The Challenge of Hospital Infection Control During a Response to Bioterrorist Attacks

ROBERT W. GROW and LEWIS RUBINSON

The purpose of this paper is to provide a concise overview of infection control practices and their implications for health care delivery for persons with responsibility for biodefense planning, program management, or policy development. Infection control practices, here defined as methods to prevent person-to-person transmission of contagious disease in health care settings, would be an integral part of interrupting the spread of an epidemic in the aftermath of a bioterrorist attack with a contagious pathogen. This paper is not intended as a definitive guide to infection control practices for health care personnel or institutions; such guidelines already exist. Instead, the focus is on the challenges that widespread implementation of rigorous infection control practices would pose to hospital operations, especially were hospitals required to deliver medical care for unusually high numbers of patients after a bioterrorist attack. Three of the six Category A biological agents/diseases (smallpox, plague, and the viral hemorrhagic fevers) are transmissible from person-to-person, and hospitals caring for patients with these diseases would need to implement aggressive infection control practices.

Contagious Disease in the Hospital Environment

As demonstrated by the SARS outbreak, hospitals can become major venues for contagious disease transmission. In Canada, as of July 11, the majority (77%) of probable SARS cases resulted from in-hospital exposures. Similarly, in Taiwan, the Director General of the Health Ministry stated that after the initial importation of SARS, almost all (94%) SARS infections were transmitted within hospitals. Past experiences with contagious diseases such as smallpox and measles have also shown that hospitals facilitate person-to-person disease transmission.

Hospitalized patients with contagious diseases can subsequently infect other patients and health care workers (HCWs). Many patients in U.S. hospitals today are highly susceptible to infection because of illnesses such as AIDS or due to therapeutic procedures such as transplants or chemotherapy. HCWs that have contact with the skin, respiratory secretions, or body fluids of contagious patients may inadvertently spread the disease to themselves or to other patients.

In 1991, the Centers for Disease Control and Prevention established the Hospital Infection Control Practices Advisory Committee (HICPAC), comprised of experts in the fields of infectious diseases, nursing, surgery, epidemiology, and public health, to develop and standardize infection control guidelines for health care institutions. The HICPAC guidelines are comprised of environmental controls and personal protection measures for health care personnel coming into contact with potentially contagious patients. Environmental controls such as air handling equipment, isolation rooms that are maintained at an air pressure less than surrounding work areas, and guidelines for proper cleaning (and/or decontamination) of facilities are of great importance in preventing the spread of contagious diseases. Readers are referred to the Centers for Disease Control and Prevention website (http://www.cdc.gov/ncidod/hip/enviro/guide.htm) for additional information regarding environmental controls. Also critical in preventing the spread of contagious disease is personal protective equipment (PPE), such as gloves, gowns, and masks. The rest of this article will discuss the infection control protocols and the PPE that HCWs must utilize to adhere to the HICPAC guidelines and offer some illumination of the logistical com-
What if there was an outbreak of smallpox?

Consider a hypothetical scenario in which a hospital nurse is providing care to four patients with smallpox. Smallpox requires Airborne precautions, meaning that health care workers need to don gloves, gown, and an N95 mask and eye protection or PAPR-type respirator before entering each patient’s room. If the nurse must visit the four patients twice each hour, during the course of an eight hour shift the nurse will change protective equipment a minimum of 64 times. If each period of dressing and subsequent removal of protective equipment takes only two minutes each (which is optimistic), the nurse in this scenario will spend over four hours of an eight-hour shift doing nothing more than changing and disposing of equipment. This estimate is conservative, since during a large-scale bioterrorist attack, nurses may be caring for even more patients and working longer shifts. In addition, other health care personnel such as physicians and custodial and food service staff would also need access to the patient. Like the nurse, each person entering the room of a person with smallpox must follow Airborne precautions.

*See footnote c in Table 1.

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plexity this might entail in the aftermath of bioterrorist attacks.

CATEGORIES OF INFECTION CONTROL PRACTICE

For contagious diseases, understanding the route of person-to-person transmission of disease is critical to preventing spread. The HICPAC guidelines organize infection control practices into four major categories, with Standard being the most modest category and Airborne being the most rigorous (see below). Diseases are assigned to a category based on how they are spread.

**Standard Precautions**

- **Use**: Recommended for diseases that can be spread by contact with the patient’s blood or body fluids (e.g. HIV, Hepatitis B/C). Not routinely used for most HCW-patient interactions.
- **PPE**: Face shield or surgical mask* with eye protection (only for interactions expected to splash or spray body fluids), gown, and gloves.
- **Environmental Controls**: None.

**Contact Precautions**

- **Use**: Recommended for diseases that can be spread by touching the patient or touching an object that the patient touched (e.g., herpes, scabies). Must be used during all patient-HCW interactions, even when HCWs are not expecting to have contact with the patient's blood or body fluids.
- **PPE**: Face shield or surgical mask with eye protection (only for interactions expected to splash or spray body fluids), gown, and gloves.
- **Environmental Controls**: Placement of patient in private room, limit movement and transport of patient, dedicated patient care equipment.

**Droplet Precautions**

- **Use**: Recommended for diseases that can spread via large-particle droplets (>5 μm) in the air (e.g., influenza, mumps). Large-particle droplets do not travel over long distances; transmission is highest at short distances (<3 feet).
- **PPE**: Face shield or surgical mask with eye protection, gown, and gloves.
- **Environmental Controls**: Placement of patient in private room, limit movement and transport of patient.

**Airborne Precautions**

- **Use**: Recommended for diseases that can be transmitted through air by small infectious particles (aka droplet nuclei) over long distances (e.g., tuberculosis, measles). Droplet nuclei may travel through ventilation systems endangering patients and HCWs that have no direct contact with the contagious patient.
- **PPE**: Gown, gloves, and an N95 mask (a specific type of filtering mask) with eye protection or a powered-air-purifying respirator (PAPR).*
- **Environmental Controls**: Placement of patient in a negative pressure isolation room with 6–12 air changes per hour and discharge of air to outdoors or through a monitored high-efficiency filtration system, room door remains closed, limit movement and transport of patient.
THE CHALLENGES POSED BY DROPLET AND AIRBORNE PRECAUTIONS

Infection control practices are incorporated in the day-to-day operations of hospitals, but at any given time in a given hospital there are typically only a small number of patients (if any) with diseases that require Droplet or Airborne precautions. Adherence to Airborne and Droplet precautions is logistically burdensome and requires considerable planning and education and constant attentiveness by HCWs. Table 1 illustrates some of the complexities, material and time costs, and operational challenges HCWs would face in implementing and adhering to infection control protocols in the setting of bioterrorism response.

Adherence to Airborne and Droplet precautions is influenced by many variables such as risk perception, physical comfort, familiarity with equipment and protocols, and perceived difficulty of adherence. The inherent challenges in adhering to these infection control protocols would be greatly magnified in situations of high acuity, high patient volume, scarcity of equipment or countermeasures, or the presence of an unfamiliar potentially lethal disease—all possible conditions in a hospital caring for victims of a bioterrorist attack with a contagious pathogen (see sidebar). In addition, it has been documented that HCWs are more likely to adhere to infection control precautions if the hospital’s protocols are designed by those considered to have expert-level knowledge. Only 56% of infection control practitioners that responded to a recent survey report receiving any training in bioterrorism preparedness.5 Recognizing the challenges that infection control practices in general, and Droplet or Airborne infection control practices specifically, would place on hospitals is important for leaders responsible for hospital and government bioterrorism planning efforts, and particularly important for those unfamiliar with clinical care and hospital function.
TABLE 1. COMPLEXITIES/CHALLENGES OF PROVIDING INFECTION CONTROL TO VICTIMS OF A BIOTERRORIST ATTACK

<table>
<thead>
<tr>
<th>Category of infection control practice:</th>
<th>Standard precautions</th>
<th>Contact precautions</th>
<th>Droplet precautions</th>
<th>Airborne precautions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Recommended For:</strong></td>
<td>Anthrax, Tularemia, Botulinum Toxin</td>
<td>Smallpox, VHF&lt;sup&gt;26&lt;/sup&gt;</td>
<td>Pneumonic Plague</td>
<td>Smallpox, VHF&lt;sup&gt;26&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>How Health Care Workers (HCWs) May Become Infected:</strong></td>
<td><em>Not</em> transmissible from person-to-person</td>
<td>Touching patient or objects patient touched</td>
<td>Being close to patient and inhaling respiratory droplets generated by talking, coughing, sneezing, and procedures like suctioning and bronchoscopy. Transmission does not occur over long distances or through ventilation systems.</td>
<td>Inhaling small infectious particles that may travel long distances including through ventilation systems. HCWs and other patients may get disease without having personal contact with the contagious patient.</td>
</tr>
<tr>
<td><strong>Necessary PPE and Time Burden (calculated for 1 nurse caring for 4 patients over an 8 hour shift):&lt;sup&gt;a&lt;/sup&gt;</strong></td>
<td>Used at discretion of HCWs, when concern of HIV and/or Hepatitis B/C transmission is present, or when patient is incontinent or undergoing procedures</td>
<td>64 Pairs of Gloves, 64 Gowns, 64 Surgical masks&lt;sup&gt;c&lt;/sup&gt; and Eye Protection or Face Shields</td>
<td>64 Pairs of Gloves, 64 Gowns, 64 Surgical masks&lt;sup&gt;c&lt;/sup&gt; and Eye Protection or Face Shields</td>
<td>64 Pairs of Gloves, 64 Gowns, 64 N95 masks&lt;sup&gt;c&lt;/sup&gt; and Eye Protection or PAPR&lt;sup&gt;c&lt;/sup&gt; hoods</td>
</tr>
<tr>
<td></td>
<td>4 hours required to don, remove, and dispose of PPE</td>
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</tr>
<tr>
<td><strong>Special Operational Challenges:</strong></td>
<td>Use of PPE for many patients will require much reserve equipment.</td>
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<td>Same challenges as for contact and droplet precautions.</td>
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</tr>
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<td></td>
<td>Need for strict adherence to PPE over long periods of time</td>
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<td>N95 masks require annual “fit testing” for all staff to ensure effectiveness.</td>
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<td></td>
<td></td>
<td></td>
<td>Very uncomfortable to wear an N95 or PAPR for extended periods of time.</td>
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<td></td>
<td></td>
<td></td>
<td>HCWs with facial hair cannot use N95 masks due to poor fit</td>
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</tbody>
</table>
PAPR inhibits hearing so listening with a stethoscope and communicating with staff or the patient are impaired. High risk of disease transmission over distances requires stringent environmental controls like negative pressure isolation rooms. Very few negative pressure rooms in most hospitals.

(HCWs) Health Care Workers  (PPE) Personal Protective Equipment  (VHF) Viral Hemorrhagic Fevers  (HIV) Human Immunodeficiency Virus

Smallpox and the viral hemorrhagic fevers may also be transmitted through direct contact thus warranting the use of Contact precautions. However, because these diseases may also be spread via droplet nuclei, the more intensive Airborne precautions would likely be used in an outbreak.

Units of equipment reflect the authors' crude estimate of the minimum to be used by a nurse caring for four patients visited twice each hour over 8 hours. Time estimates are based on a two minute period of dressing followed by two minutes of undressing and disposal. Additional time and equipment would be required for each additional staff member who interacts with the patients (e.g., clinicians, nursing assistants).

Surgical Mask:

Historically, this type of mask has been used in the operating room by health care personnel to minimize the chance of a patient’s operative wound becoming infected by health care workers. This type of mask is produced by a variety of manufacturers using different materials, and no standard for minimal filtration efficiency exists. Therefore, it is best to consider the mask as a barrier with marginal filtration and no protection against gas, vapor, or most particulate hazards.

N95:

The N95 mask is one member of a family of air-purifying masks that use both a letter and number system to describe their properties. The number designation of the mask describes its filtering efficiency. “95” means that the mask is able to remove 95 percent of particles with a median diameter greater than 0.3 μm. The letter “N” designates that the mask is “not oil proof.” Similar to surgical masks, the N95 mask does not offer protection against any type of gas or vapor, which are the likely dissemination methods for most types of chemical weapons.

PAPR:

The powered-air-purifying-respirator (PAPR) uses a battery powered fan attached to a belt to draw air across a purifying filter. The fan is connected to a hood that covers the head and shoulders. When used with smallpox or VHF patients, the hood must be decontaminated following each use or it cannot be re-used. Depending on the type of filter material selected, the PAPR can provide protection against a variety of hazards. The PAPR can be used by individuals with facial hair; it decreases the work of breathing, but can be bulky and heavy and may compromise communication due to fan noise.
REFERENCES


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