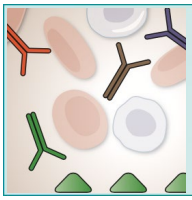

Epidemiology of Nipah Virus

hhmi | BioInteractive

Activity
Educator Materials

OVERVIEW

This worksheet complements the BioInteractive *Scientists at Work* video *Virus Hunter: Monitoring Nipah Virus in Bat Populations*. In this activity, students will play the role of epidemiologists analyzing real data from an outbreak of Nipah virus in Malaysia, attempting to identify the reservoir of the virus and curtail the outbreak. Students will make predictions, perform calculations, adapt to new information, and make recommendations to the Centers for Disease Control and Prevention (CDC) and the World Health Organization (WHO).

KEY CONCEPTS

- Viruses cause disease in some hosts and not others. Viruses are adapted to their natural host (reservoir). Often, when viruses "spill over" into new species, they are far deadlier than they are to their natural reservoirs. Most viruses infect a limited number of species, or hosts, but occasionally they adapt and spread to other hosts.
- To understand how outbreaks begin and spread, public health officials collect evidence from basic biological research, interviews, monitoring people's health status, and purposefully designed studies.
- There are many ways to assess whether an individual is infected with a virus, each with benefits and drawbacks.
- Epidemiologists must obtain data (oftentimes conflicting) from many sources and report pertinent findings succinctly to allow outbreaks to be contained.

STUDENT LEARNING TARGETS

- Use appropriate scientific terms, including "reservoir" and "spill over," in describing a disease outbreak.
- Synthesize information about antigens and antibodies with knowledge about enzymes to understand enzyme immunoassay technology.
- Use information collected in case studies to distill complex, real-world data, and perform basic calculations to make decisions on the spread of Nipah in those cases.

CURRICULUM CONNECTIONS

Standards	Curriculum Connections
NGSS (2013)	SEP3, SEP4, SEP5, SEP6, SEP7
AP Bio (2015)	2.D.3, 4.B.3, 4.C.3; SP4, SP5, SP6, SP7
IB Bio (2016)	11.1, B.4
Common Core (2010)	ELA.RST.9–12.1, RST.9–12.7, RST.9–12.9, WHST.9–12.1 Math.A-REI.3; MP2, MP3
Vision and Change (2009)	CC1, CC5; DP1, DP2, DP6

KEY TERMS

bat, ELISA, epidemiology, immunology, infectious disease, outbreak, public health, virus

TIME REQUIREMENTS

One 50-minute class period; however, any of the five parts may be assigned as homework.

SUGGESTED AUDIENCE

- High School: Biology (AP/IB)
- College: General Biology, Virology, Microbiology, Immunology, or Public Health

PRIOR KNOWLEDGE

Students should be familiar with:

- basic math skills, including order of operations and use of a four-function calculator
- basic immunology terms (antigen and antibody)
- a working knowledge of DNA and RNA, namely that they are made up of chains of nucleotides that dictate the proteins the body (or virus) contains
- a basic understanding of enzymes as proteins that perform biochemical reactions on substrates

MATERIALS

- access to the video *Virus Hunter: Monitoring Nipah Virus in Bat Populations*
- copies of the "Student Handout" and "Student Reading"
- calculator

TEACHING TIPS

- Parts 1–3 of this activity should be initiated *before* the video is viewed in Part 4. In Part 5, students revisit their hypotheses based on information provided in the video.
- Make sure to clarify that two different outbreaks of Nipah virus are discussed in different parts of this activity.
  - The outbreak in Parts 1–3 and the "Student Reading" occurred in Malaysia in 1998–1999.
  - The outbreak in Part 4 and the video occurred in Bangladesh in 2004. Only in this 2004 outbreak were bats identified as the natural reservoir for Nipah virus.
- The "Student Reading" in Part 2 describes how epidemiologists can identify infected individuals using enzyme immunoassays (EIAs). For more information or as an extension activity, students can perform a simulated enzyme immunoassay in BioInteractive's *Immunology Virtual Lab*.

ANSWER KEY

PART 1: Looking for Patterns and Making Predictions

1. Using the data in Table 1, make a prediction about the source of the Nipah virus outbreak in Port Dickson, Malaysia. Summarize the data that support your prediction.

Answers will vary. An example answer is: I predict the source of the Nipah virus outbreak in Malaysia was pig farms, as most of the 97 individuals that contracted encephalitis lived and/or worked on a pig farm.

2. What actions might you take to prevent further spread of this disease?

Answers will vary. An example answer is: I would quarantine the pig farms and kill all the pigs, preventing infected individuals from potentially spreading the virus.

3. Which animal species in this study would you test for Nipah virus antibodies? Why?

Answers will vary, but students are likely to say pigs, since they were most often found sick or dying on Nipah-affected farms (Table 3), and dogs, since they had the most reported illnesses on Nipah-affected farms (Table 2).

4. Based on the data above, which animal species was least affected by Nipah virus infection? Explain your answer using the data. Can you think of a reason why this might be?

Based on Tables 2 and 3, bats are the least affected by Nipah infection. Possible explanations for this include that the bats don't become infected, or that they are infected but don't show symptoms. Alternatively, the data for bats may be inaccurate because bats are difficult to observe, due to where they live and when they hunt.

PART 2: Reading

Provide students with the "Student Reading" handout, which contains the vocabulary and calculations to complete the rest of the activity.

PART 3: Practicing Calculations and Making Claims

1. Using this information and the calculations described in the "Student Reading" handout, calculate the following values for this Nipah outbreak:
   a. **Incidence** in Port Dickson, Malaysia: *224* new cases/*97,800* people in the population/*9* months
   b. **Prevalence** in Port Dickson, Malaysia: *0.23* %
      224 cases/97,800 people = 0.0023 → 0.23%
   c. **Morbidity** nationwide for Malaysia: *71* %
      265 cases/(265 symptomatic cases + 110 asymptomatic cases) = 0.71 → 71%
   d. **Mortality** nationwide for Malaysia: *28* %
      105 deaths/(265 symptomatic cases + 110 asymptomatic cases) = 0.28 → 28%
   e. **Case fatality ratio** nationwide for Malaysia: *40* %
      105 deaths/265 symptomatic cases = 0.40 → 40%
2. The R_0 of Nipah virus is estimated to be 0.48. Based on this information, make a claim about whether the outbreak in Malaysia is likely to have become an epidemic.

The outbreak is unlikely to have become an epidemic because the virus's R_0 value is less than 1; every infected person infects less than one new person.

PART 4: Nipah Virus Reservoir

1. What human behavior was the cause of the Nipah virus outbreak in Bangladesh? How did scientists determine this?

Drinking raw date palm sap was the cause of the Nipah virus outbreak in Bangladesh. Scientists found Nipah virus in bat excretions and discovered that bats were contaminating date palm juice with their excretions (saliva, urine).

2. Scientists determined that bats are a natural reservoir for Nipah virus in Bangladesh.
   a. In your own words, explain what a reservoir animal is.

The reservoir for a virus is its natural host or carrier. The virus can "spill over" from a reservoir to infect humans.

   b. What evidence suggested bats were the reservoir for Nipah virus?

The bats had antibodies against the virus, which suggests they were exposed to or carried the virus. Active viruses were later found in the bats' blood and excretions, which suggests the virus replicates in bats. Additionally, no other wild animals were found to carry the virus.

3. Which of the following methods, as described in the video and reading, is used to monitor Nipah virus in bat populations? Select all that apply: *a, b, and c*
   a. monitoring symptoms
   b. sequencing viral genomes
   c. detecting antibodies to specific viral peptides in an individual's blood
4. How can monitoring bat populations in this way help with human health?

By monitoring Nipah virus in bats, scientists can predict if/when spillover might occur (for example, from a Nipah-carrying bat population near a large city). They can also monitor viral mutations in order to identify changes that may affect how deadly the virus is to humans.

PART 5: Putting It All Together

1. Bats are natural reservoirs for Nipah virus and do not die from the infection. Knowing this information, would it be more valuable to report data for the **incidence** or **prevalence** of Nipah virus in bats (assuming that you also report the total number of bats in the population)? Explain your choice.

Prevalence would be more valuable, because it can be used with total population size to calculate the total number of infected bats. Incidence would give you only the number of newly infected bats over a certain time period. This

information isn't as valuable, because any infected bat, not just newly infected bats, can pass the virus on to humans.

2. Why would you need to calculate **morbidity** and **mortality** in humans but not bats? In your answer, show that you understand the definition of each of these terms.

Bats do not display symptoms or die from a Nipah infection. So both morbidity (percentage of infected individuals who display symptoms) and mortality (percentage of infected individuals who die from the infection) would always be zero for bats, which does not provide helpful information.

3. Looking back at the data in Part 1 on the Malaysia outbreak of 1998–1999, what evidence suggests that the bats, not the pigs, may have been the original source of the virus?

Pigs became sick and died at high rates, suggesting that they were not the natural reservoir for Nipah virus. Bats, on the other hand, were the least affected by the virus.

4. Explain why killing pigs may have stopped the outbreak (as described in the "Student Reading"), even if the original source of infection was bats.

The virus may be able to pass from pigs to humans as well as from bats to humans. Humans may also have been in contact with contaminated materials mainly through their interaction with the pigs (for example, pig pens may have collected bat feces).

5. Write a succinct statement (encompassing information from the entire activity) informing the CDC and WHO about Nipah virus and how it spreads, and provide recommendations for how to control it.

Answers will vary, but should include the following information:

- *Data from Malaysia suggest that Nipah virus has a high morbidity (71%), mortality rate (28%), and case fatality ratio (40%)*, though its ability to spread among humans is low ($R_0 < 1$).*
- *The animal reservoir for the virus was found to be bats, but the virus may also be transmitted to humans from pigs.*
- *One source of infection was identified to be consumption of raw date palm sap contaminated with bat excretions.*
- *Recommendations for controlling the virus include:*
    - *education on the dangers of drinking raw date palm sap (or other things that could be contaminated by bats)*
    - *education on the dangers of interacting with pigs and bats*
    - *screening of domesticated animals and bats for Nipah virus genomes and antibodies (EIA)*

**Comparable to the average Ebola CFR of 50% (World Health Organization 2019).*

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