MMWR™

Morbidity and Mortality Weekly Report

Recommendations and Reports | July 26, 2002 / Vol. 51 / No. RR-9

Hantavirus Pulmonary Syndrome — United States: Updated Recommendations for Risk Reduction

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The *MMWR* series of publications is published by the Epidemiology Program Office, Centers for Disease Control and Prevention (CDC), U.S. Department of Health and Human Services. Atlanta. GA 30333.

SUGGESTED CITATION
Centers for Disease Control and Prevention. Hantavirus pulmonary syndrome—United States: updated recommendations for risk reduction. MMWR 2002;51(No. RR-9):[inclusive page numbers].

On the Cover: Deer mouse (*Peromyscus maniculatus*), reservoir of Sin Nombre virus. L. L. Master, Mammal Image Library of the American Society of Mammalogists.

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Hantavirus Pulmonary Syndrome — United States: Updated Recommendations for Risk Reduction

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Summary

This report provides updated recommendations for prevention and control of hantavirus infections associated with rodents in the United States. It supersedes the previous report (CDC. Hantavirus infection—southwestern United States: interim recommendations for risk reduction. MMWR 1993;42[No. RR-11]:1–13). These recommendations are based on principles of rodent and infection control, and accumulating evidence that most infections result from exposure, in closed spaces, to active infestations of infected rodents. The recommendations contain updated specific measures and precautions for limiting household, recreational, and occupational exposure to rodents, eliminating rodent infestations, rodent-proofing human dwellings, cleaning up rodent-contaminated areas and dead rodents, and working in homes of persons with confirmed hantavirus infection or buildings with heavy rodent infestations.

Introduction

Background

In 1993, a previously unknown disease, hantavirus pulmonary syndrome (HPS), was identified among residents of the southwestern United States (*1–3*). HPS was subsequently recognized throughout the contiguous United States and the Americas. As of June 6, 2002, a total of 318 cases of HPS have been identified in 31 states, with a case fatality of 37%.* The association of hantaviruses with rodent reservoirs warrants recommendations to minimize exposure to wild rodents. These recommendations are based on current understanding of the epidemiologic features of hantavirus infections in the United States.

Rodent Reservoirs of Viruses Causing HPS

All hantaviruses known to cause HPS are carried by the New World rats and mice, family Muridae, subfamily Sigmodontinae. The subfamily Sigmodontinae contains at least 430 species of mice and rats, which are widespread in North and South America. These wild rodents are not generally associated with urban environments as are house mice and the black and Norway rats (all of which are in the murid subfamily Murinae). However, some species (e.g., deer mouse and white-footed mouse) will enter human habitation in rural and suburban areas. A third group of rodents, the voles and lemmings (family Muridae, subfamily Arvicolinae), is associated with a group of hantaviruses distinct from those that cause HPS. None of the numerous arvicoline viruses has been associated with human disease in the United States (*4*).

Several hantaviruses that are pathogenic for humans have been identified in the United States. In general, each virus has a single primary rodent host. Other small mammals can be infected as well, but are much less likely to transmit the virus to other animals or humans (*5–7*). The deer mouse (*Peromyscus maniculatus*) (Figure 1) is the host for Sin Nombre virus (SNV), the primary causative agent of HPS in the United States. The deer mouse is common and widespread in rural areas throughout much of the United States (Figure 2). Although prevalence varies temporally and geographically, on average approximately 10% of deer mice tested throughout the range of the species show evidence of infection with SNV (*5*).

Other hantaviruses associated with sigmodontine rodents and known to cause HPS include New York virus (*8*), hosted by the white-footed mouse, *Peromyscus leucopus* (Figures 3,4); Black Creek Canal virus (*9*), hosted by the

* Updated HPS information is available at http://www.cdc.gov/ncidod/diseases/hanta/hps/noframes/caseinfo.htm.

The material in this report was prepared for publication by the National Center for Infectious Diseases, James M. Hughes, M.D., Director; Office of Bioterrorism Preparedness and Response Activity, Scott Lillibridge, M.D., Director; and the National Immunization Program, Walter A. Orenstein, M.D., Director.

FIGURE 1. Deer mouse (*Peromyscus maniculatus*), reservoir of Sin Nombre virus

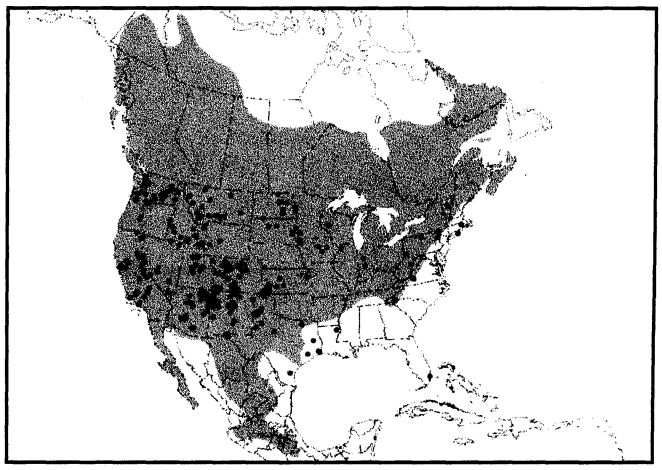
Photo/L. L. Master, Mammal Image Library of the American Society of Mammalogists

FIGURE 3. White-footed mouse (*Peromyscus leucopus*), reservoir of New York virus

Photo/L. L. Master, Mammal Image Library of the American Society of Mammalogists

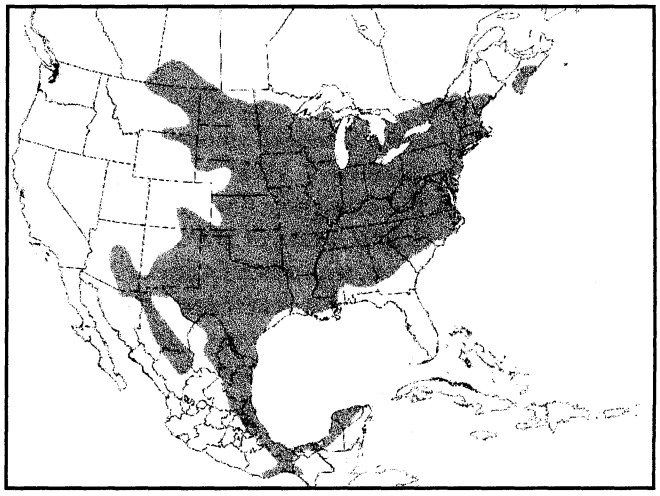
cotton rat, *Sigmodon hispidus* (Figures 5,6); and Bayou virus (*10*), hosted by the rice rat, *Oryzomys palustris* (Figures 7,8). Nearly all of the continental United States falls within the range of one or more of these host species. Several other sigmodontine rodent species in the United States are associated with additional hantaviruses that have yet to be implicated in human disease. These species include the brush mouse, *Peromyscus boylii* (*11*); and the Western harvest mouse, *Reithrodontomys megalotis* (*12*). Only the deer mouse and the white-footed mouse are commonly associated with peridomestic environments. Identifying characteristics and natural history of all these host species are available from other sources (*13,14*).

FIGURE 2. Range of the deer mouse (*Peromyscus maniculatus*) in North America and confirmed cases of hantavirus pulmonary syndrome (HPS) in the United States, as of June 6, 2002



Source: Carleton MD. Systematics and evolution. In: Kirkland GL Jr, Layne JN, eds. Advances in the study of *Peromyscus* (Rodentia). Lubbock, TX: Texas Tech University Press, 1989:7–141

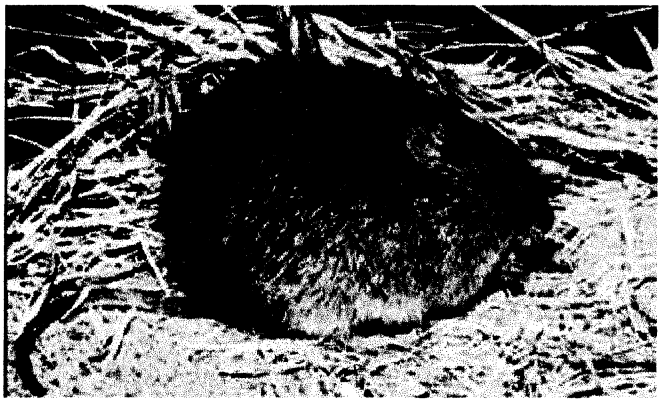
FIGURE 4. Range of the white-footed mouse (*Peromyscus leucopus*) in North America



Source: Carleton MD. Systematics and evolution. In: Kirkland GL Jr, Layne JN, eds. Advances in the study of *Peromyscus* (Rodentia). Lubbock, TX: Texas Tech University Press, 1989:7–141

Numerous species of sigmodontine rodents also are associated with HPS in South America (*4*). Several new sigmodontine hantavirus hosts have been discovered each year and more probably await discovery. Until the extent of hantavirus infection throughout the subfamily Sigmodontinae becomes known, as does the pathogenicity of hantaviruses hosted by sigmodontine species, treating all sigmodontines as potential hosts of

FIGURE 5. Cotton rat (*Sigmodon hispidus*), reservoir of Black Creek Canal virus



Photo/R. B. Forbes, Mammal Image Library of the American Society of Mammalogists

FIGURE 7. Rice rat (*Oryzomys palustris*), reservoir of Bayou virus

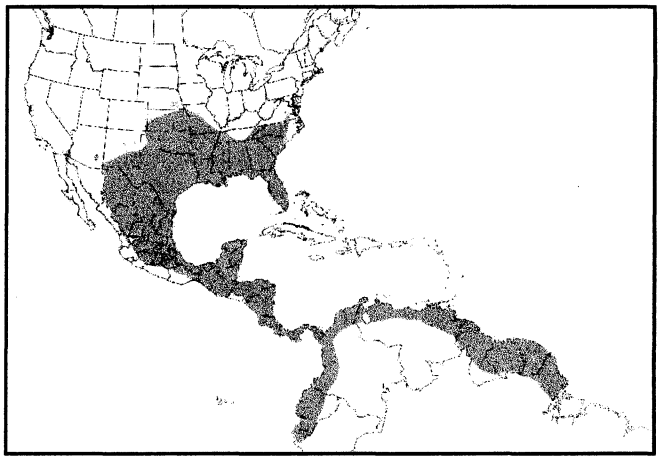
Photo/R. K. LaVal, Mammal Image Library of the American Society of Mammalogists

HPS-causing hantaviruses, and each sigmodontine rodent as though it were infected and infectious is recommended. For the general public, this recommendation applies to all wild mice and rats encountered in rural areas throughout the United States.

Other Diseases Associated with Hantavirus Infection

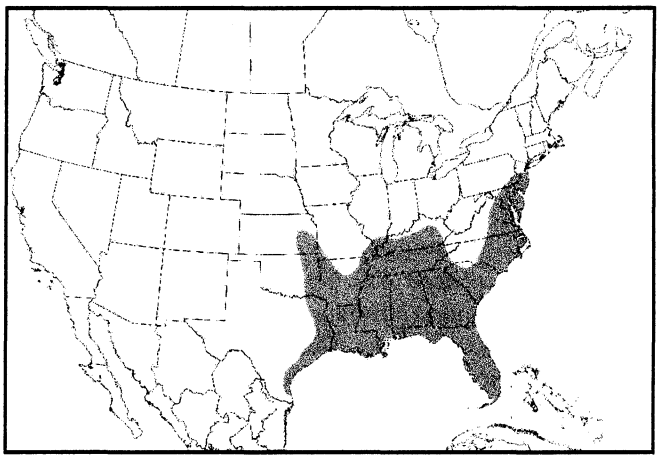
Because the sigmodontine rodents are restricted to the Americas, HPS is restricted to the Americas. Another group of

FIGURE 6. Range of the cotton rat (*Sigmodon hispidus*) in the Americas



Source: Hall ER, Kelson KR. The mammals of North America. vol II. New York, NY: Ronald Press, 1959. Hershkovitz P. South American marsh rats, genus *Holochilus*, with a summary of sigmodent rodents. Fieldiana: Zoology 1955;37:639–73.

FIGURE 8. Range of the rice rat (*Oryzomys palustris*) in North America



Source: Wolfe JL. *Oryzomys palustris*. Mammalian Species 1982;176:1–5.

hantaviruses associated with murine and arvicoline rodents causes a group of diseases of varying severity referred to as hemorrhagic fever with renal syndrome (HFRS) in Europe and Asia. Hantaan and Dobrava viruses, hosted by the murine field mice (*Apodemus agrarius* and *Apodemus flavicollis*, respectively), cause thousands of cases of severe HFRS each year in Asia and Eastern Europe. Fatality associated with these infections can be as high as 10% (*15*). The cosmopolitan Norway rat (*Rattus norvegicus*) is host for Seoul virus, which causes a mild form of HFRS in Asia. Although evidence of infection with Seoul virus has been found in Norway rats

throughout much of the world, including the United States, human disease caused by Seoul virus is largely restricted to Asia. Only three suspected cases have been reported in the United States (*16*). Overall mortality associated with Seoul virus infection is probably <1% (*15*).

Puumala virus, carried by an arvicoline rodent, the bank vole (*Clethrionomys glareolus*), causes a mild form of HFRS, referred to as nephropathia epidemica (NE). NE, which is very common in northern Europe, has a case fatality of <1%. Several other species of arvicoline rodents host hantaviruses in the northern hemisphere, including the United States; none of these have been associated with any human disease.

Infection in the Host

Hantaviruses do not cause overt illness in their reservoir hosts (*17*). Although infected rodents shed virus in saliva, urine, and feces for many weeks, months, or for life, the quantity of virus shed can be much greater approximately 3–8 weeks after infection (*18*). The demonstrated presence of infectious virus in saliva of infected rodents and the marked sensitivity of these animals to hantaviruses following intramuscular inoculation suggest that biting might be an important mode of transmission from rodent to rodent (*18,19*). Field data suggest that transmission in host populations occurs horizontally, more frequently among male rodents, and might be associated with fighting, particularly, but not exclusively, among males (*7,20*).

Occasional evidence of infection (antibody) is found in numerous other species of rodents and their predators (e.g., dogs, cats, and coyotes), indicating that many (perhaps any) mammal species coming into contact with an infected host might become infected (*21*). No evidence supports the transmission of infection to other animals or to humans from these "dead-end" hosts. However, domestic animals (e.g., cats and dogs) might bring infected rodents into contact with humans. Arthropod vectors are not known to have a role in the transmission of hantaviruses (*17,22*).

The reservoir hosts of the hantaviruses in the western United States also act as hosts for the bacterium *Yersinia pestis*, the etiologic agent of plague. Although no evidence exists that fleas and other ectoparasites play a role in hantavirus epidemiology, rodent fleas transmit plague. Species of *Peromyscus* are susceptible to *Y. pestis* infection and can act as hosts for infected fleas. Control of rodents without concurrent control of fleas might therefore increase the risk of human plague as the rodent fleas seek an alternative food source.

Transmission to Humans

The Old World hantaviruses causing HFRS, and the New World agents of HPS are believed to be transmitted by the same mechanisms. Human infection occurs most commonly through the inhalation of infectious, aerosolized saliva or excreta. Persons visiting laboratories where infected rodents were housed have been infected after only a few minutes of exposure to animal holding areas (*22*). Transmission can occur when dried materials contaminated by rodent excreta are disturbed and inhaled, directly introduced into broken skin or conjunctivae, or possibly, when ingested in contaminated food or water. Persons have also acquired HFRS and HPS after being bitten by rodents (*23,24*). High risk of exposure has been associated with entering or cleaning rodent-infested structures (*25*).

Person-to-person transmission has not been associated with any of the Old World hantaviruses (*26*) or with HPS cases in the United States (*27*). However, person-to-person transmission, including nosocomial transmission of Andes virus, was well documented for a single outbreak in southern Argentina (*28,29*) and suspected to have occurred much less extensively in another outbreak in Chile associated with the same virus (*30*).

Epidemiology

Hantavirus infections are associated with domestic, occupational, or recreational activities that bring humans into contact with infected rodents, usually in rural settings. Known hantavirus infections of humans occur primarily in adults. HPS cases in the United States occur throughout the year, but greater numbers are reported in spring and summer. Hantavirus infection (resulting in HPS or HFRS) has been epidemiologically associated with the following situations (*25,31–36*):

- increasing numbers of host rodents in human dwellings;
- occupying or cleaning previously vacant cabins or other dwellings that are actively infested with rodents;
- cleaning barns and other outbuildings;
- disturbing excreta or rodent nests around the home or workplace;
- residing in or visiting areas where substantial increases have occurred in numbers of host rodents or numbers of hantavirus-infected host rodents;
- handling mice without gloves;
- keeping captive wild rodents as pets or research subjects;
- handling equipment or machinery that has been in storage;
- disturbing excreta in rodent-infested areas while hiking or camping;
- sleeping on the ground; and
- hand plowing or planting.

However, in North America, the absolute risk of hantavirus infection to the general public is low; only 20–50 cases of HPS have been confirmed annually in the United States since the disease was described in 1993 (Figure 2).

Physical Properties of Hantaviruses

Hantaviruses have lipid envelopes that are susceptible to most disinfectants (e.g., dilute chlorine solutions, detergents, or most general-purpose household disinfectants) (*37*). Depending on environmental conditions, these viruses probably survive <1 week in indoor environments and much shorter periods (perhaps hours) when exposed to sunlight outdoors (*38*).

Prevention

Eradicating the reservoir hosts of hantaviruses is neither feasible nor desirable because of the wide distribution of sigmodontine rodents in North America and their importance in the function of natural ecosystems. The best currently available approach for disease control and prevention is risk reduction through environmental modification and hygiene practices that deter rodents from colonizing the home and work environment, as well as safe cleanup of rodent waste and nesting materials. Controlled experiments have demonstrated that simple and inexpensive methods are effective in preventing rodents from entering rural dwellings (*39*).

These recommendations emphasize the prevention of HPS associated with sigmodontine rodents in the Americas. Although the risk of acquiring hantavirus disease from contact with native arvicoline rodents in North America or introduced murine rodents throughout the Americas is low, the true pathogenicity for humans of all hantaviruses carried by these groups of rodents has not been established. Therefore, we recommend that persons avoid contact with all wild and peridomestic rats and mice. The precautions described in this report are broadly applicable to all groups of rats and mice.

Precautions To Limit Household Exposure to Rodents

Rodent control in and around the home remains the primary strategy in preventing hantavirus infection. Rodent infestation can be determined by direct observation of animals, or inferred by observation of their nests or feces on floors or in protected areas (e.g., closets, kitchen cabinets, drawers, wall voids, furnace and hot water heating cabinets, and behind ventilation screens), or from evidence that rodents have been gnawing on food or other objects. The interior and exterior of the home should be carefully inspected at least twice per year for any openings where rodents could enter the home and for conditions that could support rodent activity. If any evidence of rodent infestation is detected inside the home or in outbuildings, precautions should be taken. The guidelines in the section Special Precautions for Homes of Persons with Confirmed Hantavirus Infection or Buildings with Heavy Rodent Infestations should be followed if a structure is associated with a confirmed case of hantavirus disease or if evidence of heavy rodent infestation is present (e.g., piles of feces or numerous nests or dead rodents).

Recommendations are listed below for 1) reducing rodent shelter and food sources inside and outside the home and 2) preventing rodents from entering the home by rodent-proofing (*40–42*).

Reduction of Rodent Shelter and Food Sources Inside and Outside the Home

Precautions for Inside the Home

- Keep food and water covered and stored in rodent-proof containers.[†]
- Keep pet food covered and stored in rodent-proof containers. Allow pets only enough food for each meal, then store or discard any remaining food. Do not leave excess pet food or water out overnight.
- If storing trash and food waste inside the home, do so in rodent-proof containers, and frequently clean the interiors and exteriors of the containers with soap and water.
- Wash dishes, pans, and cooking utensils immediately after use.
- Remove leftover food and clean up all spilled food from cooking and eating areas.
- Do not store empty aluminum cans or other opened containers with food residues inside the home.
- Dispose of trash and garbage on a frequent and regular basis, and pick up or eliminate clutter.
- Keep items (e.g., boxes, clothes, and blankets) off of the floor to prevent rodents from nesting in them.
- Repair water leaks and prevent condensation from forming on cold water pipes by insulating them. Deny rodents access to moisture (e.g., mop closets, boiler rooms, catch basins under potted plants, and areas around aquarium tanks). Correct any conditions that support the growth of mold, mildew, or other fungi in the home.
- Keep exterior doors and windows closed unless protected by tight-fitting screens.
- Use spring-loaded traps[§] in the home. Use a small amount (the size of a pea) of chunky peanut butter as bait. Place the trap perpendicular to the baseboard or wall surface,

[†] A rodent-proof container is made of thick plastic, glass, or metal and has a tight-fitting lid.

[§] Only spring-loaded traps that kill rodents should be used. Live and sticky traps that do not kill rodents are not recommended. Infectious aerosols might be produced when live rodents urinate or struggle to free themselves. Disposal of live rodents also introduces the risk of rodent bite, which also can result in infection.

with the end of the trap containing the bait closest to the baseboard or wall. Place traps in areas where rodents might be entering the home. Spring-loaded traps can be painful or even dangerous if they close on fingers; they should be handled with caution, and careful consideration should be given to keep children and pets away from areas where traps are placed.

In the western United States (west of the 100th meridian, a line from mid-Texas through mid-North Dakota), a risk of plague transmission to humans from fleas exists. Use insect repellent (containing N,N-diethyl-m-toluamide [DEET]) on clothing, shoes, and hands to reduce the risk of fleabites when picking up dead rodents and traps. In cases of heavy rodent infestation in indoor spaces in the western United States, use an insecticide before trapping. Contact your local or state health department to find out if plague is a danger in the area and for additional advice on appropriate flea-control methods.

- Continue trapping for at least 1 additional week after the last rodent is caught. As a precaution against reinfestation, use several baited, spring-loaded traps inside the house at all times in locations where rodents are most likely to be found.
- Examine traps regularly. To dispose of traps or trapped animals, wear rubber, latex, vinyl, or nitrile gloves. Spray the dead rodent with a disinfectant or chlorine solution.[¶] After soaking the rodent thoroughly, either take it out of the trap by lifting the spring-loaded metal bar and letting the animal fall into a plastic bag or place the entire trap containing the dead rodent in a plastic bag and seal the bag. Then place the rodent into a second plastic bag and seal it. Dispose of the rodent in the double bag by 1) burying it in a 2- to 3-foot-deep hole or 2) burning it or 3) placing it in a covered trash can that is regularly emptied. Contact the state or local health department concerning other appropriate disposal methods.**
- If the trap will be reused, decontaminate it by immersing and washing it in a disinfectant or chlorine solution and rinsing afterward.
- For substantially severe or persistent infestations, contact a pest-control professional for rodent eradication or a building contractor for rodent exclusion (rodent-proofing).

When resident mice are removed from rural buildings without measures to prevent reentry, they are replaced almost immediately by other mice from the outside. Therefore, indoor rodent-trapping could be unsuccessful in reducing rodent infestations without simultaneous efforts to rodent-proof permeable dwellings.

Precautions for Outside the Home

- Place woodpiles and stacks of lumber, bricks, stones, or other materials ≥100 feet from the house.
- Store grains and animal feed in rodent-proof containers.
- Remove, from the vicinity of buildings, any food sources that might attract rodents.
- Keep pet food covered and stored in rodent-proof containers. Allow outside pets only enough food for each meal, then store or discard any remaining food from feeding dishes.
- Avoid using bird feeders near the home. If they must be placed near the home, use "squirrel-proof" feeders and clean up spilled seeds each evening.
- Dispose of garbage and trash in rodent-proof containers with tight-fitting lids.
- Haul away trash, abandoned vehicles, discarded tires, and other items that might serve as rodent nesting sites.
- Mow grass closely, and cut or remove brush and dense shrubbery to a distance of at least 100 feet from the home. Trim the limbs off any trees or shrubs that overhang or touch the building.
- Use raised cement foundations in new construction of sheds, barns, and outbuildings.
- Place spring-loaded traps in outbuildings (regardless of their distance from the home) and in areas that might likely serve as rodent shelter, within 100 feet around the home; use these traps continuously, replacing the bait periodically. For instructions concerning the safe use and cleaning of spring-loaded traps and the disposal of trapped rodents, see Precautions for Inside the Home.**

Preventing Rodents from Entering the Home by Rodent-Proofing

- Look for and seal up all gaps and holes inside and outside the home that are ≥¼ -inch (≥6 mm) in diameter. Inside the home, look for and seal up all gaps and holes underneath, behind, and inside kitchen cabinets; inside closets; around floor air vents and dryer vents; around the fireplace; around windows and doors; behind appliances (e.g., dishwashers, clothes washers, and stoves); around pipes under the kitchen and bathroom sinks; around all electrical, water, gas, and sewer lines (chases); and beneath or behind hot water heaters, radiators, and furnaces and around their pipes that enter the home. Outside the home, look for and seal up all gaps and holes around windows and doors; between the foundation of the home and the ground; under doors without weatherstripping; around electrical, water, gas, and sewer lines (chases); and around

[¶] See Precautions for Cleanup of Rodent-Contaminated Areas and Dead Rodents for detailed information regarding making a chlorine solution.

** Follow the recommendations specified in the section Precautions for Cleanup of Rodent-Contaminated Areas and Dead Rodents, if rodent urine, droppings, nests, or dead rodents are encountered while these measures are being carried out.

the roof, eaves, gables, and soffits. In addition, look for unscreened attic vents and crawlspace vents. In trailers, look for and seal up holes and gaps in the skirting, between the trim and metal siding, around utility lines and pipes and ducts, around roof vents, and around the trailer tongue.

- Seal all entry holes ≥¼-inch (≥6 mm) in diameter that are inside and outside the home with any of the following: cement, lath screen or lath metal,[††] wire screening, hardware cloth (<¼-inch grate size), or other patching materials (*42*). Steel wool or STUF-FIT[§§] also can be used, but caulk must be placed around the steel wool or STUF-FIT to prevent rodents from pushing it through the hole. Caulk and expanding foam can be used to reinforce any repairs where lath metal, hardware cloth, steel wool, or STUF-FIT are the primary materials; however, caulk or expanding foam alone are usually not sufficient to prevent rodent intrusion.
- If rodent burrows are found under foundations or trailer skirtings, construct a barrier around the entire foundation using 14-inch wide (35 cm), ≤¼-inch (≤6 mm) mesh, 16–19 gauge hardware cloth. Bend the hardware cloth lengthwise into a right angle with two sides of approximately 7 inches (18 cm). Secure one side of the hardware cloth tightly to the building siding. The other side should be buried at least 2 inches (5 cm) below ground level and extend out away from the wall.[¶¶]
- Consult a pest-control professional for severe or persistent infestations.

Precautions To Limit Occupational and Recreational Exposure to Rodents

Precautions for Workers Frequently Exposed to Rodents

Persons who frequently handle or are exposed to wild rodents are probably at higher risk for hantavirus infection than the general public because of the frequency of their exposures. Such persons include, but are not limited to, mammalogists, pest-control workers, some farm and domestic workers, and building and fire inspectors. Therefore, enhanced precautions are warranted to protect them against hantavirus infection, as described below.

- Workers in potentially high-risk settings should be informed by their employers about hantavirus transmission and symptoms of infection and be given detailed guidance on prevention measures. Determining the level of risk for HPS in each work setting is the responsibility of the employer.[***]
- Employers should provide a comprehensive medical screening and surveillance program to workers, including medical clearance for respirator use, baseline evaluation, and periodic examination as indicated. The physician responsible for the program should be familiar with methods used for screening and early detection of infection in high-risk populations, as well as with the physical demands of the job and the medical requirements for use of personal protective equipment. On-call medical services should be provided, and workers should be able to contact these services for 45 days after the last potential exposure.
- Workers who develop a febrile or respiratory illness within 45 days of the last potential exposure should immediately seek medical attention and inform the attending physician of the potential occupational risk of hantavirus infection. The physician should contact local public health authorities promptly if hantavirus-associated illness is suspected. A blood sample should be obtained and forwarded to the state health department for hantavirus antibody testing.
- When removing rodents from traps or handling rodents, workers should wear either a half-face, tight-seal, negative-pressure respirator or a (positive pressure) PAPR (powered air-purifying respirator), equipped with N-100 or P-100 filters (formerly designated high-efficiency particulate air filters [HEPA]). Negative-pressure respirators are not protective if facial hair interferes with the face-piece to face seal because a proper fit cannot be assured. Respirator use practices in an occupational setting should be in accordance with Occupational Safety and Health Administration (OSHA) regulation 29 CFR 1910.134, which includes a written program specific to respirator use, risk assessment for personal protective equipment, medical clearance to wear respiratory protection, and annual training and fit testing in each approved respirator type (*43*). The comprehensive user program should be supervised by a knowledgeable person (*44*). Given the predictable nature of HPS risk in certain professions or environmental

[††] Lath screen or metal is a light-gauge metal mesh and is commonly installed over wooden walls before plaster is applied. A galvanized product is preferable. Lath screen is malleable and can be folded and pushed into larger holes. These materials can be found in the masonry or building materials section at hardware or building supply stores.

[§§] STUF-FIT is a soft copper-mesh material that might be preferable to steel wool because it does not rust and is not easily pulled apart by rodents. It can be obtained from pest control retail stores or from Allen Special Products (telephone 800-848-6805).

[¶¶] Illustrated, complete instructions for rodent-proofing are available 1) in the National Park Service's manual, Mechanical Rodent Proofing Techniques; 2) on CDC's website, All About Hantaviruses (http://www.cdc.gov/ncidod/diseases/hanta/hps/index.htm); and 3) from CDC's Ramah Home Seal-up protocol, Special Pathogens Branch (e-mail dvd1spath@cdc.gov).

[***] General Duty Clause, Occupational Safety and Health Act of 1970, Section 5(a)(1); http://www.osha.gov/OshAct_data/OSHACT.htm#5.

situations, provisions should be made in advance for respiratory protection. Because of the expense associated with purchasing a PAPR system, a negative-pressure tight-seal respirator equipped with N-100 or P-100 filters is recommended when respiratory protection is required for home use. Respirators might cause stress to persons with respiratory or cardiac conditions; these persons should be medically cleared before using such a respirator. Home or other users with potentially impaired respiratory function also should be aware of the risks associated with the use of negative-pressure respirators (*43*).

- Workers should wear rubber, latex, vinyl, or nitrile gloves when handling rodents or handling traps containing rodents. Before removing the gloves, wash gloved hands in a disinfectant or chlorine solution and then wash bare hands in soap and water.**
- Mammalogists, wildlife biologists, or public health personnel who handle wild rodents for research or management purposes should refer to published safety guidelines (*45,46*). Precautions are also available on CDC's website, All About Hantaviruses (http://www.cdc.gov/ncidod/dvrd/spb/mnpages/rodentmanual.htm).

Precautions for Other Occupational Groups Having Potential Contact with Rodents

Insufficient information is available to provide general recommendations regarding risks and precautions for persons who work in occupations with unpredictable or incidental contact with rodents or their nesting sites. Examples of such occupations include telephone installers, maintenance workers, plumbers, electricians, and certain construction workers. Workers in these jobs might have to enter buildings, crawl spaces, or other sites that are potentially rodent-infested, and HPS has been reported among these workers. Recommendations for such circumstances must be made on a case-by-case basis after the specific working environment has been assessed and state or local health and labor officials or trade unions and management, as appropriate, have been consulted. Determining the level of risk present and implementing appropriate protective measures is the employer's responsibility.***

Precautions for Campers and Hikers

No evidence exists to suggest that travel should be restricted in areas where HPS cases have occurred. The majority of typical tourist activities are associated with limited or no risk that travelers will be exposed to rodents or their excreta. However, persons engaged in outdoor activities (e.g., camping or hiking) should take precautions to reduce the likelihood of exposure to potentially infectious materials by following these recommendations.

- Avoid touching live or dead rodents or disturbing rodent burrows, dens, or nests.
- Do not use cabins or other enclosed shelters that are potentially rodent-infested until they have been appropriately cleaned and disinfected. (See Precautions for Cleanup of Rodent-Contaminated Areas and Dead Rodents.) Rodent-proofing might be necessary to prevent reinfestation. (See Precautions to Limit Household Exposure to Rodents.)
- When an unoccupied cabin or other structure to be used has been closed for several weeks, ventilate the structure by opening doors and windows for at least 30 minutes before occupying. Use cross ventilation if possible. Leave the area (preferably remaining upwind) during the airing-out period. The airing helps to remove infectious primary aerosols that might be created when hantavirus-infected rodents urinate.
- Do not pitch tents or place sleeping bags in proximity to rodent feces or burrows or near possible rodent shelters (e.g., garbage dumps or woodpiles).
- Avoid sleeping on the bare ground. Use a cot with the sleeping surface at least 12 inches above the ground or use a tent with a floor.
- Keep food in rodent-proof containers.
- Dispose of all trash and garbage promptly in accordance with campsite regulations by
  — burning or burying,
  — discarding in rodent-proof trash containers, or
  — "packing out" in rodent-proof containers.

Precautions for Cleanup of Rodent-Contaminated Areas and Dead Rodents

Areas with evidence of rodent activity (e.g., dead rodents and rodent excreta) should be thoroughly cleaned to reduce the likelihood of exposure to hantavirus-infected materials. Cleanup procedures must be performed in a manner that limits the potential for dirt or dust from contaminated surfaces to become airborne. Recommendations are listed in this report for cleaning up 1) rodent urine and droppings, and surfaces potentially contaminated by rodents and 2) dead rodents and rodent nests.

Cleanup of Rodent Urine and Droppings and Contaminated Surfaces

- During cleaning, wear rubber, latex, vinyl, or nitrile gloves.

- Spray rodent urine and droppings with a disinfectant or chlorine solution until thoroughly soaked. (See Cleanup of Dead Rodents and Rodent Nests.)
- To avoid generating potentially infectious aerosols, do not vacuum or sweep rodent urine, droppings, or contaminated surfaces until they have been disinfected.
- Use a paper towel to pick up the urine and droppings. Place the paper towel in the garbage.
- After the rodent droppings and urine have been removed, disinfect items that might have been contaminated by rodents or their urine and droppings.
  - — Mop floors with a disinfectant or chlorine solution.
  - — Disinfect countertops, cabinets, drawers, and other durable surfaces with a disinfectant or chlorine solution.
  - — Spray dirt floors with a disinfectant or chlorine solution.
  - — Disinfect carpets with a disinfectant or with a commercial-grade steam cleaner or shampoo.
  - — Steam-clean or shampoo rugs and upholstered furniture.
  - — Launder potentially contaminated bedding and clothing with hot water and detergent. Use rubber, latex, vinyl, or nitrile gloves when handling contaminated laundry. Machine-dry laundry on a high setting or hang it to air dry in the sun.
  - — Leave books, papers, and other items that cannot be cleaned with a liquid disinfectant or thrown away, outdoors in the sunlight for several hours, or in an indoor area free of rodents for approximately 1 week before cleanup. After that time, the virus should no longer be infectious. Wear rubber, latex, vinyl, or nitrile gloves and wipe the items with a cloth moistened with disinfectant.
  - — Disinfect gloves before removing them with disinfectant or soap and water. After removing the clean gloves, thoroughly wash bare hands with soap and warm water.

Cleanup of Dead Rodents and Rodent Nests

- Wear rubber, latex, vinyl, or nitrile gloves.
- In the western United States, use insect repellent (containing DEET) on clothing, shoes, and hands to reduce the risk of fleabites that might transmit plague.
- Spray dead rodents and rodent nests with a disinfectant or a chlorine solution, soaking them thoroughly.
- Place the dead rodent or nest in a plastic bag or remove the dead rodent from the trap and place it in a plastic bag (See Precautions for Inside the Home.) When cleanup is complete (or when the bag is full), seal the bag, place it into a second plastic bag, and seal the second bag. Dispose of the material in the double bag by 1) burying it in a 2- to 3-foot-deep hole or 2) burning it or 3) discarding it in a covered trash can that is regularly emptied. Contact the local or state health department concerning other appropriate disposal methods.
- Clean up the surrounding area as described in Cleanup of Rodent Urine and Droppings and Contaminated Surfaces.

Disinfecting Solutions

Two types of disinfecting solutions are recommended to clean up rodent materials.

1. General-Purpose Household Disinfectant — Prepare according to the label, if not prediluted. Almost any agent commercially available in the United States is sufficient as long as the label states that it is a disinfectant. Effective agents include those based on phenols, quaternary ammonium compounds, and hypochlorite.
2. Hypochlorite Solution — A chlorine solution, freshly prepared by mixing 1½ cups of household bleach in 1 gallon of water (or a 1:10 solution) can be used in place of a commercial disinfectant. When using chlorine solution, avoid spilling the mixture on clothing or other items that might be damaged by bleach. Wear rubber, latex, vinyl, or nitrile gloves when preparing and using chlorine solutions. Chlorine solutions should be prepared fresh daily.

Cleaning Sheds and Other Outbuildings

Before cleaning closed sheds and other outbuildings, ventilate the building by opening doors and windows for at least 30 minutes. Use cross ventilation if possible. Leave the area during the airing-out period. This airing helps to remove infectious primary aerosols that might be created when hantavirus-infected rodents urinate. In substantially dirty or dusty environments, additional protective clothing or equipment may be worn. Such equipment includes coveralls (disposable when possible) and safety glasses or goggles, in addition to rubber, latex, vinyl, or nitrile gloves. For recommendations regarding precautions for cleanup of outbuildings with heavy rodent infestations, see Special Precautions for Homes of Persons with Confirmed Hantavirus Infection or Building with Heavy Rodent Infestations.

Special Precautions for Homes of Persons with Confirmed Hantavirus Infection or Buildings with Heavy Rodent Infestations

Special precautions are indicated for cleaning homes or buildings with heavy rodent infestations. A rodent infestation is

considered heavy if piles of feces or numerous nests or dead rodents are observed. Persons cleaning these homes or buildings should contact the local or state public health agency or CDC for guidance. These precautions also can apply to vacant dwellings that have attracted rodents while unoccupied and to dwellings and other structures that have been occupied by persons with confirmed hantavirus infection. Workers who are either hired specifically to perform the cleanup or asked to do so as part of their work activities should receive a thorough orientation from the responsible health agency or employer about hantavirus transmission and disease symptoms and should be trained to perform the required activities safely.

Recommendations for Cleaning Homes or Buildings with Heavy Rodent Infestations

- If the building has been closed and unoccupied for a long period (weeks or months), ventilate the building by opening doors and windows for at least 30 minutes before beginning any work. Use cross ventilation if possible. Leave the area during the airing-out period. The ventilation helps to remove aerosolized virus inside the structure.
- Persons involved in the cleanup should wear coveralls (disposable if possible); rubber boots or disposable shoe covers; rubber, latex, vinyl, or nitrile gloves; protective goggles; and an appropriate respiratory protection device as detailed in Precautions to Limit Occupational and Recreational Exposure to Rodents.
- Personal protective gear should be decontaminated or safely disposed of upon removal at the end of the day. If the coveralls are not disposable, they should be laundered on-site. If no laundry facilities are available, the coveralls should be immersed in liquid disinfectant until they can be washed.
- Unless burned on-site, all potentially infectious waste material from cleanup operations should be double-bagged in appropriate plastic bags. The material in the bags should then be labeled as infectious and disposed of in accordance with local regulations for infectious waste.
- Persons involved in the cleanup who develop a febrile or respiratory illness within 45 days of the last potential exposure should immediately seek medical attention and inform the attending physician of the potential occupational risk of hantavirus infection. The physician should contact local health authorities promptly if hantavirus-associated illness is suspected. A blood sample should be obtained and forwarded through the state health department for hantavirus antibody testing.

Applicability and Updates

The control and prevention recommendations in this report represent general measures to minimize the likelihood of human exposure to hantavirus-infected rodents in the Americas. Although different geographic areas might have varying housing types and rodent populations, the precautions should be the same. The effect and utility of the recommendations will be continually reviewed by CDC and the involved state and local health agencies as additional epidemiologic, field, and laboratory data become available. These recommendations might be supplemented or modified in the future.

These recommendations and additional information concerning hantaviruses are periodically updated and made available on CDC's website, All About Hantaviruses (http://www.cdc.gov/ncidod/disease/hanta/hps/index.htm). Additional information can be obtained by contacting CDC, National Center for Infectious Diseases (NCID), Special Pathogens Branch, Mailstop A-26, 1600 Clifton Road, N.E., Atlanta, GA 30333; e-mail dvd1spath@cdc.gov; fax 404-639-1509; or by telephone 404-639-1510.

Acknowledgments

This update is based on interim recommendations from James E. Childs, Sc.D.; Arnold F. Kaufmann, D.V.M.; and Clarence J. Peters, M.D., NCID; and Richard L. Ehrenberg, M.D., National Institute for Occupational Safety and Health. Graphics were produced by Amera R. Khan, M.P.H.; and Kent D. Wagoner, Ph.D., NCID. Jacob H. Creswell, M.P.H.; Kimberly C. Dills, M.P.H.; and Emily S. Jentes, NCID, provided technical assistance and careful reviews of the manuscript. Kathleen F. Cavallaro, M.S., NCID, helped coordinate numerous aspects of the manuscript preparation. The preparation of this document was supported in part by an appointment to the Research Participation Program at CDC's NCID, Division of Viral and Rickettsial Diseases, administered by the Oak Ridge Institute for Science and Education, Oak Ridge, TN, through an interagency agreement between the U.S. Department of Energy and CDC.

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