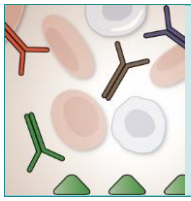

Virus Hunter: Epidemiology of Nipah Virus

hhmi | BioInteractive

Activity
Educator Materials

OVERVIEW

This worksheet complements the short video "Virus Hunter: Monitoring Nipah Virus in Bat Populations" from the *Scientists at Work* series. The Scientists at Work series is intended to provide insights into the daily work of scientists that builds toward discoveries. The series focuses especially on scientists in the field and what motivates their work. 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 (often times 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 their knowledge about enzymes to understand enzyme immunoassay technology.
- Use the information collected in the studies to distill complex, real-world data and basic calculations to make decisions on the spread of Nipah in the cases presented.

CURRICULUM CONNECTIONS

Standards	Curriculum Connections
AP Bio (2015)	1.C.3, 2.D.3, 3.C.3, 4.B.4, SP1, SP2, and SP5
IB Bio (2016)	6.3, 11.1
Vision and Change (2009)	CC1, CC5, DP1, DP2, DP5

KEY TERMS

epidemiology, immunology, Nipah, outbreak, quantitation, virus

TIME REQUIREMENTS

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

SUGGESTED AUDIENCE

- AP/IB Biology
- College-level general biology, virology, microbiology, immunology, or public health courses

PRIOR KNOWLEDGE

- Basic math skills, including order of operations and use of a four-function calculator.
- Familiarity with basic immunology terms (antigen and antibody).
- A working knowledge of DNA and RNA; 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.

TEACHING TIPS

- Parts 1-3 of this activity should be initiated *before* the Scientists at Work 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 being discussed: in the background reading, the outbreak occurred in Malaysia in 1998-1999, while the outbreak discussed in the video occurred in Bangladesh in 2004. Only in the 2004 outbreak were bats identified as the natural reservoir for Nipah virus.

ANSWERS

PART 1: LOOKING FOR PATTERNS AND MAKING PREDICTIONS

1. Using the data above, 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, and dogs, since they had the most reported illness on Nipah-affected farms. All answers should be accepted if students demonstrate sound reasoning in their answer.

4. Using 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?

Bats are least affected by Nipah infection. Possibly explanations for this:

- ***They don't become infected.***
- ***They are infected but don't show symptoms.***
- ***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 background reading, which contains the vocabulary and calculations to complete the activity.

PART 3: PRACTICING CALCULATIONS AND MAKING CLAIMS

As Nipah virus spread in Malaysia, 265 patients were diagnosed with encephalitis and 105 people died. An additional 110 individuals were found to have antibodies to Nipah virus but did not have any clinical symptoms. Of

those infected, 224 were from the Port Dickson district of Negeri Sembilan. Port Dickson has a population of about 97,800. The R_0 of Nipah virus is estimated to be 0.48.

1. Calculate the following values for the Nipah infection in Port Dickson, Malaysia:
    a. Incidence Report as: ***224*** cases/***97,800*** population/***9*** months = incidence
    b. Prevalence ***0.23%*** (224 cases/97800 people = 0.0023 *100 = 0.23%)
    c. Morbidity ***71%*** (265 cases/(265 symptomatic cases + 110 asymptomatic cases) = 0.71 *100 = 71%)
    d. Mortality ***28%*** (105 deaths/(265 symptomatic cases + 110 asymptomatic cases) = 0.28 *100 = 28%)
    e. Case-fatality ratio ***40%*** (105 deaths/265 symptomatic = 0.40 = 40%)

2. Using the R_0 value provided in the paragraph above, make a claim about whether this cluster will become an epidemic.

Answers will vary, but students should indicate that Nipah virus is unlikely to become an epidemic because its 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.

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

The reservoir for the virus is the natural host. The virus "spills over" from the reservoir to infect humans.

    b. What evidence suggested bats were the reservoir?

The virus actively replicates in bats; scientists found viral genetic material and the bats had antibodies to viral antigens. Active virus was found in bat excretions.

3. Which of the following methods is Dr. Epstein using to monitor Nipah virus in bat populations in the video?
    a. Monitoring symptoms
    b. Sequencing viral genomes
    c. Detecting antibodies to specific viral peptides in the individual's blood
    d. All of the above
    e. Both b and c

4. How can monitoring the bat population in this way help with human health?

By monitoring Nipah virus in bats, scientists can predict if/when spillover might occur (ex. 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? Explain why you selected one calculation over the other.

Prevalence, because any infected bat could pass the virus on to humans, not just newly infected bats.

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.

Because bats do not display symptoms or die from the infection, both morbidity and mortality would be zero, which does not provide any epidemiological information.

3. Looking back at the data provided from 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.

4. Explain why killing the pigs stopped the outbreak, even though the original source of infection was the 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 through their interaction with the pigs (ex. pig pens may have contained bat feces).

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

Answers may vary but should include the following information:

- ***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.***
- ***Epidemiologist recommends:***
    - ***Education on the dangers of drinking raw date palm sap.***
    - ***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 average Ebola CFR of 50% (1).*

EXTENSION ACTIVITY

Students can perform a simulated enzyme immunoassay here: http://www.hhmi.org/biointeractive/immunology-virtual-lab.

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