Knowledge regarding the modes of transmission of pandemic 2009 H1N1 influenza continues to develop, as do recommendations for the prevention of spread within healthcare facilities. The adoption of the most prudent, multifaceted approaches is recommended until there is significant evidence to reduce protective measures. The greatest threat to healthcare personnel and patients appears to be exposure to patients, healthcare personnel, or visitors who have not been recognized as contagious. The processes used within healthcare facilities must hold this concept central to any infection control plan and act in a preventive manner. This article focuses on the development of an algorithm for intensive care unit intake precautions, based on the early identification of potential source patients, as well as appropriate selection and adequate use of personal protective equipment. Visitor management, hand and respiratory hygiene, and cough etiquette have been used as measures to decrease the spread of infection. Vaccination of healthcare personnel, combined with work furlough for ill workers, is also explored. Recommendations include the elimination of potential exposures, engineering and administrative controls, and utilization of personal protective equipment. (Crit Care Med 2010; 38[Suppl.]:S000–S000)

Key Words: 2009 H1N1; influenza; pandemic; nosocomial; isolation; personal protective equipment; healthcare personnel; influenza-like illness; N95 respirator; transmission; intensive care unit; aerosolizing; precautions

Protecting the health and safety of workers is the mission of the U.S. Department of Labor’s Occupational Safety and Health Administration. In the context of the 2009 H1N1 pandemic influenza (2009 H1N1), this concern has been raised to the forefront of other agencies. The U.S. Centers for Disease Control and Prevention (CDC), the World Health Organization, the Society for Healthcare Epidemiology of America, and many other worldwide, governmental, and niche professional groups have made healthcare personnel (HCP) safety and the prevention of nosocomial spread of 2009 H1N1 top priorities. Many of the recommendations set forth here are based on the combined experiences of the authors and on the evidence available at the time of this writing; therefore they are subject to change as knowledge about 2009 H1N1 is elucidated. The focus on this article is to provide recommendations that are reasonable, practical, and prudent for preventing influenza in working HCP, and to provide recommendations on how to avoid becoming the vector of nosocomial influenza spread to peers and patients.

Although the transmission of 2009 H1N1 within the community may outpace that within hospitals, HCP are part of both communities; therefore, they have greater opportunity for exposure, particularly in the outpatient setting (1, 2). According to the Institute of Medicine report (2), factors that increase the risk for 2009 H1N1 in HCP include short incubation period, contagiousness before emergence of symptoms, shedding variability, multiple transmission routes, and efficient person-to-person spread. Additionally, nosocomial acquisition may be the result of exposure to infectious HCP and/or visitors. Occupational situations leading to 2009 H1N1 exposures are described on Table 1.

Additionally, the spread of 2009 H1N1 within the healthcare facility may be the result of lack of proper hand and respiratory hygiene, failure to utilize cough etiquette, inadequate housekeeping procedures, staff continuing to work while ill, lack of visitor restrictions, or limited availability of or improperly functioning isolation rooms. All healthcare institutions should strive to provide HCP with the proper education, supplies, and processes to ensure that all safeguards have been implemented to care for 2009 H1N1 patients and to feel safe coming to work. Nosocomial outbreaks may add up to U.S. $7500 per case, not including additional costs associated with high rates of HCP absenteeism (3), an increased length of stay, and higher morbidity and mortality rates. Thus, 2009 H1N1 is not only a worker and employee issue but also a patient safety concern.

Transmission in Healthcare Settings

Transmission of 2009 H1N1 appears to occur through the following modes, which are similar to that of other influenza viruses (4): 1) contact, usually via hands, with the patient or a fomite, followed by self-inoculation onto mucosal surfaces (i.e., nose, mouth, and eyes); 2) droplets of re-
Unprotected exposure, isolation precautions not implemented, delayed or prematurely removed

Patients with viral shedding and absence of respiratory symptoms

Patients presenting primarily with nonrespiratory illness/injury: elective surgeries, trauma, cardiac events, gastrointestinal bleeding, stroke, etc

Patients with viral shedding and presence of respiratory symptoms

Respiratory symptoms attributed to different etiology: exacerbation of chronic obstructive pulmonary disease, asthma, community-acquired bacterial pneumonias (i.e., coinfections), congestive heart failure, etc

Patients with suspected or confirmed 2009 H1N1 with isolation discontinued prematurely because of false-negative test results, incomplete testing, or continued shedding after antiviral therapy

HCP with viral shedding with or without respiratory symptoms

Visitors with viral shedding with or without respiratory symptoms

Inadequately protected exposures

Improper use of PPE

Lack of N95 respirator fit-testing

Deficiencies in donning PPE

Use of less-than-recommended level of protection

Use of droplet precautions when aerosolization occurs

Lack of PPE supplies

Lack of training and education, including HCP choosing to utilize less-than-recommended PPE

Lack of scientific evidence on transmission to make appropriate PPE recommendations

2009 H1N1, 2009 H1N1 pandemic influenza; HCP, healthcare personnel; PPE, personal protection equipment.

Table 1. Occupational situations leading to 2009 H1N1 exposure for HCP

<table>
<thead>
<tr>
<th>Situation</th>
<th>Recommended PPE</th>
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<tr>
<td>Patients with viral shedding and absence of respiratory symptoms</td>
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<td>HCP with viral shedding with or without respiratory symptoms</td>
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2009 H1N1 transmission, based on four elements: 1) elimination of potential exposures; 2) engineering controls; 3) administrative controls; and 4) personal protective equipment (PPE).

Table 2. Aerosol-generating procedures

<table>
<thead>
<tr>
<th>Procedure</th>
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<tr>
<td>Bronchoscopy</td>
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<td>Nasal washings</td>
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<td>Sputum induction</td>
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<td>Endotracheal intubation and extubation</td>
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<td>Open suctioning of airways</td>
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<td>Nebulizer treatments</td>
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<td>High-flow oxygen masks</td>
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<td>Cardiopulmonary resuscitation</td>
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<td>Autopsies</td>
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<td>Noninvasive positive pressure ventilator</td>
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<tr>
<td>Disconnection from mechanical ventilator tubing</td>
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<tr>
<td>Ventilators without high-efficiency expiratory port filtration</td>
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<tr>
<td>High-frequency oscillatory ventilation without high-efficiency filter</td>
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</tbody>
</table>

Adapted from references (2, 4, 6).

Elimination of Potential Exposures

Healthcare facilities should have as their top priority the elimination of occupational exposure to 2009 H1N1 to preserve the health of all HCP. Recognition of the infectious potential in an asymptomatic person is effective only through the implementation of systematic and widespread strategies to mount a sufficient response to reduce the threat to the healthcare team. A report during the 2003 severe acute respiratory syndrome outbreak in Canada indicated that >70% of affected HCP had provided direct care to patients unsuspected of having the disease and, therefore, no PPE was utilized (5). This demonstrates how important it is to protect the HCP from unrecognized infectious persons. At the October 2009 World Health Organization conference in Washington, DC, it was reported that 2009 H1N1 has a wide spectrum of clinical presentations and may have an asymptomatic carrier rate as high as 9%, underscoring the high risk to the healthcare team (6). Innovative triage techniques must be developed and used to safeguard HCP and patients against 2009 H1N1 exposure. Currently, exposure is defined as being within 6 ft of the patient (4) or having any direct droplet spray from a cough or sneeze without adequate PPE. Ideally, HCP would be wearing PPE at the initial contact with any patient with unknown status. In lieu of such stringent utilization of PPE, at a minimum, initial triage and history-taking should be performed while maintaining an appropriate distance until a coughing or sneezing patient is provided a surgical mask. Careful history-taking with special attention to the symptoms of any influenza-like illness (ILI) is a priority, as is inquiry about exposure to contacts with ILI. Patients who are suspected of having 2009 H1N1 or who have a febrile respiratory illness should be placed in a private room, and staff should adhere to isolation precautions. Current PPE recommendations for suspected or confirmed cases of 2009 H1N1 include a fit-tested N95 respirator and standard precautions (4, 7). These recommendations, which call for the use of a gown only during times of anticipated splashing exposure, may result in HCP not being adequately protected for the unexpected cough, sneeze, disconnection from medical equipment (i.e., ventilator circuit), or incidental contact with fomites within the room. For these reasons, we recommended the use of contact precautions, which include a disposable gown (7), in addition to a fit-tested N95 respirator (European equivalent is filtering face piece with class particulate-2 efficiency) and eye protection (i.e., goggles or splash shield).

Patients with no history of ILI symptoms and no fever are considered not considered a risk, according to the current CDC guidelines (4), and do not require the HCP to utilize PPE for 2009 H1N1 protection. However, in communities with spread occurring, it may be prudent to implement intensive care unit intake precautions because patients presenting to the intensive care unit usually are not able to provide a history at admission; therefore, one should assume the highest risk is present until proven otherwise. Intensive care unit intake precautions include HCP use of a disposable gown, gloves, goggles, fit-tested N95 respirator, and use of a private room with the door closed. Patients with anticipated aerosolizing procedures (i.e., intubation) should be preferentially placed in a negative airflow room. Once the healthcare team is able to obtain the patient's history, in the context of current symptoms, the patient should be either removed from isolation if the risk of 2009 H1N1 infection is deemed low or continued on isolation. The healthcare team can proceed with testing or work on the assumed diagnosis of 2009 H1N1 and forego any testing and continue isolation. This de-
escalating approach of assuming greater risk than data available puts the reduction of transmission to HCP at the forefront of the purpose of the intensive care unit intake precautions (6).

If testing is planned, then a rapid influenza diagnostic test for type A and B should be performed immediately. Testing protocols for handling negative rapid influenza diagnostic test screens are needed, because the false-negative rate of available tests ranges between 30% and 60% (8, 9). The ideal next step is to continue isolation and conduct real-time reverse-transcriptase polymerase chain reaction testing. This test may have a sensitivity of 80% because of dependency on specimen collection techniques and sample preservation. If there is a strong clinical suspicion of 2009 H1N1 disease, then the patient should be treated and isolation should be continued despite the negative testing (6); some centers may repeat real-time reverse-transcriptase polymerase chain reaction testing, if available. A simplified algorithm is shown in the Figure 1. Additionally, with community spread, it is important to consider the elective surgical patient and engage anesthesia departments to appropriately screen patients for ILI symptoms or exposure to persons with ILI, because most complete the preanesthesia questionnaire weeks before the surgical admission date.

Rapid response systems and code teams within hospitals may have an even greater exposure risk, because they often respond to patients with respiratory failure or distress. Careful planning and education of team members on bringing and utilizing PPE on all calls will greatly reduce the exposure risk of this indispensable group who should follow the same approach as intensive care unit intake precautions.

Engineering Controls

Patient disposition within healthcare facilities includes placing confirmed or suspected patients with 2009 H1N1 infection in a private room with the door closed. Negative-pressure rooms, with six to 12 air exchanges per hour, should be utilized when aerosol-producing procedures (Table 2) are to be undertaken. A frequently overlooked source of aerosols is the use of ventilators without filtration on the exhalation port and the use of high-frequency oscillatory ventilation without a high-efficiency filter, which has been available since 2007. Caution should be used when providing care to, or positioning patients on, mechanical ventilation to prevent disconnection from the ventilator, because both large-particle spray and aerosolization can occur.

Global projections predict that the demand for intensive care unit beds will increase by 20% (10) during this pandemic. The judicious use of negative-pressure rooms will be a key priority. If bed availability outstrips the demand, and if the room size or design allows it, then cohorting may be utilized (4, 11).

When possible, procedures and diagnostics should be performed at the bedside; however, if the intervention requires the patient to be transported within the building, then the precautions should be adjusted for the transfer. The nonintubated patient must wear a surgical mask and attendant HCP should wear gown and gloves. Additionally, the patient should be covered by a fresh, clean sheet to deter any contact spread during transfer. Notification to personnel within the receiving department is a key component to ensuring that all personnel are prepared. No other patients, HCP, or visitors should be permitted on the elevator if travel is required to another floor.

Administrative Controls

All HCP should be instructed not to report to work if they have a febrile respiratory illness and they should not be reprimanded for staying home when ill. This policy reinforces that such action is to prevent the spread of 2009 H1N1, or seasonal influenza, to both patients and other HCP. Staff should be screened each day for ILI and sent home if they have symptoms (4, 12, 13). All HCP who call in absent to work should be asked screening questions to determine whether a febrile respiratory illness is present; if so, then they should be excluded from work for at least 24 hrs after they no longer have a fever, without the use of fever-reducing medicines. Such screening minimally should include date and time of onset of symptoms and the presence or absence of fever, sore throat, cough, runny nose, nasal congestion, shortness of breath, or exposure to persons with known or suspected ILI.

If occupational exposure to 2009 H1N1 is documented, then the unvaccinated HCP should be offered antiviral prophylaxis and may continue to work if asymptomatic. If antiviral treatment is refused, then it is unclear whether the exposed HCP should be placed on work furlough for a reasonable period. Managers and administrators who contact members of the healthcare team after exposure should be scripted to inquire about the identity of any other personnel

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Figure 1. Algorithm of intensive care unit intake precautions (IIP). RIDT, rapid influenza diagnostic test; rRT-PCR, real-time reverse-transcriptase polymerase chain reaction.
that may have been exposed, because many more people provide care and enter patient rooms than are recorded on a nursing unit assignment sheet.

HCP vaccination for seasonal influenza and 2009 H1N1 must be communique dignified as a high priority to the healthcare institution. The education of the healthcare team must focus on providing the patients with a safe environment, understanding how vaccination works, and emphasizing that all HCP who do not have a contraindication should receive immunizations. Rates for seasonal influenza vaccine among HCP in the United States is usually between 40% and 50%; however, the goal of the CDC is that all HCP, in the absence of contraindications, receive the monovalent vaccine (14, 15).

Visitor management requires a comprehensive plan for patients in isolation for 2009 H1N1, as well as those visiting other patients. Creating a culture of safety that includes visitors is a daunting undertaking and requires that all levels of the organization reinforce the safety messages and develop a campaign atmosphere to generate energy regarding the topic. Signs in elevators, lobbies, waiting rooms, and bathrooms should be informative to visitors about how to prevent the spread of infection. Hand hygiene stations and alcohol foam dispensers should be placed throughout the facility.

Patients in isolation should receive only the most necessary visitors, who should be screened for ILI and undergo an evaluation of the level of exposure to the patient before admission. Ideally, all visitors to the healthcare facility should be screened for ILI in areas of community spread. Staff should be briefed on how to approach and guide visitors who appear ill. Prominently displayed signs reviewing respiratory etiquette, cough etiquette, and respiratory and hand hygiene will assist HCP in protecting not only their patients but also themselves.

Strong institutional commitment to providing HCP with the safest possible environment is requisite to instill a sense of security among staff. Education aimed at ensuring that HCP understand how and when to utilize PPE is the foundation for a prepared team. Provision of PPE is the responsibility of the employer, and concerns over shortage of supplies, mainly N95 respirators, may come to fruition. Therefore, careful stewardship of PPE supplies is a crucial aspect of supply management.

**PPE**

Providing the necessary equipment is only the first step. Ensuring that N95 respirators fit properly is not to be taken lightly. The CDC and Institute of Medicine recommendations include use of fit-tested N95 respirators. Ventilator brand, facial hair, and loss or gaining of weight all contribute to the need for ongoing fit-testing. Occupational Safety and Health Administration is reviewing the potential policy of requiring annual fit-testing of respirators in healthcare facilities. Such testing can be performed as a mass undertaking or decentralized to reach many personnel in a short period. Timing each HCP annual fit-test date to a birthday or anniversary month may increase adherence and decrease the burden of trying to fit-test all HCP at the same time. In situations in which staff members are unable to obtain an adequate fit of the N95 respirator, they should not enter the room or provide care to patients with suspected or confirmed 2009 H1N1. If available, a powered air-purifier respirator can be utilized for aerosol-producing procedures (Table 2) and in place of an N95 respirator for routine care.

Despite provision of the appropriate PPE and training, HCP still may not fully follow isolation precautions. Through self-report, >70% of HCP contracted 2009 H1N1 through probable patient contact, although HCP admitted to not using one or more components of the recommended PPE, including a physician wearing an N95 respirator without a prior fit-test (1). Further exploration to identify and remove barriers for complete adherence to PPE requirements is clearly needed. Radonovich et al (16) continue to explore the possibilities of redesign to enhance HCP adherence to N95 respirators in particular. Claims of discomfort, difficulty breathing, and facial pain have been cited as common reasons why HCP do not utilize N95 respirators. Also of concern is lack of available PPE. The California Nurses Association survey of 190 hospitals throughout nine states in the United States reported that 15% of hospitals did not have appropriate PPE available, and disposable equipment was reused in 40% of hospitals (17).

The CDC recognizes the potential shortages of N95 respirators and has endorsed the use of surgical masks to preserve the few N95 for use only during riskier procedures as needed. Although this plan may seem reasonable at first glance, it may continue to unnecessarily expose HCP. A more lasting solution would be a larger investment in nondisposable elastomeric respirators to ensure all suspected or confirmed 2009 H1N1 patient encounters provide the requisite protection levels. A recent study from Canada (18) implies that surgical masks may be as effective as N95 respirators in preventing transmission of influenza. Until more data support such effectiveness, N95 respirators should be the required respiratory protection for HCP against 2009 H1N1.

The CDC recommendations on donning and doffing PPE have been criticized in several publications (19–21), because they may allow self-contamination, particularly at wrist level, when the gloves are removed before the gown (22). A novel approach—removing the gloves as a unit with the gown—has been adopted by the Society of Critical Care Medicine’s Fundamentals of Disaster Management course (23, 24) and the World Federation of Societies of Intensive and Critical Care Medicine (25). This is facilitated during donning by taping the gown longitudinally with the glove or by “hooking” the glove from the outside as the sleeve is removed. Also, the implementation of a checklist and a partner approach are encouraged to ensure safe maneuvers are followed consistently.

**CONCLUSION**

Prevention of nosocomial transmission and the protection of the healthcare team from exposure to 2009 H1N1 will remain at the forefront of the efforts of healthcare facilities worldwide. The recommendations set forth herein may require modification as the body of scientific knowledge on this topic expands. In areas where the science is not yet conclusive, we have applied the most prudent precautions to preserve the health of HCP and to prevent the spread of 2009 H1N1 within a healthcare facility. Local infection control practitioners, budgetary constraints, and equipment scarcity may require individual facilities or municipalities to amend these recommendations. All interested parties are encouraged to periodically visit the Web sites of the CDC, World Health Organization, Society of Critical Care Medicine, and World Federation of Societies of Intensive and Critical Care Medicine for updates (26).
REFERENCES


