Eradicating COVID-19 — Not Likely

How Vaccines Led to the Elimination of Smallpox

COVID HACKS
Healthy Actions • Community Knowledge • Science

FOR GRADES
6–8 9–12

OVERVIEW

Students read an essay about the history of smallpox, the first case of human vaccination and eradication of smallpox as a naturally occurring viral disease in humans.

LEARNING OBJECTIVE

Students will describe the first documented record of vaccination against smallpox, integrate information presented in different media (text and video) and compare the original process with the ways in which modern drug and vaccine developers protect human health and safety.

SCIENCE, HEALTH AND MATH SKILLS

- Comparing and contrasting
- Interpreting
- Reading informational text

NGSS SCIENCE AND ENGINEERING PRACTICES

- Asking questions and defining problems
- Analyzing and interpreting data
- Constructing explanations and designing solutions
- Engaging in argument from evidence

TIME

- Set Up: 10 minutes
- Activity: 45 minutes

CONCEPTS

Smallpox is the only infectious disease to have been eradicated through worldwide vaccinationtion. Modern vaccines are developed and tested following rigorous and ethical processes. Scientists and engineers are guided by habits of mind, such as intellectual honesty, tolerance of ambiguity, skepticism and openness to new ideas.

MATERIALS FOR SCIENCE INVESTIGATION

- Copy (printed or electronic) of the essay entitled Eradicating COVID-19—Not Likely
- Paper, notebook or device on which to write their 3–2–1 reflections and create a table of similarities and differences between old and new methods of vaccine development
- Computer or other device to access CDC website materials

SET UP AND TEACHING TIPS

Students will read an historical essay about the development of vaccination and eventual eradication of smallpox as a naturally occurring infectious disease. You may assign this reading as homework over one or

two days, or have students read the essay in class prior to leading a discussion. Afterward, students will watch a CDC video on modern vaccine development to compare the process followed by Edward Jenner, the inventor of smallpox vaccination, and modern procedures.

PROCEDURE

ENGAGE

1. Give students the opportunity to read the essay Eradicating COVID-19—Not Likely. Have each student answer the following 3–2–1 questions about their reading.

- What are three things you learned?
- What are two questions you have?
- What is one idea or concept you would like to learn more about?

2. Discuss students' ideas and questions. If needed, use the resources at the end of this lesson for additional research by students on vaccines or smallpox.

3. Ask students if they have ever received a smallpox vaccine. Most likely, the answer will be "no." After smallpox was eliminated from the world, routine vaccination against smallpox among the general public was stopped because it was no longer needed. Follow by asking what vaccines students remember having received. Possible answers might include MMR (measles, mumps, rubella), Tdap (pertussis and tetanus), polio and influenza (flu).

4. Explain that some vaccines confer lifelong immunity to a disease, such as the MMR or polio vaccines. Others must be administered as often as every year (flu) or after several years have gone by (Tdap, for example, should be administered again as a "booster" every 10 years). Due to genetic changes in the virus strains, for example, flu vaccines are adjusted each year. Changes are based on international surveillance of the virus and scientists' predictions about which strains of flu viruses will be circulating during the coming year.

EXPLAIN

5. Have students discuss how Edward Jenner came up with the idea of vaccination. Ask, *do you think a researcher would be able to perform similar experiments today? Why or why not?*

   The answer is "no." Current biomedical research procedures are guided by principles of respect for persons, beneficence (the ethical obligation to maximize possible benefits and minimize harm), non-maleficence (avoiding harm to research subjects) and justice (vulnerable groups like children should be protected and no one group should have a disproportionate benefit or harm).

EXTEND

6. Have students watch the following video from the CDC in class or as an assignment, The Journey of Your Child's Vaccine. It describes vaccine development and clinical trials (www.youtube.com).

EVALUATE

7. Upon completion, have students work individually or in teams to answer one of the questions below.

- How does Jenner's approach to vaccine development compare to the modern approach to vaccine development described in the video? Students should create a list of at least 5 similarities and 5 differences between the old and the new approach.
- How did vaccinations stop smallpox? Write a summary of the major events.
- If you were a member of the World Health Assembly, what would you propose to fight COVID-19, based on what you learned about the elimination of smallpox?
- Will COVID-19 be eradicated or will it become endemic like seasonal flu? Use evidence to justify your answer?

THE SCIENCE

British physician Edward Jenner tested the hypothesis that infection with the cowpox virus (vaccinia) could protect an individual from a much more deadly infection from smallpox (caused by the variola virus). He observed that dairy workers, who contracted cowpox from cattle, typically did not become infected with smallpox. In 1796, he inoculated an eight-year-old boy with material from a cowpox sore on the hand of an infected dairy worker. He later exposed the boy to material taken from a human smallpox sore. Fortunately, the boy remained healthy. The process became known as vaccination.

The eradication of smallpox is an example of what can be done to fight one of the most dreaded pandemics of all time. Smallpox spanned the world, causing tens of millions of deaths over several millennia. The defeat of smallpox began with the discovery of an effective vaccination in the 18th century. Still, it took almost 200 years before vaccination became so widespread that no more cases of smallpox occurred. The World Health Assembly (the decision-making body of the World Health Organization) officially declared the world free of this disease on May 8, 1980.

Smallpox is the only virus disease ever eliminated. The essay that accompanies this activity tells how this happened and is a great lesson to inform how we handle COVID-19.

The modern process of vaccine development and testing follows rigorous ethical guidelines and oversight. Four principles must be upheld: respect for persons, beneficence (the ethical obligation to maximize possible benefits and minimize harm), non-maleficence (avoiding harm to research subjects) and justice (vulnerable groups like children should be protected and no one group should have a disproportionate benefit or harm).

RESOURCES

- Centers for Disease Control and Prevention (CDC). History of Smallpox. https://www.cdc.gov/smallpox/history/history.html.
- Centers for Disease Control and Prevention (CDC). Understanding How Vaccines Work. https://www.cdc.gov/vaccines/hcp/conversations/downloads/vacsafe-understand-color-office.pdf?fbclid=IwAR1n8hXXk_ZJtbiu7yfGW9sUiIiIsK68HVgASBrFQreMogRqIcyP8bVtBFY.
- College of Physicians of Philadelphia. The History of Vaccines. https://www.historyofvaccines.org.
- Davies, H. 2007. Ethical reflections on Edward Jenner's experimental treatment. J. Medical Ethics. 33(3):174-176. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2598263/.
- Centers for Disease Control and Prevention (CDC). Health Equity Considerations and Racial and Ethnic Minority Groups. https://www.cdc.gov/coronavirus/2019-ncov/community/health-equity/race-ethnicity.html.
- World Health Organization (WHO). Q&A on Smallpox. https://www.who.int/news-room/q-a-detail/q-a-on-smallpox.

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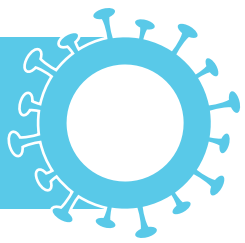

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COVID HEALTHY ACTIONS, COMMUNITY KNOWLEDGE AND SCIENCE

A SCIENCE-BASED CURRICULUM FOR THE COVID-19 PANDEMIC

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In one episode of the original science fiction television series, Star Trek, the Starship Enterprise visits planet Omega IV, whose inhabitants can live 1,000 years. The ship's doctor, Leonard McCoy, is ordered to analyze a serum that might account for this long lifespan. McCoy is not convinced the serum would do that, but quips "Who knows? It might eventually cure the common cold."

It may seem strange that modern medicine is still dealing with the common cold. Actually, it's not surprising. Of all the viruses that can infect humans, only one viral disease has ever been eliminated from occurring naturally. Diseases can be controlled with masks, physical distancing, vaccines and other steps, but the viruses that cause them to survive, awaiting an opportunity to reemerge. It also will be this way with SARS-CoV-2, the virus that causes COVID-19. It is now a part of our life.

COVID-19 is an acronym: CO stands for “corona;” VI for “virus;” and D for “disease.” The 19 indicates that the first outbreak of this previously unknown viral infection occurred in 2019. The SARS-CoV-2 virus is part of a family of viruses known as coronaviruses. There are seven other known coronaviruses. Four of them cause the common cold.

Figure 1. A 2-year-old female child by the name of **Rahima Banu**, who was actually the last known case of naturally occurring smallpox in the world. The case occurred in the Bangladesh district of Barisal, in a village named Kuralia, on Bhola Island, on October 16, 1975.

The Defeated Disease

Smallpox is the one viral disease, mentioned above, that is considered to be eradicated by world health officials. It was a very serious infectious disease, caused by the variola virus. Smallpox spread from one person to another, and about three of every 10 infected people died. Many of the survivors also were affected for the rest of their lives. Most had large

permanent scars over many areas of their bodies. Faces were especially disfigured. Some victims were left blind.

The Disease Progression

When a person contracted smallpox, the disease progressed over many stages. First came fever, head and body aches, and vomiting. In a couple of days, a rash of small red spots appeared on the tongue and mouth. The spots changed into sores that open and spread large amounts of virus into the mouth. This was the most contagious period of the virus.

A rash on the skin followed, starting on the face and then moving to the rest of the body. Pustules (hard, pea-sized bumps under the skin) appeared. In a few days, the pustules would scab over and drop off, leaving permanent scars.

The progression of smallpox took about a month. A person was considered no longer contagious only after the scabs had fallen off.

A Short Smallpox History

It is not known precisely where and when smallpox first appeared, but the discovery of smallpox-like rashes on the heads of Egyptian mummies indicate that it may have been around at least since the 3rd Century BCE (Before the Common Era). A written description of symptoms resembling those effects of smallpox was found in records from 4th Century CE (Common Era) China. Other similar descriptions were found in documents from India in the 7th century CE, and from Asia Minor in the 10th century CE.

The Centers for Disease Control provide this list of key historical events leading to the spread of smallpox.

- 6th Century: Increased trade with China and Korea introduces smallpox into Japan.
- 7th Century: Arab expansion spreads smallpox to northern Africa, Spain and Portugal.
- 11th Century: Crusades further the spread smallpox in Europe.
- 15th Century: Portuguese occupation introduces smallpox into part of western Africa.
- 16th Century: European colonization and the African slave trade import smallpox into the Caribbean region, and Central and South America.
- 17th Century: European colonization imports smallpox into North America.
- 18th Century: Exploration by Great Britain introduces smallpox into Australia.

The last naturally occurring case of smallpox was diagnosed in 1977. In 1980, the World Health Organization declared that smallpox was eradicated around Earth. It is no longer a threat to humans.

How Was Smallpox Defeated?

One of the initial efforts to control smallpox involved a technique called variolation. The term comes from the name of the virus that causes smallpox (variola). Material from an active pustule on a smallpox victim is scratched onto the skin or inserted in the nose of someone who has never had smallpox. That person would develop smallpox symptoms, but symptoms would be less severe than those experienced by people who

acquired smallpox naturally. The death rate with variolation was lower than with naturally acquired smallpox. It was a risky way to achieve immunity to the disease.

In 1796, a key experiment in the fight against smallpox also led to enormous benefits for fighting other diseases. The English doctor Edward Jenner noticed that dairy workers who had gotten a less severe disease, called cowpox, seemed to be protected from contracting smallpox. Cowpox is caused by the vaccinia virus, which is closely related to the one that causes smallpox. Once persons had been infected by vaccinia, they also appeared to develop protection against smallpox.

Most dairy workers at the time were young women. As an experiment, Jenner took material from a cowpox sore on a dairy worker and injected the material into a healthy boy named James Phipps. Months later, Jenner exposed the boy to the smallpox virus, but James never became sick.

Jenner called the process, vaccination, based on the Latin word for cow, "vacca." Vaccination based on the cowpox virus became widespread and it gradually replaced variolation as a preventive smallpox treatment. He repeated his experiments and published the results beginning in 1798. Today, such experiments on human subjects would raise ethical concerns and undergo intensive scrutiny, because they involved exposing healthy persons to severe disease threats.

In 1959, the first global effort to eradicate smallpox was proposed by the World Health Organization (WHO). The initial program failed due to a lack of funding, limited vaccine supplies and medical personnel, and poor commitment of many cooperating countries. Smallpox outbreaks were still commonplace in South America, Africa, and Asia as late as 1966.

A renewed effort to eliminate smallpox globally began in 1967. The resources needed to fight the disease were available and worldwide cooperation led to success. North America and Europe had eradicated smallpox in the early 1950s. In 1971, South America joined the smallpox-free regions, followed by Asia in 1975, and Africa in 1977.

In 1980, smallpox was officially declared eradicated. This still is considered the greatest achievement in international public health. Today, the virus that causes smallpox only exists in two secure laboratories.

What About COVID-19?

At least for the foreseeable future, the SARS-CoV-2 virus and COVID-19 will be with us. At the time of this writing, vaccines against the virus are being developed and tested using safe approaches.

Until there is a vaccine, people can take a number of steps to protect themselves and their families, friends and strangers from COVID-19. These measures include wearing masks, physical distancing and washing hands frequently with soap and water.

When a vaccine becomes available, we will have taken a major step in the COVID-19 fight. COVID-19 will still be with us, but it will be controlled if people worldwide work together for the common good.

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Student Reading

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