VaxImpact Simulator

A Middle School Investigation of Disease Spread & Vaccination

PHENOMENON → What changes the size of an outbreak?

A contagious disease enters a community such as a school. Some people are vaccinated and some are not. Use a computational model to explore how changing conditions can make an outbreak larger or smaller.

Driving Question

How do vaccination and disease conditions affect how an infectious disease spreads through a community?

NGSS 3-DIMENSIONAL LEARNING TARGETS

SCIENCE & ENGINEERING PRACTICE	DISCIPLINARY CORE IDEA	CROSSCUTTING CONCEPT
Developing & Using Models Use a computer model to describe and predict what may happen when a variable changes. Analyzing & Interpreting Data Look for patterns across repeated simulation trials.	LS2.C: Ecosystem Dynamics, Functioning & Resilience Biological changes can affect populations. Students examine how disease transmission changes a modeled human population.	Cause & Effect Use evidence to explain how changing one factor can change an outcome. Patterns Look for repeated trends across trials and conditions.

Primary Middle School Performance Expectation

MS-LS2-4

Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

In this lesson, students use simulation evidence to argue how a biological factor (infectious disease and protection from vaccination) can change a population-level outcome.

Learning Pathway

Explore the model → Complete the Outbreak Challenge → Run a fair test → Graph the pattern → Explain with evidence → Compare the model with the real world

MODEL LIMITATION

This simulation is a simplified learning model. Its numerical results are not medical recommendations and should not be used to determine a real-world vaccine target or herd-immunity cutoff.

Lesson Overview

Lesson Part	Student Goal	Suggested Class Time (~ 1 Hour)
1. Explore	Learn what each simulator variable changes.	~ 5 Minutes
2. Outbreak Challenge	Build the largest and smallest outbreak under set rules.	~ 10 Minutes
3. Controlled Investigation	Change only vaccination rate and collect repeated data.	~ 15-20 Minutes
4. Analyze, Graph, & Explain	Graph results and support a claim with evidence.	~15 Minutes
5. Cause & Effect Conclusion	Analyze Data and Use Simulator to understand effect of each Variable	~ 15 Minutes
6. Real-World Connection	Read a short CDC/news source and compare it with the model.	Remainder of Time or completed at home. ~ 15 Min

Why this structure fits middle school NGSS

- Students first explore a phenomenon and use a model rather than beginning with a lecture or formula.
- The challenge gives students a low-stakes way to discover cause-and-effect relationships among variables.
- The controlled investigation then asks students to isolate one variable and collect evidence across repeated trials.
- Analysis emphasizes patterns, evidence, and scientific reasoning instead of advanced statistics.
- The final task asks students to connect model evidence to a real-world source and identify model limitations.

NGSS Alignment Details

NGSS Element	How students demonstrate it in this lesson
MS-LS2-4 (PE)	Use simulation data as empirical evidence to make a population-level claim about disease spread.
SEP: Developing & Using Models	Use VaxImpact to test how changing model inputs affects outbreak outputs.
SEP: Analyzing & Interpreting Data	Compare repeated trials, organize results in tables, and graph total infections.
SEP: Engaging in Argument from Evidence	Make a claim about vaccination rate and support it with a specific result from the investigation.
CCC: Cause & Effect	Explain how changing vaccination rate or transmission changes outbreak size.
CCC: Patterns	Identify repeated trends across vaccination conditions and repeated trials.

Part I — Explore the Simulation & Ask a Testable Question

NGSS focus: Asking Questions • Developing & Using Models

1. WHAT IS INCLUDED IN THE SIMULATION?

The simulator (which can be found here: http://vaxshield.org) represents a simplified community in which a disease can spread. You can change selected input variables and observe how the outbreak changes. The **Main Simulation Panel** shows the modeled spread and the **Epidemic Timeline** shows how cases change over time.

Input	What you can change	What to look for
Transmission rate	How readily infection spreads in the model.	Does the outbreak become faster/larger or slower/smaller?
Infectious Period	Days an infected person remains contagious and able to infect other individuals.	Does the outbreak last longer or shorter?
Mortality rate	The proportion of infected people who die in the model.	How does this change deaths without necessarily changing transmission?
Population density	How closely/frequently people are modeled as interacting.	Does increased contact opportunity change the outbreak?
Vaccine effectiveness	How well vaccination protects vaccinated people in the model.	How does protection affect infection among vaccinated people and the wider outbreak?
Vaccination rate	The percentage of the community that is vaccinated.	How does changing coverage affect outbreak size?

Use the Learn More feature (top right corner) for additional information about the controls.

2. Explore before you test

What variable did you change?	Did you raise or lower it?	What happened?

3. Write a testable question

A testable question identifies one independent variable you will change and at least one dependent variable you will measure. For example: "Does the amount of sunlight a tomato plant receives change how fast it grows?" (You can measure the sunlight and growth). Write a testable question below.

Now identify the parts of your question:

Independent variable What will I change?	Dependent variable(s) What will I measure?	Controls What will stay the same?

4. Why should you change only one independent variable at a time in a fair test?

Note: Students can complete the additional lesson plan titled "You're the Epidemiologist: Design and Explore your Experiment Investigating Disease Outbreak" to investigate their testable hypothesis

Part II — Outbreak Challenge

Try to create the LARGEST and SMALLEST outbreak you can while following the rules.

CHALLENGE RULES

- Vaccination rate must be BELOW 100% and ABOVE 30%.
- Transmission rate must be ABOVE 20%.
- Vaccine Effectiveness must be Above 50%.
- You may change all other settings.
- Score = Total Infections and Peak Infections.

Spend Around 10 minutes changing the variables to achieve the largest and smallest outbreak

Challenge	Your settings	Outbreak Stats
LARGEST Outbreak	Transmission: ____ Infectious Period: ____ Density: ____ Vaccine effectiveness: ____ Vaccination: ____ Mortality: ____	Total Infections: _____ Peak Infections: _____ Deaths: _____ % Vaccinated Infected: _____ % Unvaccinated Infected: _____ Score (Total + Peak Infections): _____
SMALLEST Outbreak	Transmission: ____ Infectious Period: ____ Density: ____ Vaccine effectiveness: ____ Vaccination: ____ Mortality: ____	Total Infections: _____ Peak Infections: _____ Deaths: _____ % Vaccinated Infected: _____ % Unvaccinated Infected: _____ Score (Total + Peak Infections): _____

1. Which Settings Seemed Important for Making the Outbreak LARGE.

2. Which Settings Seemed most important for making the outbreak small

3. Why might repeated runs with the exact same settings differ?

Part III — Plan & Carry Out a Controlled Investigation

Change vaccination rate while keeping the other simulator settings constant.

BASELINE SETTINGS

Transmission rate:	90%	Infectious Period:	14 days
Mortality rate:	1%	Population density:	90%
Vaccine Effectiveness:	97%	Independent Variable:	Vaccination rate

1. Make your prediction

I predict the peak infections and total infections will □ increase □ decrease

because…

2. Run 3 trials at each vaccination rate. The simulator ends on its own after there are no more infectious individuals in the community. Record the outcomes measured each time after the simulator ends. Repeated trials help you identify patterns despite randomness in the model.

Experiment: 65% vaccination

Trial	Peak infections (most sick at once)	Total infected	% vaccinated sick	% unvaccinated sick
1				
2				
3				
Average				

Experiment: 80% vaccination

Trial	Peak infections (most sick at once)	Total infected	% vaccinated sick	% unvaccinated sick
1				
2				
3				
Average				

Experiment: 95% vaccination

Trial	Peak infections (most sick at once)	Total infected	% vaccinated sick	% unvaccinated sick
1				
2				
3				
Average				

Independent variable(s)	Dependent variable(s)	Controls

Part IV — Graph, Analyze, and Explain

Step 1- Graph Your Results

Graph feature	What to include
x-axis	Vaccination rate (%)
y-axis	Total and Peak infections
Data	Averages at 65%, 80%, and 95%. Average Total and Peak infections can be represented with two separate lines.
Title and labels	A title that tells what the graph shows and labels along the x and y axis

Title: _____

Step 2- Analyze the results and Explain the Trend.

1. Was your original prediction from Part III supported? Explain why or why not using evidence from your results.

2. Using your results, form a claim, evidence and reasoning. You can find the definition of a strong claim, evidence, and reasoning framework in the student guide (Included at the end of this worksheet)
Claim: ***Evidence:*** ***Reasoning:***

Part V — Cause and Effect Reasoning

Use simple cause-and-effect reasoning. You may use the simulator and your own results as evidence

1. Vaccine Effectiveness: If the vaccine becomes MORE effective, would you expect the outbreak to become larger or smaller? Explain.

2. Population Density: Imagine increasing the number of students in a classroom or a school, causing there to be more interactions between students each day. How might this change disease spread? Why?

3. Infectious Period: If infected people stay sick and contagious for a longer time, how might that affect the outbreak?

4. Community Effect: A student says, "Whether or not I am vaccinated only affects me."

If you agree with this claim, complete a claim, evidence, and reasoning framework by using evidence from your results and explaining how it supports the claim. If you disagree with the claim above, write your own claim and then use evidence from your results to support your new claim.

5. Model Limitation: Name one thing that happens in real life that the simulator does not include and explain how this may influence an outbreak.

Hint: Feel free to use this CDC Source. You can also find it by searching "CDC Appendix A: How Infections Spread". You may also use a different *credible* source that you can find to help you answer this question.
Source: (https://www.cdc.gov/children-and-school-preparedness/php/interventions/appendix-a.html **).**

Part VI — Connect the Model to the Real World

Choose ONE source to read, then answer the questions below. You may read the other sources if you're interested.

- CDC: Measles Cases and Outbreaks
- CDC: Measles Vaccination
- Associated Press: Pennsylvania measles outbreak (Oct. 2026)
- Reuters: Pennsylvania measles cases pass 1,000 (Oct. 2026)

1. Write three facts you learned from the source.

2. How do these facts connect to something you observed in the VaxImpact Simulator?

3. Why might a real outbreak be harder to predict than the computer simulation?