Multipronged Approach to Reduce Hantavirus Pulmonary Syndrome Incidence Among Rural Populations

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ABSTRACT

Hantavirus Pulmonary Syndrome (HPS) has been acknowledged as a public health concern, especially due to the high case fatality rate, justifying the need for promoting early detection and strengthening of preventive measures to save lives. Even though the condition is rare, it is an extremely fatal condition, with an average case fatality rate of 40%. Many rural households tend to have inadequate housing and improper storage standards for food and waste, which attract rodents and facilitate their habitation in human dwellings. Acknowledging the high case fatality rates and the presence of disease in rural populations, which are more at-risk with limited healthcare services, there is an essential need to implement targeted prevention and control measures to reduce the incidence of disease and the possibility of outbreaks. These interventions can range from rodent-proofing housing, community education campaigns, the use of personal protective equipment, etc. In conclusion, rural populations are extremely susceptible to Hantavirus Pulmonary Syndrome due to the presence of multiple predisposing factors. There arises the need to adopt a multipronged strategy, integrating education, environmental controls, and surveillance, which could substantially lower HPS burden in underserved rural areas.

Keywords: Hantavirus, Agricultural workers, Rural, Hantavirus pulmonary syndrome, Prevention, Zoonosis, Public health interventions

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INTRODUCTION

Hantavirus Pulmonary Syndrome (HPS) is a life-threatening zoonotic disease transmitted to humans through the inhalation of aerosolized particles from the urine, droppings, or saliva of infected rodents.[1] While Sin Nombre virus predominates in the US, similar syndromes occur with Old World hantaviruses in Eurasia.[1,2] Since the detection of the first case in 1993, ~864 cumulative cases by mid-2025 have been reported, with ongoing sporadic reports, predominantly in the rural settings of the western states of the United States.[2] However, the possibilities of underreporting in rural or low-resource settings cannot be undermined. Even though the condition is rare, it is an extremely fatal condition, with an average case fatality rate of 40%.[2] Patients generally present with flu-like symptoms and then develop respiratory distress, pulmonary edema, and shock.[2,3]

HPS: A PUBLIC HEALTH CONCERN

HPS has been acknowledged as a public health concern, especially due to the high case fatality rate, justifying the need for promoting early detection and strengthening of preventive measures to save lives.[1,2] In fact, due to the rapid progression of the disease, there is an urgent need for early clinical suspicion and prompt action, which can only be accomplished through sensitization of health workers and the general population by periodic training-cum-sensitization sessions.[3] Outbreaks have surged post-rodent population booms, as seen in the 1993 Four Corners outbreak (>40% fatality) and recent 2023-2024 spikes in the Southwest United States.[1-3] In addition, due to the absence of specific antiviral treatment or vaccine, and the serious nature of the disease, the prevention aspect, in terms of behavioural interventions, as recommended by the Centers for Disease Control and Prevention, becomes the cornerstone in reducing the morbidity and mortality.[2,4]

Moreover, the virus can cause outbreaks in localized settings, especially after an increase in rodent population because of climate (like rainfall or temperature) or ecological transitions, as reported in Latin America and Caribbean region based on the findings of a recent systematic review.[5] The findings of a literature review indicated that factors like increasing temperatures, and changing precipitation pattern can increase the rodent population in endemic areas.[6] Further, rodent control and improvement in housing standards not only safeguard against developing HPS but also improve the hygiene of the local population.[7]

Considering the limited access to healthcare services in rural settings, people are deprived of the desired healthcare, and this makes them quite vulnerable.[8] Finally, strengthening surveillance and public health response to the infection plays a vital role in improving pandemic preparedness in the affected nations.[9]

HPS AND RURAL POPULATION

Many rural households tend to have inadequate housing and improper storage standards for food and waste (like open crevices, thatched roofs, etc.), which attract rodents and facilitate their habitation in human dwellings.[10] In a field study involving rural housing units near three National Parks in the United States, active rodent infestation was reported in 59% of selected units before interventions., which significantly reduced after rodent-proofing.[11] In other words, the use of mud, wood, and organic materials in traditional homes or storage units can harbour rodents and complicate rodent control measures.[4] Poor rodent-proofing in homes and storage areas attracts rodents and significantly augments the risk of human contact with rodent droppings, which is an important route of transmission.[1,4] Moreover, farmers, herders, and agricultural labourers often work near rodent-infested areas during field work.[12] In continuation, farming activities like harvesting, grain storage, etc., tend to disturb the habitats of rodents and contribute towards the generation of aerosols containing the causative virus, especially in enclosed and dusty environments.[12] In addition, poor sanitation and improper waste disposal become the source of food and shelter for rodents, due to which their number increases remarkably around homes and workplaces.[1,10]

During the dry season and in poorly ventilated rooms, virus-laden dust can become airborne, especially while cleaning or sweeping rodent-infested areas, increasing the overall risk.[13] Further, we cannot ignore the possibility of a sudden increase in rodent population subsequent to heavy rains, which accounts for sudden rise in the risk of short-term transmission.[5] In addition, workers employed in agriculture rarely use personal protective equipment (e.g., gloves or masks while cleaning sheds or barns), and this heightens the risk of infection.[13] At the same time, the issue of limited awareness about HPS, its transmission, and preventive measures in rural communities predisposes them to a higher risk of acquiring the infection or a delay in seeking treatment in the initial phases of the disease.[14] This concern is further complicated by the shortage of trained healthcare staff, limited diagnostic facilities, and delay in seeking care due to multiple reasons (e.g., distance, involved cost, cultural values, belief in traditions, etc.).[1,4,7] Further, social determinants (like poverty and migration) also play a significant role in increasing the incidence of HPS. In fact, in South America, more than 70% of HPS cases occur in rural counties with median income less than national average.[9]

PUBLIC HEALTH INTERVENTIONS

Acknowledging the high case fatality rates and the presence of disease in rural populations, which are more at-risk with limited healthcare services, there

is an essential need to implement targeted prevention and control measures to reduce the incidence of disease and the possibility of outbreaks (Table 1).[7,9,13-21] The primary set of interventions deals with health education and community awareness in the form of launching culturally tailored awareness programs using different modes of mass media for better reach and acceptance.[14] The pilot programs in Chile showed a 25% uptake improvement, and justifying the need for similar studies in the United States.[14] The effectiveness of these campaigns can be enhanced by roping in local community and religious leaders to augment the chances of acceptance by different sections of the community.[14,15] In rural areas with limited internet, use radio or message services for education of the underserved population groups. There is a definite scope for introducing these topics into the school health curriculum to instil lifelong awareness among the youth.[16]

The next set of interventions are related with environmental and rodent control measures, wherein due emphasis should be given to improve waste management (like safe garbage disposal) to eliminate food sources for rodents, and rodent-proofing of homes and storage units by sealing cracks, installation of screens, and elevation of food storage to restrict rodent access indoors.[17,18] In addition, residents must be encouraged to use wet disinfection and wear protective equipment while cleaning households, and not engage in sweeping or using vacuum cleaners.[19] Further, people should be motivated to clear grass and woodpiles near their dwellings to minimize areas where rodents can live.[7] At the policy level, evidence-based guidelines should be formulated for prevention and outbreak response.[19] In addition, there is a definite need to adopt One Health approach, establishing collaboration between all concerned sectors (e.g., public health, agriculture, wildlife, etc.) for effectively dealing with the problem in a sustainable manner.[20]

The next domain is to improve occupational health, and this can be accomplished by supplying and encouraging the use of personal protective equipment for all workers engaged in rodent-prone areas, and through training of these workers in protective behaviours.[13] There is a definite need to frame comprehensive guidelines for rodent-exposed tasks, including pictorial instructions for dealing with rodent-contaminated environments.[18] In addition, employers must be encouraged to inspect and report rodent activity in fields and storage areas. The last set of interventions is related to strengthening surveillance, wherein trends in rodents and suspected HPS cases are reported in high-risk rural areas.[9,15] Further, healthcare professionals must be trained to recognize the early symptoms of HPS and accordingly refer patients to healthcare facilities for timely attention.[21]

Table 1: Proposed public health interventions

Intervention domain	Key actions	Expected impacts
Health education and community awareness	▪ Launch culturally tailored awareness programs via mass media. ▪ Involve community and religious leaders to improve acceptance. ▪ Introduce disease prevention topics into school health curricula.	▪ Increases reach and acceptance of prevention messages.[14,15] ▪ Builds community trust and participation.[14] ▪ Instills lifelong awareness among youth.[16]
Environmental and rodent control	▪ Improve waste management and safe garbage disposal. ▪ Rodent-proof homes and storage units (seal cracks, install screens, elevate food storage). ▪ Promote safe cleaning practices (wet disinfection, protective gear, avoid sweeping/vacuuming). ▪ Clear grass, woodpiles near dwellings. ▪ Develop policy guidelines for prevention and outbreak response. ▪ Foster intersectoral collaboration (public health, agriculture, wildlife).	▪ Reduces rodent food sources and indoor access.[17,18] ▪ Lowers risk of rodent–human contact.[7,19] ▪ Promotes safer household hygiene practices.[19] ▪ Strengthens outbreak preparedness and response.[19,20]
Occupational health	▪ Provide and promote PPE use for workers in rodent-prone areas. ▪ Train workers in protective behaviours and handling rodent-contaminated environments (using pictorial instructions). ▪ Encourage employers to inspect and report rodent activity in fields and storage areas.	▪ Protects high-risk workers from exposure.[13,18] ▪ Improves compliance and awareness among semi-literate populations.[18] ▪ Facilitates early identification of rodent infestation risks.
Surveillance and healthcare capacity	▪ Monitor rodent trends and suspected HPS cases in high-risk rural areas. ▪ Train healthcare professionals to recognize early symptoms of HPS and ensure timely referrals.	▪ Enables early detection of outbreaks and rapid response.[9,15] ▪ Improves patient outcomes through timely treatment and referral.[21]

Conclusion

In conclusion, rural populations are extremely susceptible to HPS due to the presence of multiple predisposing factors. There arises the need for urgent investment in rural HPS programs, which can prevent dozens of annual US deaths and serve as a model for global zoonotic control.

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