# Hantavirus in rural Chile

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## Abstract

Hantavirus infection facilitated by human-rodent contact is a major public health problem in rural Chile, extending to endemic proportions and reflecting a high mortality rate. To date, the Hantavirus issue has not been appropriately addressed nor effectively managed. Recognition of the environmental basis of the endemic needs to be given in order to develop sustainable solutions and effective management plans which could reduce the Hantavirus infection rate that is witnessed in rural communities.

Key words: Hantavirus, Chile, Hantavirus Cardiopulmonary Syndrome, clinical management

## Introduction

Hantaviruses compose a biological genus within the virus family Bunyaviridae (Fig 1). The natural reservoirs of pathogenic Hantaviruses are rodents in the family Muridae, in which a chronic, asymptomatic infection develops (CDC 2002). Hantavirus is transmitted from rodents to humans by the inhalation of contaminated aerosols coming from the dried excreta of infected rodents. Human infection with Hantaviruses has been associated with two diseases. One is hemorrhagic fever with renal syndrome (HFRS), occurring mainly in Asia and Europe, and the other, a severe cardio-respiratory illness known as Hantavirus Cardiopulmonary Syndrome (HCPS), is found in the Americas, including Chile. HCPS has been identified in several South American countries and the aetiology of the illness has been linked to various Hantavirus strains. In Chile, the infecting agent is Andes Hantavirus (Baro et al 1999). HCPS was first recognised in Chile in October 1995 and, in subsequent years, began to infect the population in outbreak numbers (Sotomayor and Aguilera 2000). This epidemic caused great concern in public health departments which led them to spear-head a large-scale, collaborative investigation to determine the magnitude of the HCPS outbreak and the major risk factors indicated for human infection. As a result, the major reservoir for HCPS in Chile was discovered to be the long-tailed pygmy rice rat (*Oligoryzomys longicaudatus*), a species of rat that primarily inhabits temperate forest regions (Pavletic 2000), much like those in rural, southern Chile.

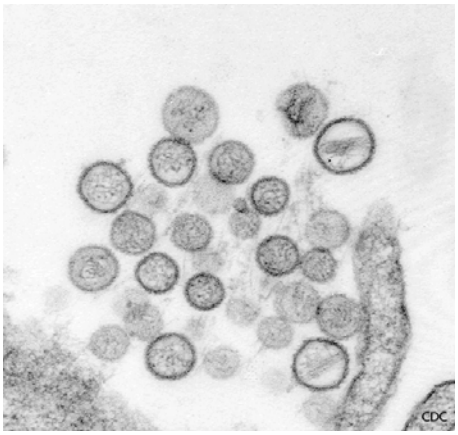



**Figure 1** – Microscopic view of a typical Hantavirus (CDC, 2002)

Since HCPS emerged in Chile, 469 cases have been reported through March 2006 (Vial et al 2006), causing a substantial impact on the public health system. Up until 2002, the death rate for HCPS in Chile exceeded the expected 40% (DoE 2002), but now averages 36% (Pini 2004, Vial et al 2006).

While a proportion of these cases were witnessed in urban regions, they were essentially isolated cases and the predominant infection sites have been and continue to be rural communities where rodent density is greatest. At the point of writing this review, HCPS continues to be a major public health problem in the southern, rural regions of Chile. This has inevitably led to the Hantavirus-infected rodent population in the problematic regions becoming a primary environmental health issue, and investigation and efforts to control infections continue. This review summarises the impact of HCPS on the Chilean population to date and the efforts and resolutions associated with the ongoing investigation and the attempts to reduce infection rates by addressing rodent infestation in rural areas.

## Investigation

In 1995, the Andes Hantavirus was identified for the first time in the central and southern regions of Chile, sparking concern among health professionals in the Chilean community on the basis that human infection with the Andes Hantavirus gives rise to the potentially fatal illness Hantavirus Cardiopulmonary Syndrome (HCPS). Such was the concern that studies were immediately conducted to determine the major risk factors for human infection. These investigations were coupled with training in specialised diagnostic techniques, training in rodent sampling protocols, and transfer of diagnostic capability to Chile from the United States of America (Baro et al

1999). The result was a definitive confirmation of the deciding factors in HCPS aetiology. It was discovered that the Andes Hantavirus is carried in rat species and transmitted to human hosts through direct contact with infected rodents, specifically, by the inhalation of spores from the excreta of infected animals (CDC 2002).

## Impact of the problem

From Oct 1995 through Oct 1997, a total of 21 HCPS cases were identified and reported. Of this total, 62% died. The mean age of patients was 26 years and 19% of the cases were children aged less than 17 years, this high proportion of cases among children is a distinctive feature of the HCPS situation in Chile (DoE 2002). More recently, a reduction in the number of children affected by the Andes Hantavirus has been reduced to 4% of the total affected population (Sportono et al 2000). The following figures depict the distribution of HCPS infection in 2002 following specific socio-demographic classifications and age groups, evidencing the impact of the environmental health problem behind the infection and were it is most felt.

**Figure 2**: Distribution of HCPS infection in Chile in 2002 (DoE 2002)

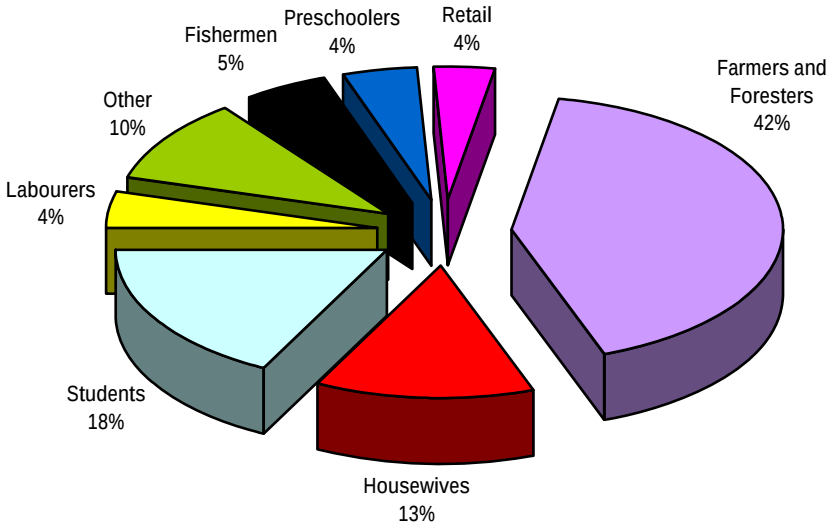
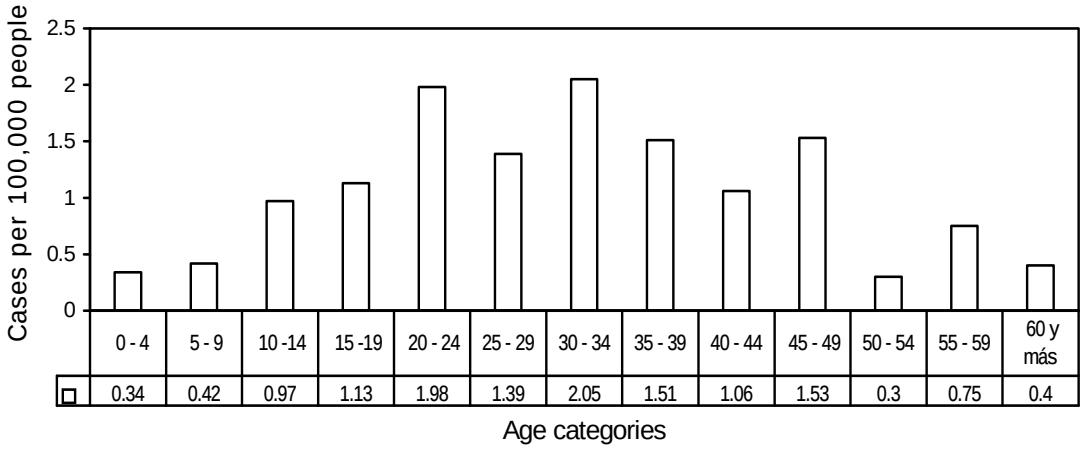


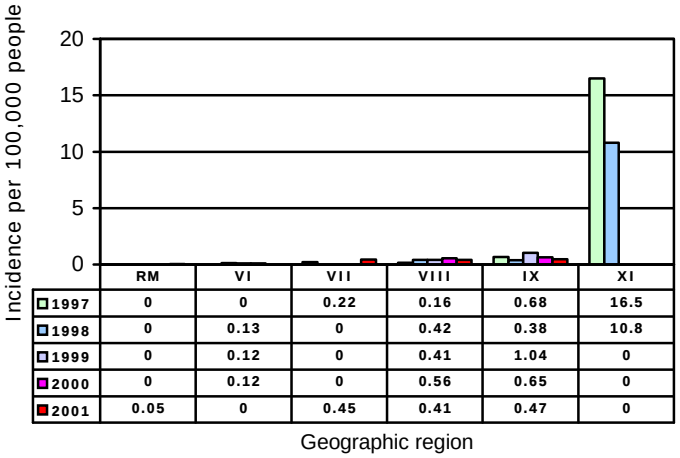

**Figure 3**: Distribution of HCPS cases in Chile according to age (DoE 2002)




The Andes Hantavirus has had a social impact across Chile but clinical infection has been confined to the country's central and southern regions (Chile is divided into 12 regions). Beginning with the metropolitan region at the centre of the country, HCPS cases steadily increase moving down the country through the 6th to 11th regions in perfect unison with the increase in rodent population seen in these predominantly rural regions. Figure 4 evidences the distribution of HCPS cases in the above mentioned regions between 1997 and 2001, also depicting an outbreak in the 11th region in the year 1997.

Just as the impact of HCPS on the Chilean rural population has been high, so is the potential for lethality. HCPS infection in Chile has surpassed the 40% death rate outcome that could be expected based on the experience of other countries (Sotomayor and Aguilera 2000).

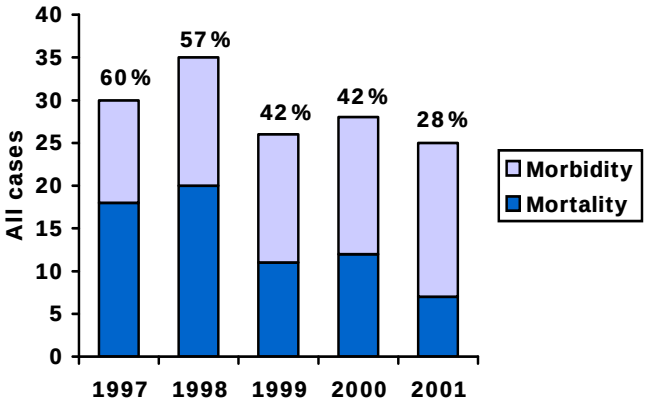
**Figure 4**: HCPS infection per 100,000 people in affected regions between 1997 and 2001 (DoE 2002).




| | RM | VI | VII | VIII | IX | XI |
|---|---|---|---|---|---|---|
| 1997 | 0 | 0 | 0.22 | 0.16 | 0.68 | 16.5 |
| 1998 | 0 | 0.13 | 0 | 0.42 | 0.38 | 10.8 |
| 1999 | 0 | 0.12 | 0 | 0.41 | 1.04 | 0 |
| 2000 | 0 | 0.12 | 0 | 0.56 | 0.65 | 0 |
| 2001 | 0.05 | 0 | 0.45 | 0.41 | 0.47 | 0 |

This high death rate as a result of HCPS supports the notion that urgent action to address the rodent problem in rural regions of Chile is required. Figure 5 shows the lethal impact of HCPS in Chile. Fortunately, there is a declining trend in lethal HCPS cases, most likely due to clinical treatment and diagnostic education among rural physicians more than the recent (and relatively unsuccessful) educational campaigns in rural communities regarding sanitation and rodent contact.

**Figure 5**: Proportion of HCPS cases resulting in death versus live outcomes between the years 1997 and 2001 (DoE 2002).




To date, HCPS, as a result of rodent infestation, continues to be a major environmental health issue in Chile which has transitioned from an acute epidemic to a chronic endemic. Furthermore, the problem is a growing concern and has the potential to increase exponentially if the current high number of rodents in rural communities is not addressed. Not only are the rural communities at risk of a worsening of the existing problem, but urban centres are also potentially vulnerable should rodent infestation spread or person-to-person transmission prove feasible in the Chilean context (as has been evidenced in Argentina).

## Cause of the problem

Current epidemiological research suggests that the incidence of HCPS infection in the Chilean population is paralleled by an exceptionally high density of potential rodent reservoir species (Baro et. al., 2000). This is particularly true in rural communities in the south of Chile where the majority of HCPS infection cases are witnessed. A great deal of research has focused on HCPS infection from an evolutionary perspective, studying the rodent population in areas of predominant infection rates. The greater proportion of these studies have been conducted in the 8th and 9th regions of Chile where rural communities are predominant and HCPS infections have been substantial. The 9th region alone is ranked third among those affected by HCPS and accounts for 25% of the documented cases in Chile (Frey 2003). Figure 6 depicts the geographical location of the 8th and 9th regions in a national context.

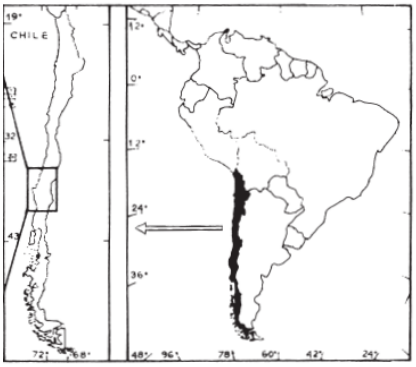



**Figure 6**: Location of the 8th and 9th regions of Chile (Frey 2003).

The studies described in above have had high rodent-trapping success. That is, traps that have been set to catch wild rodents for investigative purposes have elicited a large yield (Sportono et al 2000).

This trapping success reflects the high population density of rodents in the rural Chilean environment. Most notably, the trapping of rodents has evidenced a large population of *O. longicaudatus* rat, which is the species also preliminarily identified as the reservoir of the Andes Hantavirus in southern Argentina (CDC 2002), Chile's neighbouring nation. Figure 7 shows an *O. longicaudatus* rat, a potential reservoir for the Andes Hantavirus.

**Figure 7**: *O. longicaudatus* rat (Sportono et al 2000)

Contact with infected rodents is thus far the only identified mode of transmission of the HCPS causing Andes Hantavirus to humans in Chile. However, in previous HCPS outbreaks witnessed in Argentina, person-to-person transmission of the Andes Hantavirus was documented (CDC 2002). Although person-to-person transmission may be an aetiological possibility in Chile also, it has not been evidenced and the high rodent population in outbreak areas is demonstrably the predominant cause for infection.

In rural communities the high density of rodents increases the probability of human-rodent contact and, therefore, gives rise to an increased risk for the transmission of the rodent-borne Hantavirus to humans. The wild rodent population in the southern, rural regions of Chile is so high due to the following factors:

- The natural environment in the 8$^{th}$ and 9$^{th}$ regions is conducive to rodent inhabitation and breeding. The 8$^{th}$ and 9$^{th}$ regions of Chile is characterised by temperate forestation, grassy fields, and lakes, making it an ideal setting for rodents (Ortiz et al 2004).
- The rural communities of the 8$^{th}$ and 9$^{th}$ regions are predominantly populated by farm settlements and the presence of livestock, barns, and crops, are attractive to rodents and the perfect breeding ground (Ortiz et al 2004)
- The people living in the communities are generally poor and live in degraded housing which attracts rodents (Frey 2003).
- Living conditions in the rural communities are generally poor. Many homes lack adequate sanitation facilities and waste disposal services do not exist which again attracts rodents (DoE 2002).
- Infrastructure in the rural communities is poor, if at all existent, and not maintained. This leads to facilities frequently becoming overloaded resulting in breakdowns. For instance sewage systems are often overflowing into fields and establishing the perfect environment for a rodent infestation (DoE 2002).

The present situation of HCPS in Chile does not reflect major improvements since the first appearance of the disease in the country, and the Andes Hantavirus remains rampant with rodent populations in rural communities as numerous as ever. While no current research data (from the last 4 years) exists to support this, it is well demonstrated in the Chilean society through the media and the number of cases reported clinically.

Discussions at national level continue with the aim of devising a strategy for effectively reducing the incidence of HCPS in Chile and addressing the rodent issue in rural communities. Interim measures for combating this complex environmental health issue are predominantly centred around public health education/promotion initiatives which focus on methods for reducing human-rodent contact.

## Management History and Effects

Hantavirus infection (resulting in HCPS) in rural Chilean communities has been epidemiologically associated with the following situations (Sotomayor and Aguilera 2000):

- Increasing numbers of host rodents in human dwellings;
- Occupying or cleaning previously vacant dwellings that are actively infested with rodents;
- Cleaning barns and other outbuildings;

- Inadequate sanitation;
- 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 equipment or machinery that has been in storage;
- Sleeping on the ground; and
- Hand ploughing or planting of crops.

These factors were identified as a result of numerous investigations into the risk factors associated with the contraction of the Andes Hantavirus.

Having preliminarily identified the above elements as the major contributing factors to Hantavirus infection, the Chilean Ministry of Health has initiated a series of management strategies. Unfortunately the management strategies implemented by the government have not been very effective. Truth be told, the management efforts are in fact few and far between.

The major management effort set in place has been an educational campaign centred on health promotion from the perspective of reducing human-rodent contact. This campaign has been facilitated predominantly by the use of mass media. The following aspects formulate the main features of the Hantavirus educational campaign:

- Posters with information about HCPS and warning against human-rodent contact have been designed and displayed in prominent places in rural affected communities.
- Information about ways to prevent infection has been broadcasted to the community in newspapers and on television and radio programmes.
- Special information pamphlets have been designed for doctors to keep in stock and pass on to patients at risk (Fig 8).

This educational campaign has not had widespread effect. The methodology which has been used is too narrow to reach the intended target audience. The current strategies utilised do not account for lower literacy rates in rural communities and less televisions and radios per capita. The educational campaign, as it stands, is not appropriate for extending a health promotion message to the communities at risk of Hantavirus infection.

No other effort to manage the Hantavirus problem has been made from the perspective of working with the rural communities at risk. All other management efforts and resources have focused on epidemiological research to support clinical diagnosis and treatment of HCPS, and the clinical control of HCPS itself. Herein lays the greatest problem preventing the appropriate management of HCPS in Chile, as significant recognition of the fact that the Hantavirus endemic in rural Chile is predominantly an environmental health issue (and should be addressed as such) has not been given.


**Figure 8**: Hantavirus identification and treatment flowchart poster developed for rural physicians (DoE 2002).

While the approach of the Chilean government to managing the Hantavirus problem in rural communities has not been entirely effective, it has reduced the HCPS infection incidence by some measure in recent years (DoE 2002). This can be attributed to 2 factors:

- The information spread through media sources reached some members of the community and they took precautions following the advice given; and

- The community members who were reached by the educational campaign may have facilitated peer-education, and information was passed on through the community by word of mouth

The inherent clinical and investigative approach to hantavirus management pursued by the government, while having no effect on preventing infection, has had an impact on the mortality rate associated with HCPS. A great deal of effort has been exerted on training rural physicians to recognise HCPS in patients. National workshops have been hosted by the Epidemiology Department of the Ministry of Health in order to present the facts and features pertaining to Hantavirus infection to audiences comprised of rural physicians. Unfortunately these workshops have lacked information on preventative methodology and thus the problem has only been addressed from a treatment perspective. The following page shows a Hantavirus identification and treatment flowchart designed for rural physicians.

In their favour, the Chilean Ministry of Health, through its clinical approach to dealing with the Hantavirus problem, has developed very effective means for the identification, treatment and notification of HCPS infections. However, this form of management does nothing to control the problem and ignores the essential fact that the root of the issue is an environmental health problem and should be addressed as such.

Figure 9 exemplifies the web developed for the clinical management of HCPS infections in Chile.

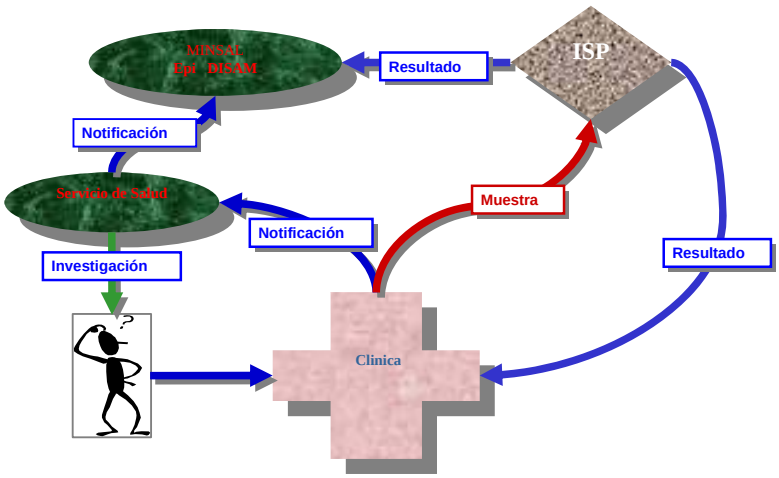



**Figure 9**: Flowchart for Hantavirus infection notification and processing of tests (DoE 2002). The flowchart depicts the integral network that has been established between various health services to facilitate the management of identified Hantavirus infection cases. The flowchart also shows an output to field investigation/research, which is another aspect to the management strategy assumed by the Chilean government.

All Hantavirus cases are notifiable (obligatory reporting) to the Department of Health and each case is to be investigated epidemiologically to determine the specific source of infection in order to isolate the index case. This is a step in the right direction and reflects a consciousness of the environmental aspect of the endemic; however it is still a 'band-aid solution'. Simply treating patients infected with the Andes Hantavirus and dealing with the source of infection for that individual does nothing to manage the larger scale endemic and protect the community. To date the Hantavirus problem in rural Chilean communities remains essentially unaddressed. While some reduction in infection incidence has been achieved through current management efforts, much remains to be done to control the endemic. It is plausible that the problem could escalate and take on a more lethal outcome if the issue is not recognised fully for what it is – an environmental health problem – and managed accordingly, dealing with the roots of the dilemma.

## Resolution

Eradicating the reservoir hosts of the Andes Hantavirus is neither feasible nor appropriate as the rodents play an important role in the homeostatic balance of the natural ecosystem (Sportono et al 2000). The ideal approach, based on the current information and management strategies available, to control Hantavirus infection is risk reduction through environmental modification and hygiene practices which would limit human-reservoir contact and therefore the possibility for infection also (Pavletic 2000).

The Hantavirus problem requires the formation of a specialised taskforce engineered to manage the endemic from an environmental health perspective. Enough research specific to the rural communities affected exists to now establish a management plan and it is time to act upon the risk factors identified by previous investigations. In considering the identified risk factors it is obvious that the underlying basis for all is the presence of diseased rodents, making the problem a prominent environmental health issue. Accordingly, the Ministry of Health, in developing a specialised Hantavirus taskforce, should call for environmental organisations to join forces with the public health and epidemiology departments of the health service to appropriately and effectively address the Hantavirus endemic in rural Chile. To manage a problem which is diverse in its context, such as the Hantavirus issue, a multidisciplinary team (MDT) is necessary. The established MDT should be responsible for visiting at risk communities and conducting a needs assessment based on the individual situations encountered. The

identified needs should then be taken and examined in the context of the risk factors epidemiologically associated with Hantavirus (as identified through previous research) to formulate a community-specific management plan. Management plans, while being specific to individual communities, should take into account some common factors and address the following as a minimum:

### Reduce human-reservoir contact

Rodent control in at risk communities is the primary strategy for preventing Hantavirus infection. Reducing the contact between diseased rodents and humans decreases the probability for virus transmission (Pavletic 2000).

The established MDT should undertake an analysis of the rural communities affected by Hantavirus and identify locations of rodent infestation.

Rodent infestation can be determined by direct observation of animals, or inferred by observation of their nests or excreta on floors or in protected areas (e.g. kitchen cabinets, drawers etc.), or from evidence that rodents have been gnawing on food or other objects (CDC 2002).

Identified infestations should be recorded in a register and this register should then be used to initiate a community wide 'clean-up' to clear buildings of rodents and their excreta. The community should be involved in the clean-up process as it will assist in transferring skills and knowledge that could be used to keep up the rodent management as a preventative measure against Hantavirus infection and the clinical development of HCPS.

Follow-up on the removal of rodent infestations would be required and the interior and exterior of all buildings in areas of risk should be carefully inspected at least twice each year to avoid re-infestation. The bi-anual inspection should aim to identify any openings where rodents could enter buildings and existing conditions that could support rodent activity.

### Educate the community

The MDT's management plan should include an educational programme for:

- Providing information about Hantavirus and how to prevent infection
- Specific information regarding rodent control
- Information on how to safely remove rodents and their excreta

Controlled experiments have demonstrated that simple and inexpensive methods are effective in preventing rodents from entering rural dwellings, and this allows for a high degree of self-protection and community initiated prevention amidst the Hantavirus endemic (Pavletic 2000).

The following precaution measures are recommended by the CDC (2002) report and would form an excellent basis for rodent control guidelines in Chilean rural communities.

### 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 aluminium 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 mould, 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, 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.
- 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.
- 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).

### Precautions for Outside the Home

- Place woodpiles and stacks of lumber, bricks, stones, or other materials $\geq$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.

### Address environmental and infrastructural risk factors

The MDT should build an inventory of environmental and infrastructure-related risk factors for rodent infestation in each community as part of their initial analysis of the situation. It is important to address these factors as they play a crucial role in determining a community's vulnerability to Hantavirus infection by way of exposure. That is, infrastructure and environments which are conducive to rodent infestation increase the probability of Hantavirus infection due to increased human-rodent contact.

Once an inventory has been built the MDT should work with the community to modify the environment and existing community infrastructure as a preventative measure. The implications of the inventory should also be recorded for use in future community planning and development to ensure that modifications to infrastructure deemed necessary would become the standard, and the preventative measures put into place would continue.

It is likely that the inventory would be different for each community; however, the following facets should be taken into consideration as a basis for community analysis and modification requirements:

- Building materials – non-porous, solid materials are best
- Sealing of buildings (rodent-proofing) – seal off opening around doors and windows, use chicken wire to create an enclosing mesh in chimneys

- Building foundation – solid cement base or stilts are best choices
- Waste services – implement a regular rubbish collection
- Waste deposit areas between collections – specify locations and place them at least 30m from any building
- Water supply – use enclosed catchments and consider treatment of water with chlorine

## Conclusion

Hantavirus infection facilitated by human-rodent contact is a major public health problem in rural Chile, extending to endemic proportions and reflecting a high mortality rate. To date, the Hantavirus issue has not been appropriately addressed nor effectively managed. Recognition of the environmental basis of the endemic needs to be given in order to develop sustainable solutions and effective management plans which could reduce the Hantavirus infection rate that is witnessed in rural communities.

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