Preventing

Although respiratory infections are not as common as other types of infections that may develop in home care and hospice patients, respiratory infections can result from the use of medical devices and respiratory supplies. These devices can contribute to the home care or hospice patient developing a respiratory infection by serving as a reservoir and supporting the growth of microorganisms and by directly infecting patients when this equipment becomes contaminated. This article presents evidenced-based guidelines and recommendations on the preferred methods for managing respiratory equipment and supplies commonly used by patients in the home setting and conducting surveillance activities to ultimately prevent respiratory infections.

Oxygen concentrators, ventilators, continuous positive airway pressure (CPAP), bilevel positive airway pressure (BiPAP), nasal cannulas, and the like these are all medical devices and respiratory supplies commonly used by patients receiving care at home. These devices can contribute to the home care or hospice patient developing a respiratory infection by serving as a reservoir and supporting the growth of microorganisms and by directly infecting...
Infections in Patients Using Respiratory Therapy Equipment in the Home

patients when this equipment becomes contaminated. Often the home care or hospice patient requiring respiratory support and ventilatory assistance is an immunocompromised individual with a chronic underlying illness that predisposes them to infection. Of the device-related infections, respiratory infections (i.e., ventilator-associated pneumonia [VAP]) can contribute to major morbidity and mortality in acute care settings, yet are not as common in home care and have received less attention in comparison to preventing device-related infections from indwelling urinary catheters and central lines. This article will present evidenced-based guidelines and recommendations for surveillance activities and the preferred methods for managing respiratory patient-care equipment and supplies commonly used by patients in the home setting to ultimately prevent respiratory infections.

Hand Hygiene
Before discussing methods for managing respiratory patient-care equipment and supplies, it goes without saying that hand hygiene is an important component of any infection prevention activity. For additional information, go to http://www.cdc.gov/ncidod/dhqp/index.html to download the Hand Hygiene in Healthcare Settings, 2002 Guideline. Hand hygiene should be performed before and after contact with any patient, especially one who has a tracheostomy tube in place, and before and after contact with any respiratory device that is used on the patient, whether or not gloves are worn (Tablan et al., 2004).

Respiratory Equipment Classification
Respiratory equipment and supplies, like all equipment and supplies, are classified into one of three categories: critical, semicritical, and noncritical items. Critical items enter sterile tissue (i.e., lower respiratory tract) and carry a high risk for infection if they are contaminated with any microorganism. Therefore, critical items should be sterile because any microbial contamination could transmit disease (Spaulding, 1968). In the healthy individual, the lower respiratory tract is a sterile site and the body possesses several defense mechanisms to prevent contamination of the lungs (Greene, & Sposato, 2009). Home care organizations generally do not perform sterilization of respiratory equipment and supplies. One type of respiratory supply classified as a critical item that may be reused with physician’s orders is a tracheal suction catheter. The patient’s age, health status, the home environment, and capability of the patient’s caregiver determines whether this critical item will be disinfected between use or whether a new sterile product will be used each time tracheal suctioning occurs (Rhinehart & McGoldrick, 2006). Semicritical items come in contact with mucous membranes or nonintact skin, and include respiratory therapy equipment (Rutala et al., 2008). Respiratory therapy and oxygen therapy equipment and supplies should be purchased sterile and replaced on a regular basis or when it becomes visibly soiled or malfunctions. Noncritical items come in contact with intact skin, but not mucous membranes (Spaulding, 1968). Noncritical respiratory
equipment surfaces should be disinfected with an Environmental Protection Agency (EPA)-registered low- or intermediate-level disinfectant at a minimum of when visibly soiled and on a regular basis (Rutala et al., 2008) and before placing the equipment back in the home for use with another patient. The term “regular basis” is defined by the individual home care and hospice organization. In 2007, the FDA issued a joint Public Health Notification that included the FDA, CDC, EPA, and Occupational Safety and Health Administration (OSHA) on avoiding hazards with using cleaners and disinfectants on electronic medical equipment (e.g., ventilators). Additional information can be obtained at http://www.fda.gov/cdrh/safety/103107-cleaners.html. Examples of critical, semicritical, and noncritical respiratory equipment and supplies are listed in Table 1.

Ventilator-Associated Pneumonia

Most patients on a ventilator are located in an acute care setting. However, many patients in the home setting are on a ventilator on a continuous or intermittent basis. Regardless of the care setting, being on a ventilator places the patient at risk for VAP. In the acute care setting, VAP is the leading cause of death among hospital-acquired infections for patients and exceeds the rate of death due to central line infections, severe sepsis, and respiratory tract infections in the nonintubated patient. In fact, the hospital mortality of ventilated patients who develop VAP is 46% compared to that of 32% for ventilated patients who do not develop VAP (Ibrahim et al., 2001). Similar data for home care are not available at this time.

The Ventilator Bundle: Strategies for Safe Ventilator Care

One approach used in the acute care setting is the Ventilator Bundle, which is recommended by the Institute for Healthcare Improvement ([IHI], 2008). This is a series of four core evidence-based strategies related to ventilator care that has been shown, when implemented together, to achieve significantly better outcomes than when implemented individually with the ultimate goal of preventing VAP. The four key components of care called the Ventilator Bundle include:

1. Elevate the head of the bed to at least 30° to 45°;
2. Daily “sedative interruption” and daily assessment of readiness to extubate;

### Table 1. Critical, Semicritical, and Noncritical Respiratory Equipment and Supplies Used in Home Care

<table>
<thead>
<tr>
<th>Critical Respiratory Equipment</th>
<th>Semicritical Respiratory Equipment</th>
<th>Noncritical Respiratory Equipment</th>
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<tbody>
<tr>
<td>• Suction catheter (tracheal)</td>
<td>• Bulb syringe</td>
<td>• Concentrator</td>
</tr>
<tr>
<td>• Tracheostomy tube</td>
<td>• Singular, such as circuit and face mask, etc.</td>
<td>• CPAP device</td>
</tr>
<tr>
<td></td>
<td>• Nasal cannula</td>
<td>• High-frequency chest-wall oscillation (cough-stimulating device)</td>
</tr>
<tr>
<td></td>
<td>• Peak flow meter</td>
<td>• IPV</td>
</tr>
<tr>
<td></td>
<td>• Resuscitation device</td>
<td>• Nebulizer-related compressor</td>
</tr>
<tr>
<td></td>
<td>• Small-volume nebulizer</td>
<td>• Oxygen analyzer</td>
</tr>
<tr>
<td></td>
<td>• Spirometer</td>
<td>• Pulse oximeter</td>
</tr>
<tr>
<td></td>
<td>• Suction catheter (oral)</td>
<td>• Respiratory assist device— BiPAP</td>
</tr>
<tr>
<td></td>
<td>• Tubing and hoses</td>
<td>• Suction canister</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Suction machine</td>
</tr>
</tbody>
</table>

BiPAP = bilevel positive airway pressure; CPAP = continuous positive airway pressure; IPV = intrapulmonary percussive ventilator.

3. Peptic ulcer disease (PUD) prophylaxis;

Most of the IHI Ventilator Bundle is not applicable to ventilator care in the home setting (e.g., item number 2); however, not all infection prevention strategies are included as the bundle is not intended to be a comprehensive list of all care that should be provided. Although not that common, the nurse could discuss with the physician the need for PUD prophylaxis and DVT prophylaxis in a bedbound, mechanically ventilated patient. For the Ventilator Bundle item number 1, in the absence of any medical contraindications, the head of the bed should be elevated to at least 30° to 45° at all times. This height may be difficult for the caregiver to visualize, and therefore visual cues should be used in the home, such as a line on the wall that can only be seen if the bed is below a 30° angle, so that it is easy to identify when the bed is in the proper position.

Mechanically Ventilated Patient Care
In the patient requiring in-home, long-term, ventilatory support, the breathing circuit (i.e., ventilator tubing and exhalation valve and the attached humidifier) should be changed weekly, at the frequency ordered by the physician, when it is visibly soiled, and/or when it mechanically malfunctions. Condensate can collect in the breathing circuit tubing and should be periodically drained and discarded with caution to not allow the condensate to drain back toward the patient (American Thoracic Society and Infectious Disease Society of America, 2005). When draining the condensate or when handling the fluid, gloves should be worn by the staff member or caregiver (Tablan et al., 2004). Condensation traps can be used, which permit drainage without opening the circuit, preventing both contaminated condensate from entering the lungs and contamination from the external environment.

Oral Care
Other interventions that could be implemented at home include oral care and subglottic suctioning (which are not included in the IHI Ventilator Bundle). Oral care should be performed as it decreases the levels of bacteria in the oropharynx and also may be performed to reduce the risk for pneumonia. When brushing the teeth, the organisms in dental plaque can dislodge into the oral secretions and possibly find their way into the lungs through subglottic secretions, which increases the risk of pneumonia (Munro et al., 2009). Routine oral decontamination can reduce the incidence of VAP by decreasing the microbial load in the oropharyngeal cavity when the oral hygiene programs consist of tooth brushing (which removes the plaque that causes bacterial growth), oral suctioning (which prevents oral secretions from pooling), and considering the use of an antiseptic agent for swabbing the mouth and tongue (e.g., with a 0.12% solution of chlorhexidine [CHG], which has bactericidal activity, and/or a 1.5% hydrogen peroxide solution). Keeping the patient’s mouth and lips moisturized with swab sticks and lip balm is also important to prevent cracked, dried skin (and of course, use a water-based moisturizer if the patient is receiving supplemental home oxygen therapy due to the increased risk of fire and subsequent patient injury). Future clinical studies are needed to determine to what extent oral care reduces the rates of infection in the lower respiratory tract for patients who are ventilator dependent or have tracheostomies.

Oral Suctioning
Bacterial infection of the lower respiratory tract typically occurs when the upper respiratory tract is colonized with pathogens, which is followed by aspiration of the oropharyngeal secretions (Garcia, 2005). Oral secretions can pool in the patient’s oropharynx and hypopharynx, especially just above a cuffed tracheostomy tube (subglottal space), and can contribute to a lower respiratory infection (LRI) if the secretions enter the patient’s lungs. To limit the secretions from entering the lungs, deep oropharyngeal suctioning of the bedbound, ventilator-dependent patient should be conducted before any major patient position change and also before deflating the cuff on the patient’s tracheostomy tube (Tablan et al., 2004).

Cleaning Respiratory Equipment
Cleaning is the act of removing visible organic residue (e.g., respiratory secretions) and inorganic salts from patient-care equipment (Rutala et al., 2008). Proper cleaning is critical in that a hard, nonporous surface cannot be disinfected if it is not properly cleaned first. This includes getting
into all small surfaces and lumens of respiratory equipment. In home care, cleaning can be performed by manually rubbing or scrubbing the soiled item using a detergent or enzymatic product along with water to remove organic matter. Decontamination is the physical or chemical removal of pathogens on a surface or item to prevent transmission of infectious agents and render the item or surface safe for handling, use, or disposal (OSHA, 1991). This step can be done in the field by the provider of the respiratory equipment (e.g., oxygen concentrator) when it is removed from the patient’s home, but is not required. The respiratory equipment can be bagged, tagged, and brought back to the area designated for equipment that is pending cleaning and disinfection by the equipment provider.

**Disinfecting Respiratory Equipment**

Disinfection is a process that eliminates most pathogenic microorganisms, except bacterial spores, on inanimate objects. Disinfection is not the same as sterilization as disinfection does not kill bacterial spores and only sterilization can eliminate all forms of microbial life, including spores. Factors that affect the effectiveness of disinfection include the amount of soiling, type and level of microbial contamination, concentration of and exposure time to the germicide, physical nature of the object (e.g., crevices, hinges, and lumens), presence of biofilms, and temperature and pH of the disinfection process (Rutala et al., 2008).

**Levels of Disinfection**

There are three levels of disinfection:

1. High-level disinfection kills all microorganisms except large numbers of bacterial spores, and should be performed on respiratory therapy equipment.
2. Intermediate-level disinfection kills mycobacteria, vegetative bacteria, most viruses, and most fungi but does not necessarily kill bacterial spores.
3. Low-level disinfection kills most vegetative bacteria, some fungi, and some viruses, and should be performed on noncritical items (Rutala et al., 2008).

**Products Used for Disinfection in the Home Setting**

Disinfectants are antimicrobials applied to inanimate objects. Chemical disinfectants used in home care include alcohol, chlorine compounds, hydrogen peroxide, phenolics, quaternary ammonium compounds, and iodophors. A complete list of EPA-registered disinfectants can be accessed at http://www.epa.gov/oppad001/chemregindex.htm. One product commonly (and successfully) used in home care for disinfecting respiratory equipment includes vinegar. This product is not recommended for the staff and caregiver’s use as it is not an EPA-registered product and should not be used for disinfecting respiratory equipment used in the home (McGoldrick, 2009). Other nonchemical disinfection options include wet pasteurization by boiling in tap water for 10 minutes or using a dishwasher with detergent for 30 minutes, if the water is hotter than 158 °F or 70 °C.

**Cleaning and Disinfecting Suction Catheters and Equipment**

Tracheal suction catheters may be reused, with the physician’s approval, for a limited period (i.e., up to 24 hours). Otherwise, a new (sterile) tracheal suction catheter should be used each time tracheal suctioning is performed. The oral suction catheter may be reused, the catheter or tonsil tip must be cleaned to remove any mucus or other particles, followed by the suctioning of a disinfectant and then air through the device to dry the internal surface to inhibit microbial growth. The outer surface of the suction device may be rinsed or wiped with 70% alcohol or 3% hydrogen peroxide. The suction catheter may also be boiled for 10 minutes after cleaning to disinfect the catheter. Once cleaned and disinfected, the suction catheter or tonsil tip should be allowed to air dry and then be stored in a clean, dry area (Rhinehart & McGoldrick, 2006). On a daily basis, the suction collection canisters should be carefully emptied into the toilet (to avoid splashing), washed with soap and water, and disinfected. The suction tubing may be cleaned in between use by suctioning 3% hydrogen peroxide through the tubing and the tubing replaced on a regular basis. Once the respiratory therapy equipment is cleaned and disinfected, care must be taken not to recontaminate the equipment in the process of rinsing, drying, and storing.
Tracheostomy Tube and Site Care
The inner cannula of a tracheostomy should be cleaned and disinfected on a daily basis with half-strength (1.5%) hydrogen peroxide. The tracheostomy tube (outer cannula) should be changed using aseptic technique while wearing a gown, mask, and eye protection and replaced with a new sterile tube at the frequency ordered by the physician. The tracheostomy stoma should be inspected daily to look for signs of irritation and inflammation and cleaned daily with mild soap and water, saline, or half-strength (1.5%) hydrogen peroxide (which will also remove adherent secretions) (American Thoracic Society, 2009). Any secretions that collect around or under the tracheostomy tube plate should also be removed by cleaning. Dressings that trap moisture should be avoided (i.e., gauze). The tracheostomy ties should be changed as needed and when soiled or wet.

Nebulizers
Small-volume, hand-held medication nebulizers are considered semicritical equipment and should be cleaned, disinfected, rinsed with sterile water (if rinsing is needed), and dried in between treatments (on the same patient). Only sterile fluid for nebulization should be used and aseptically dispensed into the nebulizer. Whenever possible, aerosolized medications will be used from a single-dose vial; however, if multiple-dose medication vials are used, the manufacturer’s instructions will be followed for handling, storing, and dispensing the medications.

Home Oxygen Therapy: Nasal Cannula and Extension Tubing
The oxygen tubing, including the humidifier tubing, any nasal prongs, or mask is considered semicritical equipment and should be purchased sterile by the manufacturer. Most oxygen tubing becomes yellowed and stiff as it ages from the skin’s oils. When the nasal cannula and tubing are removed from face, if they remain in the same shape as the patient’s cheek and face, it is time for the tubing to be changed. Most organizations change the nasal cannula every 2 weeks and the

Table 2. LRI

<table>
<thead>
<tr>
<th>Noninfectious causes of infection, such as congestive heart failure, should be ruled out. If the patient has a chest x-ray interpreted as pneumonia, probable pneumonia, or the presence of an infiltrate, and meets the criteria for an LRI, it is counted as pneumonia.</th>
</tr>
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<tbody>
<tr>
<td>Surveillance definition: A lower respiratory tract infection (i.e., bronchitis or pneumonia):</td>
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<tr>
<td>- The patient has not had a chest film or the chest film did not confirm pneumonia; and three of the following seven signs or symptoms are present</td>
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<tr>
<td>- New or increased cough</td>
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<tr>
<td>- New or increased sputum production</td>
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<tr>
<td>- New or increased purulence of sputum</td>
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<tr>
<td>- Fever (i.e., when the patient’s temperature is 2.4 °F greater than the baseline temperature)</td>
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<tr>
<td>- Pleuritic chest pain</td>
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<tr>
<td>- New or increased physical finding on chest examination</td>
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<tr>
<td>- Rales</td>
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<tr>
<td>- Rhonchi</td>
</tr>
<tr>
<td>- Bronchial breathing</td>
</tr>
<tr>
<td>- Change in status or breathing difficulty</td>
</tr>
<tr>
<td>- New or increased shortness of breath</td>
</tr>
<tr>
<td>- Respiratory rate &gt;25</td>
</tr>
<tr>
<td>- Worsening mental or functional status</td>
</tr>
</tbody>
</table>

LRI = lower respiratory infection.

oxygen tubing between 30 and 90 days, although there are no set published guidelines. If moisture is visible and is accumulating in the oxygen tubing, it should be changed to prevent mold and mildew and as it may contribute to a respiratory infection. In addition, an in-line water trap can be added to the oxygen tubing to collect excess condensation. Humidification bottles used with oxygen concentrators should be emptied, washed, dried, and refilled with new distilled water on a daily basis. Water should not be added to the humidification bottle to “top off” the fluid levels.

**Home Oxygen Therapy: Concentrator**
The external filter on the concentrator should be washed with soap and water, air dried, and replaced on the oxygen concentrator minimally on a weekly basis. The external surface of the concentrator, especially frequently touched buttons, such as the off–on switch, should be cleaned and disinfected as noncritical patient-care equipment.

**Patient Education**
One of the many important strategies in preventing respiratory infections is patient and caregiver education. Since the staff in the home are not typically with the patient on a continuous basis (i.e., unless private duty nursing services are being provided), the patient (if appropriate) and the caregiver need to be educated on strategies to prevent a respiratory tract infection. Patient education topics should include, but not be limited to:

- Performing hand hygiene.
- Practicing respiratory hygiene and cough etiquette.
- Using personal protective equipment (protective eyewear, mask, etc.) when applicable.
- Following patient-specific care instructions as directed by the physician (such as tracheostomy care and suctioning procedures) or home care or hospice nurse.
- Cleaning and disinfecting procedures for applicable respiratory care equipment and supplies.
- Keeping the head of the bed elevated 30° to 45° for the bedbound mechanically ventilated patient.
- Reporting signs and symptoms that may indicate a respiratory infection (McGoldrick, 2010a).

**Surveillance**
One important way to determine the effectiveness of the infection prevention strategies is to collect data to determine the incidence of infection. There are a number of different device-associated surveillance activities that may be performed for patients receiving home respiratory therapy. Examples of the types of respiratory infections that may be considered for surveillance activities include:

- Tracheostomy-associated LRI
- VAP

<table>
<thead>
<tr>
<th>Table 3. Sinusitis</th>
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<tbody>
<tr>
<td><strong>Surveillance definition:</strong> Sinusitis must meet at least one of the following three criteria:</td>
</tr>
<tr>
<td>■ Physician diagnosis</td>
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<tr>
<td>■ Organisms cultured from purulent material from the sinus cavity</td>
</tr>
<tr>
<td>■ One of the following four signs or symptoms with no other recognized cause:</td>
</tr>
<tr>
<td>• Fever (i.e., when the patient’s temperature is 2.4 °F greater than the baseline temperature)</td>
</tr>
<tr>
<td>• Pain or tenderness over the involved sinus</td>
</tr>
<tr>
<td>• Headache</td>
</tr>
<tr>
<td>• Purulent exudates or nasal obstruction</td>
</tr>
</tbody>
</table>

• Sinusitis in a patient receiving home oxygen therapy
• LRI in a patient receiving home oxygen therapy (McGoldrick, 2010b).

Surveillance Definitions

Through the infection control risk assessment activities, if the organization identifies that LRIs or sinusitis are to be a targeted sites for collecting surveillance data, the APIC–HICPAC Surveillance Definitions for Home Health Care and Home Hospice Infections (2008) located in Tables 2 and 3 should be used. These surveillance definitions can be used for all patients utilizing respiratory therapy equipment and related supplies in the home setting.

When collecting surveillance data, the respiratory infection would be considered a healthcare-associated infection that was home care-acquired if all criteria are met:

• The surveillance definition has been met.
• There is no evidence that the respiratory infection was present on admission, unless the respiratory infection was related to a previous admission to home care.
• The respiratory infection was acquired during the time period when care or services in the home were rendered (after 48 hours of admission to home care) or initiated (after 48 hours of initiating home respiratory therapy during the course of care in the home).

Respiratory Outcome Measures

When a home care-acquired infection has been identified, it is important to note that it does not mean that the home care or hospice staff caused the patient’s infection. It means that further investigation should be conducted to determine what, if anything, could have been done to prevent the patient’s infection (Rhinehart & McGoldrick, 2006). The next step is to quantify the number of respiratory infections by the targeted site. Table 4 contains formulas that may be used to quantify the device-associated infection and calculate respiratory outcomes. Once the aggregate data have been calculated, it should be analyzed against the targeted goal that was set, which

Table 4. Patient Surveillance: Respiratory Therapy Outcome Measures—Device-Associated Infections

<table>
<thead>
<tr>
<th>Tracheostomy-associated LRI</th>
<th>Total number of lower respiratory tract infections in patients with tracheostomies (not mechanically ventilated)</th>
<th>Total number of tracheostomy days, expressed per 1,000</th>
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<tbody>
<tr>
<td>VAP</td>
<td>Total number of lower respiratory tract infections in patients mechanically ventilated in the home</td>
<td>Total number of ventilator days for all patients requiring mechanical ventilation, expressed per 1,000</td>
</tr>
<tr>
<td>Sinusitis in a patient receiving home oxygen therapy</td>
<td>Total number of patients with sinusitis receiving home oxygen therapy</td>
<td>Total number of patients receiving oxygen therapy, expressed per 100</td>
</tr>
<tr>
<td>LRI in a patient receiving home oxygen therapy</td>
<td>Total number of patients with LRI receiving home oxygen therapy</td>
<td>Total number of patients receiving oxygen therapy, expressed per 100</td>
</tr>
</tbody>
</table>

LRI = lower respiratory infection; VAP = ventilator-associated pneumonia.

hopefully was set at zero ... achieving zero is possible (McGoldrick, 2008).

Conclusion
Respiratory equipment and supplies in the home can constitute an important reservoir for transmission of infection. Although respiratory infections are not as common as other types of infections that develop in home care and hospice patients, preventing respiratory infections in the home setting requires that evidence-based practices be consistently implemented by not only the organization’s staff but also the patient and their caregiver. By effectively combining the use of hand hygiene, barrier precautions, and meticulous cleaning and disinfection with an EPA-registered product, we can continue to keep the home environment a safe place for our patients to receive care.

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REFERENCES