

Original Paper

A Systems Approach and Notional Response Model for Preserving the Health System during the COVID-19 Pandemic

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Abstract

During any pandemic, it has long been known that local jurisdictions would need to be self-sufficient with little or no outside assistance, particularly from the federal government. While all eyes have been on California, New York, and Massachusetts, the capacities of health systems in other states have yet to be put to the test. If there are subsequent waves of COVID-19 and other jurisdictions see significant increases in disease spread, the systems used to respond will become critical.

Using a review and synthesis approach, this article explores our collective experience and knowledge as it pertains to use of alternate care sites for dealing with the patient surge created by a disease outbreak. Probing the concept of alternate care site (ACS) systems reveals various types of alternate care sites that may be employed during an outbreak. The historical value of ACS models used during outbreak response are discussed. This culminates in the development of a notional response model and list of actions that should be taken by all jurisdictions as we prepare for additional waves of disease.

Keywords

Alternative Care Sites, surge capacity, disease treatment unit, neighborhood emergency help center, outbreak response model

1. Introduction

As the COVID-19 outbreak accelerates across the globe, increased attention is being focused on preserving the healthcare infrastructure while meeting excess demands created by the disease. At the time of this writing, the case numbers are reported to be plateauing in the United States (Today, 2020). The U.S. curve is based most heavily on New York and other hard-hit areas with intense transmission. There are at least two reasons that emergency planners and health system leaders should not lower their guard: first, the epidemic curves for each region and community will be different; while New York plateaus, other areas may still be closer to the beginning (Today, 2020). Second, outbreak histories of SARS and influenza have often included additional waves (Campbell, 2006; Centers for Disease Control and Prevention, 2018a). Therefore, it remains critical that planners and leaders continue to develop and enhance plans to preserve health systems during this pandemic.

On March 2, 2020, nearly 500 public health professionals and 14 organizations signed an open letter to Vice President Mike Pence and other officials outlining principles and practices underpinning a fair and effective response to the COVID-19 pandemic (Gonsalves et al., 2020). Among the first of these principles is an enhanced capacity to manage the surge in demand for healthcare resources in a way that protects both the healthcare workforce and patients. They recognized the “health system will face severe burdens under all plausible scenarios” (Altevogt, Stroud, Nadig, & Hougan, 2010; Gonsalves et al., 2020). The purpose of developing this surge capacity is to preserve medical resources for the duration of the outbreak while continuing to deal with causes of morbidity and mortality unrelated to the SARS-CoV-2 virus (Altevogt et al., 2010; Watson, Rudge, & Coker, 2013).

During this period it is likely that mortality from all causes will climb; having more than doubled during previous outbreaks (Madhave et al., 2017). During the 2014 Ebola outbreak in West Africa routine care encounters declined, causing an indirect death toll nearly equal to the direct death toll (Madhave et al., 2017). A 2013 study into the effects of the 2006 H1N1 influenza pandemic concluded mortality risk for stroke, congestive heart failure, and acute myocardial infarction found a significant increase (Rubinson et al., 2013). The outbreak has even caused instability in the nation’s blood supply (Mast, 2020; World Health Organization, 2020).

Mathematical modelling forecasted that millions of people will die from COVID-19. Clearly, the mechanisms used to respond will be critical if we are to minimize morbidity and mortality from all causes, while avoiding collapse of the system itself. While there is an abundance of information available for dealing with a patient surge resulting from conventional disasters, there is a dearth of information on strategies for infectious disease. The distinction is important - surges produced by outbreaks are qualitatively different, are prolonged, and are confounded by other factors.

2. Self-sufficiency of Local Jurisdictions

It has long been known that localities will need to respond to outbreaks with little or no support from the federal government (Denlinger, Marsh, & Rhode, 2007; Department of Homeland Security, 2009).

In 2006, the California Department of Health Services (2006), predicted local communities will be required to be self-reliant for an extended period due to expected inabilities of the federal government to provide support. Federal policy posited it will rely on public and private resources to meet pandemic preparedness, response, and recovery needs (California Department of Health Services, 2006; Delinger et al., 2007; Department of Homeland Security, 2009). Rapid consumption of resources nationwide created additional difficulties for local jurisdictions (Thompson & Van Gorder, 2007).

CDHS predicted the total need for hospital beds will, by week two of an influenza pandemic, exceed its surge capacity (California Department of Health Services, 2006). By week five it would have been exceeded by 319%, demand for critical care beds by greater than 1,200%, and ventilators by 1,300% (California Department of Health Services, 2006). In like manner, Ontario, Canada forecasted a surge of 1823 patients per day for six weeks and an increase in ICU usage by 171% (Christian et al., 2008). Delia and Wood (2008) projected 25 states would exceed bed capacity within two weeks of a significant influenza pandemic.

The U.S. Department of Health and Human Services' (DHHS) concluded that an event producing mass casualties similar to the 1918 pandemic "may render inoperable" the U.S. healthcare system (Agency for Healthcare Research and Quality, 2017; Arizona Department of Health Services, 2018; Cantrill, Pons, Bonnett, Eisert, & Moore, 2009). In 2006, then HHS Secretary Michael Leavitt stated "any community that fails to prepare with the idea that somehow, in the end, the federal government will be able to rescue them will be tragically wrong" (Inglesby, Nuzzo, O'Toole, & Henderson, 2006). Despite these warnings, hundreds of thousands of cases in the U.S., and over a million worldwide, local health systems and emergency management personnel across the nation remain unprepared for the COVID-19 surge.

3. Preparing for an Anticipated COVID-19 Patient Surge

Nowhere is the research – practice gap more evident than it is in public health emergency planning. Further, Schmoker avers, "the problem is not that we do not know enough, it is that we do not do what we already know" (Jackson, 2006). Contributing to this gap is the disparate nature of the evidence itself – coming from multiple angles of scientific inquiry and published in journal disciplines ranging from *Manufacturing & Service Operations Management* to the *Journal of Theoretical Biology*. The disparate nature of this literature makes it difficult for local jurisdictions to plan for surges created by pandemics (California Department of Health Services, 2006; Denlinger, Marsh, & Rhode, 2007).

Recognized strategies enable facilities to increase care capacity by up to 30% while surging-in-place (Hick et al., 2006; Schultz & Koenig, 2006; Wisconsin Department of Health Services, 2015). Such strategies have included canceling elective procedures and admissions, reverse triage, and providing care in flat spaces such as parking lots, hallways, entry lobbies, classrooms, and cafeterias (Hick et al., 2006; Schultz & Koenig, 2006; Wisconsin Department of Health Services, 2015). Utilizing these strategies following the 9/11 attack on the Pentagon, four hospitals with a total of 1500 beds were able

to free up an additional 343 beds and 43 surgical suites within three hours to accommodate victims (Hick et al., 2006). These strategies, however, are not always generalizable to outbreak scenarios because: a) caring for patients in hallways may amplify disease spread, and b) patients with disease may require more than brief periods of time. The Health Resources and Services Administration (HRSA) released a benchmark for surge capacity during an infectious disease outbreak of a minimum of 500 beds per million residents (Delia & Wood, 2008).

4. Healthcare Coalitions and the Need for a Systems Approach

A disease outbreak is felt by the whole of society; no single organization can effectively prepare as a solitary endeavor (Agency for Healthcare Research and Quality, 2017; World Health Organization, 2014; World Health Organization, 2009). Planning and preparedness efforts that do not recognize the interdependent nature of all system partners will result in an uncoordinated response (World Health Organization, 2014; World Health Organization, 2009). The COVID-19 response requires unity of effort - from the nation's highest office to individual citizens (White House Office of Intergovernmental Affairs, 2020).

A healthcare coalition represents a systems approach to COVID-19 and is defined as a formal collaboration among hospitals, public health, emergency management, emergency medical services, law enforcement, and non-government organizations that are required to respond to a catastrophic health event (Barbera & Macintyre, 2007, 2009). The goal of the healthcare coalition is to enhance system resiliency, surge capacity, and continuity of operations during such events (World Health Organization, 2014). A systems approach allows for the maintenance of operational capabilities while upholding an acceptable standard of care (World Health Organization, 2009). The total system is, in fact, the solution.

While the images from the 1918 influenza pandemic rightfully strike fear in the hearts of those responsible for surge planning, a *prima facie* analysis of images of alternate care sites (ACSs) used during the pandemic reveals that a number of persons who occupied beds were potentially capable of caring for themselves, as seen in Image 1. This point is further underscored by Dr. Isaac Starr's first-hand account, who reported that "many seemed to have sought admission chiefly because everybody in the family was sick and no one was left at home who could take care of them" (Staar, 2006). This does not need to be repeated with COVID-19, or any other disease outbreak, if systems and strategies are planned and executed by an organized, unified system.



Image 1. University of Kentucky Gymnasium during 1918 Influenza Pandemic. U.S. Library of Congress

While not delineated in this manner, the literature suggests an effective response system requires four basic capabilities that will be referred to as:

- 1) Enhanced assessment capability (EAC),
- 2) Enhanced isolation capability (EIC),
- 3) Enhanced quarantine capability (EQC), and
- 4) Enhanced treatment capability (ETC).

These capabilities can be addressed through ACS systems with the goal of keeping all who do not require critical care out from hospitals and clinics.

5. Alternate Care Site Systems (ACSS)

“Alternate care sites” (ACS) refer to any location outside of the normally operating healthcare system that are established for the purpose of addressing the outbreak. This includes any location where persons are monitored by health professionals or their appointees, such as the home care environment. This allows for a more wholistic consideration of alternate care as part of a larger “system”. An ACSS is a system of locations outside of hospitals and clinics established for the purpose of the treatment or monitoring of persons who are or may be infected with the disease in question. While the home is not the focus of this article, it is included because the preferred alternate location for both quarantine and isolation is at home on a voluntary basis (Centers for Disease Control and Prevention, 2019).

An ACS can include shuttered hospitals, closed hospital wards, or facilities of opportunities such as a veterinary hospitals, schools, warehouses, auditoriums, homes, or tents (Barbera & Macintyre, 2007,

2009; The Joint Commission, 2006). In addition to reducing the strain on hospitals, a major benefit of community-based alternate care site systems is that they allow public health interventions to reach much more of the population sooner (Logan et al., 2014).

5.1 Closed (“Shuttered”) Hospitals as Alternate Care Sites

A shuttered hospital represents a better option than a school or auditorium because they were designed and engineered for inpatient care, including life safety systems such as fire suppression equipment (Zane et al., 2008). Between 1983 and 2009, there were approximately 120 permanent and temporary hospital closures in five Southern California counties alone (Hospital Association of Southern California, 2010). Between 2010 and early 2019, over 102 rural hospitals in the U.S. have closed, and another 430 of the remaining 2,045 rural hospitals are considered closure risks (Ellison, 2019; Kacik, 2019). While there are consequences accompanying hospital closures, there is a positive side for emergency planners - a shuttered hospital can potentially provide hundreds of surge beds (Hassol & Zane, 2006).

During the 2003 outbreak of severe acute respiratory syndrome (SARS) in Toronto, Canada, a shuttered hospital was successfully utilized to care for healthcare workers (HCWs) who were infected while caring for SARS patients (Agency for Healthcare Research and Quality, 2005; Campbell, 2006; Zane et al., 2008). Scarborough Grace Hospital became the index hospital for the 2003 Toronto SARS outbreak (Campbell, 2006). On March 23, 2003 twenty-one of the hospital’s health workers reported being sick with fever, thereby creating an imminent hospital closure threat (Campbell, 2006). With other area hospitals nearing or at capacity, the hospital turned to West Park Healthcare Centre, which had shuttered an old TB unit three years prior (Campbell, 2006).

Public health personnel created a brief list of selection criteria for using a closed hospital to care for the HCWs (Campbell, 2006). The criteria included (in descending order of stated preference):

- 1) Negative pressure room with a closable door,
- 2) Single patient room with its own restroom facilities,
- 3) A place for cohorting patients in a building that is:
 - a. Isolated, and
 - b. Had an independent air handling system.

It is the final criterion that had been met by West Park. Selecting West Park was important because it exemplified what the AHRQ researchers identified as facilities that are “most likely candidates for surge capacity expansion” in their report *Use of former (“shuttered”) hospitals to expand surge capacity* (2005, p. 1). AHRQ criteria for candidate facilities include:

- 1) Recent shuttering, and/or part of a partially-shuttered hospital (Agency for Healthcare Research and Quality, 2005; Hassol & Zane, 2006).
- 2) Working facilities, and life safety systems whenever possible (Agency for Healthcare Research and Quality, 2005; Hassol & Zane, 2006).

- 3) A good location with easy access (Agency for Healthcare Research and Quality, 2005; Hassol & Zane, 2006).
- 4) Certain ownership (Agency for Healthcare Research and Quality, 2005; Hassol & Zane, 2006).

Combined, the lists represent a starting point for evaluating the potential suitability for use during an outbreak.

5.2 Other Alternate Care Sites

During this surge, multiple alternate care sites will be required, with each ACS likely having different functions. The literature supports that establishing and operating an ACS is a local responsibility (Florida Department of Health, 2013). However, there is minimal agreement on capabilities or services to be offered at an ACS during a surge following an infectious disease outbreak. The author's experiences confirm that services offered will vary greatly, and the resulting model will be shaped by the incident. The model and operational dynamics of ACSs established at ground zero following the collapse of the World Trade Centers on September 11, 2001 were very different from those following the 2010 earthquake in Haiti (Images 2 & 3).



Image 2. Alternate Care Site: Surgical Unit in Haiti Following 2010 Earthquake. Photo: James F. Goss



Image 3. ACS Established at Ground Zero Following Attack on 9/11/2001. Local Deli Converted to Provide Emergency Care. Photo: James F. Goss

There are five basic ACS types that can be derived from the literature.

- 1) Primary Triage Point (PTP): The purpose of the PTP is to determine which patients should be cared for in a hospital, be sent home, or be cared for at an ACS (Cantrill, 2009; BCSF Partners, 2020; Braintree Solution Consulting, Inc., 2010; California Department of Public Health, 2007).
- 2) Low-Acuity Patient Care (LAPC): This type can be used to relieve hospitals of low acuity patients during the reverse triage process, or can be used for infected patients who require minimal care (Cantrill, 2009; BCSF Partners, 2020; Braintree Solution Consulting, Inc., 2010; California Department of Public Health, 2007).
- 3) Community-focused ambulatory care clinic (C-FACC): In the context of COVID-19, this type can be used for mass vaccination or as a prophylaxis point of distribution (POD) (Cantrill, 2009; BCSF Partners, 2020; Braintree Solution Consulting, Inc., 2010; California Department of Public Health, 2007).
- 4) Disease treatment unit (DTU): This can be compared to the Ebola treatment unit (ETU) used in West Africa during the 2014-2015 Ebola outbreak or disease-specific treatment centers used in China in its response to SARS in 2003 and now COVID-19 (Abramowitz et al., 2015; Chowell & Viboud, 2015; Sterk, 2008; UN Children's Fund, 2014; Washington & Meltzer, 2015; World Health Organization, 2014). This type of ACS may have specific design characteristics, such as one way foot traffic, and the most stringent infection control measures in place to minimize risk to healthcare workers (Abramowitz et al., 2015; Chowell & Viboud, 2015; Sterk,

2008; UN Children’s Fund, 2014; Washington & Meltzer, 2015; World Health Organization, 2014).

5) Community care centers (CCC): Discussed in greater detail below, these centers serve to sequester those who were exposed but are not yet showing signs of infection, or they may be utilized to isolate those who are infected when they are able to care for themselves but cannot be isolated at home (Chowell & Viboud, 2015). Alternatively, they could serve to capture DTU overflow (Abramowitz et al., 2015; Chowell & Viboud, 2015; Sterk, 2008; UN Children’s Fund, 2014; Washington & Meltzer, 2015; World Health Organization, 2014).

The U.S. Army conceptualized a Neighborhood Emergency Help Center (NEHC) that is scalable and intended for use as a primary triage point (Church, 2001). Conceptually, it can also be used as an LAPC or C-FACC because it is scalable - staff and beds can be added in modules (Church, 2001).

6. Community Care Centers

Those who are unable to quarantine or isolate themselves, and do not need assistance, can be temporarily housed in locations generally known as community care centers. During the Ebola emergency 2014-2015, the demand for hospital beds and safe isolation outpaced the hospital’s ability to accept and treat new patients. In response, the WHO and its partners communicated the Community Care Center (CCC) concept (Washington & Metlzer, 2015). The CCC was designed to facilitate what UNICEF labeled a “big tent approach” to community-based infectious disease control and prevention (World Health Organization, 2014). All who may have expressed any symptoms of Ebola could seek care in the CCC in an effort to identify, isolate, and remove potentially infected individuals from the community (Abramowitz et al., 2015; Chowell & Viboud, 2015; Sterk, 2008; UN Children’s Fund, 2014; Washington & Meltzer, 2015; World Health Organization, 2014). A study found that CCCs averted 4,487 cases of Ebola and when combined with the definitive care offered by Ebola Treatment Units contributed to a reduction of new cases by 9,097 as illustrated in Figure 1 and Table 1 (Washington & Meltzer, 2015).

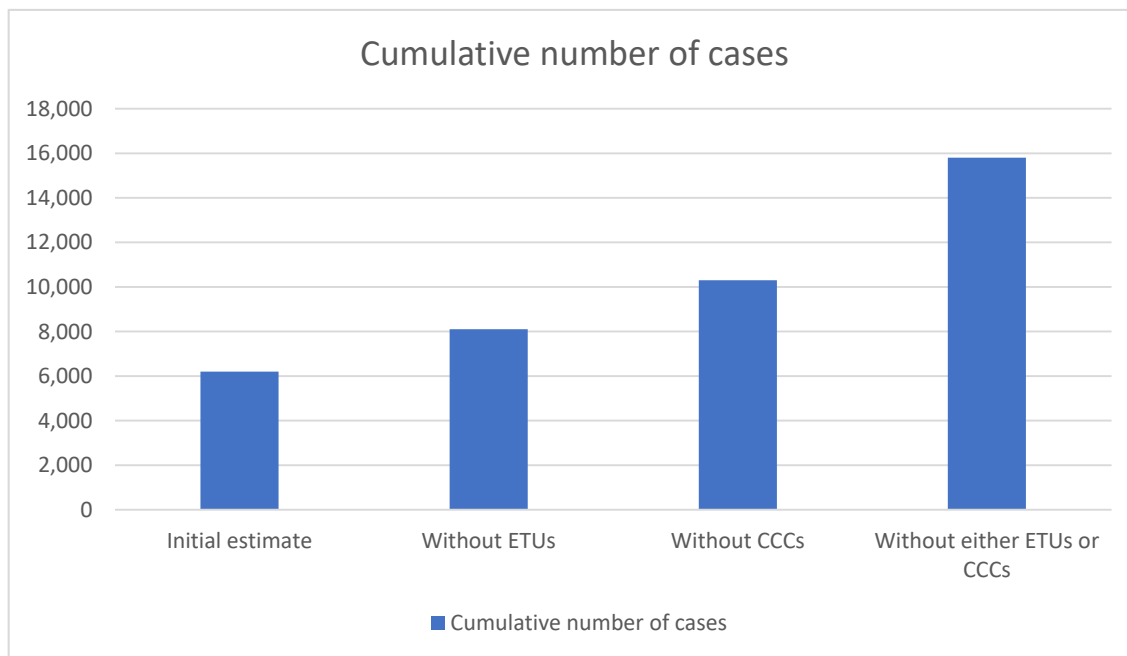


Figure 1. Approximations of the Cumulative Number of Ebola Cases with and without Ebola Treatment Units and Community Care Centers in Liberia between September 23-October 31, 2014. (From Washington & Meltzer, 2015, p. 68.)

Table 1. An Estimate of the Number of Cases of Ebola that were Prevented per 1% Increase in Patient Population in ETUs and CCCs in Liberia between September 23 – October 31, 2014 (From Washington & Meltzer, 2015, p. 69)

Patient care category	Number of cases prevented	Number of cases prevented per 1% increase in patient population*
Ebola Treatment Units	2,244	112
Community Care Centers**	4,487	128
Patients in either ETUs or CCCs	9,097	165

*This assumes a linear correlation between prevented cases and the population of ETUs and CCCs.

**For CCCs, equivalent community settings were also considered, to include safe burial and community-based programs.

7. A Notional Response Model

Based on the literature, a notional model of a systems approach to a surge during this outbreak has been proposed below. In the model of an alternate care site system (ACSS), shown in Figure 2, hospital capacity has been exceeded and patients enter the ACSS. In this model, an NEHC acts as a primary triage point providing low-acuity (non-disease related) patient care (Church, 2001). A disease treatment unit and two community care centers are established nearby. One CCC is used for isolation of infected

persons who require little or no care, and one is utilized for the quarantine of those who cannot remain home during the quarantine period. A telemedicine module is set up between the NEHC and community care centers to assure communication between volunteers and the healthcare workers who are overseeing the CCCs from the NEHC.

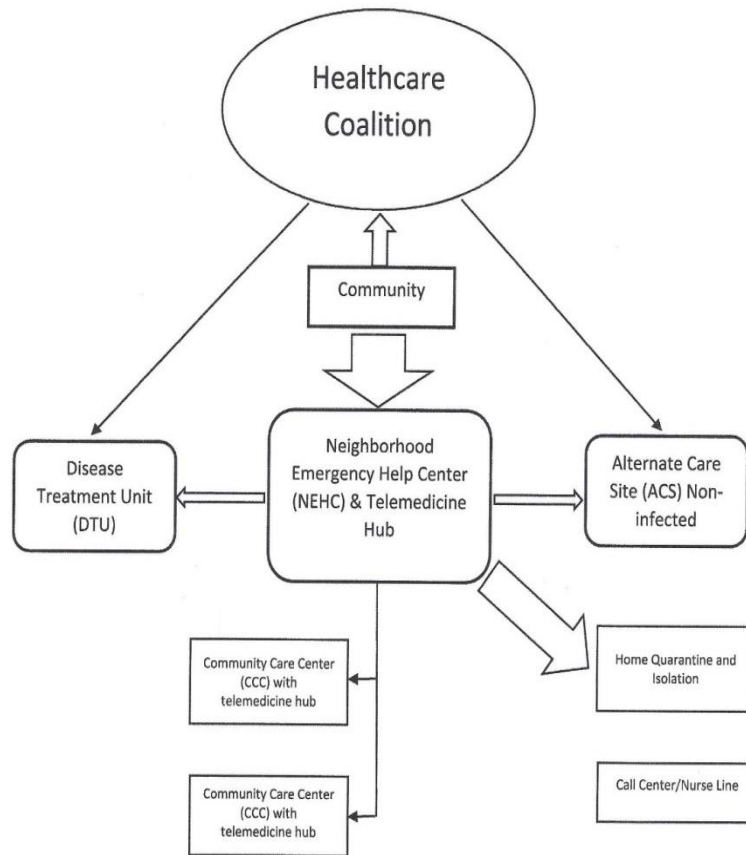


Figure 2. Conceptual Model of Alternate Care Site System during an ODHC. The Majority of Patients Can be Diverted to the PTP, Which is Represented Here as an NEHC. Ideally, Those Requiring Critical Care are Transported Directly from the Community to Hospitals within the Healthcare Coalition. From There, They are Distributed to the Various Parts of the ACSS

In this model, the goal is to divert the majority of patients expressing certain symptoms and the worried well away from coalition hospitals toward the NEHC. Low acuity patients requiring short term care and/or observation can be held at the NEHC. Non-infected patients who are of lower acuity can be sent to an ACS intended for such patients. Otherwise, patients are distributed to the home, the DTU, or one of the CCCs.

Again, a home care program is emphasized because home quarantine and isolation are more likely to be successful if supported by volunteer and medical outreach programs (DiGiovanni, Conley, Chieu, & Zabarsky, 2004). Jurisdictions may consider using paramedics for home testing and follow-up in the home during outbreaks (Glauser, 2020).

8. Critical Steps to Take Now

In a March 27, 2020 letter to emergency managers, the FEMA Administrator requested several critical actions be taken immediately (Gaynor, 2020). These include the following:

1. Create a healthcare coalition if one does not already exist. Do this by bringing together emergency managers, public health, first responders, and all communities of interest (Gaynor, 2020).
 - a) Create an alternate care site committee or team (ACSC) (World Health Organization, 2019).
2. Inventory health system capacity (Gaynor, 2020; Dayton et al., 2006):
 - a) Identify standard capacity by inventorying beds under the categories of isolation, critical care, and other (Gaynor, 2020; Dayton et al., 2006).
 - b) Determine enhanced hospital capabilities through administrative and engineering controls (Barbera & Macintyre, 2007).
3. Project requirements for different scenarios (Dayton et al., 2006). Determine the patient number that will be created by each scenario and create a chart of bed availability to each capacity (Dayton et al., 2006). Table 2 represents an example chart to determine enhanced isolation capacity (EIC) needs for a scenario "X".

Table 2. Notional Capacity Chart. Consider Completing for Each Scenario (e.g., Severe or Moderate Outbreak) and for Critical Care and Isolation

	Hospital A	Hospital B	Hospital C	Totals
Projected Patient Number Requiring Care During Isolation (Scenario X)				
- Standard isolation capacity				
- Enhanced hospital isolation capability*				
Enhanced isolation capacity (EIC) needs				

*Enhanced hospital isolation capability represents the number of additional isolation beds that can be created in the hospital through engineering, administrative, and other controls.

4. Develop strategies to enhance capabilities through an ACSS: Identify locations as well as desired capacities and capabilities of alternate care sites (Gaynor, 2020).
5. Be creative. Identify or implement help lines. Lines can be staffed by those capable of dealing with crises such as airline flight crew, school nurses, and psychiatric professionals (Campbell, 2006). They can be supervised by licensed and practicing medical professionals (Campbell, 2006).
6. Place emphasis on home quarantine and care. Enlist the help of food delivery and other volunteers to provide support (Ekisin, Keskinocak, & Swann, 2013).
7. Develop protocols for community and system paramedics to conduct COVID-19 testing at home and follow-up on persons identified as needing follow-up by public health personnel (Gaynor, 2020).

9. Summary

As the COVID-19 pandemic continues to exhaust medical systems across the globe, emergency healthcare planners can take this time to improve preparations, current response system conceptualizations, and identify lessons learned to apply to future pandemics. While this pandemic is not currently producing case rates as high as the 1918 Spanish Flu, emergency planners can easily see the threat posed to healthcare infrastructure by a large outbreak. Local systems need to be independently prepared to protect their communities during epidemics through a systems approach.

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