counter-measures	Computer simulation N/A A regression model was utilized to estimate the impact of school closure on H1N1 pandemic.	Infectious disease: H1N1 influenza	School closure	School closure should be implemented for >4 days. School closure has an effect in decreasing number of infected students at peak but is less effective in decreasing total number of infected students.
Kellerman, 2010 ⁹⁵ US 4	Reduce demand: Non-pharmaceutical counter-measures	Analysis of a single real event Post-only Web-based self-triage	Infectious Disease: Influenza	Deployment of clinical algorithm during 2009 H1N1 enabled adults with influenza-like illness to self-assess need for ED versus clinic or self-care	Two websites deployed and used during 2009 H1N1 pandemic; one via flu.gov. Approximately 800,000 visits nationwide, no reports of adverse outcomes. Unable to measure impact due to no follow up
Khan, 2013 ⁹⁷ Mexico 4	Reduce/ manage less urgent demand for health care services: Non-pharmaceutical counter-measures	Computer simulation N/A Study evaluates what would have been the effects if travelers leaving Mexico by plane had been screened for H1N1 before departure to prevent spread.	Infectious disease: A(H1N1)pdm09	Airport health screening	Early on in the pandemic, screening at 8 Mexican airports would have stopped spread by 90% in Mexico.

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Kim, 2020 ⁹⁹ South Korea 3	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Computer simulation N/A Developed model to determine effect of delaying school openings on the transmission of COVID-19.	Infectious disease: COVID-19	Delayed school opening	Model can be used to show that school closure can reduce peak rates. Outbreaks occurred in close contact settings. Contact screening, quarantine, and social distancing contributed to the reduction in daily cases.
Knipl, 2016 ¹⁰¹ UK 2	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Computer simulation N/A Intervention strategies of a general SIRS model that is appropriate for spread of infectious disease is investigated.	Infectious disease: unspecified	Movement management	Controlling only the movement of infected individuals may be sufficient for preventing an outbreak.
Kohlhoff, 2012 ¹⁰³ US, Brooklyn, NY 6	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Exercise, drill, training program Post only with comparison Tested ability of hospitals to perform mass screening, isolation, and triage according to protocol in response to outbreak of a communicable respiratory illness.	Infectious disease: Influenza	Mass screening	Correctly determined health status in 74% of cases. No correlation between determination of case status and hand washing as indicator of infection control compliance.
Koo, 2020 ¹⁰⁴ Singapore 2	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Computer simulation N/A A national spatial model of COVID-19 transmission to assess the potential impact of interventions on outbreak size.	Infectious disease: SARS-CoV-2	Quarantine School closure Workplace distancing	Immediate deployment of quarantining, workplace distancing, and school closure if local secondary transmission confirmed. Prioritize quarantine and workplace distancing over school closure at early stage.
Kraemer, 2020 ¹⁰⁶ China 1	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Analysis of single real event Post-only Real-time mobility data and detailed case data were used to elucidate the role of case importation transmission and ascertain impact of control measures.	Infectious disease: COVID-19	Isolation Mobility restrictions	Travel restrictions are useful in early stage of outbreak when confined to certain area that acts as a major source. Combination of interventions, including isolation and restriction on mobility, were successful in mitigating spread and reduced local transmission.

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Kuan, 2012 ¹⁰⁸ Taiwan 4	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Analysis of single real event Post-only Conducted a retrospective analysis of the airport fever screening program to detect individuals for dengue triage and for self-quarantine.	Infectious disease: Dengue	Airport fever screening program	The findings indicated some limitations of the airport fever screening programs for preventing the introduction of dengue. The program detected approximately 45% of the confirmed imported cases of dengue based on fever with a negative predictive value of >99.99%.
Lam, 2011 ¹¹⁰ China 3	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Computer simulation N/A A parsimonious statistical model was used to examine the effectiveness of age- specific selective travel restriction against influenza pandemic.	Infectious disease: H1N1 influenza	Age-specific travel restriction	Restricting child travels is more effective than ignoring age or restricting adults but only slightly reduces the risk of an outbreak.
Lee, 2012 ¹¹⁵ South Korea 3	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Computer simulation N/A A multi-city epidemic model was utilized to evaluate the potential impact of various influenza mitigation strategies.	Infectious disease: influenza	Wearing personal protections Travel restriction Encourage people to go to hospital	Reducing migration levels may cause more severe peak heights than without any travel restrictions.
Lewnard, 2014 ¹¹⁷ Liberia 2	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Computer simulation N/A Developed transmission model to assess how interventions (new treatment centers, contact tracing, and household protective kit allocation) could be applied individually or in combination to avoid new Ebola virus disease (EVD) cases and deaths.	Infectious disease: Ebola	Protective kits to households Contact tracing	If capacity of Ebola virus disease treatment centers is exceeded, transmission may be reduced by allocation of protective kits.
Litvinova, 2019 ¹¹⁹ Russia 2	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Analysis of single real event Post-only Conducted a diary-based contact survey to describe mixing patterns during school closure and model the effects of school closure on transmission.	Infectious disease: Influenza	School or class closure	Without the reactive school closures, the attack rate of the 2015 to 2016 influenza season would have been 33% larger.

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Loustalot, 2011 ¹²⁰ US 3	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Analysis of single real event Post-only Internet questionnaire for parents or guardians of students to gather demographic and recent disease information and to assess level of adoption of non-pharmaceutical interventions.	Infectious disease: Influenza	Preemptive high school closure for 8 days	49.1% of household members reported influenza- like illness, secondary attack rate within households was 3.7% overall and 9.1% among children up to 4 years of age.
Maharaj, 2012 ¹²² UK 0	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Computer simulation N/A Designed a model to look at social distancing effects during a pandemic.	Infectious disease: Influenza	Social distancing	Social distancing should take place early on and be strict, or else it is too late and the disease should be let to run it's course.
Mao, 2011 ¹²⁴ US 3	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Computer simulation N/A An agent-based spatially- explicit model was utilized to test the effectiveness of weekend-extension strategies on seasonal and pandemic influenza outbreaks.	Infectious disease: Influenza	Weekend extension, shortening work week	A 3-day extension strategy is capable of controlling seasonal flu epidemics and prevents it if high compliance level can be achieved. For pandemic flu, weekend extension alone is not effective.
Marcelino, 2012 ¹²⁵ UK 3	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Computer simulation N/A Modeled impacts of reducing flights and closing airports.	Infectious disease: Influenza	Travel restrictions for major airports or network hubs based on the total number of passengers of an airport	Closing down major connections had most impact.
Martinez, 2014 ¹²⁶ US 3	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Computer simulation N/A Modeled the impact of non- pharmaceutical responses to an epidemic (such as social distancing, work closure).	Infectious disease: Influenza	Home isolation of infected persons and home quarantine for family members Workplace and school closures	School closure was found to have the most impact on reducing spread.

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Modchang, 2012 ¹³⁷ Thailand 2	Reduce/ manage less urgent demand for health care services: Non-pharmaceutical counter-measures	Computer simulation N/A Outbreaks in school settings were modeled with susceptible-exposed-infectious-recovered equations to test interventions, such as school closure and student screening, on H1N1 transmission.	Infectious disease: H1N1 influenza	School closure Screening	Individual student screening appear to reduce number of total cases by 40%. For widespread outbreak of mild disease, closing school at predicted peak date of number of daily incidences plus screening for respiratory symptoms appears to be the most appropriate intervention.
Mummert, 2013 ¹³⁹ US 2	Reduce/ manage less urgent demand for health care services: Non-pharmaceutical counter-measures	Computer simulation N/A Examined interplay between three different media strategies (and impact on behavior), social distancing, and infection spread in a small city.	Infectious disease: Influenza	Social distancing (restricting socializing and travel, and using barrier protections) Local health authorities working with the media for information campaigns	Reporting early has an impact, for long-term outbreaks historical data reporting has negative impacts compared to no reporting. For a spectrum of outbreaks, leaving isolation (stopping applying social distancing measures) for up to 4 hours each day has modest effect on the overall morbidity and mortality.
Ngonghal a, 2020 ¹⁴⁰ US 3	Reduce/ manage less urgent demand for health care services: Non-pharmaceutical counter-measures	Computer simulation N/A Created a model to look at effects of variables such as social distancing, and masks (of different levels of efficacy),.	Infectious disease: COVID-19	Face-mask use in public Contact-tracing Social distancing	The results emphasize the important role social-distancing plays in curtailing the burden of COVID19. Using face-masks in public (including the low efficacy cloth masks) is very useful in minimizing community transmission and burden of COVID-19, provided their coverage level is high. The masks coverage needed to eliminate COVID-19 decreases if the masks-based intervention is combined with the strict social-distancing strategy.
Nishiura, 2011 ¹⁴³ Napan, Narita 5	Reduce/ manage less urgent demand for health care services: Non-pharmaceutical counter-measures	Analysis of single real event Post-only Looked at sensitivity of health screenings.	Infectious disease: H1N1	Fever screening at airport	Fever alone is not likely to be a best method of screening for influenza. The sensitivity of the infrared thermoscanners in detecting fever varied.

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Nishiura, 2014 ¹⁴² Japan 5	Reduce/ manage less urgent demand for health care services: Non-pharmaceutical counter-measures	Computer simulation N/A A mathematical model was used to examine the optimal timing and length of school closure, taking into account cost effectiveness.	Infectious disease: influenza	School closure	School closure at the epidemic peak appears to minimize the cumulative incidence, but the time of epidemic peak shows to be dependent on transmissibility. When risk of death was 3 times or greater than that of H1N1, school closure was seen to be cost effective. There is no fixed timing and duration of school closure that can be recommended as universal for different types of influenza viruses
Peak, 2017 ¹⁴⁹ US 3	Reduce/ manage less urgent demand for health care services: Non-pharmaceutical counter-measures	Computer simulation N/A An agent-based branching model was used to examine the relationship between epidemic containment and a variety of infectious diseases.	Infectious disease: Ebola, hepatitis A, influenza A, MERS, pertussis, SARS, smallpox	Symptom monitoring via contact tracing Quarantine of patients with infection	Benefit of quarantine over symptom monitoring is generally maximized for fast-course diseases and in settings where isolation is highly effective, large fraction of contacts traced, or long delay between symptom onset and isolation.
Pinkas, 2020 ¹⁵⁰ Poland 1	Reduce/ manage less urgent demand for health care services: Non-pharmaceutical counter-measures	Analysis of multiple real events Post-only The public health interventions aimed at mitigating the early spread of SARS-CoV-2 implemented are presented.	Infectious disease: Severe acute respiratory syndrome coronavirus 2	Quarantine Border control Closures Hospital unification	Due to the ongoing epidemic, it is too early to forecast the impact of the adopted policies on the spread of severe acute respiratory syndrome coronavirus 2 in Poland.
Potter, 2012 ¹⁵¹ US 3	Reduce/ manage less urgent demand for health care services: Non-pharmaceutical counter-measures	Computer simulation N/A Developed model to evaluate six criterion-based school closure scenarios.	Infectious disease: Influenza	School closure	School closure decisions can be made at the statewide or local level and based on local monitoring of cases. Shorter durations for school closure can reduce attack rates similar to longer durations.
Prem, 2020 ¹⁵³ China 4	Reduce/ manage less urgent demand for health care services: Non-pharmaceutical counter-measures	Computer simulation N/A Used data from Wuhan corona outbreak to support future decisions on social distancing.	Infectious disease: Covid-19	Physical distancing	Physical distancing measures were most effective if the staggered return to work was at the beginning of April; this reduced the median number of infections by more than 92% (IQR 66-97) and 24% (13-90) in mid-2020 and end-2020, respectively.

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Priest, 2011 ¹⁵⁴ New Zealand 5	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Exercise, drill, training program Post-only Looked at effectiveness of a thermal camera which was to detect travelers with high temperatures in an airport.	Infectious disease: Influenza	Temperature- sensing camera in airport	The procedure performed moderately well in detecting fever but during a seasonal epidemic of predominantly influenza type B, the proportion of influenza- infected travellers who were febrile was low and the system was not much better than chance at identifying travellers likely to be infected with influenza.
Priest, 2015 ¹⁵⁵ New Zealand, Christchurch 6	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Exercise, drill, training program Post-only Screening methods included a health survey, temperature taking, and respiratory sampling.	Infectious disease: Influenza	Health survey/ questionnaire distribution to travelers at the airport Temperature and respiratory sampling from selected travelers	Self-reporting surveys did not prove to be the most effective, as non-symptomatic people would overreport and those who were sick would underreport; temperature taking was semi effective.
Ringa, 2018 ¹⁵⁷ Botswana 3	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Computer simulation N/A A pair approximation model was utilized to explore the impacts of NPIs on the spread of an infectious disease.	Infectious disease: unspecified	Non- pharmaceutical interventions Social learning Exposure learning	Social and exposure learning of non-pharmaceutical interventions lead to a decrease in the final size of infection. Social learning can outperform exposure learning if social learning begins early enough before the epidemic.
Ross, 2015 ¹⁵⁸ Australia 4	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Computer simulation N/A A model was used to investigate the use of contact tracing on an outbreak.	Infectious disease: H1N1 influenza	Contact tracing	Contact tracing has considerable impact in overcoming reductions in antiviral efficacy from delays; contact tracing should be used in conjunction with antiviral use.
Savoia, 2009 ¹⁶⁴ US 4	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Exercise, drill, or training program Pre-post Tabletop Exercise (and didactic session) to train Public Health officials in what steps they can legally take to limit spread in response to a pandemic	Infectious disease: Influenza	Train Public Health officials in what steps they can legally take to limit spread in response to a pandemic	After participating in the course there was a statistically significant increase in most participants' knowledge of and level of confidence in their legal authority to take specific response actions (such as imposing quarantine) to limit pandemic spread.

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Schull, 2007 ¹⁶⁵ Canada/ Australia/ New Zealand 4	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Analysis of single real event Pre-post with comparison group: Ottawa and London, similar but unaffected regions in Canada	Infectious disease: SARS	Restrict ambulatory and inpatient medical and surgical activity to urgent cases Respiratory isolation rooms were expanded Visitor access was severely restricted Centralized system to screen all requests for inter-hospital patient transfers	The rate of overall and medical admissions decreased by 10–12%; there was no change in the comparison regions. The rate of elective surgery in Toronto fell by 22% and 15% during the early and late restriction periods respectively and by 8% in the comparison regions. Decrease in high acuity ED visits and inter- hospital transfers in Toronto relative to comparison regions suggests potential unintended consequences.
Sjodin, 2020 ¹⁷¹ Italy 1	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Computer simulation N/A Simulation model to evaluate the effect of quarantine and household size on transmission of COVID-19	Infectious disease: COVID-19	Quarantine/physi cal distancing	Very high adherence to community quarantine (total stay-home policy) and a small household size is necessary for curbing the outbreak in a locked-down town.
Tian, 2020 ¹⁷³ China, Wuhan 3	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Analysis of single real event Post-only Analyzed impact of Wuhan shutdown - travel restrictions, and other initiatives.	Infectious disease: COVID-19	Shutdown travel in and out of the city Ceasing public gatherings Closing entertainment venues	The shutdown slowed spread by an estimated 2.91 days (95% CI 2.54-3.29) to outside areas. Other cities that implemented control measures preemptively reported 33.3% (11.1-44.4%) fewer cases in the first week of their outbreaks (13.0; 7.1- 18.8) compared with cities that started control later (20.6; 14.5-26.8). Suspending intra-city public transport, closing entertainment venues and banning public gatherings were the most impactful initiatives.
Towers, 2012 ¹⁷⁴ US 2	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Computer simulation N/A Susceptible, Infected, Recovered mathematical model used to assess school closure impact on pandemic influenza	Infectious disease: Influenza	School closures to control and prevent influenza pandemic	Timing of start of school closure strongly affects pandemic influenza progression.

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Uchida, 2012 ¹⁷⁵ Japan 6	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Analysis of single real event Post-only The effect of short-term class and school closures was investigated.	Infectious disease: H1N1 influenza	School closure Class closure	Short-term closures, even those lasting a few days, can effectively decrease number of infections after resumption of classes. School closure was more effective than class closure in decreasing the number of infections and reducing likelihood of subsequent epidemic, especially among older children. Class closure may result in a repeat epidemic of strongly transmissible infectious disease. Instructions that children avoid school friends during closure period will be necessary to strengthen effect of school closure.
Velasco- Hernandez, 2011 ¹⁷⁶ Mexico 3	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Computer simulation N/A A model was utilized to observe patterns of the H1N1 epidemic in terms of reproduction number and social isolation measures.	Infectious disease: H1N1 influenza	Social isolation	If social isolation is implemented fast enough, the second peak will be delayed approximately one year which allows for time to take preventative actions before the seasonal influenza epidemics outbreak.
Wang, 2012 ¹⁷⁹ China 3	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Computer simulation N/A Model looks at patient isolation and travel restrictions.	Infectious disease: Influenza	Travel restrictions Patient isolation	Intrapopulation interventions, e.g., patient isolation, perform better than the interpopulation strategies such as travel restriction if the response time is short.
Wilson, 2012 ¹⁸³ US 3	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Analysis of single real event Post-only Implementation of radiological screening and decontamination of travelers after earthquake and tsunami near nuclear reactor complex in Japan.	Natural disaster: Earthquake, tsunami	Radiation detection protocol in airports	Despite the severity and widespread impact of the nuclear incident no large numbers of contaminated travelers arrived in the United States (screening identified 3 travelers with low level contamination, 543,000 travelers were screened).
Wong, 2016 ¹⁸⁴ West Africa/Libe ria 2	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Computer simulation N/A Model looks at variables like screening, gauging compliance, to determine strategies.	Infectious disease: Ebola	Screening everyone Travel limitations	40% compliance to mitigation measures is sufficient to stop the outbreak. Travel restrictions are effective at reducing the risks associated with compliance substantially below the 40% level, shortening the outbreak, and enabling efforts to be focused on affected areas.

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Wong, 2016 ¹⁸⁵ Hong Kong 2	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Computer simulation N/A Use past data to develop a model on health and economic effects of school closures in Hong Kong.	Infectious disease: H1N1	School closure	Closing all schools, and/or having a smaller threshold rule for when to close schools, had the biggest health impact.
Xue, 2012 ¹⁸⁹ Norway 5	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Computer simulation N/A Analyzes cost-effectiveness of school closures, and what conditions contribute to effectiveness.	Infectious disease: Influenza	School closure	School closure has moderate impact on the epidemic's scope, but disruption to society imposes a potentially great cost in productivity from parents' work absenteeism.
Yu, 2020 ¹⁰⁹ China 3	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Computer simulation N/A Models spread of Covid to rest of China, and impacts of non pharmaceutical interventions	Infectious disease: COVID-19	Inter-city travel restrictions Social distancing and contact reductions Early case detection and isolation	Combined non- pharmacological interventions, inter-city travel restrictions, social distancing and contact reductions, as well as early case detection and isolations, have substantially reduced COVID- 19 transmission across China. Early detection and isolation were seen as most impactful, and according to the model without non- pharmaceutical interventions, the number of Covid cases would have been up to 67 times worse.
Zhang, 2012 ¹⁹⁹ , Zhang, 2011 ²¹⁵ Singapore 2	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Computer simulation N/A Model was built to examine impact of school and work closures on spread of a disease.	Infectious disease: Influenza	School closure Work shifts (not every worker attending every day)	Combined interventions do not always outperform individual interventions but are more effective for example when the duration is longer than 6 weeks; combined interventions may be more effective if school closure starts first when the duration is less than 4 weeks or workforce shift starts first when the duration is longer than 4 weeks.

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Zhang, 2012 ²⁰¹ China 2	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- measures	Analysis of single real event Post-only The characteristics of imported cases of H1N1 influenza was described and effectiveness of intervention measures were assessed.	Infectious disease: H1N1 influenza	Border entry screening Influenza-like illness screening in hospital Medical follow- up of travelers from overseas Quarantine of close contacts	21.8% of all imported cases were detected through border entry screening. Quarantine of close contacts had a detection rate 120 times higher than border entry screening; use of resources for this strategy was very high. The detection rate for medical follow-up of overseas travelers was low at 0.005%. Influenza-like illness screening in hospitals was a very effective measure with 56.3% of imported cases detected.
Zhang, 2014 ¹⁹⁸ China 3	Reduce/ manage less urgent demand for health care services: Non- pharmaceutic al counter- rmeasures	Computer simulation N/A A compartmental model was utilized to evaluate the effect of using antiviral drugs for prophylaxis and isolation strategy for reduction of transmission.	Infectious disease: Influenza	Isolation strategy Antiviral drugs strategy	Implementing an isolation strategy is very effective if antivirals are not effective enough. Containment is not successful if proportion of asymptomatic cases exceeds a specific value even though intervention strategies are efficient enough. Antiviral prophylaxis and isolation strategy should be implemented in the early stage of an outbreak and if containment not achievable, other interventions such as self-isolation should be considered.
Ablah, 2010 ² Nassau Co, NY 6	Reduce/ manage less urgent demand for health care services: Medical counter- measures	Exercise, drill, or training program Post only with comparison group Use of centralized point of dispensing model, as compared with a hybrid model.	Infectious disease: Anthrax	Centralized point of dispensing model for chemo- prophylaxis Hybrid point of dispensing model for chemo- prophylaxis	Centralized model had slightly faster processing time than the hybrid model. Centralized and hybrid models had similar quality control outcomes overall. However, hybrid models were more likely to follow the individual steps in the protocol designed to reduce medication error. Centralized points were slightly more accurate in dispensing the correct medication. Centralized points processed 0.75 patients/minute, compared with 0.48 patients per minute.

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Banks, 2013 ¹⁸ US, Albuquerque, NM 7	Reduce/ manage less urgent demand for health care services: Medical counter- measures	Analysis of single real event Post-only Measured total throughput time for 2 drive-through vaccination clinics (vehicle flow and vaccination procedures).	Infectious disease: Influenza	Drive-through vaccination clinics	Maximum number of vaccinations were 200 and 361 per hour for the clinics. Median throughput time was 5 minutes and median vaccination time was 48 seconds.
Bravata, 2006 ²⁵ 4	Reduce/ manage less urgent demand for health care services: Medical counter- measures	Computer simulation	Infectious disease: Anthrax	Comparison of broad categories of strategies, including: (1) enhancing bioterrorism event detection, (2) increasing local dispensing capacity, (3) increasing local inventories of antibiotics, and (4) increasing the amount of inventory deployed from the SNS to the site of an attack.	Surveillance strategies to enhance attack detection do not result in reduced mortality when dispensing capacity is low. Increasing local antibiotic stockpiles and instituting surveillance systems to reduce the delay in attack detection, are cost-effective only if the community can achieve a high dispensing capacity, if the probability of an attack is greater than 0.0001 per year, and if the attack is large.
Caum, 2013 ³⁰ US 3	Reduce/ manage less urgent demand for health care services: Medical counter- measures	Exercise, drill, training program Post-only Conducted no-notice exercise to administer an influenza vaccination clinic at a local boarding school.	Infectious disease: Influenza	Vaccination clinic	Vaccination at 57.8 per hour due in part to high-throughput vaccination station model.
Charland, 2014 ³² Canada 2	Reduce/ manage less urgent demand for health care services: Medical counter- measures	Computer simulation N/A Developed gravity model to examine characteristics associated with flow of individuals to mass vaccination clinics.	Infectious disease: Influenza	Mass vaccination clinics	Vaccination uptake was lower in census tract areas with greater proportions of new immigrants, residents living below the poverty level, or residents not speaking English or French. Areas with high residential density, higher material deprivation, and high violent crime rates had fewer vaccinations at mass vaccination clinics.

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Chowell, 2019 ⁴⁰ US 4	Reduce/ manage less urgent demand for health care services: Medical counter-measures	Computer simulation N/A An individual-level stochastic transmission model was used to evaluate vaccination strategies for containing Ebola epidemics in varying communities.	Infectious disease: Ebola	Ring vaccination that requires the prompt immunization of close contacts of infected individuals Community vaccination ("3rd ring," vaccination in the community even people unrelated to the infected individuals)	For lower levels of inaccessibility, probability of containment increases over time; for higher levels, vaccination strategies can help reduce incidence levels. Ring vaccination is effective for containing outbreak until level of inaccessibility exceeds about 10%. A combined ring and community vaccination is effective until level of inaccessibility exceeds about 50%.
de Montigny, 2013 ⁴⁷ Canada, Montreal 4	Reduce/ manage less urgent demand for health care services: Medical counter-measures	Analysis of single real event Pre-post Conducted analysis of the association between vaccination rates and clinic capacity, public health interventions, eligibility for vaccination based on risk, and weather (snow, rain).	Infectious disease: Influenza	Telephone intervention to enhance vaccination uptake in neighborhoods with lower coverage rates	Vaccination coverage for identified areas was marginally lower than for those not included in telephone intervention (47.9% versus 51.2%).
Glasser, 2010 ⁶⁷ 2	Reduce/ manage less urgent demand for health care services: Medical counter-measures	Computer simulation	Infectious disease: Influenza	Target pandemic flu vaccine to specific demographic groups	A strategy of vaccinating children, adolescents, and young adults reduced morbidity the most during a simulated pandemic, while a strategy of vaccinating infants, older adults, and young adults had the largest impact on reducing mortality.
Hays, 2018 ⁸⁰ US 4	Reduce/ manage less urgent demand for health care services: Medical counter-measures	Exercise, drill, training program Post-only Conducted student-driven, community-based vaccination program for administration of influenza vaccinations to economically disadvantaged individuals.	Infectious disease: Influenza	Mass vaccination program	Over the course of the program increases were seen in participating sites, community partners, and student volunteers and the effort also served as a pandemic planning drill.
Huang, 2017 ⁸⁵ US 3	Reduce/ manage less urgent demand for health care services: Medical counter-measures	Analysis of single real event N/A Modeling to optimize allocation of vaccines (and different types of vaccines) to different groups throughout Texas.	Infectious disease: H1N1 influenza	Ensuring proportional and geographic equity of vaccine distribution Push-based vaccine allocation Pull-based vaccine allocation	The size of the discretionary reserve directly impacts the equity of distribution of resources across the state.

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Kilianski, 2014 ⁹⁸ US, Cook County, IL 3	Reduce/ manage less urgent demand for health care services: Medical counter- measures	Exercise, drill, training program Post-only Conducted an exercise to determine the ability of Cook County Department of Public Health to coordinate a mass prophylaxis operation.	Infectious disease: Anthrax	Point of dispensing clinic for mass prophylaxis	Areas for improvement were identified and included training, set-up of clinic, screening and consent forms for patients, and command structure/communication.
Koh, 2008 ¹⁰² Boston, MA 6	Reduce/ manage less urgent demand for health care services: Medical counter- measures	Exercise, drill, or training program Post only with comparison group: Implicit benchmark standard Compared point of dispensing strategy for mass distribution of prophylactic antibiotics within 48 hours after an Anthrax release	Infectious disease: Anthrax	Streamlined point of dispensing strategy for mass distribution of antibiotics within 48 hours Push method of dispensing (via U.S. Postal Service mail carriers) for mass distribution of antibiotics	Number of people served per hour per point of dispensing (relative to benchmark standard): 1988 person/hour (about 33/hour/staff person). Number of people served per hour via mail carrier: 23,000 persons in 6 hours (120 people/hour/carrier)
Larson, 2012 ¹¹¹ US 2	Reduce/ manage less urgent demand for health care services: Medical counter- measures	Computer simulation N/A Developed model for epidemic curve for influenza and the impact of timing on vaccine effectiveness.	Infectious disease: Influenza	National stockpile vaccine allocation	Southern states experienced peak infection several weeks before northern states, and most of the vaccine was delivered well after the peak of the southern flu wave. The vaccine appears to have had minimal ameliorative impact in the southern states and measurable positive impact in the northern states; vaccine delivery after peak results in a smaller fraction of the population's seeking the vaccine. Analyses suggest that current CDC policy of allocating flu vaccine over time in direct proportion to the populations of states may not be ideal for averting nationally the maximum possible number of infections.
Lawrenz, 2013 ¹¹² US 3	Reduce/ manage less urgent demand for health care services: Medical counter- measures	Analysis of single real event Post-only Evaluated the effectiveness of a student-led mass vaccination drive for community point-of- distribution sites.	Infectious disease: Influenza	Mass vaccination campaign with volunteer students	During the 1-day vaccination effort, 430 individuals of an at-risk population were vaccinated

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Lee, 2012 ¹¹⁶ US 0	Reduce/ manage less urgent demand for health care services: Medical counter- measures	Computer simulation N/A Used 2009 Mexican H1N1 data to model optimal pandemic strategies.	Infectious disease: Influenza	Age-based vaccine policies	Optimal age-based modeling depends upon transmission rates for the disease, the supply of vaccines, and timing.
Li, 2018 ¹¹⁸ US 4	Reduce/ manage less urgent demand for health care services: Medical counter- measures	Computer simulation N/A Modelling techniques were used to anticipate spread of influenza under two vaccine allocation strategies.	Infectious disease: Influenza	Increase vaccine inventory visibility and information sharing	The presence of information on vaccine inventory decreased the infection rate by 1% and decreased the amount of leftover inventory.
Massad, 2019 ¹²⁷ Brazil 3	Reduce/ manage less urgent demand for health care services: Medical counter- measures	Computer simulation N/A Use past outbreaks to model the point in an outbreak at which a vaccine campaign should be deployed	Infectious disease: Zika and Dengue	Different introduction dates of vaccines Different number of population vaccinated	The campaign for vaccination for Zika virus should be deployed early, with the goal of herd immunity in mind.
Matraj, 2013 ¹²⁹ US 1	Reduce/ manage less urgent demand for health care services: Medical counter- measures	Computer simulation N/A Developed model for optimizing vaccine allocation in network of cities with limited number of doses.	Infectious disease: Influenza	Vaccination strategies	Optimal vaccination strategies substantially reduced the illness attack rate, with a maximal reduction in the attack rate of 85%. Cooperative strategies where the resources are optimally distributed among the cities perform much better than strategies where the vaccine is equally distributed among the network, yielding an illness attack rate 17% lower.
Matrajt, 2015 ¹²⁸ US 4	Reduce/ manage less urgent demand for health care services: Medical counter- measures	Computer simulation N/A Tested effects of implementing two different vaccine allocation strategies.	Infectious disease: Influenza	One-dose vaccine to many individuals Two-doses to half as many individuals	There is a threshold at which a one dose strategy becomes better than the two dose strategy.

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Mbah, 2013 ¹³⁰ US 0	Reduce/ manage less urgent demand for health care services: Medical counter- measures	Computer simulation N/A Developed a mathematical model for optimal vaccination allocation strategies for seasonal influenza.	Infectious disease: Influenza	Vaccination allocation strategies	Vaccination priority should be for children and young adults for minimization of infections or hospitalizations and priority should be for people at risk of complications for minimization of deaths, years of life loss, or contingent valuation.
McVernon , 2010 ¹³⁴ 4	Reduce/ manage less urgent demand for health care services: Medical counter- measures	Computer simulation	Infectious disease: Influenza	Continuous pre- exposure prophylaxis for health care workers during a influenza pandemic	Provision of continuous pre- exposure prophylaxis to 300,000 healthcare workers consumed 46% of the stockpile over 18 weeks. While appreciably depleting resources, such use had a negligible impact on the containment effort. Continuous distribution of antiviral prophylaxis to healthcare workers is considered necessary in the early phases of the pandemic response to ensure continuity of healthcare services, the finding suggest it does not compromise population disease control.
Medlock, 2009 ¹³⁵ 4	Reduce/ manage less urgent demand for health care services: Medical counter- measures	Computer simulation N/A Model to determine optimal vaccine allocation strategy for mass prophylaxis to a novel virus. But the strategy field should just say Vaccine allocation	Infectious disease: Influenza	Model to determine optimal vaccine allocation strategy for mass prophylaxis to a novel virus	Mortality (relative to status quo strategy) and other outcomes were usually most reduced by vaccinating children 5-19 years old (highest transmission group) and child-rearing aged adults (30-39 years), but reduced mortality by 20-40% relative to current CDC recommendations.
Nguyen, 2016 ¹⁴¹ US 3	Reduce/ manage less urgent demand for health care services: Medical counter- measures	Computer simulation N/A Analysis of factors surrounding vaccine allocation in a spreading disease environment.	Infectious disease: Influenza	Vaccination Different timing of vaccination	The earlier a population undergoes mass vaccination, the more effective the intervention, and less vaccine will be required to eradicate the epidemic.
Panovska- Griffiths, 2019 ¹⁴⁶ UK 2	Reduce/ manage less urgent demand for health care services: Medical counter- measures	Computer simulation N/A Conducted a simulation of a pandemic and the impacts of vaccination strategies (a more anticipatory vaccination vs response vaccination).	Infectious disease: Influenza	Vaccination strategies	Quickly employed response vaccination policies are the most beneficial strategy in the study's models of previous outbreaks.

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Park, 2016 ¹⁴⁷ South Korea 1	Reduce/ manage less urgent demand for health care services: Medical counter- measures	Computer simulation N/A A model under stochastic Susceptible-Infected- Susceptible environment was developed to analyze the optimal vaccination strategy for pandemic disease.	Infectious disease: H1N1 influenza	Vaccination policy	Considering social costs and benefits of vaccination efforts, high transmission rates due to dense population and complex social network structure justifies impulsive vaccination at a larger scale as a counter-measure of pandemic.
Potter, 2012 ¹⁵² US 3	Reduce/ manage less urgent demand for health care services: Medical counter- measures	Computer simulation N/A Utilizing Strategic National Stockpile scores, simulations of different vaccination scenarios were used to compare influenza case rates on a national and state level	Infectious disease: Influenza	Vaccine distribution	Raising influenza preparedness, such as vaccine distribution, of less prepared states would benefit better prepared states and the nation as a whole.
Saha, 2014 ¹⁶⁰ US, Los Angeles County, CA 5	Reduce/ manage less urgent demand for health care services: Medical counter- measures	Analysis of single real event Post-only Reviewed data for points of dispensing for H1N1 vaccine to determine how future mass vaccination campaigns could improve efficiency and equity.	Infectious disease: Influenza	Point of dispensing for vaccines	Average of 239 doses administered per hour per point. Vaccination rates was 257/10,000 persons for Asians, 114/10,000 person for Hispanics, 75/10,000 persons for Whites, and 37/10,000 persons for African Americans. Average distance traveled was 6.3 miles for Asians, 4.7 miles for Hispanics, 6.6 miles for Whites, and 5.6 miles for African Americans. Placing points in census tracts of high population density could effectively reach larger numbers of persons.

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Saito, 2013 ¹⁶¹ Japan 2	Reduce/ manage less urgent demand for health care services: Medical counter- measures	Computer simulation N/A A multi-agent simulation was used to evaluate the effectiveness of vaccinations in suppressing an influenza epidemic in an urban area.	Infectious disease: Influenza	Vaccinating arbitrarily chosen residents with national stockpile (in addition to vaccinating priority groups) Vaccinating employees, or vaccinating students, or vaccinating students and employees Vaccinating domiciliaries Vaccinating train passengers Vaccinating employees and students who use trains to get to their offices or schools	Intensive vaccination of students and employees in the first 90 days can reduce to an attack rate that is acceptable for a virus that is not highly pathogenic.
Veltri, 2011 ¹⁷⁷ US 3	Reduce/ manage less urgent demand for health care services: Medical counter- measures	Exercise, drill, training program Post-only Conducted an exercise to evaluate the effect of Push- point-of-dispensing model in hospital-based mass prophylaxis vaccination simulation.	Infectious disease: Influenza	Push-point-of- dispensing model, hospital- based mass prophylaxis vaccination	942 health care workers successfully vaccinated in 4- hour period.
Venkatra manan, 2019 ¹⁷⁸ US 1	Reduce/ manage less urgent demand for health care services: Medical counter- measures	Computer simulation N/A Developed model for spread of influenza and algorithm for allocation of vaccine.	Infectious disease: Influenza	Vaccine allocation strategy	National attack size could be reduced by up to 17% with allocation of early vaccines around origin of epidemic.
Yi, 2015 ¹⁹² US 1	Reduce/ manage less urgent demand for health care services: Medical counter- measures	Computer simulation N/A The model explored strategies of how to most fairly distribute vaccines in a shortage.	Infectious disease: Influenza	Vaccine distribution strategies	The best strategy found was that of prioritizing vaccination in larger households and focusing on vaccinating young children.

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Zaric, 2008 ¹⁹⁵ 3	Reduce/ manage less urgent demand for health care services: Medical counter- measures	Computer simulation N/A Develop a model to optimize the logistical response to a bioterrorism event.	Infectious disease: Anthrax	Stockpiling of supplies Dispensing capacity Surveillance	The demonstration model provides the following insights: (1) communities should focus on dispensing capacity rather than stockpiling of supplies. (2) improved surveillance can reduce mortality if adequate dispensing capacity exists. (3) the mortality from an attack is significantly affected by the number of unexposed individuals who seek prophylaxis and treatment.
Zerwekh, 2007 ¹⁹⁷ Hawaii 6	Reduce/ manage less urgent demand for health care services: Medical counter- measure	Exercise, drill, or training program Post-only The Hawaii Department of Health developed a clinic design for vehicles based on previous exercises and research on sample throughput rates.	All-hazards	Drive-thru clinic model for dispensing of Strategic National Stockpile with triage area near the entrance and consecutive stations for the public to register, have an evaluation for drug contradictions, and receive the medication	In two hours, a total of 622 people were processed in their vehicles for an overall rate of 5.2 persons per minute. Although patient services were reduced in comparison to walk-in clinic models, the public received prophylactic medication in a timely manner with a high rate of accuracy and minimal human-to-human contact.
Andradotti r, 2011 ⁸ Canada, Hamilton, Ontario 2	Reduce/ manage less urgent demand for health care services: Medical and non- pharmaceutic al counter- measures	Computer simulation N/A Developed model to analyze the effects of reactive interventions on pandemic (e.g., vaccination, antivirals, social distancing) and estimate cost associated with morbidity and mortality.	Infectious disease: Influenza	Vaccination strategies Antiviral treatment and household prophylaxis School closure/social distancing interventions	Attack rate with no intervention was 34.1% with an estimated total cost of \$81.1 million. Strategies that involve combinations of interventions reduce transmission and associated costs.

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Bolton, 2012 ²³ Mongolia 2	Reduce/ manage less urgent demand for health care services: Medical and non- pharmaceutic al counter- measures	Computer simulation N/A A model was utilized to evaluate the effects of travel restrictions, school closure, general social distancing, quarantine of close contacts, and distribution of antivirals.	Infectious disease: Influenza	Travel restrictions School closure Social distancing Quarantine of close contacts Antiviral distribution	At early phases of the pandemic, school closures, generalized social distancing, or sustained travel restrictions had a substantial mitigating effect. For school closure to be effective, the attack rate in children had to be over double that in adults. Social distancing was seen to reduce attack rate and delay time of peak influenza-like illness reporting rate by almost 2 weeks and reduced peak case-load by 8%. When 50% of known contacts were traced and quarantined, peak case-load decreased by 25%, attack rate reduced more than 1.5%, and time of peak incidence was delayed by 1 week. If half of known contacts were traced and given antivirals, mean attack rate reduced by 2%, peak case-load delayed by a mean of 2-3 weeks and reduced peak case-load by about 30%.
Chao, 2011 ³¹ US 3	Reduce/ manage less urgent demand for health care services: Medical and non- pharmaceutic al counter- measures	Computer simulation N/A Described the use of a previous epidemic model to simulate vaccination intervention in recent influenza pandemic.	Infectious disease: Influenza	Mass vaccination campaign School closures	Short-term school closures would delay peak but not the magnitude of the pandemic, longer school closures may delay for mass vaccination to be effective but is not economically feasible. Vaccination strategy change to protect people at high risk of complications from influenza showed a reduction in peak rates, deaths, and hospitalizations but not timing of peak.
Chong, 2012 ³⁹ Hong Kong, China 1	Reduce/ manage less urgent demand for health care services: Medical and non- pharmaceutic al counter- measures	Computer simulation N/A Developed model to evaluate the effectiveness of travel restrictions combined with other interventions or parameters.	Infectious disease: Influenza	Travel restrictions Antivirals	Combination of restriction for 99% of travelers with antivirals and hospitalizations results in delays to allow vaccine production.

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Cordova- Villalobos, 2017 ⁴⁵ Mexico 1	Reduce/ manage less urgent demand for health care services: Medical and non- pharmaceutic al counter- measures	Analysis of single real event Post-only Described the experience for Mexico with the 2009 influenza pandemic.	Infectious disease: Influenza	Use of vaccine, antivirals, and personal protective equipment stockpile Surveillance and reporting Risk communication strategies to comply with social distancing (workplace and school closures, household quarantine)	Antivirals that had been stockpiled in bulk powder resulted in delays in providing doses due to issues with reconstitution delaying treatment for distant regions. Influenza vaccine production was slow so doses were late to arrive and were limited in quantity. Compliance with vaccination recommendations was affected by misinformation provided to the public. Risk communication to the public needs to be transparent, timely, and effective to prevent panic and mistrust.
Dafilis, 2012 ⁴⁶ Australia 2	Reduce/ manage less urgent demand for health care services: Medical and non- pharmaceutic al counter- measures	Computer simulation N/A Developed model to evaluate antiviral resistance due to selective pressure caused by use of antivirals for treatment and/or prophylaxis.	Infectious disease: Influenza	Antiviral treatment Prophylaxis Contact tracing	Reserving antiviral drugs for treatment only does not have an impact on the development of antiviral resistance. Definitive containment of transmission could only be achieved through early liberal post- exposure prophylaxis of known contacts of treated cases.
Engelbrechtsen, 2019 ⁵⁴ Norway 5	Reduce/ manage less urgent demand for health care services: Medical and non- pharmaceutic al counter- measures	Computer simulation N/A A model was utilized to explore the effect of internal travel restrictions and vaccination of infectious disease spread when clustering of population is continuously varied.	Infectious disease: Influenza	Internal travel restrictions Vaccination	The effect of travel restrictions on decreasing the final size was stronger for higher clustering levels. Travel restrictions were more effective in delaying the peak for lower clustering levels. Vaccination intervention was more effective in reducing the final size than internal travel restrictions. Preferentially vaccinating urban locations was the single most effective strategy in reducing final size but only slightly better than vaccinating uniformly. With combination of 99% travel restrictions and vaccination, the most effective strategy for reducing the final size of the epidemic was a combination of travel restrictions with urban vaccination for all clustering levels.

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Gonzalez- Parra, 2011 ⁶⁹ US 1	Reduce/ manage less urgent demand for health care services: Medical and non- pharmaceutic al counter- measures	Computer simulation N/A Developed model to assess interventions such as social distancing and antiviral treatment to reduce transmission.	Infectious disease: Influenza	Social distancing Antiviral treatment	As a single intervention, social distancing was more effective than antiviral treatment. Implementation of social distancing and antiviral treatment was more effective than either alone.
Guo, 2015 ⁷³ US 0	Reduce/ manage less urgent demand for health care services: Medical and non- pharmaceutic al counter- measures	Computer simulation N/A Used models to mimic a pandemic, and then developed strategies for vaccine allocation and school closure.	Infectious disease: Influenza	Vaccination School closure	Combining targeted group vaccination and school closure may achieve the best results.
Hadler, 2011 ⁷⁶ Australia 2	Reduce/ manage less urgent demand for health care services: medical and non- pharmaceutic al counter- measures	Computer simulation N/A Simulated various pandemic response strategies, and assessed costs and benefits.	Infectious disease: H1N1	School closure Household prophylaxis with antivirals	A combination of treatment, household anti-viral treatment, and school closure were found to be most cost- effective.
Halder, 2014 ⁷⁷ Australia 3	Reduce/ manage less urgent demand for health care services: Medical and non- pharmaceutic al counter- measures	Computer simulation N/A Developed model to simulate cost-effectiveness of two vaccination strategies with and without social distancing and antiviral use.	Infectious disease: Influenza	Vaccination strategies Social distancing	Preemptive vaccination is more effective and less costly than a reactive vaccination strategy and is more cost- effective based on cost per life-year saved, assuming that the vaccine was at least 30% effective. If no effective vaccine was developed, reactive vaccination was more cost-effective. Social distancing and antiviral use, when added to either vaccination strategy, were more effective than vaccination alone but cost- effectiveness was dependent on efficacy of vaccines, duration of social distancing, and severity of pandemic.

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Hanse, 2011 ⁷⁹ Canada 2	Reduce/ manage less urgent demand for health care services: Medical and non- pharmaceutic al counter- measures	Computer simulation N/A Model seeks to identify the optimal solution (distancing, vaccine) depending on different pandemic conditions.	Infectious disease: Influenza	Isolation-only Vaccination-only Isolation+vaccin ation	There can be more than one optimal solution (depending on conditions), and the optimal mixed strategy is not necessarily the combination of the two optimal individual solutions.
Huo, 2015 ⁸⁶ US 3	Reduce/ manage less urgent demand for health care services: Medical and non- pharmaceutic al counter- measures	Computer simulation N/A Models were utilized to observe the ring and mass vaccination and contact tracing in smallpox and Severe Acute Respiratory Syndrome.	Infectious disease: Severe Acute Respiratory Syndrome and smallpox	Ring vaccination Mass vaccination Contact tracing	With limited vaccine stockpiles and healthcare workers, ring vaccination is more efficient in preventing disease from spreading than mass vaccination. Contact tracing and quarantine help avert more cases when isolation of symptomatic cases is ineffective.
Karimi, 2015 ⁹² Canada 3	Reduce/ manage less urgent demand for health care services: Medical and non- pharmaceutic al counter- measures	Computer simulation N/A Agent-based model was used to examine self- initiated protective behaviors on the spread of influenza.	Infectious disease: Influenza	Vaccination Non- pharmaceutical interventions (social distancing) Educational programs	Instinctive protective behaviors can controlled an outbreak in a high contact rate location with an attack rate decrease of 17 % and a 25 % reduction in the peak number of cases. Vaccination and non-pharmaceutical interventions are able to control outbreak of disease. Effect of Health Belief Model educational programs can increase rate of applying target intervention and control outbreak.
Kelso, 2013 ⁹⁶ ; Kelso, 2013 ²⁰⁷ Australia 5	Reduce/ manage less urgent demand for health care services: Medical and non- pharmaceutic al counter- measures	Computer simulation N/A Simulate effect of pandemic severity on total cost and analyze effect of intervention strategies on total costs.	Infectious disease: Influenza	Antiviral treatment or prophylaxis School closure Social distancing	No single intervention was effective in reducing the attack rate by 50% when the reproduction number was 1.8. . For severe pandemic, the combination of antiviral use for treatment or prophylaxis, school closure for an extended duration, and social distancing to reduce contacts in the community reduced total cost to the lowest amount.

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Lee, 2013 ¹¹⁴ South Korea 2	Reduce/ manage less urgent demand for health care services: Medical and non-pharmaceutical counter-measures	Computer simulation N/A A model was used to seek optimal control strategies that can minimize incidence while considering intervention costs.	Infectious disease: Influenza	Vaccination Antivirals Social distancing	To effectively control an epidemic, vaccination should occur at the highest possible rate as early as possible. Vaccination strategy should be focused on high transmission groups such as school-age children. For treatment and social distancing, strategy should be tailored to dynamics of infected population.
Luangkesorn, 2013 ¹²¹ US 3	Reduce/ manage less urgent demand for health care services: Medical and non-pharmaceutical counter-measures	Computer simulation N/A Proposed a model that combines vaccination strategy and school closures.	Infectious disease: H1N1	School closure (if the attack rate in a given school increases a certain threshold, close the school) Advisory Committee on Immunization Practices (ACIP) recommendations on vaccine priorities is used Vaccination priority rule to be used in the case where	Best model included policies with low school closure threshold, follow the ACIP recommendations on vaccine priority, and 10- or 15-day school closure periods. The priority scheme for the second dose for those 9 years and younger did not have a significant effect on the simulated attack rate.
Mao, 2011 ¹²³ US, Buffalo, NY 3	Reduce/ manage less urgent demand for health care services: Medical and non-pharmaceutical counter-measures	Computer simulation N/A Simulated interaction between community closures/distancing measures and vaccination/anti-viral campaigns.	Infectious disease: Influenza	Targeted antiviral prophylaxis - identify sick individuals, and vaccinate/supply antivirals to their family members Work and school closure Travel restriction	Individuals' preventative measures can lessen the demand for heavy, mandated control measures, as voluntary preventative measures combined with weaker control measures is impactful. The combined strategies outperform each of the three single strategies.
McCaw, 2014 ¹³¹ Australia 1	Reduce/ manage less urgent demand for health care services: Medical and non-pharmaceutical counter-measures	Computer simulation N/A Developed model to assess the impact of interventions on transmission of a pandemic.	Infectious disease: Influenza	Antiviral drugs School closure	Specific targeted interventions such as antiviral use would only be effective in pandemics that have low transmission and high severity. Interventions such as school closure which can reduce transmission may be more effective but should be evaluated based on societal and economic cost.

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Milne, 2013 ¹³⁶ Australia 3	Reduce/ manage less urgent demand for health care services: Medical and non- pharmaceutic al counter- measures	Computer simulation N/A Developed a model to estimate the cost- effectiveness of interventions such as social distancing and antiviral use for an influenza pandemic.	Infectious disease: Influenza	School closure Antiviral drugs for treatment and prophylaxis Workplace non- attendance Community contact reduction	Antiviral use as treatment or prophylaxis combined with school closure were the most cost-effective strategies for all categories of severity. Total costs varies based on severity of the pandemic with high severity having the most effective attack rate reduction and being most cost effective.
Pan, 2020 ¹⁴⁵ Hartley, 2020 ²¹⁶ China 6	Reduce/ manage less urgent demand for health care services: Medical and non- pharmaceutic al counter- measures	Analysis of single real event Post-only Cohort study to determine effects of multiple interventions (social distancing, home or centralized quarantine, traffic restriction, cordons sanitaire, and universal symptom survey) on number of COVID-19 cases.	Infectious disease: COVID-19	Travel restrictions Mask wearing Social distancing Self- quarantine/stay- at-home policies Antiviral treatment or prophylaxis Screening	Implementation of multiple interventions was able to improve control of the outbreak. The reproduction number decreased from the initial peak of 3.82 to 0.3 after introduction of interventions.
Prosper, 2011 ¹⁵⁶ US 1	Reduce/ manage less urgent demand for health care services: Medical and non- pharmaceutic al counter- measures	Computer simulation N/A Developed model to analyze transmission and the impact of the 2009-2010 H1N1 influenza pandemic.	Infectious disease: Influenza	Vaccination strategy Social distancing Antiviral treatment	The number of infections was reduced more than 99% with the combination of social distancing and antiviral treatment and with social distancing along during the 100-day control period. Antiviral treatment reduces the number of cases by 59% with seasonal vaccine and 37% without vaccine.
Sato, 2013 ¹⁶² Japan, Kounu 1	Reduce/ manage less urgent demand for health care services: Medical and non- pharmaceutic al counter- measures	Computer simulation N/A Model evaluating policies such as closures and distancing.	Infectious disease: H1N1	School closure Cancelling large events Preventive actions Treatment with antivirals	Event and school closures made effective impact on preventing spread.

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Saunders- Hastings, 2017 ¹⁶³ Canada 5	Reduce/ manage less urgent demand for health care services: Medical and non- pharmaceutic al counter- measures	Computer simulation N/A Impact of a major pandemic (in terms of people affected) and spread in Ottawa.	Infectious disease: Influenza	Vaccination Antiviral treatment Antiviral prophylaxis School closure Community- contact reduction Personal protective measures Voluntary isolation and quarantine	Using all interventions, the disease attack impact was around 8%, and with no interventions it was 54%. Vaccination, personal protective measures and isolation of infected individuals were the most effective interventions. School closure, community- contact reduction, antiviral therapy, and antiviral prophylaxis had less effect on pandemic burden.
Shim, 2013 ¹⁶⁸ US 2	Reduce/ manage less urgent demand for health care services: Medical and non- pharmaceutic al counter- measures	Computer simulation N/A Mathematical model utilized to evaluate optimal strategies of vaccination and social distancing against seasonal influenza.	Infectious disease: Influenza	Social distancing Optimal vaccination timing	Control strategies of seasonal influenza should include efforts to encourage social distancing as well as early vaccination.
Weng, 2015 ¹⁸² China 3	Reduce/ manage less urgent demand for health care services: Medical and non- pharmaceutic al counter- measures	Computer simulation N/A A model combining meta- population approach and agent-based model was used to evaluate containment and mitigation strategies for an H1N1 pandemic in China.	Infectious disease: H1N1 influenza	Contact tracing Quarantine of contacts Vaccination School closure Travel restriction	Contact tracing and quarantine of contacts at assembly sites in the early stage is effective in delaying epidemic. Rapid vaccines delivered to students first was a correct vaccination strategy in decreasing H1N1 cases. Travel-related interventions implemented with other mitigation strategies would produce significant compound effect on reducing epidemic burden.

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Wu, 2014 ¹⁸⁶ Taiwan 3	Reduce/ manage less urgent demand for health care services: Medical and non-pharmaceutical counter-measures	Analysis of single real event Post-only Multicenter, hospital-wide, clinical and epidemiological study to determine the effectiveness of mass vaccination campaign.	Infectious disease: Influenza	Mass vaccination program Control measures (border control and quarantine, policies for school and class suspensions, distribution of surgical masks, and increased surveillance) Testing Antiviral treatment	Establishing community flu clinics averted 8.7 daily cases from hospitals. For every 10% increase in immunity through vaccination a reduction of 5.1 daily cases in one hospital was observed (reported as similar in other 2 hospitals). Model showed that mass vaccination was more effective than antiviral therapy and that vaccination of school-aged children had greater impact on the control of the pandemic than older adults.
Xia, 2013 ¹⁸⁷ Hong Kong 3	Reduce/ manage less urgent demand for health care services: Medical and non-pharmaceutical counter-measures	Computer simulation N/A A model is utilized to identify priorities of subpopulations for vaccine allocation and contact reduction.	Infectious disease: H1N1 influenza	Social contact Vaccination strategy	Prioritization of age subpopulations and/or social settings can improve disease control; reduction of social contact in school should be implemented immediately after disease onset and lasting for the whole period of disease spread; vaccination target age differs depending on stage of disease outbreak
Xie, 2012 ¹⁸⁸ Liberia 2	Reduce/ manage less urgent demand for health care services: Medical and non-pharmaceutical counter-measures	Computer simulation N/A Analyzed epidemic trends with epidemiological model and evaluated efficacy of mass vaccination intervention.	Infectious disease: Ebola	Randomized mass vaccination Ring vaccination (vaccinating anyone who has come into contact with a person infected with Ebola, as well as contacts of theirs) Contact tracing	Vaccination should be implemented as soon as possible if a randomized mass vaccination strategy should be used. A delay in intervention by 2 weeks would result in a total case increase of about 68%. Early intervention and early vaccination should be implemented simultaneously to achieve the greatest effectiveness.
Yaari, 2016 ¹⁹⁰ Israel 1	Reduce/ manage less urgent demand for health care services: Medical and non-pharmaceutical counter-measures	Computer simulation N/A A model was utilized to show the effect of school vacation timing and vaccination allocation on the outcomes of an A/H1N1 influenza epidemic.	Infectious disease: A/H1N1 Influenza	Timing of school vacations can effect outcome of influenza epidemic Optimizing vaccine allocation can mitigate pandemic	Early school closure in epidemic delays epidemic but only advantageous if vaccinating during this delay. Vaccinating children is advantageous over vaccinating adults.

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Yaesoubi, 2016 ¹⁹¹ US 0	Reduce/ manage less urgent demand for health care services: Medical and non- pharmaceutic al counter- measures	Computer simulation N/A Developed decision model to define and optimize dynamic policies for controlling epidemics.	Infectious disease: Novel pathogen	Dynamic strategies (to decide when to employ or lift a transmission- reducing intervention such as school closure and how to prioritize population members for vaccination) Static strategies following a pre- determined sequence of interventions	Dynamic policies can produce better health outcomes for similar investment than static policies.
Yu, 2016 ¹⁹³ Canada 0	Reduce/ manage less urgent demand for health care services: Medical and non- pharmaceutic al counter- measures	Computer simulation N/A Developed a model for vaccine distribution, which looks at impacts of different distribution techniques, vaccine coverage, and releasing times.	Infectious disease: Influenza	Vaccination Antiviral prophylaxis and treatment Area and household quarantines	The combination of vaccination and segregation strategies is more effective than a single-focus strategy for controlling the spread of an infectious disease.
Zenihana, 2010 ¹⁹⁶ Japan 4	Reduce/ manage less urgent demand for health care services: Medical and non- pharmaceutic al counter- measures	Computer simulation N/A Aimed at the evaluation of countermeasures in terms of the total number of patients and deaths, the number of vaccine doses used, and the time for eradication as examined through simulations of the outbreak of smallpox following a bioterrorist attack.	Infectious disease: Smallpox bioterrorism	School closure Contact tracing Mass vaccination Traced vaccination (patients are traced and persons who came into contact with those patients are vaccinated)	According to the simulations results, it was advisable to carry out mass vaccination, or both traced vaccination and mass vaccination, simultaneously with school closure.
van Asten, 2009 ¹² The Netherlan ds 2	Optimize use of existing resources	Computer simulation, guideline N/A Coalition to strengthening national lab surge capacity with regard to diagnostic demand	Infectious Disease: Avian influenza	Load sharing national network of laboratories	National network of laboratories has capacity to handle diagnostic requests from hospitals, but probably insufficient for a surge generated in the non- hospitalized population

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Becker, 2011 ²⁰ Australia 2	Optimize use of existing resources	Computer simulation N/A A model was utilized to assess the impact of using antiviral drugs to mitigate influenza transmission.	Infectious disease: Influenza	Stockpile antiviral drugs to to mitigate transmission Dispensing antiviral drugs to infected households	Liberal and timely use of antiviral drugs should be part of an attempt at local containment of transmission. Prophylactic use of antiviral drugs should be abandoned once there is strong evidence that containment is unlikely to succeed. Dispense antiviral drugs to close contacts by targeting household members of cases who present with clinical symptoms; even when antivirals are adequately effective, containment is not possible if more than a modest fraction of primary household cases fail to present symptoms early.
Breakwell, 2016 ²⁶ Africa 3	Optimize use of existing resources	Analysis of single real event Post-only Reviewed involvement of CDC in African countries through the High-Risk Countries Team that was formed.	Infectious disease: Ebola	High Risk Countries Team worked with WHO and country officials in 15 African countries Standardized protocol for contact tracing Travel restrictions, border patrol, airport screenings Epidemiology 5 week training program for health officials	Imported cases were successfully maintained, and countries are better prepared for Ebola.
Chen, 2018 ³⁶ China 2	Optimize use of existing resources	Computer simulation N/A Model simulated to analyze the allocation of resources for optimal management of an epidemic outbreak based on disease spreading.	Infectious disease: Not specified	Resource allocation for prevention Resource allocation for treatment	An adaptive resource allocation strategy is proposed: in the early stage of the disease spreading, resources should be allocated to the high infectious nodes, while after the early stage, resources should be allocated to the low infectious nodes to optimally suppress disease.

Author, Year Location Critical Appraisal score*	Strategy Category	Study Type Study Design Study Description	Mass Casualty Event	Strategies	Findings
Cicero, 2019 ⁴² US, Connectic ut 3	Optimize use of existing resources	Exercise, drill, training program, consensus guideline Post only with comparison Conducted exercise to determine emergency medical services preparedness according to established guideline.	All-hazards: Bus crash and rollover	Regional collaboration plan for pediatric disasters	Intra-hospital sources for surge capacity endorsed by 66.7% of respondents; specific pediatric surge capacity procedures were in four of five hospitals; no large gaps in disaster preparedness identified following exercise.
Dover, 2016 ⁴⁹ Canada 3	Optimize use of existing resources	Computer simulation N/A Developed model to assess antiviral use and vaccination as control measures.	Infectious disease: Influenza	Immediate stockpile release of antiviral treatment Concurrent immunization	Immediate release of antiviral treatment or vaccine resulted in a reduction in total number of exposed, total hospitalizations, and total deaths compared to release at peak of pandemic. Combined release of both resulted in even greater reductions in all outcomes with greatest effect with immediate release of antiviral treatment and vaccine.
Enanoria, 2013 ⁵³ US 2	Optimize use of existing resources	Analysis of single real event Post-only Key informant interviews from local health departments were conducted to collect information about epidemiology and surveillance response.	Infectious disease: H1N1 influenza	Incident Command System use to manage response Data collection using case reports and laboratory testing data Regular communication between health jurisdictions about key decisions related to response	Solutions to insufficient staff handling disease investigations tasks were surge capacity staff and external sources, incident command system implemented by all the local health departments, benefits seen in sharing of laboratory capacity, regional preparedness and response planning and public messaging from public health leaders, benefits in prior planning and preparedness activities on organizational response and communication.

Author, Year Location Critical Appraisal score*	Strategy Category	Study Type Study Design Study Description	Mass Casualty Event	Strategies	Findings
Epley, 2006 ⁵⁵ Southwest Texas 4	Optimize use of existing resources: Load sharing	Analysis of multiple real events Pre-post with comparison group: Routine trauma system (pre-/post-) and disaster trauma system	All-hazards, Natural Disaster: Hurricane	Use of comparable coordinated regional trauma systems for routine (Medcom) and disaster (Regional Medical Operations Center) operations to facilitate the rapid transfer of hospitalized and special needs patients following small-scale trauma events and disasters.	Pre-post- analysis of Medcom: Pre-Medcom: Transfer decision time 115 +/-3 min; transfer accept time 30.5min; total transfer time 145+/-12min. Post-Medcom: Transfer decision time 80+/-1min, transfer accept time 10 +/-2 min, total transfer time 91 +/- 1 min. Regional Medical Operations Center: Post-Hurricane Katrina transferred 6 patients/hour and 170 patients/hour from two incoming transports; pre-Hurricane Rita: transferred 20 patients/hour
Gong, 2020 ⁶⁸ China 6	Optimize use of existing resources	Analysis of single real event Post-only Analysis of the use of internet hospitals in COVID-19 outbreak setting.	Infectious disease: COVID-19	Internet hospital providing online advice	Internet hospitals can serve different types of epidemic counselees, offer essential medical supports to the public during the COVID-19 outbreak, reduce the social panic, promote social distancing, enhance the public's ability of self-protection, correct improper medical-seeking behaviors, reduce the chance of nosocomial cross-infection, and facilitate epidemiological screening,
Graeden, 2015 ⁷⁰ US 0	Optimize use of existing resources	Computer simulation N/A Developed a model to test the relative value of available medical countermeasures including the vaccine and an antiviral and to compared various public health response options for emergency response plans.	Infectious disease: Smallpox	Medical countermeasures for prophylaxis or treatment	Any mitigation (vaccination alone or with tecovirimat treatment) reduces the effects of the epidemic. Addition of tecovirimat treatment further reduces morbidity and mortality as well as viral shedding and contagiousness. Vaccination prophylaxis can control the outbreak when minimally contagious or a high percentage of prophylaxis in the population. When vaccine coverage drops below 70%, tecovirimat treatment is required to control the outbreak.

Author, Year Location Critical Appraisal score*	Strategy Category	Study Type Study Design Study Description	Mass Casualty Event	Strategies	Findings
Heberlein- Larson, 2019 ⁸¹ US, Florida 6	Optimize use of existing resources	Analysis of single real event Post-only Described the establishment of partnerships between Florida's Bureau of Public Health Laboratories (BPHL), the CDC, and a commercial laboratory to provide timely quality laboratory results during infectious disease public health emergency.	Infectious disease: Zika virus	Community partnership for laboratory testing and specimen triage	Partnerships reduced test turnaround time for testing during peak period of local transmission.
Kanter, 2012 ⁹¹ US 4	Optimize use of existing resources	Analysis of single real event Post-only Key informants were interviewed in order to obtain empirical description of the integration of pediatric disaster services into regional systems of care after a tornado.	Natural disaster: tornado	Integrating pediatric disaster services and regional systems of care Sharing photos across hospitals to identify unaccompanied children who were too small or too shocked to speak	Resuscitation and stabilization were performed by nonpediatric prehospital and emergency department staff. No preventable adverse events were identified in the resuscitation and secondary transport phases of care. Stockpiled supplies and equipment were adequate to serve the needs of the disaster victims, including the children.
McCaw, 2008 ¹³² 4	Optimize use of existing resources	Computer simulation N/A Evaluating the optimal strategy for allocation of antivirals from the Strategic National Stockpile during an influenza pandemic (if there are two effective drugs).	Infectious disease: Influenza	Two-drug strategy: give a different drug to cases vs their contacts, i.e., different drug for treatment vs prophylaxis) Other strategies (e.g., develop drug useful for treatment and prophylaxis)	The two-drug strategy is superior to other strategies because it produces greater delays in: a) propagation of the epidemic and b) the emergence of drug resistance (including multi-drug resistance), but when resistance does emerge, it is more likely to be multi-drug resistance.

Author, Year Location Critical Appraisal score*	Strategy Category	Study Type Study Design Study Description	Mass Casualty Event	Strategies	Findings
McNeill, 2019 ¹³³ US 3	Optimize use of existing resources	Computer simulation N/A Evaluating a model for utilizing existing home health agencies to increase capacity for distributing medical stockpile supplies within a shorter time frame than is currently in place for emergency events.	All-hazards: Healthcare emergency where supplies would be distributed in a short time frame	Home health agencies as point of dispensing "head of household" scheme where one person from a family could pick up medical counter measures for the whole family Distribution could also occur through mail, workplace, and delivery by school bus	Home health agency dispensing model shows promise as it can decrease demand at open point of dispensing and increase the reach to vulnerable populations.
Morchel, 2015 ¹³⁸ US 2	Optimize use of existing resources	Analysis of single real event Pre-post Described use of an automated drug distribution cabinet system for medication supply in a disaster response mobile Emergency Department vehicle deployed for emergency medical care at the 2014 Super Bowl.	All-hazards: Emergency medical care, not specified	Automated drug distribution cabinet	Deployment of drug distribution cabinet was highly successful.
Okumura, 2015 ¹⁴⁴ Japan 1	Optimize use of existing resources	Analysis of single real event Post-only Case study on government's work in assisting with evacuation during the 2011 earthquake and the Fukushima Daiichi Nuclear Power Plant Accident.	Natural disaster: Earthquake	Use of Disaster Medical Assistance Teams to carry out evacuations	Hospital evacuation was successfully performed with the aid of local emergency physicians and Disaster Medical Assistance Teams.
Saberian, 2019 ¹⁵⁹ Iran 1	Optimize use of existing resources	Analysis of multiple real events Post-only Described the actions taken by emergency medical service after 3 earthquakes in Iran	Natural disaster: Earthquake	Using provincial capacity Rapid warning system and response	Using provincial capacity reduced the need for injured to be transferred to other provinces.
Shen, 2012 ¹⁶⁷ China 3	Optimize use of existing resources	Analysis of single real event Post-only Reviewed experiences for medical rescue after earthquake.	Natural disaster: Earthquake	Emergency response system for triage, surveillance, rescue, and communication	Rapid launch of emergency response with command system was effective in managing tasks including medical triage, rescue, surveillance for infectious diseases, and communication.

Author, Year Location Critical Appraisal score*	Strategy Category	Study Type Study Design Study Description	Mass Casualty Event	Strategies	Findings
Simon, 2001 ¹⁶⁹ New York City 4	Optimize use of existing resources: Load sharing	Analysis of single real event Post only with comparison group: Qualitatively compared against counterfactual	Explosive, Terrorism: 9/11 attacks	Control the distribution of urgent patients through scene or central command to limit overwhelming the nearest hospital Site emergency management centers in a low vulnerability location Use robust and interoperable emergency communications system.	No enforced patient distribution system led to moderate and critical patients swamping the 2 nearest trauma centers, while a 3rd trauma center 3 miles from scene sat idle. Attack damage to Office of Emergency Management dramatically exacerbated communication and coordination efforts including patient distribution. Cell phone and radio disruptions (from attack damage and post-attack overload) prevented response coordination - most patient distribution was blind to hospital resource availability.
Simonetti, 2018 ¹⁷⁰ US 2	Optimize use of existing resources	Computer simulation N/A National emergency's impact on existing blood supply chains.	Infectious disease: Pandemic	Inter-regional blood transfer system coordinating regionally to optimize blood distribution	According to the models, demand for blood will be adequately met.
Yuen, 2012 ¹⁹⁴ China 2	Optimize use of existing resources	Computer simulation N/A Simulation conducted to assess the effectiveness of installing window-mounted exhaust fans to create negative-pressure airflow in a hospital during the SARS outbreak	Infectious disease: Severe acute respiratory syndrome	Window-mounted exhaust fans used to create negative-pressure airflow in hospitals	Installation of local extraction fans can yield ventilation performance comparable to or even better than that of standard isolation rooms. Can be alternative for surges in isolation patients during pandemics.
Zhang, 2014 ²⁰⁰ China 3	Optimize use of existing resources	Computer simulation N/A Developed two regional dynamic models to determine optimal strategies for control and prevention of spread with three control measures (antiviral treatment, patient isolation, and immigration detection).	Infectious disease: Influenza	Antiviral treatment Isolation	As a single control measure, antiviral treatment was the most effective in controlling clinical infection with a reduction in total and peak proportion of clinical infected individuals. Isolation prolonged the duration of an epidemic controlling only the peak and not the total number of clinical patients. Antivirals were more cost-effective than other nonpharmacologic measures. Epidemic is hard to control by nonpharmacologic interventions when antiviral resources are exhausted.

Author, Year Location Critical Appraisal score*	Strategy Category	Study Type Study Design Study Description	Mass Casualty Event	Strategies	Findings
Zodd, 2014 ²⁰² US, St. Louis 4	Optimize use of existing resources	Exercise, drill, training program Post-only Held an exercise to simulate distribution of medication to people with functional needs.	All-hazards: Public health emergency	Collaborating with community agencies that assist individuals with disabilities to distribute medication	Medications were successfully distributed in the exercise phase.
Adini, 2015 ³ Israel 0	Augment resources	Computer simulation N/A Developed load index model as tool to help decision makers in evacuation in emergency situation.	All-hazards: Mass casualty, not specified	Decision support tool	In simulation exercises, use of the load index model reduced variability in casualty allocation between hospitals and groups. 92% of stakeholders agreed that there was a need for a tool for decision making and 82.5% felt that the model contributed or highly contributed to the decision-making process.
Arora, 2010 ¹¹ US 4	Augment resources: Mutual aid agreements	Computer simulation N/A The study reviews a resource allocation approach for optimizing regional aid during public health emergencies	Infectious disease: Influenza	Proportion of CDC stockpile to pre-allocate in response to pandemic flu outbreak Mutual aid agreements that allow transshipment of antivirals between counties CDC stockpile allocation according to age group, gross attack rate, or population only Stockpile use for prophylaxis vs. treatment for pandemic flu outbreak	Postponing allocation is optimal by allowing allocation according to the infected population rather than the susceptible population. Transshipment through mutual aid agreements is an optimal policy when infection rates vary across counties and counties with small populations are affected. Allocate CDC antiviral stockpile according to gross attack rates rather than population is the optimal strategy. Age-based allocation may also be optimal. Limit use of CDC antiviral stockpile for prophylaxis when supplies are limited and focus on treatment instead.
Balch, 2004 ¹⁵ US 2	Augment resources	Analysis of single real event Post-only Conducted an exercise to demonstrate community readiness and medical response to a mass casualty event	Natural disaster: Earthquake	Commercial products supporting homeland security, community readiness, and medical response	Shadow Bowl earthquake scenario demonstrated significant strain on the healthcare system.

Author, Year Location Critical Appraisal score*	Strategy Category	Study Type Study Design Study Description	Mass Casualty Event	Strategies	Findings
Bame, 2012 ¹⁷ US 6	Augment resources	Analysis of multiple real events Post-only Analyze disaster call data after two hurricanes to determine unmet needs.	Natural disaster: Hurricane	Disaster call centers	A total of 635,983 calls were recorded in Texas. In the second week post Katrina landfall, calls spiked to >7000 per day.
Blackwell, 2007 ²² US 3	Augment resources: Temporary facilities	Analysis of single real event Post only with comparison group: Qualitatively compared to implied standard of limited or no care available.	Natural Disaster: Hurricane	Deploy a mobile field hospital	7,400 patients were evaluated and treated over a 6-week period.
Chauvelin, 2019 ³³ France, Nice 1	Augment resources	Analysis of single real event Post-only Described the psychological emergency interventions.	All-hazards: Terrorism (Nice, France)	Psychological emergency care setup dedicated to children and families during the first 48 hours after a terrorist attack	The study documents the importance to organize a specialized psychiatric reception dedicated to children and family victims of a terrorist attack; the impact should be assessed in future studies.
Chen, 2018 ³⁴ China 1	Augment resources	Computer simulation N/A Deployment of optimal pre- positioning inventories of multiple products for potential disaster response was explored using an analytical model developed by employing the multi- product newsvendor approach.	All-hazards: Disasters	Joint stockpiling	Flexible storage policy where nonprofit organization holds partial purchased inventories and offers subsidies as incentives for the supplier to store residual parts is proposed as this can be valuable for both sides of the relief supply chain.
Dimitrov, 2011 ⁴⁸ US 2	Augment resources	Computer simulation N/A Present a tactical optimization model for distributing this stockpile for treatment of infected cases during the early stages of a pandemic like 2009 pH1N1, prior to the wide availability of a strain-specific vaccine.	Infectious disease: Pandemic	Antiviral stockpile distribution strategies	An aggressive community- based antiviral treatment strategy involving early, widespread, pro-rata distribution of antivirals to States can contribute to slowing the transmission of mildly transmissible strains. For more highly transmissible strains, outcomes of antiviral use are impacted by choice of distribution intervals, quantities per shipment, and timing of shipments in relation to pandemic spread.

Author, Year Location Critical Appraisal score*	Strategy Category	Study Type Study Design Study Description	Mass Casualty Event	Strategies	Findings
Eastman, 2007 ⁵¹ Dallas, TX 4	Augment resources: Temporary facilities	Analysis of single real event Pre-post	Natural Disaster: Hurricane	Implement alternate-site surge capacity facility during a mass casualty event	All other trauma centers/EDs in Dallas had no statistically significant increases in visit rates during the two-week period in which the alternate care site was operational compared to visit rates in the prior year. There were no incidents of safety or contamination breaches during operation of the alternate care site.
Fletcher, 2014 ⁵⁹ US 7	Augment resources	Exercise, drill, training program Pre-post Conducted exercise to evaluate closed point-of- dispensing site for mass medication distribution.	Infectious disease: Anthrax	Point-of- dispensing	Throughput rate increased (25.4 to 22.3 hours for processing population), medication dispensing accuracy for both type and dose increased from 84.7% to 92.4%.
Gist, 2016 ⁶⁵ US 5	Augment resources	Exercise, drill, training program Post-only An exercise was run where volunteers were used to complete tasks as if it were a disaster.	Infectious disease: Influenza	Use of Medical Reserve Corps volunteers	Those evaluating the exercise were overall pleased with the work of the volunteers.
Glass, 2018 ⁶⁶ US 5	Augment resources	Exercise, drill, training program Post-only Conducted an exercise testing effects on time (efficiency) of following the study's developed protocol.	Infectious disease: Bioterrorism	Model supporting the allocation of volunteers at the site to stations of triage, registration, screening, and dispensing	The group which used the model utilized time more efficiently than the control group.
Grasselli, 2020 ⁷¹ Lorenzoni, 2020 ²¹⁷ Italy 1	Augment resources	Analysis of single real event Post-only Coordinated critical care response to COVID-19 outbreak increasing surge ICU capacity and implementing measures for containment	Infectious disease: COVID-19	Emergency task force	Dedicated ICU cohort beds increased from 130 in 15 hub hospitals to 482 in 55 hospitals within 2 weeks.

Author, Year Location Critical Appraisal score*	Strategy Category	Study Type Study Design Study Description	Mass Casualty Event	Strategies	Findings
Greer, 2013 ⁷² Canada 0	Augment resources	Computer simulation N/A Developed dynamic model for pandemic influenza in Canada structured by age and risk to calculate demand for antivirals in influenza pandemic	Infectious disease: Influenza	National antiviral stockpile models	Stockpiling for a “treat all” approach may not be logistically feasible and alternatives may need to be considered (e.g., targeting subgroups, examining creative procurement arrangements to reduce upfront stockpile requirements). If the next pandemic strain emerges in late spring or summer and a vaccine is available before the anticipated fall wave, the median prediction was reduced to 6% (IQR 0.7- 14%). Under the strategy of offering empirical treatment to all patients with influenza like symptoms who present for care, demand could increase to between 65 and 144%.
Gupta, 2011 ⁷⁴ US, Kanawha County, WV 4	Augment resources	Analysis of single real event Post-only Looked at response to H1N1 by focusing on community partnerships that emerged as a response to the epidemic.	Infectious disease: H1N1	Strategic team of major community stakeholders to address pandemic including vaccination clinics in elementary schools and child care centers	The timely enhancement of the existing community partnerships enabled successful response activities with local community support. High vaccination rates for school aged children compared to other jurisdictions across the nation.
Gutierrez- Mendoza, 2012 ⁷⁵ Mexico 2	Augment resources	Analysis of single real event Post-only A retrospective analysis study was conducted to analyze the storage, distribution, and dispensation of antivirals during the H1N1 influenza pandemic.	Infectious disease: Influenza	Antivirals Stockpiling	Stockpile of antivirals should include a mix of bulk powder, capsules, and suspension of oseltamivir plus other antivirals. A portion of stockpile should be decentralized. There is a need to define quantity and dispensing criteria a priori to facilitate strategic stockpile management during outbreak.

Author, Year Location Critical Appraisal score*	Strategy Category	Study Type Study Design Study Description	Mass Casualty Event	Strategies	Findings
Huang, 2017 ⁸⁴ US, Texas 2	Augment resources	Analysis of a single event N/A Developed optimization framework for allocating mechanical ventilators to local and central stockpiles to ensure adequate surge capacity in future pandemic.	Infectious disease: Influenza	Stockpile of ventilators models (regional, national)	During the 2009 pandemic, hospitals across Texas held an estimated 3,730 ventilators. Given this ample regional surge capacity, there would have been no need for central stockpiling. Under mild and moderate pandemic scenarios, we projected expected statewide demands for 230 and 903 ventilators. Under the severe scenario, the projected statewide demand is 10,333 ventilators, far exceeding 2009 stockpiles.
Irvin, 2007 ⁸⁷ US 2	Augment resources	Analysis of single real event Post-only Description of a multidisciplinary Hurricane Katrina Evacuation Center	Natural disaster: Hurricane	Surge, alternate care site-real event	Successful non-ED alternative to address non- emergent medical concerns
Jokela, 2012 ⁸⁹ Finland, Sweden 2	Augment resources	Exercise, drill, training program Post-only A simulation exercise was performed in order to test the feasibility of Radio Frequency Identification in a mass-casualty incident.	All-hazards: Passenger ship accident, aircraft crash	Communication system (prototype utilizing commercially available, low- cost components, including Radio Frequency Identification and mobile phone technology)	Radio Frequency Identification surpassed paper-based systems in all respects except simplicity.
Knauf, 2013 ¹⁰⁰ US, Connectic ut 4	Augment resources	Exercise, drill, training program Post-only Health department serving a population of 21,000 conducted an exercise to rapid dispensing of medication through a school-based point-of- dispensing model	All-hazards: Not specified	Medication distribution through school- based point of dispensing model	Medication was dispensed in 50 minutes to 10% of the local population. The public school notification system worked well for distribution information to parents.
Kotani, 2020 ¹⁰⁵ Japan 5	Augment resources	Computer simulation N/A Review survey results for the use of a shopping street with disaster-proof buildings as locations for food distribution and as evacuation shelters after an earthquake.	Natural disaster: Earthquake	Using a shopping street as site for food distribution and evacuation shelter	Local shops and restaurants could provide food and drink amounts of 1200-1700 person-days with outages of utilities and 2800 person- days with utilities. The disaster-proof buildings could serve as overnight shelters for 2300 people. Food and drink could be stockpiled in unoccupied spaces in structures.

Author, Year Location Critical Appraisal score*	Strategy Category	Study Type Study Design Study Description	Mass Casualty Event	Strategies	Findings
Kraushar, 2015 ¹⁰⁷ US 4	Augment resources	Analysis of single real event Post-only Analysis of the use of an ad hoc, volunteer team to assist with medical relief in response to the emergency.	Natural disaster: Hurricane Sandy	Use volunteers to assist in reaching medically fragile individuals who became isolated to help with their medical needs	The volunteers helped to fill gaps in reaching vulnerable populations, however this effort was far from what should have been required for the situation.
Lee, 2006 ¹¹³ Atlanta, Georgia 4	Augment resources	Exercise, drill, or training program Post only with comparison group: 7 counties not using decision support software	Infectious disease: Anthrax	Use of integrated simulation and decision-support software (RealOpt) to determine appropriate staffing for point of dispensing medical countermeasure following Anthrax release	The only county that used RealOpt, achieved the highest throughput compared to all other participating counties. It was the only county to exceed 450 targeted households; its throughput was 50% higher than the next highest county (which processed only 71% of target households). External evaluators reported that the county produced the most efficient floor plan (with no path crossing), the most cost-effective dispensing (lowest labor/throughput value), and the smoothest operations (shortest average wait time, average queue length, and equalized utilization rate). No quantitative measures were reported for these parameters.
Park, 2020 ¹⁴⁸ South Korea 2	Augment resources	Analysis of single real event Post-only Created an out-of-hospital Community Treatment Center which treated patients for Covid-19 which served 309 patients.	Infectious disease: COVID-19	Create an intermediary treatment facility	The implementation significantly reduced the number of patients who needed hospital beds.
Shartar, 2017 ¹⁶⁶ US 1	Augment resources	Exercise, drill, or training program, guideline Post-only Created and implemented mass casualty surge plan and patient distribution tools with regional stakeholders.	All-hazards: Mass casualty, not specified	Patient distribution model Casualty distribution tool	Tools are widely distributed and applied.

Author, Year Location Critical Appraisal score*	Strategy Category	Study Type Study Design Study Description	Mass Casualty Event	Strategies	Findings
Su, 2019 ¹⁷² Taiwan 1	Augment resources	Exercise, drill, or training program, guideline Post-only Summary of Taiwan's plan for managing seasonal influenza epidemics.	Infectious disease: Influenza	Special flu clinics Review resources Real-time dashboard showing occupancy and capabilities of hospitals Regional emergency medical operation centers Incentives for hospitals Information campaign Establishing communication channels	1114 special flu clinics sharing 24% of influenza-like illness patient load in the emergency room and only 2.8 hospitals/day fully occupied.
Weddle, 2000 ¹⁸⁰ 1	Augment resources	Analysis of single real event Post-only Improve the efficiency of deployable military hospitals to supplement surviving local health care capabilities after disasters	Natural disaster: Hurricane	Use of deployable military hospitals	Analysis shows the need to improve communications while requesting resources, broaden the range of available health assets, position resources regionally or in the civilian sector, and create clear indications for full-scale deployable hospitals when they are required.
Wein, 2003 ¹⁸¹ US 4	Augment resources: Temporary staff	Computer simulation	Infectious disease: Anthrax	Expanding point of distribution and hospital surge capacity (e.g., by cross training and using non- hospital volunteers to extend trained personnel, and mobile servers from other federal agencies to provide hospital surge capacity) Aggressive and rapid antibiotic distribution	The Number of Deaths (relative to base case strategy of no or very delayed treatment) is a function of the speed of distribution - mass antibiotic distribution reduces deaths to 8.3% vs 44% if only symptomatic patients are treated. Deaths as a function of hospital capacity dramatically decreased with sufficient personnel (10-fold or more) and mobile servers (e.g., from other federal agencies)

Author, Year Location Critical Appraisal score*	Strategy Category	Study Type Study Design Study Description	Mass Casualty Event	Strategies	Findings
Etienne, 2010 ⁵⁷ Haiti 4	Crisis standards of care	Guideline and ethics committee N/A Multidisciplinary Healthcare Ethics Committee to determine allocation of resources	Earthquake	Ethics committee established guiding principles for ethic allocation of resources	Process enabled ethical decision making in a timely manner

*See Appendix D. ED emergency department, N/A not available, not applicable. Note that some studies addressed multiple strategies across categories (e.g., optimizing available and augmenting the existing resources) but they are listed under the main category and not included multiple times. Augmenting resources included strategies that added resources that are not typically available (e.g., adding volunteers, constructing temporary facilities). Optimizing resources included strategies that used available resources differently and that did not involve working outside of their typical work realm (e.g., using local labs for testing). Reducing/manage less urgent demand included strategies that primarily aimed to reduce the need for healthcare and visits to existing healthcare facilities (e.g., mass vaccination strategies, school closures).

APPENDIX D. Critical Appraisal

We used the same critical appraisal score and threshold as in the 2012 AHRQ report and assessed the following:

- Data collection
 - Empirical data has been collected and data collection was systematic (and if so, whether it was retrospective [1 point] or prospective [2 points])
- Strategy description
 - The level of detail used to describe the resource allocation strategy was adequate [1 point]
- Fidelity
 - Defined as the degree to which the strategy was implemented consistently [1 point]; fidelity was measured or could be inferred from the data provided; simulation studies were rated as not applicable
- Generalizability
 - Generalizability of the findings was addressed [up to 2 points]
- Confounders
 - Potential confounders to the strategy's effectiveness were discussed [up to 2 points].

Possible scores ranged from 0 to 8. The figure shows the score distribution across the included studies.

Figure D-1. Critical appraisal

