Infection Control and Isolation Considerations for the Pediatric Practitioner

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Education Gap

With the increasing trend of transitioning acute care to outpatient care, pediatricians in the office setting should be aware of and adopt infection control measures.

Objectives

After completing this article, readers should be able to:

1. Provide evidence for providers working in all care delivery settings regarding the need for good infection control practices.
2. Define the differences in patient populations and aspects of care delivery that influence isolation practices for pediatric patients.
3. Define the different types of precautions used and emphasize the need for standard precautions, including effective hand hygiene, in all settings.
4. Differentiate between the isolation types based on transmission of the likely pathogen.
5. Identify specific infection control strategies to decrease health-care–associated infections.
6. Outline local, regional, and national strategies to decrease the burden of health-care–associated infections in pediatric patients, including new ideas that may change or contribute to the field in the coming years.

AUTHOR DISCLOSURE Dr. Munjal has disclosed that in addition to her appointment at Montefiore Medical center, she is now a full-time employee at Pfizer in vaccine research and development. This commentary does not contain a discussion of an unapproved/investigative use of a commercial product/device.

ABBREVIATIONS

CDC	Centers for Disease Control and Prevention
HAI	health-care–associated infection
MDR	multidrug-resistant
PPE	personal protective equipment
RSV	respiratory syncytial virus

INTRODUCTION

Health-care–associated infections (HAIs) continue to represent a major burden to pediatric patients in the United States and are often preventable. (1)(2) It is estimated that 3% to 5% of children admitted to hospitals acquire an HAI, (3) which is associated with significant costs to the health-care system. (4) Infection preventionists have become a staple of acute care facilities, and their efforts have been shown to be cost-effective. (5) In the acute setting, this investment in infection prevention infrastructure is paying off. A significant reduction in central line–associated bloodstream infections was demonstrated between the last 2 major

national surveys in 2008 and 2014. There have also been reductions in *Clostridium difficile* and methicillin-resistant *Staphyloccoccus aureus* HAIs in acute care hospitals. (6)

With the increasing trend to transition care from acute care to outpatient or chronic care settings, leadership in these areas is increasingly tasked with a variety of infection control issues. This is often coupled with a lack of shared and readily available infrastructure that has proved so beneficial in the inpatient arena. This places an increasing burden on individual pediatric providers to familiarize themselves with the application of infection prevention and control. Those with oversight of the patient care facility must ensure that they have sufficient human resources and a design layout that facilitates compliance with infection prevention and occupational health best practices.

THE CHANGING WORLD

In addition to the shifts in care location, less predictable external factors are challenging the way we approach isolation issues for infectious pathogens. These factors include the increase in global traffic and human urbanization. These factors bring all patients in closer proximity to emerging infectious pathogens not previously encountered in the United States. Just as severe acute respiratory syndrome coronavirus and pandemic influenza brought to light the need to have procedures in place to contain droplet and aerosolizing procedures, so have Ebola virus and Middle East respiratory syndrome coronavirus highlighted the importance of obtaining a travel history to determine a patient's isolation status. (7)(8)(9) Biocontainment units and comprehensive personal protective equipment (PPE) coverage have thus moved from the reels of Hollywood outbreak movies to Centers for Disease Control and Prevention (CDC) updates and national headlines. There is a disturbing trend away from immunizing children. In some ways, we can capitalize on these trends by taking the opportunity to address infection control issues with our patients and our staff. We can incorporate good practices such as cough etiquette and vaccination in a discussion of factors that we can control in what has become a less predictable infectious disease landscape.

Another factor that highlights a new reliance on infection control in practice involves the emergence of multidrug-resistant (MDR) organisms or bacteria and viruses for which treatment options are either very limited or nonexistent. Chief among these threats is the presence of carbapenem-resistant Enterobacteriaceae. These gram-negative bacteria have rapidly spread during the past 20 years, with isolates now found in 44 states. (10) Resistant to drugs of last resort, often these patients can be treated only with drugs such as colistin. The recent discovery of a colistin-resistant *Escherichia coli* harboring a plasmid-borne resistance gene, *mcr-1*, in May 2016 in a US patient with no recent travel indicates that through transmission of genetic material, pan-resistant bacteria are on the horizon. (11) It will take many years to develop newer antimicrobials against these resistant microbes, leaving prevention through isolation and safe hospital practices the sole weapon in our armamentarium.

PEDIATRIC CHALLENGES IN INFECTION CONTROL

It is important to note that there are factors that increase the likelihood of the transfer of infectious material during the routine care of pediatric patients that is not seen in other populations. Young children readily acquire and transmit infections. Aspects of care such as feeding, cuddling, changing, and playing require a level of close and sustained intimate contact. Anticipating the need for these practices should appropriately inform decisions around isolation and PPE. In addition, the constant presence of caregivers who provide meaningful support for the patient is encouraged, but those same caregivers may be the very ones who are at risk for acquiring or transmitting an infectious agent. Pediatric patients are known to be at higher risk for acquiring infections from the community while hospitalized. This may be due to the physical design of clinical spaces or to the presence of many visitors, including siblings and other children. It has long been a practice to build multibedded pediatric units such as NICUs or chronic care facilities. These present a daily challenge and are prone to experience outbreaks in an extremely vulnerable patient population.

There are also congregative pediatric policies designed to encourage social development that may complicate infection control, including kangaroo care in the neonatal units, parental rooming in, and the grouping of patients during in-hospital schooling or playroom activities. In both the inpatient and outpatient settings, toys and other objects that stimulate play are encouraged for comfort and stimulation but, when not properly cleaned and disinfected, pose a risk for transmission.

PATHOGEN TRANSMISSION

Prevention is the mainstay of infection control, and the proactive identification and containment of an infectious pathogen requires knowledge and preparedness. The isolation status of a patient is determined by the potential for transmission of an organism within its environment (Table 1). This requires access to knowledge about a suspected

infectious agent and how it is transmitted for all staff, including greeters or nonmedical staff. The principal modes by which all infections can be spread are direct and indirect contact, droplet, and airborne transmission. (7) Direct contact involves the direct physical transfer of a microorganism between an infected or colonized person and a susceptible host. Examples include touching, kissing, or sexual contact. Transmission via indirect contact involves the spread of a pathogen through a colonized fomite, such as bedding, toys, utensils, biological products, or medical equipment (including catheters). Food and drinks can also represent vehicles through which infectious agents can pass. In both droplet and airborne transmission, infectious particles are propelled through the air. With droplet transmission, the particles are large (>20 μm), are relatively heavy, and fall to the ground after traveling only short distances (historically ≤3 feet). Patients standing within 3 to 6 feet risk direct deposition on their mucous membranes or skin. Subsequent entry to the respiratory tract can then occur. Airborne droplets, on the other hand, tend to be much smaller particles (approximately ≤5 μm). They are relatively light and can be suspended in air for extended periods or become more widely dispersed (eg, through ventilation systems) before contact with a host's mucous membranes. (7)(12) This is the basis for nosocomial transmission of tuberculosis (airborne transmission) around entire hospital wards, whereas pertussis (droplet transmission) typically affects those in the same room or clinical space.

STANDARD BEST PRACTICE = STANDARD PRECAUTIONS

All clinical providers should use the tiered system of standard precautions plus the addition of any transmission-based precautions as needed for certain infections. Standard precautions must be used consistently in all health-care settings regardless of the suspected or confirmed presence of an infectious agent to decrease the risk of transmission of pathogens to staff and other patients. (7)(13) Standard precautions include consistent hand hygiene, the use of PPE befitting the pathogen and exposure, maintaining a safe environment, and promoting good respiratory hygiene. Because clinical providers routinely encounter bodily fluids during the course of patient care, standard precautions are designed to protect against the acquisition of seen and unseen agents that may be present.

Hand hygiene is the single most important factor in reducing HAIs. (14) Despite the abundance of efficacy data, however, published compliance rates remain alarmingly low, and outbreaks due to transient flora transmission via the contaminated hands of health-care workers continue to be reported. (15) Factors that contribute to poor compliance include understaffing, high patient acuity, defective materials, structural design barriers, and education. Steps must be taken to address these challenges up front to ensure the best chance of success. For example, positioning easy access to sinks or full alcohol-based hand rub dispensers may be

TABLE 1. **Examples of Common Transmission-Based Precautions (12)**

CONTACT PRECAUTIONS	DROPLET PRECAUTIONS	AIRBORNE PRECAUTIONS
Clostridium difficile	Adenovirus	*Mycobacterium tuberculosis*
Enteroviruses	*Bordetella pertussis*	Measles
Hepatitis A	*Haemophilus influenza*	Varicella (with contact precautions)
Herpes simplex	Influenza	
Major, draining abscess	*Mycoplasma pneumoniae*	
Multidrug-resistant organisms[a]	*Neisseria meningitidis*	
Parainfluenza virus	Parvovirus B19	
Respiratory syncytial virus	Rhinovirus	
Staphyloccoccus aureus		
Salmonella		
Scabies		
Shigella		

[a]*Multidrug-resistant organisms are bacteria that have developed resistance to multiple classes of antibiotics.*

the first step to improved infection control practices in a facility.

Hand hygiene must be used before and after each patient contact and after removing any necessary PPE, including gloves. Hands should be washed with soap and (warm or cold) water for 20 seconds while paying special attention to frequently missed areas, including the backs of the hands, the spaces between the fingers, the fingertips, and under the nails. Soap and water is preferred in cases in which the hands are visibly soiled or in which exposure to a spore-forming organism is suspected (*C difficile* being the most common). In many infection control programs, proper hand hygiene also includes restricting those in high-risk health-care settings from keeping nails long or wearing artificial nails because they have been associated with outbreaks of gram-negative bacillus and candidal infections. (7)

Waterless sanitizers with at least 60% alcohol can be used when hands are not visibly dirty or greasy and the removal of harmful drugs or chemicals is not a concern. Alcohol-based hand rubs cannot be used when certain agents, particularly diarrhea-causing *C difficile,* norovirus, and C*ryptosporidium,* are being considered. Different alcohol-based hand rub delivery systems, including foams, gels, and wipes, have equal efficacy in the context of a clinical trial, (16) but products that require a prolonged dry time may lead to reduced amounts used and thus reduced efficacy. (17) Standard dispensers that administer the appropriate amount are advised. Alcohol-based products vary, but most require approximately 3 mL of product rubbed on the hands for approximately 30 seconds, or until the recommended amount of product evaporates, and the hands are completely dry. (18) As with soap and water, attention must be given to the backs of the hands using a hand over hand technique, the spaces between the fingers, the tips of the fingers, and under the nails.

Studies have shown improved compliance by switching from handwashing to the use of an alcohol-based hand antiseptic. (19) Therefore, alcohol-based hand antiseptics should be emphasized where compliance is low, particularly when easy access to a handwashing station is limited. Alcohol-based products can cause cracking or drying of the skin. Lotions should be readily available because they may increase skin hydration and aid the normal lipid barrier and increase compliance with hand hygiene. (20)

PROTECTIVE PERSONAL EQUIPMENT

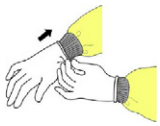
Gloves, isolation gowns, protective eye equipment, and other personal gear are important components of PPE (Tables 2 and 3). In addition to reducing patient-to-patient spread, they are mandated by the Occupational Safety and Health Administration Bloodborne Pathogens Standard for the protection of providers. (21) As the medical community collectively learned in the Ebola virus epidemic, the proper technique for putting on (donning) and taking off (doffing) PPE is as important as the specific equipment used in protecting against occupational pathogens. (22)

Gloves should be worn when coming into contact with body fluids and potentially hazardous infectious material. (7) Under standard precautions, this applies to any anticipated contact with blood and all body fluids, secretions, and excretions (except sweat); nonintact skin; and mucous membranes. Tasks should be performed that go from clean to dirty body sites to prevent cross-contamination, and gloves should be changed if they are used in areas of high infectivity (eg, a purulent dressing change). While using gloves, it is critical to avoid touching one's own face or adjusting glasses, hair, or masks. Gloves should be removed or changed during a patient encounter if a handheld or electronic device is used. Gloves are always single use and immediately should be disposed of after removal. It is important to then immediately perform hand hygiene even if a new set of gloves is to be worn because hands may have become contaminated during glove removal. Small perforations may also be present in gloves, particularly those worn for extended periods.

Isolation gowns should be used during procedures or patient care activities in which a provider's exposed skin and/or clothing is anticipated to come into contact with blood, body fluids, secretions, or excretions. (7) Gowns should be made of an impervious material that prevents contamination of skin or clothing. When needed, gowns should be the first piece of PPE to be put on before entering a patient's room and should be removed before exiting. Care must be taken to avoid skin gaps, particularly around the wrist area, and gowns should be secured at the neck and waist to prevent slippage during care.

Masks should routinely be worn to protect the mouth and nose when a procedure is likely to spray or splash fluids (such as endotracheal suctioning). Masks should also be worn to protect patients during procedures in which oral or nasal secretions could contaminate a sterile field (eg, during a dressing change for a central line). Finally, patients who are coughing and have the potential to disseminate respiratory secretions should also wear masks, particularly when traveling within a facility or in common areas. The additional use of eye shields, goggles, or full-cover PPE should be considered in select circumstances where exposure to those areas is anticipated. (7)

TABLE 2. **Recommendations for the Application of Precautions for the Care of Patients on Standard and Enhanced Precautions (7)**

COMPONENT[a]	TECHNIQUE	INDICATED
Soap and water	Wash hands for 20 seconds. Sinks should be conveniently placed and free of clutter.	Before and after each patient contact and after doffing gloves or PPE Preferred over alcohol-based hand sanitizer in the following circumstances: When hands are visibly soiled Required with *Clostridium difficile*, norovirus, *Cryptosporidium*, or *Bacillus anthracis* Before eating After using the restroom
Alcohol-based hand sanitizer (must contain ≥60% alcohol)	Apply the product to the palm of one hand as per the label instructions. Rub hands together until the product is completely dry.	When soap and water is not required
Gloves 	Make sure that gloves are pulled on all the way and cover the forearm or sleeves. Remove before other PPE by grasping the exterior of the glove with the other hand. Pull off the glove with the contaminated exterior folded on the inside. Holding the contaminated glove in the gloved hand, slide a finger from the ungloved hand under the wristband of the remaining glove. Gently pull off the glove so that it is also inside out, forming a bag for the other glove, and discard the pair. Wash hands after removal.	Required for contact with blood, body fluids, mucous membranes, nonintact skin, and contaminated items
Surgical or procedure mask 	Masks should be applied before donning gloves. Make sure that the front fully covers the nose and mouth snuggly, then secure it to the head with ties or elastic. The front of the mask should be considered contaminated. The mask should be removed from behind after all other PPE to prevent mucous membrane exposure during the doffing process.	During procedures likely to generate splashes or sprays of blood or body fluids Required within 3–6 feet of patients with infections proved to be transmitted via large respiratory droplets to protect mouth and nose
N95 respirator mask (round or trifold)[b] 	They require annual fit testing to ensure that the provider can get a good seal. Place on the face and apply the top strap at the crown of the head and bottom at the base of the neck. Straps should not be crossed. Ensure that it is sealed with a seal check before use. The mask should be removed from behind with the bottom strap released first. The mask is removed after all other PPE to prevent mucous membrane exposure during the doffing process.	During aerosol-generating procedures or on patients with infections proved to be transmitted by respiratory aerosols
Eye protection 	These can be found either attached to a surgical mask or separately in the form of goggles or safety glasses. They should be placed snug on the face. They should be removed by the straps because the front should be considered contaminated.	Required during procedures likely to generate splashes or sprays of blood or body fluids into the eyes

Continued

TABLE 2. (Continued)

COMPONENT[a]	TECHNIQUE	INDICATED
Face shield 	The face shield should cover the forehead, extend below the chin, and wrap around the side of the face.	Required during procedures likely to generate splashes or sprays of blood or body fluids When skin protection, in addition to mouth, nose, and eye protection, is needed or desired, eg, when irrigating a wound or suctioning copious secretions
Surgical gown 	If worn, it should be put on as the first piece of PPE. You must secure the upper portion at the neck and lower portion using simple bows. To remove, unfasten the bows and roll down away from the body with the clean side facing out in a bundle.	Protect skin and/or clothing from contact with blood or bodily fluids Used with patients on contact precautions

PPE=personal protective equipment.
[a]*The pictures are from CDC Guidance for the Selection and Use of PPE in Healthcare Settings (https://www.cdc.gov/HAI/prevent/ppe.html).*
[b]*More N95 respirator examples can be found at https://www.cdc.gov/niosh/npptl/topics/respirators/disp_part/respsource3healthcare.html#e.*

Other equipment, including eye goggles or face shields, must be considered during certain patient tasks or with certain pathogens. Aerosol-generating procedures (ie, bronchoscopy) can propel larger droplets farther and can impact all mucous membranes. If an area is very soiled or a procedure results in exposure below the waist (ie, during deliveries), shoe or shoe and leg coverings should be used.

SAFE ENVIRONMENTS

Standard precautions also govern the use of safe injection practices, the proper handling or disposal of items contaminated with infectious body fluids, and keeping a clean patient environment. This includes the use of sterile, single-use disposable needles and syringes for each injection. (23) After use, needles should not be recapped and should be placed into a designated, puncture-resistant container. Reusable equipment is not to be used for the care of another patient until it has been appropriately cleaned and reprocessed, and single-use items must be discarded. This includes all small, frequently used items such as stethoscopes and blood pressure cuffs and larger, more problematic items such as endoscopes that must be cleaned between patients by dedicated, trained staff. (24) Patient care and waiting areas should be properly cleaned and disinfected. High-touch reusable equipment should be wiped down at least daily and more often if visibly soiled or comes into contact with a potentially infected patient. During environmental disinfection, special attention should be given to high-touch surfaces, including doorknobs, bed rails, and examination tables. Items less commonly encountered by patients (ie, computers, keyboards, etc) should still be cleaned and disinfected regularly, particularly if shared among staff members.

OPERATIONALIZING INFECTION CONTROL

The modern shift away from acute care increases the likelihood that well patients, even those who are immunosuppressed, are integrated into outpatient practices alongside patients who may be contagious. A plan should be established for the triage and placement of patients at all points of entry within a facility to screen for those at increased risk for transmission. This can include signage and general questions regarding fever, rash, travel, and acute illness. Patients thought to be infectious can then be advised to wear a surgical mask and be offered tissues and hand sanitizer. When available, they can be prioritized into designated isolation areas that do not exhaust circulating air into common areas. Isolation rooms that are most functional contain a covered commode and emesis bags in addition to externally placed PPE supplies that allow the provider space to properly don them before entry. When isolation areas are not available, and respiratory pathogens are a concern, patients can be instructed on cough etiquette (covering their nose and mouth when coughing or sneezing), to wear a surgical mask, and to be spatially separated as much as is feasible (optimally 6 feet). Patients who are at increased risk of acquiring infection (eg, immunocompromised patients or unvaccinated newborns and others) should also be

TABLE 3. **Requirements for Standard and Transmission-Based Precautions (12)**

	STANDARD	CONTACT TRANSMISSION	DROPLET TRANSMISSION	AIRBORNE TRANSMISSION
Single-patient room	No	Yes[a]	Yes[a]	Yes, negative pressure ventilation[b]
Door closed	No	No	Yes	Yes
Dedicated durable medical equipment (eg, blood pressure cuff)	No	Yes	Yes	No
Gloves	No[c]	Yes	No	No
Gowns	No[c]	Yes	No	No
Masks	No[c]	No	Yes	Yes

[a] *May be a cohort of patients with the same pathogen.*
[b] *Also called* airborne infection isolation room.
[c] *Additional precautions are to be applied in any setting as needed.*

identified and scheduled for visits in a manner that decreases their exposure. Separate waiting areas for sick and well children can also be considered.

Before use in patient care facilities, the type of high-touch toys or play surfaces should be carefully considered. Only washable, nonabsorbent toys should be placed in common play areas. Because children may place toys in their mouths, they should be not only routinely disinfected but also rinsed with water (at least weekly). (25)(26) Toys that are composed of fabric or fur can be given to individual patients for single use. These carry higher amounts of coliforms and cannot be adequately disinfected. A toy wash bin can be provided to facilitate the separation of clean and dirty items.

TRANSMISSION-BASED PRECAUTIONS

Transmission-based precautions add a level of enhanced protection beyond standard precautions through the use of PPE. They are to be performed with patients who are known or suspected to be infected with or colonized with epidemiologically important infectious agents that are easily spread. These precautions decrease rates of transmission within and around facilities and complement good environmental programs and disinfection. (27) They also provide protection for the provider by decreasing the risk of person-to-person transmission. Optimally, health-care workers caring for patients who require isolation should receive comprehensive training and demonstrate competency in performing infection control procedures.

Transmission-based precautions must often be initiated empirically based on certain clinical syndromes or conditions. Most pathogens are spread via a preferred route based on common patient presenting symptoms, but some infectious agents can be transmitted by more than 1 route, depending on the symptoms (eg, adenovirus). Enhanced use of PPE up front is, therefore, preferred during an initial evaluation, and modifications in isolation can be made once a diagnosis is known. Signage and a partnership with patients to encourage self-identification of infectious agents will help enhance the efforts of staff.

Contact precautions apply to patients who are incontinent of stool or have draining wounds, uncontrolled secretions, or draining ostomy tubes or catheters. In this precaution category, gloves and gowns are not only recommended but also required during all contact with a patient's environment. Patients should be kept in single rooms or at a distance of greater than 3 feet in a multipatient space with a dedicated commode to reduce the opportunity for fomites to pass between patients. Durable medical equipment must be sanitized between patients.

Contact precautions are indicated for patients infected or colonized with MDR bacteria, including methicillin-resistant *S aureus*, vancomycin-resistant enterococcus, and MDR gram-negative bacilli. Other indications include pathogens transmitted via the fecal-oral route. Children with respiratory syncytial virus (RSV), parainfluenza, or enterovirus should also be placed under contact precautions. Due to the resistance to alcohol-based hand rubs and their tendency to cause institutional outbreaks when disinfection practices

are not in place, extra precautions should be considered empirically for the presentation of diarrheal disease until *C difficile* and norovirus are ruled out. (7)(28)

Droplet precautions require the use of a mask before room entry in addition to standard precautions. Although spread to mucous membranes is a concern within 3 to 6 feet, the droplets are not suspended in air and, therefore, do not require special ventilation systems or fine particle masks unless an aerosol-generating procedure is performed. Single-patient rooms are again preferred. If cohorting of patients with the same respiratory pathogen is needed for space considerations, a distance of 3 to 6 feet must be maintained between patients, with a curtain drawn at all times. Patients traveling within a facility where they may come into contact with others should wear a surgical mask themselves.

Because many respiratory infections are not identified, and bronchiolitis and viral pneumonia may be triggered by etiologies that are spread by either droplet (adenovirus, influenza, etc) or contact (RSV, parainfluenza virus, etc) precautions, combined contact plus droplet precautions can be considered for upper respiratory tract pathogens that are unidentified. Pathogen-specific precautions may be modified when an etiology is determined, although codetection of multiple respiratory pathogens transmitted via different routes (eg, influenza by droplet and human metapneumovirus by contact) is not uncommon. (29)

Airborne isolation requires protection against droplet nuclei by the addition of a respirator and a designated airborne isolation room. An appropriate respirator is one that filters 1-μm particles with 95% efficiency (ie, an N95 mask). For infectious particulate matter, there is no advantage of one product over the other as long as they are approved by the National Institute for Occupational Safety and Health. (30) If nasal skin breakdown occurs, the trifold N95 masks may be preferred. A powered air-purifying respirator with a hood, as used with full impermeable suits by some Ebola virus and chemical hazard ready teams, can be considered for improved comfort and airflow if it is anticipated that care will have to be continuously delivered for prolonged periods or exposure will be high. However, powered air-purifying respirators must be charged, and the unit must be cleaned and disinfected, including changing filters according to the manufacturer's instructions. (22)

Patients with concern for airborne isolation should be placed in rooms that can accommodate the airflow required to clear fine particle agents. These negative pressure airborne isolation rooms should perform a minimum of 6, but preferably 12, air changes per hour. Their room's door must remain closed at all times. If unable to accommodate patients in a room with a high number of air exchanges, place a surgical mask on the patient before he or she is placed into an unoccupied room. The room should be left vacant for enough time to allow the probability of acquiring tuberculosis through low-volume exchange to decrease. In a typical medical office, there are typically 4 to 6 air changes per hour. Because, the number of droplet nuclei in that setting will be reduced by 99% in 49 to 69 minutes, leaving the room unused for at least an hour should be sufficient to prevent almost all cases of airborne transmission. (31) People with proven immunity to varicella or measles do not have to wear a mask to protect against those conditions even though airborne isolation is used for susceptible personnel.

Transmission-based precautions remain in effect for most diseases for limited periods until the natural course of the infection has concluded (eg, 7 days for influenza or for the duration of illness with disease due to parainfluenza virus). If the organism is highly susceptible to antimicrobial therapy (eg, meningococcal meningitis or group A *streptococcus*), 24 hours after initiation of appropriate treatment is the typical duration of isolation. When contact isolation is used for many MDR pathogens, they may remain in place for prolonged periods, until the patient leaves the facility or is proved to no longer be colonized. This can be modified on the advice of local and regional authorities. Patients may continue to shed MDR pathogens even when not symptomatic, and decolonization regimens remain unproved.

Common pathogens and their typical routes of transmission and isolation status are listed in Table 1. Certain pathogens merit particular mention, either by their infectivity or the frequency with which they are encountered in the pediatric domain. For example, although influenza virus is commonly spread via the droplet route, it has the capacity to remain suspended in air, and N95 masks are required for aerosolizing procedures. (32) Influenza is known to survive on environmental surfaces for extended periods and to be spread by direct and indirect contact. (33) Patients who present with an influenzalike illness can either have an alternate diagnosis or be co-infected with a virus spread via the contact route (eg, metapneumovirus). Owing to all these factors, some settings opt to use both droplet and contact precautions for individuals with symptoms consistent with influenza to greatly reduce propagation throughout the health-care setting.

Respiratory syncytial virus was found to be spread via the contact route in a study that found that volunteers acquired RSV when directly exposed to infected infants or indirectly exposed to contaminated surfaces but not at a distance of 6 feet. (34) Since then, contact precautions have been

effectively used to prevent health-care transmission. However, RSV easily propagates around patient care settings even among providers who have measurable immunity. Therefore, some institutions have added masks and/or eyewear to prevent the risk of hand to mouth or eye contact in the close care required in a pediatric population, particularly in outbreak scenarios. (35)(36) There is some evidence of aerosolized RSV particles, but nosocomial spread via this route is not proved. (37)

C difficile and norovirus, although both spread via contact transmission, should be thought of as distinct in this category. They require soap and water for hand hygiene due to their resistance to alcohol. They are also difficult to eradicate from the environment and are quickly spread over high-touch surfaces. The patient care area should be disinfected with bleach-containing products, and dedicated equipment should be used for each patient. Therefore, in our institution, these 2 pathogens are differentiated from others in the contact isolation category as being *Contact "Plus."*

Other modes of transmission, including those via a vectorborne route and a vehicle route (ie, blood products), should be considered but would typically not affect isolation precautions from casual contact. This is true for diseases such as Zika virus disease and dengue. It is important, however, to identify other potential causes for diseases that may present in a similar manner (ie, meningococcal disease) that do require isolation and prompt evaluation.

PRECAUTIONS FOR VISITORS

When caregivers or other visitors accompany patients, questions regarding isolation of those persons must also be considered. This is important both for the protection of the caregiver and for the potential need to shield the patient or the facility from any infectious pathogens that the visitor may be incubating. Due to the anticipated limited movement of the caregiver among other patients, the likelihood that the caregiver and the patient have had sustained contact before the visit, and the difficulty in educating about and enforcing PPE use, most facilities do not use isolation precautions of any kind among visitors. The Society for Healthcare Epidemiology of America has supported this approach for visitors with "extensive documented exposure to the symptomatic patient prior to hospitalization." (38) However, there is likely a role for doing "just-in-time" training and using isolation for caretaker/patient dyads in which either the caregiver has not been exposed to the patient's suspected pathogen or for cases in which limiting spread of the pathogen is in the interest of public health. For example, contact precautions are advised for visitors to patients with extensively drug-resistant organisms, including carbapenem-resistant Enterobacteriaceae. Using contact precautions for visitors should also be considered for enteric pathogens, including norovirus, which have a high likelihood of causing illness in caregivers. (38) This is also pertinent in outbreak scenarios or in the case of a highly infectious emerging infectious disease, such as was the case with Ebola. Practically speaking in pediatrics, however, the prolonged care provided to most pediatric patients by their caregivers makes the use of PPE for inpatient or long-term care facility visitors impractical. It may be appropriate to suspend the use of PPE in these scenarios after a discussion with the families of the risk of the suspected pathogen. However, there continues to be a role for hand hygiene education and information regarding how the infectious disease is transmitted even if visitor PPE is not used. Visitors who are entering isolation rooms should also have limited movement to other parts of the health-care facility. (9)

Screening of visitors for communicable diseases should be part of a larger visitation policy that can balance family-centered care with infection control guidance. Visitors with active infections or a recent exposure to a communicable disease should be restricted. This may include but is not limited to fever, upper respiratory tract infections, rash, acute gastroenteritis, sore throat, flulike illness, or a history of oral polio vaccine receipt within the previous 3 to 6 weeks. Signage educating visitors on cough etiquette helps prevent the propagation of respiratory pathogens. Younger children may need to be screened or restricted, even if they are asymptomatic, because they frequently harbor and shed upper respiratory tract infections and may have difficulty containing their secretions. This is particularly true when circulating respiratory pathogens are at their peak. Furthermore, young patients should be discouraged from visiting rooms where another patient requires isolation for transmission-based precautions because these young visiting patients may not be able to reliably comply with hand hygiene and other practices to protect themselves.

OUTBREAKS, EXPOSURES, AND REPORTING

Providers in all care delivery environments must also be versed in policies around outbreaks and family notification of a communicable disease exposure when proactive measures fail to capture and isolate patients with active infections. Most outbreaks occur when standard precautions lapse. Whereas HAIs more broadly indicate infections acquired in any health-care delivery environment, nosocomial

infections typically refer to those that are acquired in the inpatient setting, including those that appear after discharge and those that are acquired by staff.

For the purposes of tracking and reporting nosocomial infections through the National Healthcare Safety Network to the CDC, a nosocomial infection must *not* be incubating or present at the time of hospitalization, defined as the first 48 hours after admission. Depending on specific local, state, or national legislation, nosocomial infections may have to be reported through the National Healthcare Safety Network or other means. Physicians must be aware of the rules and regulations in their municipality, and policies and procedures for communication should be established with local and state health authorities regarding reportable diseases and suspected outbreaks. Tracking of all HAIs can also help serve as a surrogate measure of compliance to isolation measures.

When a breach in good isolation practices has occurred, exposed parties should be identified and notified based on the transmission capabilities of the proven infection, the susceptibility of the person to acquiring it, and the method of exposure. For some infections, there is available postexposure prophylaxis (ie, vaccination or varicella zoster immune globulin [human] [VARIZIG; Aptevo BioTherapeutics LLC, Berwyn, PA] for certain high-risk patients exposed to varicella) (39) that will significantly decrease the acquisition or severity of a disease and should be promptly considered. For others, postexposure prophylaxis is either not warranted or not available. Communication with patients and public health entities is important given that exposed patients may seek further care during the period of infectivity and place others at risk.

OCCUPATIONAL HEALTH

Occupational health is an important component of infection prevention and control and limits the spread of nosocomial transmission. It is virtually impossible to protect all susceptible individuals from certain infections such as varicella, measles, and influenza by avoidance alone because these diseases are highly communicable. Transmission overall is greatly reduced in the setting of a highly vaccinated population. Every health-care facility should have clear guidance regarding employee vaccination. Employee vaccination programs significantly reduce absenteeism and are associated with lower rates of disease-associated complications. (40) (41)(42) Programs that are the most successful at reaching full compliance in employee vaccination are those that use mandates. Other strategies, such as compliance training for those who refuse, are also successful.

Policies around the management of work exposures and work restrictions for those who are infectious should also be clear. Steps should be taken to eliminate all barriers to postexposure care for personnel. For example, postexposure prophylaxis against human immunodeficiency virus after occupation exposure should ideally be started within 2 hours of the event. (43) Many large institutions should and do keep postexposure prophylaxis packets on hand, and smaller facilities should know how to access medication and testing for workers in a timely manner.

PERSONNEL ATTIRE

Horizontal transmission of HAIs has been thought to involve not only the hands but also the attire of health-care workers. For the past several years, the National Health Service in the United Kingdom has mandated a "bare below the elbows" campaign in patient care to ensure optimal hand hygiene. Providers are required to wear short sleeves or long sleeves that are rolled up, and wristwatches, jewelry, and ties are prohibited. Although there is a good rationale for this practice, the Society for Healthcare Epidemiology of America has stated that there is insufficient evidence to support mandating such an approach because the effect on HAIs is unknown. There are several studies that report the presence of pathogenic bacteria on neckties: white coats and ties should be secured and white coats removed before contact with the patient's environment to prevent patient-to-patient transfer of pathogens. Providers who opt to use white coats should launder them at least weekly and whenever they are contaminated or visibly soiled. (44)

PARTNERSHIPS AND RESOURCES

Not only government entities but also third-party payers and patients themselves are increasingly demanding reductions in medical care complications, including HAIs. Good isolation practices are a vital part of a multipronged approach to achieving the desired elimination of HAIs (ie, getting to zero). In this effort, building bridges to local, regional, and national partners is key. Not only can shared resources enhance individual compliance, but a reduction in transmission of pathogens at any one site affects the global health-care community. Infectious diseases gain access beyond hospital walls, and having the support of nearby epidemiology data and assistance is vital. Knowing, for example, the local incidence of methicillin-resistant *S aureus* or data regarding vaccine compliance to measles in your area helps to inform a practice from isolation to antimicrobial selection to disease identification. There are many

national initiatives and educational tools to rely on (Table 4). In June 2015, the US Department of Health and Human Services announced that there are 9 health departments and associated hospitals in a national network of 46 other treatment centers that will become ongoing public and private partners to provide care to patients with severe, highly infectious diseases. These centers will enhance the nation's response to outbreaks on a global scale.

Other approaches, including preventing or replacing colonization of patients with MDR organisms should also be integrated into a holistic infection control program. Perturbations in bacterial flora are seen more in the most critical patients, (45) in whom isolation practices are the most challenging to maintain given the high care demands. Restoring high-risk patients to their normal microbiome may be more effective in the prevention of MDR organism HAIs than the use of antimicrobial prophylaxis or contact precautions.

Steps are also being taken to reduce unnecessary antimicrobials to minimize the emergence of MDR organisms through antimicrobial stewardship programs. In 2015, the White House released a National Action Plan for Combating Antibiotic-Resistant Bacteria to emphasize the importance of antimicrobial stewardship in complementing a good infection control program. One pathogen targeted for improvement is the reduction in antibiotic-associated *C difficile*. In pediatrics, both care and prescribing of antibiotics are primarily in the outpatient arena. More than 70% of pediatric *C difficile* infections occur in children in the general community, with most having recently taken antibiotics prescribed in a physician's office. (46) Reducing unnecessary administration of antibiotics for viral upper respiratory tract infections is one step that all physicians can take to decrease the need for isolation due to *C difficile*.

Universal adherence to best infection control practices remains low, and direct observation and feedback, considered the gold standard in observing compliance, can be costly and result in a Hawthorne effect (observer effect). The ability of a provider to follow best practices may compete with multiple patients who may have urgent care needs. New tools are needed given all the challenges around complying with hand hygiene, environmental, and isolation practices. Electronic hand hygiene dispensing counters, radiofrequency identification of compliance, alcohol vapor detection sensors, and video surveillance are among the many automated processes that are being trialed to improve hand hygiene rates. Hospitals are increasingly adopting UV lighting to enhance traditional cleaning, with a notable reduction in rates of pathogenic bacteria. Low-budget solutions exist too: wall-mounted alcohol dispensers should be installed in easy-to-reach locations in all practice settings, and physicians themselves can carry around portable containers of waterless agents. For providers who simultaneously care for multiple patients, compliance decreases as more patients are placed into isolation, with approximately 40% of a patient load as the "tipping point." (47) Nursing and other staffing assignments should be aware of

TABLE 4. **Resources for Infection Control Guidance**

Centers for Disease Control and Prevention
Clean Hands Count campaign: http://www.cdc.gov/handhygiene/providers/index.html
Guideline for isolation precautions: preventing transmission of infectious agents in healthcare settings: http://www.cdc.gov/hicpac/pdf/isolation/Isolation2007.pdf
Guide to infection prevention for outpatient settings: http://www.cdc.gov/hai/pdfs/guidelines/Ambulatory-Care+Checklist_508_11_2015.pdf
Guideline for disinfection and sterilization in health-care facilities: http://www.cdc.gov/hicpac/pdf/guidelines/disinfection_nov_2008.pdf
Guidance on public reporting of healthcare-associated infections: recommendations of the Healthcare Infection Control Practice Committee: http://www.cdc.gov/hicpac/pdf/PublicReportingGuide.pdf
Occupational guidance
Guideline for infection control in healthcare personnel: http://www.cdc.gov/hicpac/pdf/InfectControl98
Vaccines for healthcare workers: http://www.cdc.gov/vaccines/adults/rec-vac/hcw.html
CDC Safe Injection Practices Coalition One and Only campaign: http://www.oneandonlycampaign.org
Occupational Safety and Health Administration bloodborne pathogens and needlestick prevention: http://www.osha.gove/SLT/bloodbornepathogens/index.html
HIV prophylaxis after occupational exposure: https://www.hivguidelines.org/pep-for-hiv-prevention/occupational/
Other
Pickering LK, Baker CJ, Kimberlin DW, Long SS, eds. *Red Book*: 2012 Report of the Committee on Infectious Diseases. 29th ed. Elk Grove Village, IL: American Academy of Pediatrics; 2012.
Munoz-Price LS, Banach DB, Bearman G, et al. Isolation precautions for visitors. *Infect Control Hosp Epidemiol*. 2015;36(7):747–758.
National Action Plan for Combating Antibiotic-Resistant Bacteria, 2015: https://www.cdc.gov/drugresistance/pdf/national_action_plan_for_combating_antibotic-resistant_bacteria.pdf

CDC=Centers for Disease Control and Prevention; HIV=human immunodeficiency virus.

this limitation compliance and adjust workloads of caregivers accordingly.

The intimacy of pediatric care and the high rates of circulating respiratory pathogens in this population necessitate that meticulous hand hygiene and appropriate attention to standard isolation precautions occur during every patient contact event. Health-care facilities should continue to be places where patients can seek care without the fear of contracting infectious diseases. To do this, providers must enhance their knowledge, preparedness, and ability to track adherence to infection control practices. Work environments should be conducive to compliance, and education should be ongoing to reinforce the importance of practicing standard precautions on every patient.

Summary

- Dedicating staff and resources to infection prevention and control decreases rates of health-care–associated infections (HAIs) and reduces health-care–associated costs (evidence quality B). (5)
- Adherence to hand hygiene is the single most important factor in reducing HAIs, including the preferential use of alcohol-based hand rub for routine antisepsis and soap and water in instances when hands are visibly dirty, soiled, or with certain pathogens, including *Clostridium difficile* (evidence quality A). (14)
- Certain employee policies can affect rates of HAIs, including limitations on artificial nails (evidence quality A) (7) and mandated vaccination programs (evidence quality B). (40)(41)(42)
- Personal protective equipment, including gowns, gloves, and masks, should be used as part of standard precautions for patient interactions that involve contact with blood or body fluids (evidence quality B).
- In addition to standard precautions, strong evidence indicates that transmission-based precautions should be used for patients with suspected or documented clinically important pathogens (evidence quality A).
- Based on expert opinion supported by some observational studies, patients should be identified for isolation through systems that detect and manage potentially infectious persons at the point of entry for a patient encounter (evidence quality C).
- Developing policies that limit visitation through signage and education decreases spread of communicable diseases to the most vulnerable patient populations (evidence quality B).

References for this article are at http://pedsinreview.aappublications.org/content/39/3/107.

PIR Quiz

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3. To learn how to claim MOC points, go to: http://www.aappublications.org/content/moc-credit.

1. A 15-year-old girl with cystic fibrosis is admitted to the hospital for an acute pulmonary exacerbation. Her most recent sputum culture from the cystic fibrosis clinic grew multidrug-resistant *Pseudomonas aeruginosa.* Which of the following are the most appropriate transmission-based precautions for this patient?

   A. Airborne precautions.
   B. Contact precautions.
   C. Contact and droplet precautions.
   D. Droplet precautions.
   E. Standard precautions only.

2. A previously healthy 7-month-old girl is admitted to the hospital for bronchiolitis in January from the emergency department with a 3-day history of congestion, worsening cough, and decreased feeding. Her oxygen saturation level on room air is 86%. Respiratory syncytial virus and influenza virus are circulating at epidemic levels in the community. Which of the following is the most appropriate initial transmission-based precautions for this patient?

   A. Airborne precautions.
   B. Contact precautions.
   C. Contact and droplet precautions.
   D. Droplet precautions.
   E. Standard precautions only.

3. A previously healthy 18-month-old boy is seen in the office with a 7-day history of cough, decreased feeding, and intermittent fever. His grandmother emigrated from India 2 months ago and lives with the family. The grandmother was diagnosed yesterday as having active tuberculosis. A surgical mask is placed on the infant by the nurse when he arrives at the office and is put in an examination room immediately. The infant is subsequently admitted to the hospital for suspected tuberculosis and is placed in airborne precautions. How long should the examination room that the infant was seen in be left vacant before being used again?

   A. At least 1 hour.
   B. Fifteen minutes.
   C. Forty-eight hours.
   D. The room can be used immediately.
   E. Twenty-four hours.

4. A 4-month-old girl is admitted to the hospital with a 3-day history of fever, increasing irritability, and vomiting for the past day. A lumbar puncture shows cloudy cerebrospinal fluid (CSF). She is started on intravenous ceftriaxone and vancomycin and is placed in isolation with droplet precautions. The CSF polymerase chain reaction is positive for *Neisseria meningitidis.* Which of the following represents the best time to safely discontinue the droplet precautions for this patient?

   A. At the end of her 7-day course of antimicrobial therapy.
   B. Five days after admission.
   C. Immediately because only standard precautions are indicated for *N meningitidis* meningitis.
   D. Twenty-four hours after antibiotics were first administered.
   E. When a repeated CSF culture is negative for *N meningitidis.*

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5. A 9-year-old boy with acute lymphocytic leukemia was admitted to the hospital 4 days ago for neutropenic fever and developed diarrhea the past day. He has been receiving intravenous cefepime since admission. Stool *Clostridium difficile* assay is positive. Which of the following is the most appropriate method of hand hygiene for those caring for this patient?

   A. Alcohol-based foam.
   B. Alcohol-based lotion.
   C. Alcohol-based ointment.
   D. Chlorhexidine wipes.
   E. Soap and water.