

# Risks and Prevention of Nosocomial Transmission of Rare Zoonotic Diseases

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Americans are increasingly exposed to exotic zoonotic diseases through travel, contact with exotic pets, occupational exposure, and leisure pursuits. Appropriate isolation precautions are required to prevent nosocomial transmission of rare zoonotic diseases for which person-to-person transmission has been documented. This minireview provides guidelines for the isolation of patients and management of staff exposed to the following infectious diseases with documented person-to-person transmission: Andes hantavirus disease, anthrax, B virus infection, hemorrhagic fevers (due to Ebola, Marburg, Lassa, Crimean-Congo hemorrhagic fever, Argentine hemorrhagic fever, and Bolivian hemorrhagic fever viruses), monkeypox, plague, Q fever, and rabies. Several of these infections may also be encountered as bioterrorism hazards (i.e., anthrax, hemorrhagic fever viruses, plague, and Q fever). Adherence to recommended isolation precautions will allow for proper patient care while protecting the health care workers who provide care to patients with known or suspected zoonotic infections capable of nosocomial transmission.

There are several reasons why Americans are increasingly vulnerable to being exposed to exotic infectious agents, especially zoonoses. First, Americans keep a variety of animals as household pets, most commonly cats, dogs, and birds. In 1996, 31.6% of households owned a dog, 27.3% owned a cat, and 4.6% owned a pet bird [1]. More-exotic pets have become popular, which raises concerns about the risks of infection associated with these pets, including the transmission of *Salmonella* species from reptiles [2], rabies from ferrets [3], and B virus from macaques [4]. Although the importation of primates is strictly regulated and private ownership is illegal, monkey bites from “pets” continue to be reported [4]. Second, leisure pursuits in rural venues, such as hunting, camping, and spelunking, have become increasingly popular; these pursuits bring people into close contact with wild animals, arthropods, and potentially

contaminated water supplies. Third, increasing numbers of Americans travel to remote regions of the world where they may be exposed to zoonotic diseases rarely seen in the United States. In addition, immigrants and visitors from foreign countries may introduce zoonotic diseases into the United States. Finally, many Americans work in occupations that involve direct contact with animals, including abattoir work, animal husbandry, animal control, farming, laboratory research, and veterinary medicine. In addition, many of the etiologic agents that could potentially be used in biological warfare (e.g., *Bacillus anthracis* and *Yersinia pestis*) are zoonotic pathogens (table 1).

In this article, we review rare zoonoses that pose a nosocomial hazard with a focus on preexposure prophylaxis, proper isolation of the infected patient, and management of the exposure of health care providers.

## ZOONOTIC PATHOGENS AS POTENTIAL AGENTS FOR BIOLOGICAL WARFARE

In recent years, there has been increased concern about the threat posed by bioterrorism [5–9]. In part, this concern stems from the fact that bioterrorism is within the capabilities of both nation states and small cults. In the United States, multiple incidents of anthrax release have been threatened (all hoaxes),

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**Table 1. Importance of selected zoonotic diseases.**

Disease	No. of US <sup>a</sup> cases in 1990–1998	Bioterrorism potential <sup>b</sup>	Infection control concern
Andes virus pulmonary syndrome	Not reportable	+	++
Anthrax	1	+++	+
B virus infection	Not reportable	None	+
Hemorrhagic fever (due to filoviruses and arenaviruses)	Not reportable	+++	+++
Monkeypox	Not reportable	?	++
Plague	80	+++	+++
Q fever	Not reportable	++	+
Rabies	25	None	+

**NOTE.** +++, high concern; ++, moderate concern; +, low concern; ?, unknown.

<sup>a</sup> Some zoonotic diseases, although not reportable nationally, may be reportable in individual states.

<sup>b</sup> Data are from [5].

and 2 cases of bioterrorism have been documented: a large community outbreak of salmonellosis that resulted from intentional contamination of restaurant salad bars [10] and an outbreak of *Shigella dysenteriae* type 2 infection that occurred in laboratory workers because of intentional food contamination [11]. Containment of bioterrorism will depend on clinical recognition of exotic infection, realization of an outbreak, rapid identification of the etiologic agent, appropriate isolation of infected persons, use of chemoprophylaxis (if available) or vaccination (if available), and treatment of ill patients. It is likely that infectious disease physicians and infection control professionals will play an important role in the recognition and containment of such outbreaks. Because many of the infectious agents likely to be used in a biological attack are zoonoses, infection control professionals should be aware of the current recommendations for isolation of patients known or suspected to be infected with zoonotic agents that potentially pose a nosocomial hazard. Consensus recommendations for the management of biological warfare agents have been reported for anthrax [12], smallpox [13], and plague [14].

### ZOONOTIC DISEASES AS A NOSOCOMIAL THREAT

Human-to-human transmission has been demonstrated only for a limited number of zoonotic diseases. The nosocomial risks associated with these infections are summarized in table 2. Isolation precautions recommended by the Centers for Disease Control and Prevention (CDC) [15] and the authors are summarized in table 3, and preexposure and postexposure prophylaxis regimens are summarized in table 4.

This article is designed to supplement the excellent isolation recommendations published by the CDC [15]. Supplementary isolation recommendations by the authors were made for the following reasons. First, the CDC guidelines do not include

several emerging diseases, including Andes virus, B virus, and monkeypox. Second, the CDC guidelines do not review the scientific basis for their recommendations. Third, additional precautions may be required for some diseases that are not adequately incorporated into the CDC scheme (e.g., the need for protection of mucous membranes to avert rabies infection). Finally, detailed CDC recommendations for some diseases (e.g., hemorrhagic fevers, plague, and rabies) were not reproduced in the general guideline.

In this article, we use the same system of isolation precautions defined by the CDC [15]. Standard precautions apply to blood, all body fluids, secretions, excretions (except sweat), nonintact skin, and mucous membranes. Standard precautions include hand washing before and after contact with each patient; use of gloves when touching blood, body fluids, secretions, excretions, and contaminated items; use of a mask and eye protection or a face shield during procedures that are likely to generate splashes or sprays of blood, body fluids, secretions, and excretions; and use of a gown, when appropriate, to protect skin and to prevent soiling of clothes during patient care activities that are likely to generate splashes or sprays of blood, body fluids, secretions, and excretions.

Contact precautions are used in addition to standard precautions during encounters with patients known or suspected to be infected or colonized with epidemiologically important microorganisms that can be transmitted directly (by contact with the patient) or indirectly (by contact with environmental surfaces). Contact precautions include placing the patient in a private room, wearing gloves when entering the room, and wearing a gown when substantial contact with the patient or environment is anticipated. Airborne precautions are used for patients known or suspected to be infected with microorganisms transmitted by airborne droplet nuclei (size,  $\leq 5 \mu\text{m}$ ); these precautions include placement of the patient in a private room with negative pressure, 6–12 air exchanges per hour, and air

**Table 2. Zoonotic diseases: mode(s) of transmission and risk of human-to-human transmission.**

Disease	Pathogen	Mode(s) of transmission	Risk of human-to-human transmission
Hantavirus pulmonary syndrome	Andes virus	Inhalation of host rodent feces, urine, or saliva	Undefined; epidemiological and molecular evidence supports hypotheses regarding person-to-person transmission
Anthrax	<i>Bacillus anthracis</i>	Direct contact with contaminated animal products (e.g., hides), inhalation of spores, or ingestion of contaminated food	Rare cases of human-to-human transmission via direct contact with cutaneous lesions; risk of infection via inhalation from contaminated clothes and/or patient items
B virus infection	Cercopithecine herpesvirus 1	Direct contact with macaques (e.g., animal bites or scratches, cage scratch, or contaminated sharp injury); direct contact with infected cell culture	Rare; only a single case reported following direct contact with herpetic lesion
Hemorrhagic fever	Multiple agents <sup>a</sup>	Direct contact with potentially infective material (e.g., blood, vomitus, stool, or tissue)	High; person-to-person transmission common; nosocomial transmission frequent
Monkeypox	<i>Orthopoxvirus</i>	Contact with lesions; droplet transmission (?)	Attack rate among household contacts (unvaccinated), ~10%
Plague	<i>Yersinia pestis</i>	Flea bite; cat scratch; inhalation	High for pneumonic plague; theoretical for cutaneous plague (via inhalation from aspiration or wound irrigation); risk of infection via inhalation from contaminated clothes and/or patient items
Q fever	<i>Coxiella burnetii</i>	Contact with products of conception; inhalation	Rare; single case of human-to-human transmission (obstetrician); risk of infection via inhalation from contaminated clothes and/or patient items
Rabies	Rhabdovirus	Animal bites or scratches; rarely, mucous membrane contamination with animal saliva, aerosol transmission while spelunking or in a laboratory, or corneal transplantation; exposure frequently unknown	Animal-to-human transmission via nonintact skin and mucosal contact with saliva is well documented; human-to-human transmission theoretically possible; anecdotal reports of human-to-human transmission; nosocomial transmission not reported

**NOTE.** ?, unknown.

<sup>a</sup> Including Ebola, Marburg, Lassa, Crimean-Congo hemorrhagic fever, Argentine hemorrhagic fever, and Bolivian hemorrhagic fever viruses.

directly exhausted to the outside. Health care workers who enter the room should wear appropriate respiratory protection. Droplet precautions are used for a patient known or suspected to be infected with microorganisms transmitted by droplets (size, >5  $\mu\text{m}$ ) and include placement of the patient in a private room. Health care workers who enter the room should wear a mask when they work within 3 feet of the patient.

The CDC recommends standard precautions for several diseases that could potentially be acquired by direct contact, such as anthrax, plague, and rabies. We have chosen to recommend contact precautions for these diseases for the following reasons. First, a contact precaution sign on the door would alert health care workers to the danger of potential disease acquisition by means of direct contact. Second, in the absence of contact precautions, inadvertent contact with infectious lesions might occur while routine patient care activities (e.g., turning patient in bed) are performed. Third, strict adherence to standard precautions may be lacking. For example, from 1994 through 1998, we recorded 9 instances at our hospital when employees were

exposed to syphilis via unprotected hand contact with the skin lesions of secondary syphilis (authors' unpublished data). Finally, despite the efficacy of standard precautions, exposed workers are likely to receive postexposure prophylaxis. For example, despite the use of standard precautions, which were believed to fully protect employees who care for a patient with rabies, hospital administrators at an institution thought that they were obligated to offer postexposure prophylaxis to all 256 health care workers involved in the patient's care; 18 workers accepted this prophylaxis at a total cost of \$23,028 [16]. Given the rarity of these zoonotic diseases, the use of contact precautions will not result in an important expenditure.

The US Food and Drug Administration has approved vaccines for preexposure and postexposure prophylaxis for several zoonotic diseases with the potential for person-to-person transmission, including anthrax [17], monkeypox (vaccinia vaccine) [18], plague [19], and rabies [20]. Plague vaccine is no longer being produced [14], and anthrax vaccine is not currently available for civilian use. These vaccines are recommended for lab-

**Table 3. Recommended isolation precautions for selected rare and exotic diseases.**

Disease	CDC recommendations	Authors' recommendations <sup>a</sup>
Andes virus infection	No recommendation	Standard plus droplet precautions; airborne precautions plus goggles (HEPA mask) for aerosol-inducing procedures (e.g., intubation)
Anthrax	Standard recommendations	Contact precautions for cutaneous anthrax until lesions are resolved <sup>b</sup> ; disposal of items contaminated by drainage from lesions as regulated medical waste
B virus infection	No recommendation	Contact precautions <sup>b</sup>
Hemorrhagic fever	See Appendix B	See Appendix B
Monkeypox	No recommendation	Contact <sup>b</sup> plus droplet precautions until lesions are dried and crusted
Plague	Standard (bubonic) and droplet (pneumonic) recommendations	Droplet precautions until patient is treated for 72 h (pneumonic) or pneumonia is excluded; standard precautions for bubonic plague; droplet precautions (aspiration or irrigation of buboes) for pneumonic plague
Q fever	Standard recommendations	Standard plus droplet precautions (obstetrical procedures for pregnant women); safe disposal of products of conception and placenta; standard precautions for pneumonia
Rabies	Standard recommendations	Contact precautions that include mucous membrane protection (mouth and eyes)

**NOTE.** See text for explanation and justification of authors' recommendations. CDC, Centers for Disease Control and Prevention; HEPA, high-efficiency particulate air.

<sup>a</sup> Standard precautions should be used for all patients.

<sup>b</sup> Health care facilities may wish to use a door sign that indicates modified contact precautions (i.e., use of gloves when touching potentially infective lesions).

oratory and research personnel who directly handle cultures of these agents and for persons who work with contaminated or infected animals. Investigational vaccines against Argentine hemorrhagic fever, Q fever, Rift Valley fever, and vaccinia virus-vectored Hantaan virus infection are available [21]. Persons providing occupational health care in medical facilities should be aware of the indications, contraindications, and administration of these vaccines.

## ANDES VIRUS INFECTION

Although hantaviruses include >12 viruses capable of causing human infection [22–24], human-to-human transmission has been documented only for Andes virus. Hantavirus infection in humans can be categorized into 2 major syndromes: one characterized by hemorrhage and renal failure, and another characterized by respiratory distress [22]. Recent investigations have revealed several New World hantaviruses that cause infection characterized by respiratory distress, including Andes virus (which was identified in Argentina in 1995).

Hantaviruses are transmitted from rodents to humans via direct contact with infected rodents, rodent droppings, or nests, or through inhalation of dried rodent feces, urine, or saliva. Infection has also been transmitted via a rodent bite, work with infected laboratory rats, and handling of rat plasmocytoma cells in the laboratory.

**Nosocomial risk and disease prevention.** There is no ev-

idence for person-to-person transmission of hantaviruses, with the exception of the Andes virus [25]. A serological study of health care workers who care for patients infected with Sin nombre virus failed to detect evidence of nosocomial acquisition [26]. However, investigation of the outbreak of Andes virus infection in Argentina in 1996–1997 strongly suggested person-to-person and nosocomial transmission [23, 27–29]. The Pan American Health Organization [24] recommends that, in South America, if health care workers believe they might have encountered patients with hantavirus infection characterized by respiratory distress, standard precautions should be used along with the use of surgical masks and the placement of the patient into a private room. In addition, goggles and a high-efficiency particulate air (HEPA) mask should be used when procedures that may generate a high concentration of droplets and small particle aerosols, such as tracheostomy and intubation, are performed.

Preexposure or postexposure prophylaxis is not available for hantavirus exposure. A diagnosis of Andes virus infection should be considered for health care personnel who develop clinical illness compatible with Andes virus infection within 4 weeks of exposure to infected persons.

## ANTHRAX

Anthrax is an acute infectious disease caused by *B. anthracis*, a gram-positive, spore-forming bacillus that has worldwide dis-

**Table 4. Pre-exposure and postexposure prophylaxis and therapy recommendations.**

Disease	Preexposure prophylaxis	Postexposure prophylaxis	Definition of exposure	Therapy
Andes virus infection	None	None available	Possible inhalation of infective aerosol	Supportive
Anthrax <sup>a</sup>	Vaccine	Vaccine plus Cpx (alternative: Amox or Dox) <sup>b</sup>	Possible inhalation or ingestion of <i>Bacillus anthracis</i> spores, or nonintact skin contact with infective lesion	Cpx (alternative: Pen G or Dox) <sup>c</sup>
B virus infection	None	Acy (?)	Bite or scratch by macaque; contact by nonintact skin with lesion	Acy <sup>d</sup>
Hemorrhagic fever	None	None available	Possible inhalation or contact by nonintact skin or mucous membranes with infective body fluid or tissue	Supportive, ribavirin (CCHF virus/arenaviruses), passive antibody (AHF, BHF, Lassa, and CCHF viruses)
Monkeypox	Vaccine	None recommended	Contact with infective lesion	Supportive
Plague	Vaccine	Dox (alternative: Cpx or Chl) <sup>e</sup>	Possible inhalation or nonintact skin exposure by <i>Yersinia pestis</i>	Stm or Gm (alternative: Dox or Chl) <sup>f</sup>
Q fever <sup>a</sup>	Vaccine <sup>g</sup>	Dox <sup>h</sup>	Possible inhalation of infective aerosol	Dox (acute disease) <sup>i</sup>
Rabies	Vaccine	Vaccine plus rabies Ig (avoid rabies Ig if previously immunized)	Contact with infective saliva via bite or scratch, or contact of nonintact skin or mucous membranes by infective saliva	Supportive

**NOTE.** Acy, acyclovir; AHF, Argentine hemorrhagic fever; Amox, amoxicillin; BHF, Bolivian hemorrhagic fever; CCHF, Crimean-Congo hemorrhagic fever; Chl, chloramphenicol; Cpx, ciprofloxacin; Dox, doxycycline; Gm, gentamicin; Pen G, penicillin G; Stm, streptomycin; ?, unknown.

<sup>a</sup> Postexposure prophylaxis should be provided regardless of preexposure vaccine prophylaxis.

<sup>b</sup> Ciprofloxacin (500 mg orally every 12 h for 60 d) optimal therapy if strain is proven susceptible, amoxicillin (500 mg orally every 8 h for 60 d) or doxycycline (100 mg orally every 12 h for 60 d).

<sup>c</sup> Ciprofloxacin (400 mg iv every 12 h for 60 d) optimal therapy if strain is proven susceptible, penicillin G (4 million units iv every 4 h for 60 d) or doxycycline (100 mg iv every 12 h for 60 d). Substitute oral antibiotics as soon as clinical condition improves.

<sup>d</sup> Acyclovir (10 mg/kg iv every 8 h; see [42] for duration and switch to oral therapy).

<sup>e</sup> Doxycycline (100 mg orally every 12 h for 7 d); alternative: ciprofloxacin (500 mg orally every 12 h for 7 d) or chloramphenicol (25 mg/kg orally 4 times daily for 7 d).

<sup>f</sup> Streptomycin (15 mg/kg im every 12 h for 10 d or gentamicin); alternative: doxycycline (100 mg iv every 12 h for 10–14 d) or chloramphenicol (1 g iv every 6 h for 10–14 d).

<sup>g</sup> Not approved by the US Food and Drug Administration. Administer single 0.5-mL dose subcutaneously.

<sup>h</sup> Doxycycline (100 mg orally every 12 h for 5 days; start 8–12 days after exposure).

<sup>i</sup> Doxycycline (100 mg orally every 12 h for 5–7 d) or tetracycline (500 mg orally every 6 h for 5–7 d).

tribution [30–32]. Anthrax is primarily an epizootic or enzootic disease of herbivores (e.g., cattle, goats, and sheep) that acquire the disease from direct contact with contaminated soil. Humans usually become infected via contact, ingestion, or inhalation of *B. anthracis* from spores from infected animals or their products (e.g., hair, bone, and hide). Human disease occurs primarily in 3 forms: cutaneous, respiratory, and gastrointestinal.

**Nosocomial risk and disease prevention.** Despite the fact that the CDC has stated that human-to-human transmission of anthrax does not occur [30], multiple anecdotal or case reports of transmission after contact with cutaneous lesions have been described [33–36]. There have been reports of human-to-human transmission after contact with contaminated dressings from a patient with cutaneous anthrax [37] and via

a communal toilet article [38]. Given these reports, use of contact precautions for patients with draining lesions appears warranted. Dressings with drainage from the lesions should be incinerated, autoclaved, or otherwise disposed of as regulated medical waste. Human-to-human transmission from patients with pulmonary or gastrointestinal disease has not been reported. Although pneumonia is not typically present in cases of inhalational anthrax, bloody sputum has been reported and should be considered infectious [39]. Standard precautions should be used for postmortem care. If autopsies are performed, all related instruments should be autoclaved or incinerated [12]. Because embalming of bodies could be associated with special risks, consideration should be given to cremation [12].

A potential risk exists for health care workers who care for

persons exposed to *B. anthracis* spores as a result of acts of bioterrorism, a laboratory accident, or industrial contamination. The likelihood of the development of cutaneous disease after exposure of *B. anthracis* spores to intact skin is low [30]. The risk for “secondary” anthrax through reaerosolization appears to be low in settings where *B. anthracis* spores are released unintentionally or are present in low levels. However, clothing contaminated with spores has served as a source for infection. Therefore, the CDC recommends that, in situations where the threat for transmission of *B. anthracis* spores is deemed credible, decontamination of skin and potential fomites (e.g., clothing or desks) may be considered to reduce the risk for cutaneous and gastrointestinal forms of disease [30] (Appendix A).

Persons exposed to *B. anthracis* spores during a proven biological incident should be provided with vaccination and postexposure chemoprophylaxis [30]. Optimal postexposure protection is afforded by a combination of antibiotic therapy and immunization. If the licensed anthrax vaccine is available, immunization should begin with doses given at 0, 2, and 4 weeks, and the duration of postexposure prophylaxis can be shortened to 30–45 days [39]. Oral fluoroquinolones are the drugs of choice for chemoprophylaxis for adults, including pregnant women [30].

## B VIRUS INFECTION

Cercopithecine herpesvirus 1 (*Herpesvirus simiae* or B virus) is a member of the herpes group of viruses indigenous only to Asian monkeys of the genus *Macaca* [40–42]. More than 25 cases of B virus infection in humans have been described. B virus infections in humans usually result from macaque bites, monkey scratches, or cage scratches, and have occurred in biomedical research employees with occupational exposure to macaques. Human infection has also resulted from direct contamination of a preexisting wound with monkey saliva, cuts sustained from tissue culture bottles contaminated with monkey kidney cells, and needlestick injuries that happen after needle use in macaques. A seroprevalence survey of primate handlers detected no evidence of asymptomatic B virus infection [43].

In humans, B virus infection most commonly presents as rapidly ascending encephalomyelitis. The incubation period in humans has been reported to be as short as 2 days, but it most commonly lasts 2–5 weeks. The case-fatality rate has historically been ~70%, but this rate appears to have declined recently [42].

**Nosocomial risk and disease prevention.** Only a single case of human-to-human transmission of B virus infection has been reported [44]. This case involved direct repeated inoculation of drainage from an active primary B virus herpetic lesion onto skin disrupted by contact dermatitis. Transmission may also have been facilitated by the use of corticosteroid cream by the exposed person. Humans with known or suspected B

virus infection should be managed with the use of strict barrier precautions (i.e., contact precautions) to protect health care workers from contact with the infected person’s blood, other body fluids, or wound drainage [42]. The CDC has published guidelines for persons who work with macaques [45] and for laboratory workers exposed to B virus–contaminated primary rhesus monkey cell cultures [46].

A consensus guideline that provides detailed recommendations for the diagnosis and treatment of human B virus infection has been reported [42]. The prophylactic use of antiviral agents in asymptomatic persons who have had potential exposure to B virus (e.g., via a macaque bite or scratch) is controversial, and the advantages and disadvantages of treatment with these agents should be carefully discussed with the exposed employee [42].

## HEMORRHAGIC FEVERS DUE TO CRIMEAN-CONGO HEMORRHAGIC FEVER, EBOLA, LASSA, AND MARBURG VIRUSES

Viral hemorrhagic fever (VHF) is caused by a diverse group of viruses belonging to the families *Arenaviridae*, *Bunyaviridae*, *Filoviridae*, and *Flaviviridae*. All VHFs have a similar clinical picture, with mortality rates of 15%–30%; in the case of VHF due to Ebola virus, this rate is as high as 80% [47].

**Nosocomial risk and disease prevention.** Person-to-person transmission and nosocomial transmission have been demonstrated for VHFs due to Ebola [48], Marburg [49], Lassa [50], Crimean-Congo hemorrhagic fever [51], Argentine hemorrhagic fever [52], and Bolivian hemorrhagic fever [53] viruses. Transmission of VHF has been associated with reuse of unsterile needles and syringes and with provision of patient care without appropriate barrier precautions to prevent exposure to blood and other body fluids that contain the virus (including vomitus, urine, and stool) [54]. Airborne transmission of VHF has been described in primates [54] but has never been described in humans; it is considered a possibility only in rare instances that involve persons with advanced stages of disease. One patient with Lassa fever who had extensive pulmonary involvement may have transmitted infection by the airborne route [55].

The CDC has published guidelines for the management of patients with suspected VHF (Appendix B) [54, 56]. In general, a combination of contact and airborne isolation precautions should be used for patients who are suspected of having VHF. The use of an adjoining anteroom is suggested, if available, but its need has not been scientifically demonstrated. Careful evaluation of outbreaks should be undertaken to assess the need for some of the CDC recommendations that exceed those contained in contact and airborne isolation precautions, including

the suggestion for an anteroom and decontamination of body fluids before disposal via a sanitary sewer (i.e., a toilet).

## MONKEYPOX

Monkeypox, which is caused by a member of the genus *Orthopoxvirus*, is enzootic in squirrels and monkeys in the rain forests of western and central Africa. Clinical signs of monkeypox include a centrifugally distributed vesiculopustular rash, respiratory distress, and, frequently, lymphadenopathy (this aids in its differentiation from smallpox and varicella). The case-fatality rate was reported to be 11% in one outbreak among persons not vaccinated against smallpox [58]; death was not described in vaccinated patients.

Monkeypox has occurred sporadically in humans in Africa. Person-to-person transmission is well described, with a secondary attack rate of ~10%. Multiple generations (up to 5) of person-to-person transmitted disease have been reported. However, computer simulations have predicted that, even though individual outbreaks might last as long as 14 generations before dying out, self-sustaining transmission is highly unlikely [59].

**Nosocomial risk and disease prevention.** Like variola virus, monkeypox virus appears to enter through skin abrasions or the mucosa of the upper respiratory tract. Person-to-person spread is well documented, but the risk of nosocomial transmission has not been assessed. Given the likely modes of viral transmission, contact and droplet precautions should be used when treating infected patients until lesions are dried and crusted.

If possible, contact with patients who have monkeypox should be limited to medical workers who have received smallpox vaccination. No specific guidelines have been reported regarding possible postexposure prophylaxis. Vaccinia immune globulin is available, but its use as postexposure prophylaxis has not been evaluated.

## PLAGUE

*Y. pestis*, the etiologic agent of plague, is maintained in the western United States as an enzootic agent in rodents and their fleas [60]. Humans become infected through contact with infected animals (most commonly, rock squirrels, prairie dogs, or cats) or their fleas. Plague may manifest in 1 of 3 clinical forms: bubonic, septicemic, or pneumonic.

**Nosocomial risk and disease prevention.** Patients with plague may transmit infection via the droplet route if they have pneumonia and are coughing. The last case of plague acquired from person-to-person spread in the United States was reported in 1925. Droplet precautions plus eye protection (e.g., use of face shields to minimize the risk of conjunctival infection) should be used for patients with known or suspected plague

until pneumonia has been excluded as a diagnosis or until the patient has received 72 h of therapy and clinical improvement occurs [15, 61]. Contact and droplet precautions should be used during aspiration or irrigation of buboes. Close contacts (i.e., contact with a patient at <2-m of distance) of persons with untreated pneumonic plague should receive postexposure prophylaxis [14].

Individuals who have died of plague should be handled with routine strict precautions [14]. Contact with remains should be limited to trained personnel, and the safety precautions for transporting corpses for burial should be the same as those for transporting ill patients. Aerosol-generating procedures, such as bone sawing associated with surgery or postmortem examinations, are associated with special risks of transmission and are not recommended [14]. If such aerosol-generating procedures are necessary, high-efficiency particulate air-filtered masks and negative pressure rooms should be used [14].

## Q FEVER

Q fever, a zoonotic disease with worldwide distribution, is caused by *Coxiella burnetii*, an intracellular, gram-negative bacillus [62]. *C. burnetii* has been isolated from many animals, but the most important sources for human infection have been livestock (cattle, sheep, and goats) and domestic cats.

In humans, *C. burnetii* may cause both acute illness (flulike febrile illness, prolonged unexplained fever, and “atypical pneumonia”) and chronic illness (endocarditis, osteomyelitis, and chronic hepatitis).

**Nosocomial risk and disease prevention.** The primary mode of acquisition of *C. burnetii* infection is via inhalation of infected fomites (small-droplet aerosol transmission from domestic animals), especially after contact with parturient female animals and their birth products; acquisition may also occur via the ingestion of contaminated food, usually raw milk. *C. burnetii* is able to survive for extended periods in the environment and may be spread long distances by the wind. Contaminated clothes have served as a source for human infection.

Sporadic human infections have been reported to occur via intradermal injection, blood transfusion, and transplacental transmission resulting in congenital infection, and during autopsies. In addition, Q fever has been reported in an obstetrician who performed an abortion on an infected pregnant woman. Standard precautions are adequate for the management of patients with *C. burnetii* pneumonia. It would be reasonable to use contact plus droplet precautions during obstetric procedures for infected pregnant women. Additional practice should include safe disposal of the products of conception and avoidance of aerosolization of amniotic fluid [63]. Given the rarity of person-to-person transmission, prophylaxis after exposure to an infected person is probably not necessary.

## RABIES

Rabies is primarily a disease of animals [64, 65]. The epidemiology of human rabies is a reflection of both the distribution of the disease in animals and the degree of contact with these animals [64]. Rabies is most commonly acquired via a bite or scratch from a rabid animal or from contact between nonintact skin and infective saliva. Saliva and nervous tissue are highly infectious. Generally, contact with other body fluids does not constitute exposure. Uncommon routes of infection include contamination of mucous membranes, corneal transplantation (8 cases), exposure to aerosols from spelunking or laboratory activities, and iatrogenic infection through improperly inactivated vaccines [66]. Clinical signs attributed to rabies include paresthesia, anxiety, agitation, confusion, disorientation, hydrophobia, aerophobia, hypersalivation, dysphagia, paresis, paralysis, and fluctuating levels of consciousness [67].

**Nosocomial risk and disease prevention.** There are anecdotal reports of person-to-person transmission of rabies [68]. Fluids from the upper and lower respiratory tracts of humans frequently test positive for rabies virus [69]. Despite the lack of proven nosocomial transmission, ~30% of health care worker contacts have been treated with postexposure prophylaxis [69]. Given the mechanism of disease transmission and concern among health care workers, contact isolation precautions should be used for patients with known or suspected rabies, and health care workers who care for such patients should wear either masks and eye protection or face shields. Health care workers with nonintact skin or mucous membrane exposure to infective saliva should receive postexposure prophylaxis.

## CONCLUSION

Zoonotic diseases pose a nosocomial hazard [70]. However, prompt recognition and use of established isolation precautions can successfully protect health care workers. Preexposure and postexposure prophylaxis regimens exist for many potentially serious zoonotic diseases.

## APPENDIX A

**Decontamination of persons possibly contaminated with *Bacillus anthracis*, *Yersinia pestis*, or *Coxiella burnetii*.** The need for decontamination depends on the exposure that is suspected; in most cases, decontamination will not be necessary. The goal of decontamination after potential exposure to a bioterroristic agent or a laboratory accident is to reduce the extent of external contamination of the patient and to contain the

contamination to prevent further spread. Decontamination should only be considered in instances of gross contamination.

1. Patients should be instructed to remove their contaminated clothing and store it in labeled plastic bags.
2. After removal of contaminated clothing, patients should be instructed (or assisted, if necessary) to shower immediately with soap and water.
3. Potentially harmful practices, such as the bathing of patients with bleach solutions, are unnecessary and should be avoided.
4. Clean water, saline solution, or commercial ophthalmic solutions are recommended for rinsing eyes.
5. If indicated, after removal of patient clothing at the decontamination site, the clothing should be handled only by personnel wearing appropriate protective equipment (gloves, gown, and surgical mask) and placed in a plastic bag to prevent further environmental contamination.
6. Environmental surfaces should be decontaminated with a US Environmental Protection Agency–registered, facility-approved sporicidal/germicidal agent or with 0.5% hypochlorite solution (1 part household bleach added to 9 parts water).

NOTE. Data are from [7, 30].

## APPENDIX B

**Management of patients with suspected viral hemorrhagic fevers (VHFs) due to Marburg, Ebola, and Crimean-Congo hemorrhagic fever viruses.** The following recommendations apply to patients who, within 3 weeks before the onset of fever, have either traveled in the specific area of a country where VHF has recently occurred; had direct contact with blood, other body fluids, secretions, or excretions from a person or animal with VHF; or worked in a laboratory or animal facility that handles viruses that cause hemorrhagic fever. The likelihood of acquisition of VHF is considered extremely low for persons who do not meet any of these criteria. The cause of fever in persons who have traveled in areas where VHF is endemic is more likely to be a different infectious disease (e.g., malaria or typhoid fever); evaluation for and treatment of these other potentially serious infections should not be delayed.

1. Because most ill persons who undergo prehospital evaluation and transport are in the early stages of disease and would not be expected to have symptoms that increase the likelihood of contact with infectious body fluids (e.g., vomiting, diarrhea, or hemorrhage), standard precautions are generally sufficient. If a patient has respiratory symptoms (e.g., cough), face shields or surgical masks and eye protection should be worn by caregivers to prevent droplet contact. Blood, urine, feces, or vomitus, if present,

should be handled as described in the following recommendations for hospitalized patients.

2. Patients in a hospital outpatient or inpatient setting should be placed in a private room. A negative-pressure room is not required during the early stages of illness but should be considered at the time of hospitalization to avoid the need for subsequent transfer of the patient. Nonessential staff and visitors should be restricted from entering the room. Health care workers should use barrier precautions to prevent skin and mucous membrane exposure to blood, other body fluids, secretions, and excretions. All persons who enter the room should wear gloves and gowns to prevent contact with items or environmental surfaces that may be soiled. In addition, face shields or surgical masks and eye protection (e.g., goggles or eyeglasses with side shields) should be worn by persons coming within ~1 m of the patient to prevent contact with blood, other body fluids, secretions (including respiratory droplets), or excretions. The need for additional barriers depends on the potential for fluid contact, as determined by the procedure performed and the presence of clinical symptoms that increase the likelihood of contact with body fluids from the patient. For example, if copious amounts of blood, other body fluids, vomit, or feces are present in the environment, leg and shoe coverings also may be needed. Before entering the hallway, all protective barriers should be removed, and shoes that are soiled with body fluids should be cleaned and disinfected as described below (see recommendation 6). An anteroom for putting on and removing protective barriers and for storing supplies would be useful, if available.
3. For patients with suspected VHF who have a prominent cough, vomiting, diarrhea, or hemorrhage, additional precautions are indicated to prevent possible exposure to airborne particles that may contain virus. Patients with these symptoms should be placed in a negative-pressure room. Persons who enter the room should wear personal protective respirators as recommended for care of patients with tuberculosis (i.e., N-95 masks).
4. Measures to prevent percutaneous injuries associated with the use and disposal of needles and other sharp instruments should be undertaken as outlined in recommendations for isolation precautions [57].
5. Because of the potential risks associated with handling infectious materials, laboratory testing should be the minimum necessary for diagnostic evaluation and patient care. Clinical laboratory specimens should be obtained according to the precautions outlined above (see recommendations 1–4), placed in plastic bags that are sealed, and then transported in clearly labeled, durable, leakproof containers directly to the specimen handling area of the laboratory. Care should be taken not to contaminate the external surfaces of the container. Laboratory staff should be alerted to the nature of the specimens, which should remain in the custody of a designated person until testing is done. Specimens in clinical laboratories should be handled in a class II biological safety cabinet according to biosafety level 3 practices. Serum samples used in laboratory tests should be pretreated with polyethylene glycol *p*-tert-octylphenyl ether (Triton X-100); treatment with 10  $\mu$ L of 10% Triton X-100/1 mL of serum for 1 h reduces the titer of viruses that cause VHF in serum, although 100% efficacy in inactivation of these viruses should not be assumed. Blood smears (e.g., for malaria) are not infectious after fixation in solvents. Routine procedures can be used for automated analyzers; analyzers should be disinfected as recommended by the manufacturer or with a 500-ppm solution of sodium hypochlorite (1:100 dilution bleach) after use. Virus isolation or cultivation must be done at biosafety level 4.
6. Environmental surfaces or inanimate objects contaminated with blood, body fluids, secretions, or excretions should be cleaned and disinfected according to standard procedures. Disinfection can be accomplished by use of a US Environmental Protection Agency (EPA)–registered hospital disinfectant or a 1:100 dilution of household bleach.
7. Soiled linens should be placed in clearly labeled leakproof bags at the site of use and transported directly to the decontamination area. Linens can be decontaminated in a gravity displacement autoclave or incinerated. Alternatively, linens can be laundered in a normal hot water cycle with bleach if universal precautions to prevent exposures are precisely followed [57] and linens are placed directly into washing machines without sorting.
8. There is no evidence of transmission of viruses that cause VHF to humans or animals through exposure to contaminated sewage. As an added precaution, measures should be taken to eliminate or reduce the infectivity of bulk blood, suctioned fluids, secretions, and excretions before disposal. These fluids should be autoclaved, processed in a chemical toilet, or treated with several ounces of household bleach for >5 minutes (e.g., in a bedpan or commode) before flushing or disposal in a drain connected to a sanitary sewer. Care should be taken to avoid splashing when disposing of these materials. Potentially infectious medical waste (e.g., contaminated needles, syringes, and tubing) should be either incinerated or decontaminated by autoclaving or immersion in a suitable chemical germicide (i.e., a US EPA–registered hospital disinfectant or a 1:100 dilution of household bleach) and then handled according to existing local and state regulations for waste

management.

9. If the patient dies, the amount of handling of the body should be minimal. The corpse should be wrapped in sealed leakproof material (not embalmed) and cremated or buried promptly in a sealed casket. If an autopsy is necessary, the state health department and Centers for Disease Control and Prevention should be consulted regarding appropriate precautions.
10. Persons with percutaneous or mucocutaneous exposures to blood, body fluids, secretions, or excretions from a person with suspected VHF should immediately wash the affected skin surfaces with soap and water. Application of an antiseptic solution or hand washing product may be considered also, although the efficacy of this supplemental measure is unknown. Mucous membranes (e.g., conjunctiva) should be irrigated with copious amounts of water or eyewash solution. Exposed persons should receive medical evaluation and follow-up management.

NOTE. Data were adapted from [54, 56].

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