

HANTAVIRUS PULMONARY SYNDROME



Figure 1. The Deer Mouse, *Peromyscus maniculatus*

I. INTRODUCTION

Hantavirus Pulmonary Syndrome (HPS) is an acute zoonotic viral disease characterized by fever, muscle aches and gastrointestinal complaints followed by the abrupt onset of respiratory distress and hypotension. The illness progresses rapidly to severe respiratory failure and shock. The reservoir for the virus in New Mexico is rodents of the genus *Peromyscus*, mainly the deer mouse, which excretes the virus in its urine, feces and saliva. Humans acquire infection through direct contact with infected rodents, rodent droppings, nests, or inhalation of aerosolized virus particles from rodent urine, droppings or saliva.

II. HISTORY

Hantaviruses belong to the family Bunyaviridae. Within the hantavirus genus are the viruses that cause hemorrhagic fever with renal syndrome (HFRS) in Europe and Asia and the viruses associated with HPS in the Americas. Each hantavirus variant appears to have a particular rodent species that is the major reservoir. The rodent host becomes chronically infected with the virus but does not die from it. No arthropod vector has been established for any of the hantaviruses.

In May 1993, an outbreak of an unexplained respiratory illness occurred in the southwestern United States in an area shared by Arizona, New Mexico, Colorado and Utah known as the Four Corners. Previously healthy, young adults were dying of acute respiratory distress after a short

illness of flu-like symptoms followed by shortness of breath. The state health departments of the Four Corners states, the Indian Health Service, the Navajo Nation, the University of New Mexico, the New Mexico Office of Medical Investigations and the Centers for Disease Control and Prevention (CDC) worked together to identify more cases and find the source of the outbreak. After much laboratory testing and field work, the cause of the outbreak was identified as a previously unrecognized strain of hantavirus, which was later named Sin Nombre virus. Unlike HFRS in the Old World, Sin Nombre virus causes fluid buildup in the lungs (pulmonary edema), severe hypoxemia (insufficient oxygenation of the blood), hypotension, and in some cases cardiac and respiratory arrest.

Rodent trapping around case and control homes identified the deer mouse, *Peromyscus maniculatus*, as the reservoir of this particular strain of hantavirus. About 30% of the deer mice tested in the summer of 1993 were positive for hantavirus. In November 1993, the virus was isolated and positively linked the deer mouse to human cases. To put the rapid isolation of the Sin Nombre virus in perspective, it took several decades for the first hantavirus discovered, the Hantaan virus, to be isolated.

It is now known that Sin Nombre virus has been present in rodents and causing disease in the U.S. since at least 1959. Isolated cases of adult respiratory distress syndrome with no known cause were retrospectively identified; testing conducted on survivors and on preserved tissue samples of fatal cases have identified 32 additional cases of HPS (19 of those fatal) prior to 1993.

As of March 26, 2007, there have been 465 cases of Hantavirus Pulmonary Syndrome in the U.S. Although the majority of cases have been identified in the western U.S., HPS cases have occurred in all regions of the country (see Figure 2).

**Hantavirus Pulmonary Syndrome Cases
by State of Exposure through March 26, 2007**
(Total N = 465)

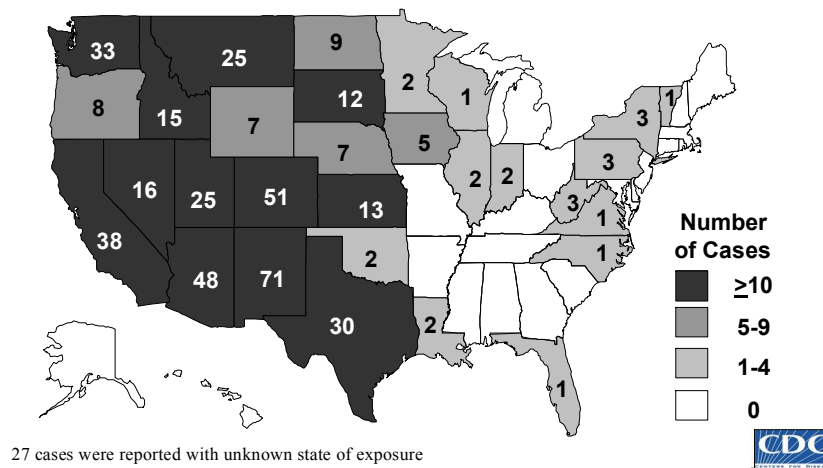
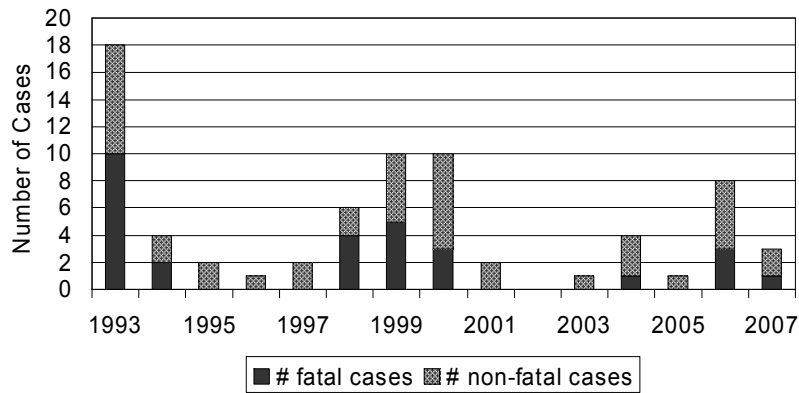


Figure 2.

The majority of U.S. cases have been caused by the Sin Nombre virus. However, three other strains of hantavirus causing HPS have been identified in the U.S. All of the rodent carriers of HPS in the U.S. are in the family Muridae, subfamily Sigmodontinae. Bayou virus, carried by the rice rat, *Oryzomys palustris*, was the source of a case of HPS in Louisiana. A Florida case was linked to yet another hantavirus called Black Creek Canal virus, carried by the cotton rat (*Sigmodon hispidus*). Another case occurred in New York. The Sin Nombre-like virus, named New York virus, is carried by the white-footed mouse, *Peromyscus leucopus*.

New Mexico has recorded 76 cases of Hantavirus Pulmonary Syndrome; 29 (40%) were fatal. Figures 3 and 4 show NM cases by year and by county.

HPS in NM, Cases by Year, 1993 - 2007

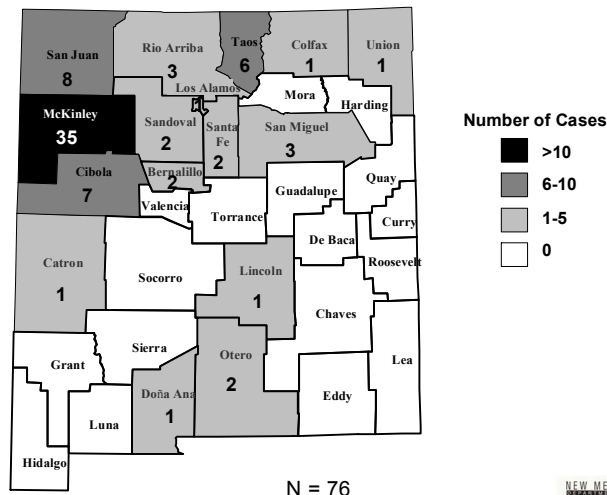


N = 72; 4 cases prior to 1993 not shown



Figure 3.

HPS in NM, Cases by County, 1975 - 2007



N = 76



Figure 4.

III. THE DISEASE

Transmission of hantavirus between rodents probably occurs through biting when the rodents fight over territories (thus older, male rodents are more likely to be infected). Infected rodents shed the virus in their urine, saliva and droppings. Aerosolization of the virus occurs when virus-infected materials, such as droppings or nesting materials, are stirred up and tiny droplets containing the virus get into the air. Transmission to humans can occur any place that infected rodents have infested, such as homes, barns or sheds. Transmission to humans can potentially also occur from rodent bites (apparently rare), or if a person touches something contaminated with rodent urine, droppings, or saliva, and then touches their eyes, nose, or mouth.

The incubation period of HPS has not been completely defined, but is typically two to three weeks, with a possible range of one to six weeks. The early symptoms of HPS include fatigue, fever, and muscle aches, especially the large muscle groups – thighs, hips, back and sometimes shoulders. These symptoms are universal. About half of all HPS patients also experience headaches, dizziness, chills and/or abdominal problems such as nausea, vomiting, diarrhea and abdominal pain. Four to ten days after the initial symptoms, late symptoms of HPS appear. These include coughing and shortness of breath as a result of fluid leaking from the capillaries into the air sacs of the lungs.

There is no specific treatment or cure for hantavirus infection. However, if infected individuals are recognized early and are taken to an intensive care unit, some patients may do better. In intensive care, patients are intubated and given oxygen therapy to help them through the period of severe respiratory distress. The most severely ill patients may also benefit from ECMO (extra-corporeal membrane oxygenation). The strain of hantavirus found in the U.S. does not spread from person to person.

Characteristics		Total U.S.	Total N.M.
	Number of Cases	465 (100%)	76 (100%)
Gender			
	Male	292 (64%)	38 (50%)
	Female	173 (37%)	38 (50%)
Race			
	White	355 (78%)	27 (35%)
	American Indian	87 (19%)	46 (61%)
	Black	7 (2%)	1 (1%)
	Asian	3 (1%)	0
Ethnicity			
	Hispanic	65 (14%)	12 (16%)
Case Fatality			
	Dead	165 (35%)	29 (41%)
Age (years)			
	Mean [Range]	38 [10-83]	37 [10-75]

+ 2 unknown race/ethnicity in NM

Figure 5. Characteristics of U.S. and NM HPS Cases

IV. RISK FACTORS

Most HPS infections result from exposure, in closed spaces, to active infestations of infected rodents. The deer mouse (*Peromyscus maniculatus*) is common and widespread in rural areas throughout much of the U.S. 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 Sin Nombre virus. Several other related rodent species are associated with additional hantaviruses that have yet to be implicated in human disease, including the brush mouse (*Peromyscus boylii*) and the Western harvest mouse (*Reithrodontomys megalotis*). Only the deer mouse and the white-footed mouse (*Peromyscus leucopus*) commonly enter homes. New hantavirus hosts have been discovered each year and more probably await discovery. Until the extent of hantavirus infection throughout the Sigmodontinae becomes known, treating each sigmodontine rodent as though it were infected and infectious is recommended. This applies to all wild mice and rats encountered in rural areas throughout the United States.



Figure 6. From top, *Peromyscus maniculatus*, *Peromyscus leucopus*, *Peromyscus truei*.
Note that all have bi-colored tails and white bellies and feet

One's risk for acquiring hantavirus is not a factor of age, race, sex, or geographic area. Infections with HPS are associated with domestic, occupational, or leisure activities bringing humans into contact with infected rodents, usually in a rural setting. Risky activities include:

- Living in cabins or other dwellings where rodents have nested or are nesting
- Cleaning houses, barns and other outbuildings where rodents have nested
- Disturbing rodent burrows while hiking or camping
- Entering any enclosed space where rodents are nesting and disturbing the nests or droppings.

In the U.S., cats and dogs are not known to be carriers of hantaviruses, but they could bring infected rodents into contact with humans. There is no evidence that arthropods can transmit hantavirus from the rodent host to a human.

V. PREVENTION

Eradicating the host reservoir is neither feasible nor desirable. The best approach for hantavirus control and prevention is risk reduction through sanitation practices that discourage rodents from infesting the home and work environment and that minimize aerosolization and contact with virus in saliva and excreta. Not all types of rodents carry hantavirus. Yet because it can be difficult to tell just what kinds of rodents are present, and because the potential for new hantaviruses to cause disease is unknown, the precautions below are recommended for any rodent infestation.

The main steps of hantavirus prevention are rodent-proofing, sanitation, removing rodents that are infesting the home or workplace, and disinfection procedures to kill the virus and minimize exposure.

Rodent-proofing:

- Seal all entry holes $\frac{1}{4}$ inch wide or more with metal lath or lath screen, cement, copper mesh (STUF-FIT), caulking or other patching materials (see Figures 7 and 8).
- Protect the perimeter of foundations and trailer skirting by installing 14 inch wide, $\frac{1}{4}$ inch, 16-19-gauge hardware cloth. Bend it lengthwise into an L shape; tightly attach one side 5-6 inches above ground level. Bury the other side at least 2 inches deep and extending out at least 6 inches away from the wall (Figure 9).



Figure 7. Rodent entry around pipe



Figure 8. Pipe well sealed with cement to prevent rodent entry

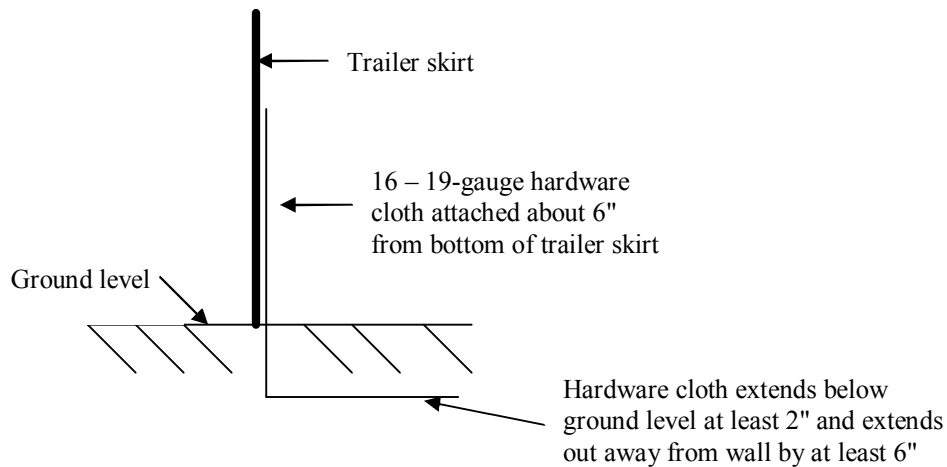


Figure 9. Protection for foundations or trailer skirting

Sanitation:

- Wash dishes and cooking items immediately after use, and clean up any food that may have spilled on the floor. Also, don't leave food out on the countertops.
- Store food (including pet food) in rodent-proof containers. A rodent-proof container is made of thick plastic, glass or metal and has a tight-fitting lid. Discard or put away uneaten pet food at the end of the day.
- Put garbage in rodent-proof containers and dispose of trash and garbage regularly.
- Elevate hay, woodpiles, and garbage cans at least 12 inches to eliminate possible nesting sites (see Figure 10). Store them at least 100 ft away from your house, if possible.
- Clear grass, brush, and dense shrubbery from around house foundations to eliminate a source of nesting materials. Lay gravel in an 18" zone around the foundation instead.
- Haul away abandoned vehicles and other items that might provide nesting sites for rodents.



Figure 10. Elevated woodpiles to prevent rodent nesting

Remove Rodents:

- Use spring-loaded rodent traps baited with peanut butter to kill rodents in the home or workplace. Place the traps near baseboards where rodents tend to run (Fig. 11).
- To prevent exposure to plague-infected fleas from the trapped rodents, apply an insecticide labeled for household use around the rodent trap to kill any fleas that may jump off the mouse. Always follow label directions.



Figure 11. Spring-loaded mouse trap

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 can result in infection. For severe or persistent infestations, consult a pest control professional for rodent control and a building contractor for rodent-proofing.

Disinfection of Rodent Wastes and Rodent Contaminated Areas:

The hantavirus is surrounded by a lipid envelope that makes it susceptible to most disinfectants, including 10% bleach and general purpose disinfectants such as Lysol. To make a 10% bleach solution, mix 1½ cups household bleach in one gallon of water. Depending on environmental conditions, these viruses probably survive less than one week indoors, and much shorter periods (perhaps hours) when exposed to sunlight outdoors.

- When going into buildings that have been closed or unoccupied for a while, open them up and air out for at least 30 minutes before cleaning.
- Put on latex rubber gloves before cleaning up.
- Don't stir up dust by sweeping or vacuuming droppings, urine or nesting materials.
- Thoroughly wet contaminated areas with disinfectant or 10% bleach solution.
- Spray dead rodents, nests, droppings and runways (see Figures 12 and 13).
- Wipe up the wet material with paper towels and place the dead rodents, droppings and other material in a plastic bag and seal. Put the plastic bag into another plastic bag, seal and dispose in the trash or by burying.
- Spray or mop the area again with disinfectant.
- Steam clean or shampoo carpets, rugs and upholstered furniture.
- Leave books, papers and other items that cannot be cleaned with a liquid disinfectant outdoors in the sunlight for several hours. Wipe the items with a cloth moistened with disinfectant.
- Thoroughly disinfect the trap before reusing or disposing.
- Spray gloves with disinfectant or wash them thoroughly with soap and water before taking them off. Wash hands with soap and warm water after removing gloves.



Figure 12. Disposing of nesting material



Figure 13. Spraying dead mouse in trap with bleach solution

Precautions for Campers and Hikers:

- Avoid contact with rodents and their burrows and nests; avoid disturbing dens (such as pack rat nests).
- Air out and then disinfect cabins or shelters before using them.
- Do not pitch tents or place sleeping bags near rodent droppings or burrows or near rodent shelters or feeding sites (e.g. garbage dumps or woodpiles).
- If possible, do not sleep on the bare ground. Use a cot or a tent with a floor.
- Keep food in rodent-proof containers to avoid attracting rodents to your campsite.
- Carry out all garbage and trash, or discard in covered trash containers.
- Do not feed or handle any rodents or other wild animals that show up at your campsite.

Special Precautions for Heavily Infested Dwellings or Regular Occupational Exposure to Rodents:

Workers who are regularly exposed to potentially infected rodents, such as pest control operators or persons who enter a heavily infested building to clean, should take additional precautions including the use of a respirator. A rodent infestation is considered heavy if piles of feces or numerous nests or dead rodents are observed. Workers should wear a half-face negative-pressure respirator (Figure 14) or PAPR (powered-air purifying respirator, Figure 15) equipped with N-100 filters (formerly HEPA filters) when removing rodents from traps, entering and cleaning a heavily infested building, or entering an enclosed space such as a crawl space that is or may be rodent-infested. All negative-pressure respirators are fit-dependent. The user must be fit-tested with the same make, model, style and size of respirator that will actually be used. Negative-pressure respirators are not considered protective if facial hair interferes with the face seal, since proper fit cannot be assured. Respirators should not be considered a substitute for proper disinfection of rodent wastes. Persons involved in cleanup of heavily infested buildings should also wear coveralls, rubber boots or shoe covers, rubber gloves and protective goggles. Personal protective gear should be decontaminated or safely disposed of at the end of the day.



Figure 14. Half-face respirator with goggles



Figure 15. PAPR

Much of the information in this chapter was obtained from the CDC and the National Park Service. See:

“Hantavirus Pulmonary Syndrome – United States: Updated Recommendations for Risk Reduction”, James Mills et al., MMWR Recommendations and Reports, 2002, vol. 51:1-12.

“Mechanical Rodent Proofing Techniques”, Gerard Hoddenbach et al., National Park Service, Public Health Program, 1997.

See also the CDC hantavirus web page at:

<http://www.cdc.gov/ncidod/diseases/hanta/hps/index.htm>