CHEST

Business and Continuity of Operations

Care of the Critically Ill and Injured During Pandemics and Disasters: CHEST Consensus Statement

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BACKGROUND: During disasters, supply chain vulnerabilities, such as power, transportation, and communication, may affect the delivery of medications and medical supplies and hamper the ability to deliver critical care services. Disasters also have the potential to disrupt information technology (IT) in health-care systems, resulting in interruptions in patient care, particularly critical care, and other health-care business functions. The suggestions in this article are important for all of those involved in a large-scale pandemic or disaster with multiple critically ill or injured patients, including front-line clinicians, hospital administrators, and public health or government officials.

METHODS: The Business and Continuity of Operations Panel followed the American College of Chest Physicians (CHEST) Guidelines Oversight Committee's methodology in developing key questions regarding medication and supply shortages and the impact disasters may have on healthcare IT. Task force members met in person to develop the 13 key questions believed to be most relevant for Business and Continuity of Operations. A systematic literature review was then performed for relevant articles and documents, reports, and gray literature reported since 2007. No studies of sufficient quality were identified upon which to make evidence-based recommendations. Therefore, the panel developed expert opinion-based suggestions using a modified Delphi process.

RESULTS: Eighteen suggestions addressing mitigation strategies for supply chain vulnerabilities including medications and IT were generated. Suggestions offered to hospitals and health system leadership regarding medication and supply shortages include: (1) purchase key medications and supplies from more than one supplier, (2) substituted medications or supplies should ideally be similar to those already used by an institution's providers, (3) inventories should be tracked electronically to monitor medication/supply levels, (4) consider higher inventories of medications and supplies known or projected to be in short supply, (5) institute alternate use protocols when a (potential) shortage is identified, and 6) support government and nongovernmental organizations in efforts to address supply chain vulnerability. Healthcare IT can be damaged in a disaster, and hospitals and health system leadership should have plans for urgently reestablishing local area networks. Planning should include using portable technology, plans for providing power, maintenance of a patient database that can accompany each patient, and protection of patient privacy. Additionally, long-term planning should include prioritizing servers and memory disk drives and possibly increasing inventory of critical IT supplies in preparedness planning.

CONCLUSIONS: The provision of care to the critically ill or injured during a pandemic or disaster is dependent on key processes, such as the supply chain, and infrastructure, such as IT systems. Hospitals and health systems will help minimize the impact of medication and supply shortages with a focused strategy using the steps suggested. IT preparedness for maintaining local area networks, functioning clinical information systems, and adequate server and memory storage capacity will greatly enhance preparedness for hospital and health system clinical and business operations. CHEST 2014; 146(4_Suppl):e103S-e117S

ABBREVIATIONS: API = active pharmaceutical ingredient; IT = information technology

Summary of Suggestions

Supply Chain Vulnerabilities in Mass Critical Care

1. We suggest highest priority critical care supplies and medications needed for routine day-to-day care, and crucial in mass casualty events, for which no substitutions are available be identified (eg, ventilator circuits, N95 masks, insulin, etc). Once identified, dual sourcing should be used for routine purchasing of these key supplies and medications to reduce the impact of a supply chain disruption.

2. We suggest available alternatives for routinely used critical care supplies and medications (eg, sedatives, vasopressors, antimicrobials, etc) be identified in routine practice and pre-event planning to anticipate solutions to supply chain disruptions.

3. We suggest health-care systems use integrated electronic systems to track purchase, storage, and use of medical supplies.

4. We suggest these systems be used to identify equipment, supplies, and medications that are in short supply and for which increased routine inventory levels would be needed to adequately address both day-to-day and mass casualty event planning.

5. We suggest modified use protocols, which restrict routine use of affected medications and supplies and encourage use of alternatives, be implemented at the earliest opportunity when impending medication and medical supply shortages are identified, and for which adequate resupply may not be available in a timely manner.

6. We suggest health-care facilities, health systems, and health-care coalitions encourage, comply with, and support ongoing governmental and non-governmental organizational efforts to reduce global medical supply chain vulnerabilities.

Health Information Technology Continuity in Disasters

Portable Mobile Support Information Networks

7. We suggest hospitals have the mobile technology necessary to identify patients quickly and effectively, including in austere parts of the hospital (eg, parking lots).

8. We suggest hospitals have the ability to set up ad-hoc secure networks in austere sections of the hospital campuses for mobile technology.

9. We suggest hospitals have a strategy for supplying austere sites with electric power to charge the mobile devices, provide local network facilities, and provide essential services for an extended period of time.

10. We suggest hospitals be capable of transferring patient identification, identification of next of kin with contact information, and a defined minimal database of medical history with every patient. This minimal database of medical history should be able to be printed, or handwritten if necessary, in the absence of computer technology.

11. We suggest hospitals have the ability to effectively and quickly download all patient-related information into a mobile package (eg, a flash drive or disk) that can be easily read by other information systems, and can be rapidly prepared for transport with the patient. This should obey the clinical document architecture/continuity of care document documents currently specified under meaningful use proposals, making them both human and digitally readable.

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12. We suggest hospitals have real-time connection to databases for uploading and downloading clinical information.

13. We suggest hospitals have the necessary information technology (IT) functionality to store health information when hospital systems are not available, and be able to rapidly upload and download clinical information once connections are reestablished.

14. We suggest hospitals have the means to ensure confidentiality of all patient protected information.

15. We suggest patient information may be uploaded and stored in central, off site databases, similar to that used by the Veterans Administration system in the United States, and consistent with local health-care laws and regulation pertaining to patient privacy and protections.

Hospitals and Health-care IT Preparedness Planning

16. We suggest hospitals have a plan for rapid movement of the data center to offsite remote operations in the case of prolonged local power disruption for critical functions.

17. We suggest a plan be in place to provide power to the client machines, analyzers, networking equipment, etc along with the data center for an extended period of time.

18. We suggest hospitals plan around extended supply disruption of critical IT supplies, such as servers and disk drives.

Introduction

Business and Continuity of Operations in a disaster is a broad area; therefore, the task force chose to focus on medication/medical supply shortages and continuity of information technology (IT) operations, as they are both key issues affecting critical care patients identified by several of the topic groups (see "Evacuation of the ICU" article by King et al,[1] "Surge Capacity Principles" article by Hick et al,[2] "Surge Capacity Logistics" article by Einav et al,[3] "System Level Planning, Coordination, and Communication" article by Dichter et al,[4] and "Triage" article by Christian et al[5] in this consensus statement) as enablers.

Industrial globalization, including manufacturing of medications and medical supplies, has helped to increase production and reduce costs, allowing for the wide availability of products throughout the world.[6] However, as production now depends on the integration of increasingly interdependent global networks of raw materials, manufacturing, packaging, and distribution, globalization has also contributed to increased vulnerability of the medical supply chain to disruptions caused by natural and man-made events.[6-9] As such, there are steps health-care institutions should take to help prepare and account for potential medical supply chain disruptions, especially shortages of key critical care medications and supplies, regardless of the location of the disruption.[10]

Equally important, an intact IT information infrastructure is essential for any hospital or health system in providing patient care and financial accounting for services rendered, among other functions. Only 57% of hospitals have the ability to bring clinical systems back online within 24 h after complete loss of their primary data center.[11] If there is damage to off-site centers or cloud-based storage systems, recovery time will most certainly be longer. In a catastrophic disaster, such as the Haiti earthquake, effective clinical systems were instituted and functioning quickly using local networks, portable devices, and currently available software.[12,13] As part of IT disaster preparedness, hospitals and health systems should have the means to reestablish local networks with functioning information systems quickly and have plans for management of long-term IT storage if a disaster is prolonged.[11]

The suggestions in this chapter are important for all of those involved in a disaster or pandemic with multiple critically ill patients, including front-line clinicians, hospital administrators, and public health or government officials. Although it is important for all providers to be familiar with all aspects of business continuity, Table 1 provides an overview of the suggestions of most interest to each of the groups above.

Materials and Methods

The Business and Continuity of Operations panel followed the American College of Chest Physicians (CHEST) Guidelines Oversight Committee's methodology to develop suggestions, based on a consensus development process (see "Methodology" article by Ornelas et al[14] in this consensus statement). The Business and Continuity of Operations panel developed 13 key questions. (See e-Appendix 1 for key questions list, corresponding search terms and results, and data tables if sufficient evidence found). A systematic literature review was then performed for relevant articles and documents, reports, and gray literature reported since 2007 to 2012; English language papers were included, and non-English language papers were excluded. No studies of sufficient quality were identified upon which to make evidence-based recommendations. Therefore, the panel developed expert opinion-based suggestions using a modified Delphi process.

TABLE 1] List of Suggestions, With Recommended Category of Health-care Professionals for Which Each Set of Suggestions Is Intended

Suggestion Number	Primary Target Audience: Clinicians	Hospital Administrators	Public Health and Government
1	✓	✓	
2	✓	✓	
3	✓	✓	
4	✓	✓	
5	✓	✓	
6		✓	✓
7		✓	
8		✓	
9		✓	
10	✓	✓	
11	✓	✓	
12	✓	✓	
13	✓	✓	
14	✓	✓	
15		✓	
16		✓	
17		✓	
18		✓	

Results

Supply Chain Vulnerability in Mass Critical Care

1. We suggest highest priority critical care supplies and medications needed for routine day-to-day care, and crucial in mass casualty events, for which no substitutions are available be identified (eg, ventilator circuits, N95 masks, insulin, etc). Once identified, dual sourcing should be used for routine purchasing of these key supplies and medications to reduce the impact of a supply chain disruption.

2. We suggest available alternatives for routinely used critical care supplies and medications (eg, sedatives, vasopressors, antimicrobials, etc) be identified in routine practice and pre-event planning to anticipate solutions to supply chain disruptions.

3. We suggest health-care systems use integrated electronic systems to track purchase, storage, and use of medical supplies.

4. We suggest these systems be used to identify equipment, supplies, and medications that are in short supply and for which increased routine inventory levels would be needed to adequately address both day-to-day and mass casualty event planning.

5. We suggest modified use protocols, which restrict routine use of affected medications and supplies and encourage use of alternatives, be implemented at the earliest opportunity when impending medication and medical supply shortages are identified, and for which adequate resupply may not be available in a timely manner.

6. We suggest health-care facilities, health systems, and health-care coalitions encourage, comply with, and support ongoing governmental and non-governmental organizational efforts to reduce global medical supply chain vulnerabilities.

Periodic disruptions in medical supply chains can occur along the continuum of the manufacturing process from the availability of raw materials to final packaging and distribution.[15-18] Although large-scale disasters can result in large and far-reaching shortages of a wide array of manufactured goods, substantial supply chain disruptions can be caused by seemingly benign events, such as normal fluctuations in materials and labor or even a manufacturing platform upgrade.[7,15,18-22] An example of the dramatic impact of seemingly unrelated events on availability of medical supplies was the global shortage of medical examination gloves in the summer of 2008 due, in large part, to the temporary scheduled closure in China of one of the world's largest manufacturers of medical examination gloves in an effort to improve air quality during the 2008 Beijing Olympic Games.[23,24]

The increased global manufacturing interdependence also introduces quality assurance variability to medications and medical supplies.[7,25,26] Lapses in quality assurance have led to fatal hypersensitivity reactions caused by manufacturing defects in IV heparin and fatal fungal meningitis caused by contamination of IV methylprednisolone acetate.[27,28]

There have been fewer companies globally producing key components of medical supplies and of active pharmaceutical ingredients (APIs), most notably sterile, injectable medications.[7,15,29-34] The global reliance on fewer manufacturers may not be readily apparent to health-care institutions, as APIs are often reformulated, compounded, and packaged by several different companies, resulting in the finished product being available from several sources, despite the limited number of key ingredient manufacturers. As examples, a single plant in

Demark is the source for more than 40% of the world's supply of insulin; China is the API source for 90% of the world's vitamins and nutritional supplements, 70% of the world's penicillin, 50% of the world's aspirin, and 35% of the world's acetaminophen[25,35]; and Indian and Chinese companies supply 40% of the APIs used in US-made pharmaceuticals.[25] The US Food and Drug Administration and American Society of Health-System Pharmacists both maintain updated lists of medication shortages that are available online (http://www.fda.gov/drugs/drugsafety/drugshortages and http://www.ashp.org).

In critical care medicine, supply chain vulnerabilities have already resulted in many key medication shortages, including antimicrobials, sedatives, vasopressor medications, and anesthetics (Table 2, e-Table 1).[19,36-44] These shortages are not due to disasters, and, hence, when disasters occur, they will exacerbate these preexisting vulnerabilities.

When medication shortages occur, alternative agents are often used, but they are often associated with suboptimal results or adverse events.[9,17,19,21,36,40,42,45-48] Reasons attributed to inferiority of these substitutes include a lack of familiarity with the substituted medications, inherent increased toxicity of the alternative agent, and others, such as increased antimicrobial resistance rates. Even when substitutions can be made without immediate clinical consequences, they may lead to increased costs or use of a branded medication and a substantial increased time and effort by providers, pharmacists, and hospital administrators to address shortages.[9,38,41,45,49-51]

Large-scale assessments of medication and medical supply chain vulnerability and shortages have been undertaken to help inform US national policy as well as institutional preparedness. Although these assessments were undertaken in the United States, the results and conclusions can be generally applied to other nations and provide important perspectives for future preparedness (Table 3).[52,53]

Although the long-term problem of medication and medical supply chain vulnerability is recognized and addressed by national governments, international cooperatives, nonprofit organizations, manufacturers, and others, individual health-care facilities and systems can use six strategies to prepare for and mitigate the impact of medication and medical supply shortages when they occur.[54] These strategies form the foundation for supply chain vulnerability suggestions and are particularly important when considering the abrupt nature of mass critical care events; they are summarized here and in Table 4.

- Strategy 1: Routine purchasing of key critical care supplies and medications from more than one supplier may minimize the impact of a drug shortage as well as having clinical familiarity with the other suppliers' product. For most drug shortages there are alternative manufacturers or suppliers available.
- Strategy 2: Pre-event planning should be tailored at individual health-care facilities to identify commonly used critical care products and alternatives for which providers at the facility already have some degree of familiarity. To limit adverse events, it is preferable to use alternative products already in use and familiar to health-care workers rather than similar product alternatives with which they may have little experience. As such, determining alternative agents in pre-event planning requires multidisciplinary provider engagement.
- Strategy 3: Use of computer systems that integrate purchasing, storage, and use of medical supplies through technologies such as radio-frequency identification or other bar code system will allow a health-care facility to assess its real-time inventory and use of medications and medical supplies.[55-61] The ability to track medication and supply levels in real time will alert a facility to predictable patterns of increased use (eg, increased use of masks during influenza season) and provide information on how much inventory is on hand at any given time.
- Strategy 4: Once a facility's medical product and storage levels are elucidated, anticipated critical product need during potential mass critical care events may be estimated to ensure that sufficient inventories are maintained and readily available. Given financial imperatives to maintain just-in-time inventories, essential supplies and medications should be prioritized for increased routine inventories.[62] Increased purchasing should be incremental rather than bulk, both to minimize expense and avoid sudden demand on an already vulnerable supply chain.[63] Stockpiling by individual institutions should be avoided during shortages, as it creates strain at a regional level, and hospitals and health systems will be well served by addressing stockpiling at the health-care coalition/regional health authority level (see "System Level Planning, Coordination, and Communication" article by Dichter et al[4] in this consensus statement).[54] For products known to be in short supply, hospitals and health systems should consider assigning priority (eg, normal, low, critically low) based on their actual and projected level of availability.[54,59]

TABLE 2] Shortages of Critical Care Medications in the United States 2010 to 2013 by Medication Category

Medication Category	No. of Medications in Shortage	No. of Medication Shortages Resolved	Medications in Shortage for Which No Alternative Source/Formation Was Available	Medications in Shortage: Representative Examples[a]
Analgesic	8	3	1	Fentanyl injection
				Hydromorphone hydrochloride injection
				Ketorolac tromethamine injection
				Oxycodone immediate release tablets and capsules
Antiinfective	53	24	11	Acyclovir capsules and tablets, and topical cream, ointment
				Ampicillin sulbactam
				Azithromycin injection, and suspension
				Aztreonam injection
				Cefazolin injection
				Cefotaxime injection
				Ceftazidime injection
				Ciprofloxacin injection and immediate-release tablets
				Clindamycin injection
				Doxycycline hyclate injection
				Fluconazole injection
				Levofloxacin injection
				Meropenem injection
				Metronidazole injection, tablets, and capsules
				Nafcillin sodium injection
				Oseltamivir phosphate oral suspension
				Sulfamethoxazole/trimethoprim injection
				Vancomycin hydrochloride injection
Antiinflammatory	5	0	0	Methylprednisolone acetate injection
				Prednisone tablets
Cardiovascular	26	6	2	Adenosine injection
				Amiodarone hydrochloride injection
				Atropine sulfate injection
				Digoxin injection
				Diltiazem injection
				Dobutamine injection
				Enalaprilat injection
				Epinephrine 0.1 mg/mL emergency syringes and injection
				Esmolol injection
				Hydralazine injection

(Continued)

TABLE 2] *(continued)*

Medication Category	No. of Medications in Shortage	No. of Medication Shortages Resolved	Medications in Shortage for Which No Alternative Source/Formation Was Available	Medications in Shortage: Representative Examples[a]
				Labetalol injection
				Metoprolol injection
				Nicardipine hydrochloride injection
				Nitroglycerin injection
				Norepinephrine injection
				Phenylephrine hydrochloride injection
				Vasopressin injection
Coagulation	9	5	3	Argatroban injection
				Enoxaparin injection
				Heparin sodium injection
				Phytonadione (vitamin K) injection
				Protamine sulfate
				Warfarin sodium tablets
Diuretic	4	0	1	Furosemide injection
				Torsemide injection
Gastrointestinal	4	1	0	Famotidine injection
				Octreotide injection
				Pantoprazole injection
Neurologic	6	2	1	Fosphenytoin injection
				Levetiracetam injection
				Phenytoin injection
				Valproate sodium injection
Nutrition/electrolyte	7	0	3	Amino acid products with electrolytes in dextrose with calcium (Clinimix E)
				Calcium chloride and gluconate injections
				Magnesium sulfate injection
				Potassium chloride injection
Paralytic	5	0	1	Atracurium injection
				Pancuronium injection
				Rocuronium injection
				Succinylcholine chloride injection
				Vecuronium bromide injection
Sedative	7	0	1	Diazepam injection
				Etomidate injection
				Lorazepam injectable presentations
				Midazolam injections
				Propofol injection
Other	6	4	1	Naloxone injection
				Ondansetron injection
Total	140	45	25	...

Data from Reference 44.
[a]See e-Appendix 1 for complete list.

TABLE 3] Summary, FDA Review of Medication Shortages From 2001 to 2011, With the Number of Medication Shortages Steadily Increasing From 61 in 2005 to 178 in 2010,[52] and the Bureau of Industry and Security Office of Technology Evaluation at the US Department of Commerce Report Released in December 2011 Evaluating the Reliance on Foreign Sourcing for Medications and Medical Supplies[53]

Key Shortage, Supply Disruption, Product Area, or Strategy	Implications
Injectable medications, breakdown of shortages by drug class. Evaluation of shortages between January 2010 and August 2011 found that sterile injectable medications composed the vast majority (80%) of drug shortages. Tablet and capsule medications composed 10%, and other routes of administration (eg, transdermal, inhalation, suspension/solution) composed the remaining 10%.[52]	28% were chemotherapeutic agents.
	13% were antimicrobials.
	11% were electrolyte/nutrition medications.
	9% were neuromodulators.
	6% were hormonal medications.
	33% were of drug classes with five or fewer shortages.[52]
Injectable medication shortages, market implications	In 2010, the top three manufacturers held 71% of the generic injectable medication market, and the top five manufacturers held 80% of the market.[52]
	There were 342 injectable molecules for which a single manufacturer held > 90% of the market share and 451 injectable molecules for which only two manufacturers held > 90% of the market share.[52]
	Factors contributing to sterile injectable drug shortages include a paucity of manufacturers, the need for specialized facilities for dedicated production lines, and a change on the part of medical facilities toward the use of just-in-time inventories.[52]
Primary reasons for disruption in medication production and supply. This includes the factors identified at right, with the FDA's concluding that the "problem of medical product shortages is complex and stems from economic, legal, regulatory, policy, and clinical decisions that are deeply connected."[52]	43% were related to problems at the manufacturing facility.
	15% were due to delays in manufacturing or shipping.
	10% were due to API shortage.
	8% were due to business decisions to discontinue production.
	5% were due to loss of manufacturing site.
	4% were due to non-API component shortage.
	4% were due to increase in demand.
	2% were due to improper labeling.
	9% were due to other/unknown causes.[52]
Top *medication product areas* for which critical components, materials, or products were from non-US suppliers: includes many medications used commonly in critical care medicine, including insulin, imipenem, clindamycin, lidocaine, hydrocortisone, hydrochlorothiazide, ibuprofen, and acetaminophen.[53]	33% had no alternative source available.
	33% had a different non-US alternative source available.
	4% had a US source available.
	13% had both a US source and a non-US source available.[53]

(Continued)

TABLE 3] *(continued)*

Key Shortage, Supply Disruption, Product Area, or Strategy	Implications
Top *medical supply product areas*, for which critical components, materials, or products were from non-US suppliers: includes those used in critical care such as infusion/IV pumps, defibrillators, pacemakers, medical needles, syringes, sterilizers, oxygen analyzers, and IV catheters.[53]	44% had no alternative US source.
	17% had a different non-US alternative source available.
	10% had a US source available.
	23% had both a US source and a non-US source available.[53]
Implications of "just-in-time inventory" strategies now routinely used by hospitals	10% of health-care facilities maintain <1 mo of inventory of medications and medical supplies.
	76% of health-care facilities maintain 1-3 mo of inventory of medications and medical supplies.[53]

API = active pharmaceutical ingredient; FDA = US Food and Drug Administration.

- Strategy 5: Once an impending medication or supply shortage is identified, health-care facilities should institute protocols to encourage the use of alternative products whenever possible and to restrict use of the product in shortage such that it is only used when there is no available alternative or when the use of alternatives is prohibited due to substantial differences in efficacy or toxicity.
- Strategy 6: Health-care facilities and the health-care industry should support ongoing efforts from policy makers and national and international governmental and nongovernmental organizations to reduce supply chain vulnerability in medical supplies and medications. Interventions currently considered include requirement of early reporting of anticipated shortages or manufacturing difficulties, expedited review of alternative manufacturing processes, providing incentives to manufacturers to produce critical medical products, requiring regulatory approval for manufacturing redundancies in sourcing and production, and improving communication between manufacturers and regulatory authorities.[7,21,25,30,34,64-70]

TABLE 4] Summary of Six Key Strategies Hospitals Can Use to Prepare for and Mitigate the Effects of Supply Chain Vulnerability

Strategy	Task Force Suggestion, Summary
1	The purchase of key medications and supplies should ideally be from >1 supplier
2	Substituted medications and supplies should ideally be similar to those already used by an institution's providers
3	Inventories should be tracked electronically to monitor medication and supply levels
4	Consider maintaining higher inventories of medications and supplies known or projected to be in short supply
5	Institute alternate use protocols as soon as a known or potential medication or supply shortage is identified
6	Support government and nongovernmental organizations in efforts to address supply chain vulnerability

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7. We suggest hospitals have the mobile technology necessary to identify patients quickly and effectively, including in austere parts of the hospital (eg, parking lots).

8. We suggest hospitals have the ability to set up ad-hoc secure networks in austere sections of the hospital campuses for mobile technology.

9. We suggest hospitals have a strategy for supplying austere sites with electric power to charge the mobile devices, provide local network facilities, and provide essential services for an extended period of time.

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15. We suggest patient information may be uploaded and stored in central, off site databases, similar to that used by the Veterans Administration system in the United States, and consistent with local healthcare laws and regulation pertaining to patient privacy and protections.

Hospitals IT systems can be affected to varying degrees, from being physically intact but surging to accept large numbers of patients, to partial infrastructure damage but functioning, and, finally, to (near) complete loss of infrastructure (Table 5).[71] In disasters requiring significant hospital surge where infrastructure and IT systems are intact, all that may be required is an extension of existing network capability and power to clinically unused or austere areas of an hospital (eg, parking lots) using available networking equipment, portable hardware, and software.

Patient care and billing functions are top information priorities for all hospitals and health systems, and when

TABLE 5] Technology Required to Maintain Information Systems Under Different Levels of Disasters

Level of Disaster	Likely Level of Technology	Suggestions
External to health care: such as 9/11 or Boston Marathon bombing	Although the hospital may experience a surge of patients, hospital operations are fully operational	Ability to flow hospital functions to overflow, possibly austere areas (parking lots, lobbies, and so forth). These areas essentially form an operational ward of the hospital, requiring networking and power (long extension cords) and potentially capable of full system functionality, and may need to be EHR defined in advance.
		Power is often more of a problem than networking, as wireless networks can cover large areas, and power is often scarce.
		May be simulated by placing systems in these areas and load testing them.
Hospital affected directly: such as Hurricane Sandy[71]	Hospital systems affected, and hospital will be working without all usual systems	Patients likely need to be evacuated to distant sites, and records must be transferred.
		Computerized record transfer preferable; paper records may be required.
		While transfer in process, contingency systems must be able to sustain the limited operations possible.
Massive regional disaster: Hurricane Katrina, Haiti earthquake	Hospital operations completely offline, and care is being delivered in (field) hospitals under possible “battlefield” conditions	Portable, self-powered solutions may provide basic support for registration, tracking, and simple documentation.[6]

EHR = electronic health record.

hospital infrastructures are damaged or otherwise unavailable, we suggest planning and preparing for a portable mobile-support information network. The investment of resources and time for this level of preparedness may best be accomplished at the health-care coalition/regional health authority level (see "System Level Planning, Coordination, and Communication" article by Dichter et al[4] in this consensus statement).

Wireless local area networks are suggested, as they may be less vulnerable to damage, can be used for monitoring patients and for high-speed data applications (eg, picture archiving and communication system), and are capable of supporting most portable or handheld hardware (Fig 1).[12,72,73] Cellular-based solutions may be less preferred, as cellular networks are not available in all circumstances.[72]

There are no ready-made disaster network solutions, but effective network communication systems have been implemented under actual disasters and in training exercises.[13,72,74,75] An example implemented after the Haiti earthquake in 2010 was a field hospital that used laptop computers with a wireless local area network powered by gas generators, which was operational within 6 h after arrival; a wired network was added within 48 h and was capable of managing data-intensive applications, such as picture archiving and communication systems.[13] Generators may maintain electrical power even under extreme circumstances,[12,71,76] but plans for alternative power sources should include sufficient battery power, or possibly even solar power. In any dire circumstance, providing available power for immediate clinical needs must be balanced with the benefit of maintaining a functioning information network.

Patient identity and tracking may be done using paper bar-coded or electronic tags, which may carry some information, or be dependent on mobile provider handheld technology, and can be used to electronically input patient data and used for tracking.[72,73,77] Other portable IT software applications are available, are faster than paper in entering patient information completely and accurately, and are effective for patient monitoring and tracking and useful for improving initial triage functions.[72,73,78]

For providers, easily portable equipment is preferred, although potential limitations include short battery life,

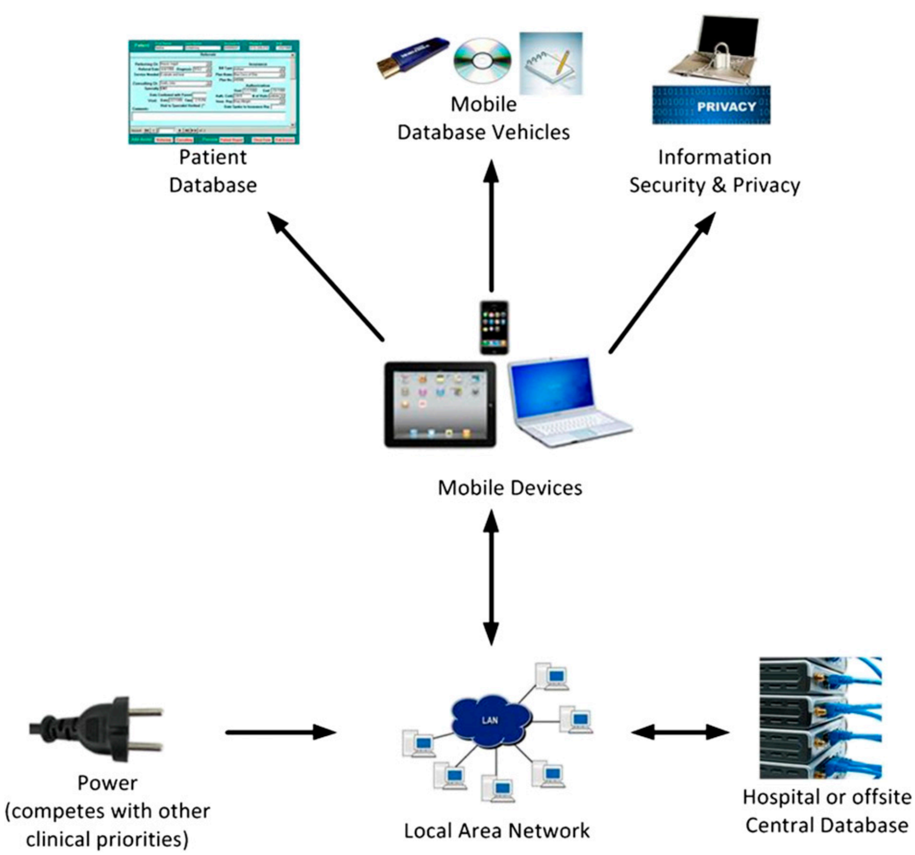

Figure 1 – *Information technology/information priorities, including secure local area networks and mobile devices, and transferrable patient data.*

bulky size, difficulty of data input under disaster circumstances, and cost.[12,72] Provider familiarity with equipment and software is also an important consideration, and technology choices should focus on equipment already familiar and/or software that is easy to learn and, perhaps, already routinely used.[12,72]

For these reasons, we strongly suggest setting up emergency networks that use consumer products, including laptop computers, "smart" cell phones, and electronic note pads, among others.[12,73] The power of consumer mobile computing devices now rivals traditional desktop computers. They are ideal devices for use during mass casualty events because of high mobility and built-in network capability, low cost, and very low power usage. They are already owned and routinely used by most hospital staff and are quite rugged, surviving daily usage in unprotected settings. Although not traditionally managed by the hospital's IT protocols, they are a large reservoir of readily available portable technology with low capital investment.

The information priorities established by the task force under these circumstances are:

- Have the necessary portable hardware and software functionality to store health information when hospital systems are unavailable, and being able to upload information when systems are again online.
- Track basic patient information, including patient demographics with next of kin with contact information, and a defined minimal database of medical history that can be transferred with every patient to other points of care (see the "Evacuation of the ICU" article by King et al[1] in this consensus statement).
- Store this information electronically on a portable medium such as a compact disk or USB-flash drive. USB-flash drives are preferred, as they are ubiquitous, inexpensive, rugged, and readable by virtually every modern computer. Patient data require little memory, and very small capacity drives (1-2 gb) can be used, which in bulk represents a tiny investment. Use of standard software, such as the Clinical Document Architecture Release 2,12 allows records to be computer- and human-readable on any modern browser without special software and helps ensure security and privacy. Although electronic technology is preferred, experience has shown that during disasters patient information must at times be handwritten. A plan for centralizing and cataloging paper records in disaster-safe mode should be in place (see the "Evacuation of the ICU" article by King et al[1] in this consensus statement).
- Ensure confidentiality of patient information. Although protecting private patient information may pose risk under difficult circumstances, the benefit of sending each patient's important information with him/her during transport outweighs this risk.
- Store patient information in off-site databases if disaster-related circumstances require.

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16. We suggest hospitals have a plan for rapid movement of the data center to offsite remote operations in the case of prolonged local power disruption for critical functions.

17. We suggest a plan be in place to provide power to the client machines, analyzers, networking equipment, etc along with the data center for an extended period of time.

18. We suggest hospitals plan around extended supply disruption of critical IT supplies, such as servers and disk drives.

When a disaster directly damages a hospital's facilities, direct damages to the IT infrastructure are likely, as well as to local utility and transportation networks. Continuity of operations will require both onsite and offsite redundant systems. Hospitals are required to have 72 h of onsite power generation capability; however, although in an extended disaster this is insufficient, extended-capacity systems are not required by the Joint Commission on Accreditation of Health-Care Organizations and are unlikely to be installed because of current financial pressures on hospitals.[79] If local transportation networks are affected, difficulties may occur in obtaining sufficient quantities of diesel fuel to run generators[80] as well as transport fuel where it is needed.[71]

In addition, supply chain interruptions may affect hospital IT functions. The floods in Bang-Pa, Thailand, in 2011 impacted worldwide availability of hard drives, as all three hard-disk world manufacturers are located within a kilometer of each other; although one of the manufacturers was spared, the flood still resulted in a 66% reduction in worldwide hard-disk supply overnight and a 2-year period of insufficient supply.[81] Stocking of IT supplies should be done with the knowledge that they have expiration dates mainly due to compatibility and performance.

We suggest hospitals and health systems maintain an inventory of all computer systems, especially servers and memory storage capacity (disk drives), with a predefined hierarchy of "most-to-least important" in terms of continuity of patient care and financial operations. In extreme shortages, lower prioritized systems may increasingly be repurposed as needed. Hospitals should also consider maintaining stockpiles of critical IT equipment.

Conclusions

Continuity of operations requires effective preparedness planning and is a daily occurrence in health care. Routine challenges to normal day-to-day functioning should provide experience and expertise necessary in contending with similar, although bigger, issues in an actual disaster. Planning and preparedness for daily and disaster-related medication and medical supply shortages will be more effective with a focused strategy using the six steps outlined in this manuscript.

IT disruptions affect all aspects of patient care, but with disproportionate impact on those patients who are critically ill. IT preparedness should include the ability to urgently reestablish local area networks with available power, use portable hardware, plan for each patient's portable database, and protect patient's information privacy. Concurrent planning for prioritizing server and memory storage needs and requirements will increase longer-term preparedness to support clinical and business operations.

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