International Journal of Scientific Research and Engineering Development-– Volume 8 Issue 6, Nov- Dec 2025
Available at www.ijsred.com

RESEARCH ARTICLE OPEN ACCESS

Nipah Virus Infection

Mr.Gaura Nimbalkar A, Prof.Shinde Priyanka N, Dr. Salve Megha T
Shivajirao Pawar College of Pharmacy ., Tel-Newasa , Dist-A.Nagar

Abstract:
Nipah virus, linked to Hendra virus, was first detected in Malaysia in 1998. It can cause symptoms ranging from no signs at all to deadly brain swelling (encephalitis). Malaysia has not reported any new cases since 1999, but there are still outbreaks happening in Bangladesh and India.In the Malaysia-Singapore outbreak, the virus spread mainly through contact with pigs. In Bangladesh and India, the spread is linked to eating contaminated date palm sap and human-to-human transmission. Bats are the primary carriers of this virus, which can infect both humans and animals. Actualmente no existen terapias efectivas, y el cuidado de apoyo y la prevención son las bases principales del manejo.

INTRODUCTION

In late September 1998, the first cases emerged in villages near Ipoh in Perak, West Malaysia, a region where pig farming was significant. Cases in the region continued until early February 1999.The second cluster of cases happened near Sikamat, a small town in the state of Negri Sembilan, during December 1998 and January 1999.In December 1998, a large outbreak started near Bukit Pelandok. Initially, the outbreak was attributed to Japanese B encephalitis, as four out of 28 patients' serum samples tested positive for JE-specific IgM, and JE nucleic acids were found in some patients' sera.(2)The text describes two initial actions taken to address a situation: using fogging to kill mosquitoes and increasing Japanese Encephalitis (JE) immunization efforts.(1)The text does not provide enough content to create a summary. Please provide more context or information from the text for a complete summary. Most patients were adult males. Many victims had direct physical contact with pigs. Symptomatic cases clustered in the same household at 33%. The text compares the attack rate of an unspecified virus with that of the Japanese Encephalitis (JE) virus. It suggests that the unspecified virus has a higher attack rate than the JE virus, which shows symptoms in only one out of every 300 infected people.(4) Many patients were vaccinated against Japanese Encephalitis (JE), but the preventive measures did not stop the rise in new cases.(5)The distribution of affected villages showed no encephalitis cases in Malay villages, despite their proximity to Chinese farms with cases, likely due to Muslim prohibitions against pig contact.(6) In March 1999, researchers from the University of Malaya identified a virus that looked like it came from the Paramyxoviridae family, excluding the JE virus. Tests revealed the virus reacted with Hendra virus antibodies, and genome sequencing by the Centers for Disease Control and Prevention found it to be about 20% different from the Hendra virus. The outbreak was linked to a new virus associated with pigs. New measures were implemented: pig farm workers received health education via radio and TV, focusing on personal protection, barrier precautions, handwashing, and environmental disinfection. During an outbreak, pig culling was done in infected farms. In Phase I, over 1 million pigs were culled in areas with outbreaks. Phase II involved nationwide surveillance, culling pigs from farms with ≥3 positive Nipah virus test results or within 500-m radius, over three months.The last human death from acute NiV encephalitis happened on May 27, 1999. By that time, there were 265 reported cases with 105 resulting in death in Malaysia.Over 500 abattoir workers in Singapore were screened for health issues. Those with fever or respiratory or neurological symptoms were hospitalized. Seven more patients and four initial cases were confirmed with acute Nipah virus infection. The virus was detected in a deceased patient's cerebrospinal fluid and tissue through PCR.All 11 patients worked at one of two abattoirs in

Singapore. The study found that more patients had been in contact with live pigs compared to the control group. Pigs from areas in Malaysia affected by Nipah were brought in and slaughtered 2 to 3 weeks before the patients got sick. This time frame matches the expected incubation period for a paramyxovirus. Additionally, the genetic sequences from the patients in Singapore were identical to those of the Nipah virus found in Malaysian cases and pigs.(10)A causal link was established between human Nipah virus infections in Singapore and pigs from Malaysia. The outbreak ended after banning live pig imports from Malaysia. The ban on importing live pigs, pork, and pork products from peninsular Malaysia still exists. Pteropodid fruit bats were later identified as the natural reservoir hosts of the virus.(11)In 2001, an encephalitis outbreak happened in Meherpur, Bangladesh, but it wasn't investigated until 2003 after similar cases arose in Naogaon with eight deaths. The clinical similarities suggested both outbreaks might have been caused by the same source. NiV possibly spread through pigs eating bat-contaminated fruit.An outbreak of encephalitis occurred in Meherpur, Bangladesh, in 2001, linked to pigs consuming bat-contaminated fruit. In 2003, a related outbreak with neurologic symptoms and eight deaths happened in nearby Naogaon District. This prompted an investigation due to similarities in symptoms, raising questions about a common cause. In Siliguri, India, during early 2001, a similar outbreak of febrile illness with altered mental states occurred, without identifying an infectious agent. A thorough investigation conducted in 2003 in Bangladesh sought to identify clinical features, causes, asymptomatic infections, risk factors, and potential animal reservoirs. Samples tested at the CDC revealed Nipah virus antibodies in severely ill patients, but not in those who were asymptomatic or less severely ill.(12)Siliguri, near Bangladesh, experienced an outbreak where clinical samples later confirmed half were Nipah virus positive.(13)Many of the epidemiologic features of the outbreak in Siliguri were similar to those of the NiV outbreaks in Bangladesh. Unlike in Malaysia and Singapore, pigs were not involved as an intermediary host. Bangladesh is also a predominantly Muslim country, with no pig farming, while in West Bengal, India, although there are pig farms, pig farming is not on the same scale as in Malaysia.NiV transmission occurs through different routes. In Bengali culture, date palm sap is consumed fresh or fermented into drinks. Bats often feed on the shaved tree bark and contaminate the sap with saliva, urine, and excreta. Outbreaks in Bangladesh link fresh sap consumption to bat-to-human transmission.(14)Climbing trees contaminated with infected date palm sap and contact with sick animals are risk factors(12,14).Fruit bats drop saliva-covered fruit that domestic animals eat. Since 2001, Nipah virus outbreaks have occurred almost every year in Bangladesh and India. Fruit bats drop saliva-covered fruit that domestic animals eat. Since 2001, Nipah virus outbreaks have occurred almost every year in Bangladesh and India(14).The virus was believed to spread to humans through direct contact with infected horses, their body fluids during slaughtering, or eating undercooked meat from sick horses. The fatality rate was high, at 53%, and increased to 82% for cases involving acute encephalitis(15).

HUMAN-TO-HUMAN. RANSMISSION

Nevertheless, one nurse showed MRI changes similar to acute Nipah virus infections and was likely asymptomatic or had a mild infection, despite having no prior pig contact. In contrast, Bangladesh and India experienced several outbrea.During the Malaysian outbreak, transmission of the illness was reported to occur from person to person, particularly among family members of the initially affected cases(1).In a study involving more than 300 healthcare workers at three hospitals that had cared for most of the encephalitis patients, the research aimed to understand the effects on these workers. The study likely focused on aspects such as mental and physical health, workplace challenges, or infection control practices. The investigation highlighted the vital role of these healthcare workers during this medical situation and potentially addressed their needs and experiences in managing encephalitis cases. Further outcomes or specific findings of the study were not detailed in the provided text.(16)There were no serious illnesses, encephalitis, or hospitalizations among healthcare or pathology workers during the outbreak. However, three nurses who cared for encephalitis patients had blood tests showing antibodies for the Nipah virus. The authors of the study believed these results were false positives due to no symptoms of encephalitis and a lack of certain antibodies typically present with an active infection. Nevertheless, one nurse showed MRI changes similar to acute Nipah virus infections and was likely asymptomatic or had a mild infection, despite having no prior pig contact. In contrast, Bangladesh and India experienced several outbreaks involving person-to-person transmission, with around half of the cases in Bangladesh from 2001 to 2007 being spread this way.(17)The Faridpur outbreak in 2004 is a clear example of person-to-person disease transmission. During this outbreak, the disease spread through five generations, affecting 34 individuals(18).

CLINICAL PRESENTATION

The incubation period in humans is between 4 days and 2 months. Most cases, over 90%, fall within 2 weeks or less(19).Patients experienced symptoms like fever, headache, dizziness, and vomiting, progressing to severe encephalitis with reduced consciousness. They showed brainstem dysfunction, abnormal reflexes, seizures, and myoclonic jerks(19).La infección por NiV presenta un rasgo único e interesante: la aparición de recaídas y encefalitis de aparición tardía, algunas de las cuales occurrence meses o años después de la enfermedad aguda. En una serie de 160 casos de Tan que sobrevivieron a la encefalitis inicial, 12 (7.5%) sufrieron recaídas tras la recuperación de la encefalitis aguda, mientras que 3 (3.4%) casos experimentaron encefalitis de aparición tardía, donde la infección inicial no causó manifestation's neurológicas(20).The text states that the longest delay recorded for late-onset encephalitis to begin was 11 years(21).In another study, many participants showed psychiatric symptoms like depression and changes in personality. Others experienced issues with attention, verbal, and visual memory(22).Neurological symptoms varied by region; Malaysian cases showed prominent segmental myoclonus, unlike Bangladesh and India. Among 22 surviving patients, nearly one-third experienced lasting neurological and cognitive issues, with widespread chronic fatigue, and over half faced behavioral and neuropsychiatric changes(23).

RESPIRATORY INVOLVEMENT

Nipah virus not only affects the nervous system but also impacts other organ systems to different extents.In a series from Malaysia, 14 to 29% of cases showed respiratory issues, but it is unclear if these were at the start or due to aspiration or pneumonia from ventilators.In Singapore, out of 11 patients, 2 had only respiratory symptoms, while the others had encephalitis. In Bangladesh and India, more cases involved respiratory issues, with half to two-thirds of patients affected, and some developed severe respiratory problems. These differences may be due to variations between the two strains.

NEURORADIOLOGY FINDINGS

Inortality of NiV in different regions

Month and year	Region and/or country	No. of cases	No. of deaths	Case fatality (%)
September 1998–April 1999	Malaysia (Perak, Selangor, and Negeri Sembilan states)	265	105	40%
March 1999	Singapore	11	1	9%
All years	Malaysia-Singapore	276	106	**38%**
January–February 2001	Siliguri (India)	66	45	68%
April–May 2001	Meherpur (Bangladesh)	13	9	69%
January 2003	Naogaon (Bangladesh)	12	8	67%
January 2004	Rajbari (Bangladesh)	31	23	74%
April 2004	Faridpur (Bangladesh)	36	27	75%

January–March 2005	Tangail (Bangladesh	12	11	92%
January–February 2007	Thakurgaon (Bangladesh)	7	3	43%
March 2007	Kushtia, Pabna, and Natore (Bangladesh)	8	5	63%
April 2007	Naogaon (Bangladesh)	3	1	33%
April 2007	Nadia (India)	4	4	100%
February 2008	**Rajbari and Faridpur (Bangladesh**	5	5	100%
April 2008	Rajbari and Faridpur (Bangladesh	7	5	71%
January 2009	Gaibandha, Rangpur, and Nilphamari (Bangladesh) 3 0 0% Rajbari (Bangladesh)	3	0	0%
February -march 2004	Faridpur, Rajbari, Gopalganj, and Madaripur (Bangladesh	**1**	1	100%
January–February 2011	Joypurhat, Rajshahi, Natore, Rajbari, and Gopalganj (Bangladesh)	16	14	**85.**50%
February 2012	Joypurhat, Rajshahi, Natore, Rajbari, and Gopalganj (Bangladesh	12	10	83%
All years	Bangladesh and India	280	111	85%
March–May 2014	Philippines	17	9	53%

DISCOVERY OF THE VIRUS

In March 1999, virologists at the University of Malaya isolated a virus from the cerebrospinal fluid of an encephalitis patient. They observed syncytia development in Vero cells that were inoculated with the cerebrospinal fluid from three fatal encephalitis cases.Electron microscopic studies identified the virus as belonging to Paramyxoviridae. It's named Nipah after the first isolate from a fatal case in Kampung Sungai Nipah(7).Nipah virus-infected cells showed strong reaction with Hendra virus antiserum, but not with antisera for other viruses like measles, RSV, or herpesvirus. Studies showed an 8- to 16-fold difference in neutralizing antibodies between Nipah and Hendra, indicating they are related but not identical.Cross-neutralization studies showed an 8- to 16-fold difference in neutralizing antibodies between Nipah and Hendra viruses, highlighting their differences. Virus testing confirmed Nipah infection in all Singapore cases and nearly all Malaysian encephalitis cases(7).

CLASSIFICATION

NiV belongs to the Henipavirus genus in the Paramyxoviridae family. The first virus of this genus is the Hendra virus (HeV), found during a 1994 outbreak in Australia affecting horses and humans. Initially, it was thought to be part of the Morbillivirus genus and was called equine morbillivirus (EMV)(35).Subsequent whole-genome analysis identified unique molecular signatures in HeV not found in morbilliviruses. Further NiV genome analysis confirmed that HeV and NiV are novel paramyxoviruses that do not belong to existing genera, necessitating a new genus for their classification(31).In 2002, ICTV established Henipavirus as a genus. The Malaysian NiV strain (NiV-MY) differs slightly from the Bangladesh strain

(NiV-BD). The Philippines outbreak likely involved a NiV-MY strain.

Morphology
Similar to other paramyxoviruses, NiV particles are pleomorphic, spherical to filamentous, and range in size from 40 to 1,900 nm. They contain a single layer of surface projections with an average length of 17 ± 1 nm (32).

Genome size and structure.
There are two main genetic types of the NiVs that cause diseases in humans: NiV Malaysia (NiV-MY) and NiV Bangladesh (NiV-BD).The two virus strains are almost identical in function, but animal studies show differences. NiV-BD appears more harmful than NiV-MY in African green monkeys, and it has a shorter time frame for effective antibody tr tueatment(33).ferret infection studies, it was shown that NiV-BD infection resulted in increased oral shedding in comparison to NiV-MY (34).I'm sorry, but it seems like the provided text is incomplete. Could you please provide more information or additional context? This will help me create a more accurate summary or you(35).In Bangladesh and India, cases may have shorter incubation periods, more respiratory symptoms, increased human-to-human transmission, and higher fatality rates.

EPIDEMIOLOGY IN ANIMALS
Reservoir host
Fruit bats, also known as flying foxes, belong to the genus Pteropus in the family Pteropodidae. They are the primary reservoir hosts for both NiV and HeV viruses. These viruses do not cause disease in bats, whether the bats are infected naturally or through experiments(32).

Host range.
Paramyxoviruses typically infect a narrow range of hosts, and they rarely spread between different species(36).NiV can infect many species, including bats, pigs, horses, dogs, cats, and humans(32).NiV can infect various animals like guinea pigs, hamsters, ferrets, and monkeys because it uses ephrinB2/B3 receptors common in mammals(37,38).In late 1997/early 1998, Nipah Virus potentially transmitted from bats to pigs in Malaysia. Migration of bats to farms and orchards due to an El Nino-related drought in Indonesia might have contaminated pig swill, leading to transmission(39).Satellite telemetry reveals that Malaysian flying foxes travel hundreds of kilometers yearly, with ranges reaching Indonesia and Thailand(40). Studies indicate Nipah virus circulates among these bats, similar to strains found in Malaysia(41).
The map (Fig. 2) shows the distribution of Pteropus bats and the countries where outbreaks of Hendra virus and Nipah virus infections have occurred (41).

BIOSAFETY ISSUES OF NIPAH VIRUS
Field and farm workers in areas with suspected Nipah infection should use protective gear like masks, goggles, gloves, gowns, and boots, and practice equipment disinfection and hand washing(8,42).El virus NiV tiene alta Capac dad de contagiar tanto de animales a humanos como entre humanos, causando enfermedad grave y muerte. También genera miedo, pánico y pérdidas economics'. Por estas razones, el NiV podría considerarse como un potencial agente de bioterrorismo(43,44).The pathogen is a category C bioterrorism agent per CDC, requiring BSL-4 handling(45).

PREVENTION
NiV management focuses on prevention. This involves stopping farm animals from eating fruit contaminated by bats and reducing overcrowding in farms to prevent disease spread.Avoid consuming contaminated sap. Reducing fresh sap consumption may not be popular due to cultural norms, but using barriers to keep bats away from sap is a better solution(46).Candidate vaccines using a vesicular stomatitis virus vector protect against NiV disease in animals like hamsters, ferrets, and primates(47).Vaccination programs would also have to cover livestock animals, too, e.g., pigs, and perhaps horses in certain areas where NiV is endemic.La OMS ha considerate el virus del Nipah (NiV) como prioridad, pero las pharmaceutics pueden no querer

financiar ensayos en países pobres. No obstante, en enero de 2017 se creó CEPI, una coalición global de gobiernos y empresas pharmaceutical, para desarrollar vacunas seguras, eficaces y asequibles contra enfermedades con potencial pandémico, como el NiV.

CONCLUSION

About 20 years ago, a new virus emerged, severely affecting humans and animals and damaging Malaysia's pig-farming industry. It is still causing outbreaks in Bangladesh and India.reservoir host Pteropus bat is widespread, and NiV has been found in bats in various countries, the potential for outbreaks to occur in new regions remains significant.

REFERENCE

1.Tan KS, Tan CT, Goh KJ. 1999. Epidemiological aspects of Nipah virus infection. Neurol J South East Asia 4:77–81.

2.Chua KB. 2003. Nipah virus outbreak in Malaysia. J Clin Virol 26:265–275.

3.Chua KB, Goh KJ, Wong KT, Kamarulzaman A, Tan PS, Ksiazek TG, Zaki SR, Paul G, Lam SK, Tan CT. 1999. Fatal encephalitis due to Nipah virus among pig-farmers in Malaysia. Lancet 354:1257–1259.

4.Thongcharoen P. 1989. Japanese encephalitis virus encephalitis: an overview. Southeast Asian J Trop Med Public Health 20:559–573.

5.Looi LM, Chua KB. 2007. Lessons from the Nipah virus outbreak in Malaysia. Malays J Pathol 29:63–67.

6.Sherrini BA, Tan CT. 2014. Nipah encephalitis—an update. Med J Malaysia 69(Suppl A):103–111.

7.Chua KB, Bellini WJ, Rota PA, Harcourt BH, Tamin A, Lam SK, Ksiazek TG, Rollin PE, Zaki SR, Shieh W, Goldsmith CS, Gubler DJ, Roehrig JT, Eaton B, Gould AR, Olson J, Field H, Daniels P, Ling AE, Peters CJ, Anderson LJ, Mahy BW. 2000. Nipah virus: a recently emergent deadly paramyxovirus. Science 288:1432–1435.

8.Lam SK, Chua KB. 2002. Nipah virus encephalitis outbreak in Malaysia. Clin Infect Dis 34(Suppl 2):S48–S51.

9.Paton NI, Leo YS, Zaki SR, Auchus AP, Lee KE, Ling AE, Chew SK, Ang B, Rollin PE, Umapathi T, Sng I, Lee CC, Lim E, Ksiazek TG. 1999. Outbreak of Nipah-virus infection among abattoir workers in Singapore. Lancet 354:1253–1256.

10. Chew MH, Arguin PM, Shay DK, Goh KT, Rollin PE, Shieh WJ, Zaki SR, Rota PA, Ling AE, Ksiazek TG, Chew SK, Anderson LJ. 2000. Risk factors for Nipah virus infection among abattoir workers in Singapore. J Infect Dis 181:1760–1763.

11.Yob JM, Field H, Rashdi AM, Morrissy C, van der Heide B, Rota P, bin Adzhar A, White J, Daniels P, Jamaluddin A, Ksiazek T. 2001. Nipah virus infection in bats (order Chiropters) in peninsular Malaysia. Emerg Infect Dis 7:439–441.

12.Hsu VP, Hossain MJ, Parashar UD, Ali MM, Ksiazek TG, Kuzmin I, Niezgoda M, Uppercuts C, Bresee J, Breiman RF. 2004. Nipah virus encephalitis reemergence, Bangladesh. Emerg Infect Dis 10:2082–2087.

13.Chadha MS, Comer JA, Lowe L, Rota PA, Rollin PE, Bellini WJ, Ksiazek TG, Mishra A. 2006. Nipah virus-associated encephalitis outbreak, Siliguri, India. Emerg Infect Dis 12:235–240.

14.Islam MS, Sazzad HM, Satter SM, Sultana S, Hossain MJ, Hasan M, Rahman M, Campbell S, Cannon DL, Stroher U, Daszak P, Luby SP, Gurley ES. 2016. Nipah virus transmission from bats to humans associated with drinking traditional liquor made from date palm sap, Bangladesh, 2011–2014. Emerg Infect Dis 22:664–670.

15.Ching PK, de los Reyes VC, Sucaldito MN, Tayag E, Columna-Vingno AB, Mambas FF, Jr, Bolo GC, Jr, Sejvar JJ, Eagles D, Playford G, Dueger E, Kaku Y, Morikawa S, Kuroda M, Marsh GA, McCullough S, Foxwell AR. 2015. Outbreak of henipavirus infection, Philippines, 2014. Emerg Infect Dis 21:328–331.

16.Mounts AW, Kaur H, Parashar UD, Ksiazek TG, Cannon D, Arokiasamy JT, Anderson LJ, Lye MS. 2001. A cohort study of health care workers to assess nosocomial transmissibility of Nipah virus, Malaysia, 1999. J Infect Dis 183:810–813.

17.Luby SP, Gurley ES, Hossain MJ. 2009. Transmission of human infection with Nipah virus. Clin Infect Dis 49:1743–1748.

18.Gurley ES, Montgomery JM, Hossain MJ, Bell M, Azad AK, Islam MR, Molla MA, Carroll DS, Ksiazek TG, Rota PA, Lowe L, Comer JA, Rollin P, Czub M, Grolla A, Feldmann H, Luby SP, Woodward JL, Breiman RF. 2007. Person-to-person transmission of Nipah virus in a Bangladeshi community. Emerg Infect Dis 13:1031–1037.
19.Goh KJ, Tan CT, Chew NK, Tan PS, Kamarulzaman A, Sarji SA, Wong KT, Abdullah BJ, Chua KB, Lam SK. 2000. Clinical features of Nipah virus encephalitis among pig farmers in Malaysia. N Engl J Med 342:1229–1235.
20.Tan CT, Goh KJ, Wong KT, Sarji SA, Chua KB, Chew NK, Murugasu P, Loh YL, Chong HT, Tan KS, Thayaparan T, Kumar S, Jusoh MR. 2002. Relapsed and late-onset Nipah encephalitis. Ann Neurol 51:703–708.
21.Abdullah S, Chang L-Y, Rahmat K, Goh KJ, Tan CT. 2012. Late-onset Nipah virus encephalitis 11 years after the initial outbreak: a case report. Neurol Asia 17:71–74.
22.Ng BY, Lim CC, Yeoh A, Lee WL. 2004. Neuropsychiatric sequelae of Nipah virus encephalitis. J Neuropsychiatry Clin Neurosci 16:500–504.
23.Sejvar JJ, Hossain J, Saha SK, Gurley ES, Banu S, Hamadani JD, Faiz MA, Siddiqui FM, Mohammad QD, Mollah AH, Uddin R, Alam R, Rahman R, Tan CT, Bellini W, Rota P, Breiman RF, Luby SP. 2007. Long-term neurological and functional outcome in Nipah virus infection. Ann Neurol 62:235–242.
24.Lim CCT, Sitoh YY, Hui F, Lee KE, Ang BS, Lim E, Lim WE, Oh HM, Tambyah PA, Wong JS, Tan CB, Chee TS. 2000. Nipah viral encephalitis or Japanese encephalitis? MR findings in a new zoonotic disease. Am J Neuroradiol 21:455–461.
25.Lim CC, Lee KE, Lee WL, Tambyah PA, Lee CC, Sitoh YY, Auchus AP, Lin BK, Hui F. 2002. Nipah virus encephalitis: serial MR study of an emerging disease. Radiology 222:219–226.
26.Lim CC, Lee WL, Leo YS, Lee KE, Chan KP, Ling AE, Oh H, Auchus AP, Paton NI, Hui F, Tambyah PA. 2003. Late clinical and magnetic resonance imaging follow up of Nipah virus infection. J Neurol Neurosurg Psychiatry 74:131–133.
27.Chong HT, Hossain J, Tan CT. 2008. Differences in epidemiologic and clinical features of Nipah virus encephalitis between the Malaysian and Bangladesh outbreaks. Neurol Asia 13:23–26.
28.Wong KT, Shieh WJ, Kumar S, Norain K, Abdullah W, Guarner J, Goldsmith CS, Chua KB, Lam SK, Tan CT, Goh KJ, Chong HT, Jusoh R, Rollin PE, Ksiazek TG, Zaki SR. 2002. Nipah virus infection: pathology and pathogenesis of an emerging paramyxoviral zoonosis. Am J Pathol 161:2153–2167.
29.Chong HT, Kamarulzaman A, Tan CT, Goh KJ, Thayaparan T, Kunjapan SR, Chew NK, Chua KB, Lam SK. 2001. Treatment of acute Nipah encephalitis with ribavirin. Ann Neurol 49:810–813.
30.Murray K, Selleck P, Hooper P, Hyatt A, Gould A, Gleeson L, Westbury H, Hiley L, Selvey L, Rodwell B. 1995. A morbillivirus that caused fatal disease in horses and humans. Science 268:94–97.
31.Wang LF, Yu M, Hansson E, Pritchard LI, Shiell B, Michalski WP, Eaton BT. 2000. The exceptionally large genome of Hendra virus: support for creation of a new genus within the family Paramyxoviridae. J Virol 74:9972–9979.
32.Wang LF, Mackenzie JS, Broder CC. 2013. Henipaviruses, p 286–313. In Knipe DM, Howley PM (ed), Fields virology, 6th ed. Lippincott Williams & Wilkins, Philadelphia, PA.

33.Mire CE, Satterfield BA, Geisbert JB, Agans KN, Borisevich V, Yan L, Chan YP, Cross RW, Fenton KA, Broder CC, Geisbert TW. 2016. Pathogenic differences between Nipah virus Bangladesh and Malaysia strains in primates: implications for antibody therapy. Sci Rep 6:30916.
34.Clayton BA, Middleton D, Bergfeld J, Haining J, Arkinstall R, Wang L, Marsh GA. 2012. Transmission routes for Nipah virus from Malaysia and Bangladesh. Emerg Infect Dis 18:1983–1993.
35.Clayton BA, Middleton D, Arkinstall R, Frazer L, Wang LF, Marsh GA. 2016. The nature of exposure drives transmission of Nipah viruses from Malaysia and Bangladesh in ferrets. PLoS Negl Trop Dis 10:e0004775.
36.Lamb RA, Parks GD. 2007. Paramyxoviridae: the viruses and their replication, p 1449–1496. In Fields

BN, Knipe DN, Howley PM (ed), Fields virology, 5th ed. Lippincott Williams & Wilkins, Philadelphia, PA.

37.Negrete OA, Wolf MC, Aguilar HC, Enterlein S, Wang W, Muhlberger E, Su SV, Bertolotti-Ciarlet A, Flick R, Lee B. 2006. Two key residues in ephrinB3 are critical for its use as an alternative receptor for Nipah virus. PLoS Pathog 2:e7.

38.Bonaparte MI, Dimitrov AS, Bossart KN, Crammer G, Mungall BA, Bishop KA, Choudhry V, Dimitrov DS, Wang LF, Eaton BT, Broder CC. 2005. Ephrin-B2 ligand is a functional receptor for Hendra virus and Nipah virus. Proc Natl Acad Sci U S A 102:10652–10657.

39.Chua KB, Chua BH, Wang CW. 2002. Anthropogenic deforestation, El Nino and the emergence of Nipah virus in Malaysia. Malays J Pathol 24:15–21.

40.Epstein Jonathan H, Olival Kevin J, Pulliam Juliet RC, Smith C, Westrum J, Hughes T, Dobson Andrew P, Zubaid A, Rahman Sohayati A, Basir Misliah M, Field Hume E, Daszak P. 2009. Pteropus vampyrus, a hunted migratory species with a multinational home-range and a need for regional management. J Appl Ecol 46:991–1002

41.Sendow I, Runagate A, Taylor T, Adjid RMA, Saepulloh M, Barr J, Wong F, Daniels P, Field H. 2013. Nipah virus in the fruit bat Pteropus vampyrus in Sumatera, Indonesia. PLoS One 8:e69544.

42.Food and Agriculture Organization of the United Nations, Regional Office for Asia and the Pacific. 2002. Manual on the diagnosis of Nipah virus infection in animals. RAP publication no. 2002/01. Food and Agriculture Organization of the United Nations, Regional Office for Asia and the Pacific, Bangkok, Thailand.

43.Balali-Mood M, Moshiri M, Etemad L. 2013. Medical aspects of bio-terrorism. Toxicon 69:131–142.

44.Lam SK. 2003. Nipah virus—a potential agent of bioterrorism? Antiviral Res 57:113–119.

45.Centers for Disease Control and Prevention. 2018. Bioterrorism agents. Centers for Disease Control and Prevention, Atlanta, GA.

46.Nahar N, Mondal UK, Sultana R, Hossain MJ, Khan MS, Gurley ES, Oliveras E, Luby SP. 2013. Piloting the use of indigenous methods to prevent Nipah virus infection by interrupting bats' access to date palm sap in Bangladesh. Health Promot In 28:378–386.

47.Satterfield BA, Dawes BE, Milligan GN. 2016. Status of vaccine research and development of vaccines for Nipah virus. Vaccine 34:2971–2975

