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Chapter 5. Essential equipment, pharmaceuticals and supplies

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On behalf of the European Society of
Intensive Care Medicine's Task Force for
Intensive Care Unit Triage during an
Influenza Epidemic or Mass Disaster.

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Abstract *Purpose:* To provide recommendations and standard operating procedures for intensive care unit and hospital preparations for an influenza pandemic or mass disaster with a specific focus on essential equipment, pharmaceuticals and supplies.

Methods: Based on a literature review and expert opinion, a Delphi process was used to define the essential topics including essential equipment, pharmaceuticals and supplies.

Results: Key recommendations include: (1) ensure that adequate essential medical equipment, pharmaceuticals and important supplies are available during a disaster; (2) develop a communication and coordination system between health care facilities and local/regional/state/country governmental authorities for the provision of additional support; (3) determine the required resources, order and stockpile adequate resources, and judiciously distribute them; (4) acquire additional mechanical ventilators that are portable, provide adequate gas exchange for a range of clinical conditions, function with low-flow oxygen and without high

pressure, and are safe for patients and staff; (5) provide advanced ventilatory support and rescue therapies including high levels of inspired oxygen and positive end-expiratory pressure, volume and pressure control ventilation, inhaled nitric oxide, high-frequency ventilation, prone positioning ventilation and extracorporeal membrane oxygenation; (6) triage scarce resources including equipment, pharmaceuticals and supplies based on those who are likely to benefit most or on a 'first come, first served' basis. *Conclusions:* Judicious planning and adoption of protocols for providing adequate equipment, pharmaceuticals and supplies are necessary to optimize outcomes during a pandemic.

Keywords Equipment ·
Pharmaceuticals · Drugs · Supplies ·
Recommendations · Standard
operating procedures · Intensive care
unit · Hospital · H1N1 · Influenza
epidemic · Pandemic · Disaster

Introduction

Outbreaks of H5N1 and H1N1 influenza [1, 2] have emphasized the importance of preparing for a human influenza pandemic [3–6]. Plans to allocate hospital resources, which will become extremely scarce during a

pandemic [3–6], present a real challenge. The difficulty is greater as the present usage rate of intensive care unit (ICU) services in many countries for patients without influenza is at or above 100% [7]. During a severe disaster or a pandemic requiring a much greater number of critical care beds, recommendations have suggested preparing for

an increase of up to three times the usual ICU census [8]. Such a crisis will also require an increase in essential equipment (mechanical ventilators, syringe pumps, etc.), pharmaceuticals (antiviral, antibiotic, bronchodilators, sedatives, etc.) and other important supplies.

Purpose

To ensure that during a severe pandemic or disaster adequate medical equipment, pharmaceuticals and other supplies are readily available at hospitals and other health care facilities to provide the best possible patient care.

Scope

This standard operating procedure (SOP) focuses on essential medical equipment, pharmaceuticals and supplies that are required for critical care delivery within health care facilities and systems. The SOP includes the following departments:

- Physicians (intensivists, anesthesiologists, internists especially respiratory physicians, emergency medicine, infectious disease and microbiology physicians and surgeons)
- Registered nurses (RN) and licensed vocational nurses (LVN)
- Respiratory care specialists and therapists
- Pharmacists
- Clinical infectious disease and microbiology personnel
- Hospital and ICU administration
- Technicians and equipment specialists
- Infection control
- Nutrition and dietary staff
- Ancillary staff (e.g., assistants, transport)

Health care facilities and other organizations responsible for health care should implement this SOP within the broad network of cooperation at a local, regional/state and national level. Health care facilities should stockpile equipment, pharmaceuticals and supplies for a limited time, but after a prolonged period, they may need help from higher authoritative levels in providing additional equipment (ventilators, syringe pumps) or replenishing used supplies (anti-virals, antibiotics, sedatives, nutrition, etc.). Therefore, coordination with the local, regional, state and/or national Emergency Executive Control Groups may be required to provide adequate care.

Goals and objectives

To establish a system of coordinating the stockpiling and provision of medical equipment, pharmaceuticals and

other supplies to ICUs and other departments within a hospital by:

- Identifying key personnel within various departments to identify the medical equipment, pharmaceuticals and other supplies that will be needed immediately and over a period of time during a pandemic or disaster.
- Creating a system to order, stockpiling and judiciously distributing as needed essential medical equipment, pharmaceuticals and other supplies.
- Providing a hospital structure and process to ensure the maintenance of adequate numbers of medical equipment, pharmaceuticals and other supplies.
- Developing good communication between the required hospital departments to implement this SOP.
- Determining the necessary local, regional, state and/or national Emergency Executive Control Groups that can provide the extra medical equipment, pharmaceuticals and other supplies that are needed during a crisis.

Education, awareness, preparation and communication are required to ensure the defining of the roles and responsibilities of the key individuals to implement this SOP.

Definitions

1. Hospital Emergency Executive Control Group: the coordinating center of the health care facility. Decisions should be made after communication and coordination with the relevant department representatives.
2. Local Emergency Executive Control Group: the coordinating center of the local health care facilities. Decisions should be made after communication and coordination with local health care facilities.
3. Regional Emergency Executive Control Group: the coordinating center of the regional health care facilities. This could include state or federal authorities or Ministries of Health depending on the specific country characteristics. Decisions should be made after communication and coordination with the relevant local, regional, state or federal authorities.
4. Critical care supervisor: the senior intensivist responsible for collecting information from all the hospital ICUs regarding the requirements of the ICUs for medical equipment, pharmaceuticals and supplies. The critical care supervisor provides assistance and information to the Hospital Emergency Executive Control Group in coordinating hospital resources (equipment, pharmaceuticals and supplies) needed.
5. Personal protective equipment (PPE): protective measures such as masks, gloves and gowns used by the staff for reducing transmission of disease.

Basic assumptions

1. During a pandemic or disaster crisis situation, there will not be adequate medical equipment, pharmaceuticals and other supplies.
2. Stockpiling of additional medical equipment, pharmaceuticals and other supplies should occur prior to the crisis to make certain that adequate medical equipment, pharmaceuticals and supplies are available during the crisis. Essential medical equipment, pharmaceuticals and supplies are shown in Table 1. Prompt medical treatment should include neuraminidase inhibitors as survivors were more likely to have received treatment with neuraminidase inhibitors in one study, although this was only one study with a low level of evidence [10].
3. Stockpiling of medical equipment, pharmaceuticals and supplies for each individual health care facility should vary based on the arrangements with various equipment, pharmaceutical and other companies and local, regional, state and/or national level centers. For instance, in some countries, anti-virals are dispensed by Ministries of Health and do not have to be purchased. One should err on the side of purchasing more medical equipment, pharmaceuticals and supplies as in times of crisis normal or expected sources may not deliver.
4. Health care facility pharmacies should increase their reserves of drugs. This is particularly important for the medications listed in Table 1. Depending on sources of supply (this may vary in different countries), ICU, hospital and regional stockpiles may have to be increased by weeks or even months.
5. Most hospitals may not have sufficient “extra” ventilators available to provide for doubling the number of ventilators required to ventilate patients during a severe epidemic outbreak or mass disaster. It is unlikely under these circumstances that ventilator companies will be able to supply large numbers of ventilators on short notice. Various local, state or federal agencies may provide additional ventilators to hospitals. It is important that hospitals know the exact numbers and types of ventilators that will be transferred. Present recommendations are for one mechanical ventilator per patient concurrently receiving sustained ventilatory support [8].
6. Additional mechanical ventilators should have as many of the following attributes as possible: be portable, rapidly available, provide adequate gas exchange for a range of clinical conditions, function with low-flow oxygen and without high pressures (important with a loss of high pressure oxygen supply due to expansion outside conventional hospital settings or failure of delivery), provide volume and pressure control ventilation, be safe for patients (disconnect alarm capabilities) and safe for staff

Table 1 Essential medical equipment, pharmaceuticals and supplies

Essential medical equipment include
Mechanical ventilators
Monitors: heart rate, blood pressure, respiration, electrocardiography
Non-invasive blood pressure cuffs
Intravenous pumps
Pumps for nutrition
Ambu bags
Nebulizers (and nebulizers for drug administration via ventilators)
ICU beds
Dialysis or hemofiltration machines
Pulse oximeters
Sequential compression devices
Suction machines
Essential pharmaceuticals include
Anti-virals (especially neuraminidase inhibitors)
Antibiotics
Vasopressors
Bronchodilators
Sedatives
Analgesics
Neuromuscular blocking agents
Steroids (although WHO recommendation are that steroids not be administered to patients with H1N1-related ARDS because of increased viral spread [9], many physicians have used them [10, 11])
Thromboembolism prophylaxis
Gastrointestinal hemorrhage prophylaxis
Fluids for resuscitation
Other essential supplies include
Nutrition: enteral and parenteral
Masks: Ambu, CPAP, tracheal, oxygen, oxygen + nebulizer, surgical
Respirators: N95 respirator, powered air purifying respirators (PAPR)
Endotracheal and tracheostomy tubes
Catheters: triple, double and single lumen for central lines
Catheter: regular peripheral intravenous
Catheters: arterial lines
Catheters: regular suction, closed-circuit suction, Yankauer suction
Catheter: urinary and collection bags
Catheter supplies: administration sets, flush, dressings
Connector for suction catheter (finger tip)
Suction tubing
Suction container: wall mounted, disposable
Suction trap and hoses
Nasogastric or orogastric tubes
Oral airway
Full face shields; goggles
Gloves: sterile and non-sterile
Oxygen tubing and regulators
Ventilatory circuits
Filters including high efficiency particulate air (HEPA)
Humidifiers
Respiratory medication delivery systems: metered dose inhaler (MDI) adapters, nebulizers
Medical gas: compressed air, compressed oxygen, liquid oxygen
T tube
Mouth suction piece
Syringes: for arterial blood gases, bloods
Oxygen regulators and clock
Vacuum clock

Table 1 continued

Electrocardiography cables and leads
Electrodes
Gowns: sterile and non-sterile
Nasal prongs
Culture bottles
Thermometers
Needles
Other important equipment which may not be present in every hospital
Extracorporeal membrane oxygenation (ECMO)
Pumpless extracorporeal lung assist (pECLA)
High frequency jet ventilator or oscillator
Machines or tanks providing nitric oxide

(reduce staff time in patients' rooms especially if contagious disease is involved), and should allow for efficient use of staff [4, 8].

7. If sufficient ventilators are not available to treat all patients who require ventilatory support, manual ventilation after endotracheal intubation is a possibility. Manual ventilation is usually not recommended during a pandemic flu outbreak as in addition to operator fatigue and patient hypoventilation, individuals manually ventilating patients are at high risk for transmission of the flu and other contagious diseases. Each facility should determine whether manual ventilation will be considered based on availability of personnel, equipment and safety for staff.
8. As initial reports of H1N1 patients requiring ICU have noted some cases with severe hypoxemia [10–13], hospitals should be able to provide ventilators with capabilities to ventilate with high pressures and other modalities such as nitric oxide, high frequency ventilation or oscillation, prone position and ECMO.
9. The person responsible in the Hospital Emergency Executive Control Group should liaise with key personnel within various departments to determine the required resources, order and stockpile adequate numbers and judiciously distribute them. Depending on sources of supply, which may vary in different countries, ICU, hospital and regional stockpiles of equipment and supplies as well as the pharmaceuticals noted above may have to be increased by weeks or even months. The Hospital Emergency Executive Control Group should also communicate with the local, regional, state and/or national Emergency Executive Control Groups regarding medical equipment, pharmaceuticals and supplies.

Lines of authority

The coordination of the necessary medical equipment, pharmaceuticals and supplies should occur at the level of the

hospital, local jurisdiction and the region/state/country depending on the country involved. Initial authority should be managed internally by each of the individual hospitals at the direction of the Hospital Emergency Executive Control Group. The needs of each department should be assessed and integrated by the operations, logistics and planning sections of the Hospital Emergency Executive Control Group with input from each of the department representatives.

Prior to an epidemic outbreak or disaster, a communication and coordination system between each hospital and the local jurisdiction and the regional/state/country authorities should be developed. The latter might also include Ministries of Health. Once the medical equipment, pharmaceuticals and supply needs exceed those of the local health care facility, the local or regional/state/country authorities should provide support to each health care facility.

Concepts of operations

During the crisis, hospitals should plan on the following guidelines:

1. Preparatory stockpiles of medical equipment, pharmaceuticals and supplies should last for several days or even weeks depending on the amount of stockpiling and the severity and numbers of patients admitted and requiring ICU services.
2. Initially, medical equipment, pharmaceuticals and supplies may be used as they are under normal circumstances.
3. As the hospital stockpiles become depleted, local or regional/state/country authorities should provide additional medical equipment, pharmaceuticals and supplies to each health care facility. They should let hospitals know in advance what resources will be potentially available.

When medical equipment, pharmaceuticals and supplies become depleted, the following guidelines may have to be implemented:

1. To provide “the greatest good for the greatest number” of patients [14], hospitals may have to consider restricting interventions that (a) demonstrate an improved survival and without which death is likely; (b) require extraordinarily expensive equipment; and (c) consume extensive staff or hospital resources [4].
2. Despite all the preparations, sufficient medical equipment (ventilators), pharmaceuticals [neuraminidase inhibitors such as oseltamivir (tamiflu), zanamivir (relenza) or peramivir (which can be given intravenously) [15]] and supplies may not be available for all deserving patients. Triage decisions for admission to intensive care have been based on those who are likely to

- benefit most [16] or on a ‘first come, first served’ basis [17]. As difficult as these ethical decisions are to make during usual circumstances, they will be exceedingly more difficult in times of crisis. As benefit under these circumstances is not known, it may be best to triage these scarce resources on a ‘first come, first served’ basis. It is likely, however, that resources will still be allocated based on those who are likely to benefit most.
3. To conserve the use of scarce medications, pharmacies may need to make modifications in the use of drugs. This may include rules for drug substitutions, decreases in medication frequency, change of parenteral to oral or enteral administration when feasible, restricting medications in short supply, extending drug shelf-life and authorizing certain medical personnel to prescribe scarce medications [8].
 4. Redistribution of equipment (oxygen saturation monitors only for patients on ventilators or on high-flow oxygen with spot checks for others) or conservation of equipment (medications that must be given by pumps vs. those that can safely be given by gravity flow) may be required.
 5. Hospitals and intensivists should expect the greatest surge of ICU patients approximately 4–6 weeks after the first confirmed winter ICU admission and a substantial extra workload lasting several weeks from then [2, 11].
 6. As critical illness occurs rapidly after hospital admission and is associated with severe oxygenation failure, a requirement for prolonged mechanical ventilation and the frequent use of rescue therapies [10, 11], invasive mechanical ventilation can be expected in a large numbers of patients. Preliminary data in H1N1 patients show that 65–97% of ICU patients require mechanical ventilation [2, 11, 12, 18] with median ventilatory durations in survivors of 7–15 days [10–12].
 7. Hospital staff should be prepared for severely hypoxemic patients only responsive to advanced ventilatory support and rescue therapies, including high levels of inspired oxygen and positive end-expiratory pressure (PEEP), pressure control and airway pressure release ventilation, inhaled nitric oxide, high-frequency oscillatory ventilation, prone positioning ventilation, neuromuscular blockade and ECMO [10, 11, 13].
 8. If hospitals cannot provide advanced ventilatory support and rescue therapies, they should consider transferring patients with severe disease to regional centers with these capabilities [19].
- priorities for medical equipment, pharmaceuticals and supplies to ensure the best possible care for the greatest number of patients.
2. Critical care physicians: intensivists provide planning expertise for the requirements of medical equipment, pharmaceuticals and supplies. Information regarding the need for ventilators requiring high pressures, volume and pressure control and airway pressure release ventilation, inhaled nitric oxide, high frequency ventilation or oscillation, prone positioning ventilation and ECMO should be provided. During a crisis the critical care supervisor provides assistance and information to the Hospital Emergency Executive Control Group including information on the resources (equipment, pharmaceuticals and supplies) needed. Other physicians supervising individual units update the critical care supervisor regarding their ICU’s needs for equipment, pharmaceuticals and supplies.
 3. Critical care nursing staff: nursing supervisors facilitate supply and resource requests to internal hospital departments (pharmacy, central supply) and the Hospital Emergency Executive Control Group.
 4. Pharmaceutical staff: the director of the pharmacy and his/her staff should keep an ongoing assessment of the amounts of medications (especially neuraminidase inhibitors, antibiotics, vasopressors, bronchodilators, sedatives, analgesics, steroids, thromboembolism prophylaxis and gastrointestinal hemorrhage prophylaxis) required and being consumed. During a crisis the director of the pharmacy provides assistance and information (regarding pharmaceuticals) to the Hospital Emergency Executive Control Group.
 5. Central supply: the director of central supply and his/her staff should keep an ongoing assessment of the supplies required and being consumed. During a crisis the director of central supply provides assistance and information (regarding essential supplies) to the Hospital Emergency Executive Control Group.
 6. Respiratory care specialists and therapists: the director of respiratory therapy and his/her staff should keep an ongoing assessment of the mechanical ventilators and their associated supplies required and being consumed. During a crisis the director of respiratory therapy provides assistance and information (regarding ventilators and associated supplies) to the Hospital Emergency Executive Control Group.
 7. Ancillary staff: provide supply and resource support along with food supply and nutrition and transfer/transport assistance.
 8. Local/Regional Hospital Emergency Executive Control Groups: the coordinating centers of the local, regional, state or federal authorities should communicate, coordinate and try to supply the additional medical equipment, pharmaceuticals and supplies to hospitals before and during a crisis.

Functional roles and responsibilities of the internal personnel and labor workforce

1. Hospital Emergency Executive Control Group: sets overall priorities and management decisions regarding

Logistics support and requirements necessary for the effective implementation of the SOPs

1. A central inventory of all equipment, pharmaceuticals and supplies at each health care facility should be determined.
2. A central database for equipment, pharmaceuticals and supplies should be developed and made available at the local, regional, state or federal level in order to provide the necessary resources to individual health care facilities.
3. Fair and prospectively defined distribution methods for supplying different departments with necessary equipment, pharmaceuticals and supplies should be developed.
4. All members of the Local/Regional Hospital Emergency Executive Control Groups, departmental heads or deputy and designated supervisors should be contactable 24 h per day, 7 days a week.
5. Methods should be established to disseminate information regarding equipment, pharmaceuticals and supplies to frontline staff in the various departments.

Maintenance of standard operating procedures

Hospitals should participate and evaluate one full-scale exercise annually plus one review exercise annually. This exercise should include an evaluation of the (1) stockpiling plan for equipment, pharmaceuticals and supplies, (2) communication and coordination between departments within health care facilities and (3) communication

and coordination between health care facilities and the local, regional, state or federal authorities for the ordering and distribution of medical equipment, pharmaceuticals and supplies as outlined in this SOP. The exercise should be designed to identify and assess gaps in preparedness and response competencies for key individuals (department or unit heads). An evaluation process should occur immediately after each exercise or event by internal and external evaluators. The SOPs should be modified and updated following each review to ensure that communication, processes, protocols and the information contained within them are current and appropriate.

Recommended training and exercise activities

The initial development of the plan to assess medical equipment, pharmaceuticals and supplies needs, stockpiling and re-supply should include a draft, with discussion, revision and feedback to the facility stakeholders in each department. Once a preliminary plan is complete, a tabletop exercise should test basic assumptions of the plan with revisions as needed. After each exercise or event, an after-action review should identify areas for improvement and corrective actions as well as realistic needs. The SOP should be redrafted as needed based on the experiences, new literature or additional preparedness/planning activities.

Conflict of interest None.

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