



## Disease? Let's *B. cereus*...

Grace Kim | Fall 2024

**Field(s) of Interest:** Epidemiology, microbiology/biology, pathogenicity, virology, vaccinology

### **Brief Overview (1-3 sentences):**

Mentees will explore the topic of epidemiology and apply it to current trends of disease. They will also be encouraged to try and identify potential solutions to fictional diseases, burgeoning their problem-solving skills. *The modules in this lesson are interconnected, with the aim of creating a pathogen, observing its transmission patterns, and identifying solutions for the pathogen in question. When delivering this lesson, try and illustrate the lesson as a story, beginning with the development of new pathogens in a mad scientist lab, the accidental release of one of the new pathogens, and the collaborative effort of epidemiologists to try and solve the new issue.*

### **Agenda:**

- Introduction (5 min)
- Module 1: Plague Inc. (15 min)
- Module 2: ZomBEAMs (10-15 min)
- Module 3: Can We Fix It? Yes, We Can! (15 min)
- Conclusion (5 min)

<b>Main Teaching Goals/Key Terms:</b> <ul style="list-style-type: none"><li>→ Pathogen</li><li>→ Symptom</li><li>→ Modes of Transmission</li><li>→ Transmission</li><li>→ Pandemic</li><li>→ Pathogen Classification</li><li>→ Patient Zero</li><li>→ Vaccines</li><li>→ Social Distancing</li><li>→ Quarantine/Isolation</li><li>→ Hygiene</li><li>→ Animal Vector Control</li></ul>	<b>Mentor Development Goals:</b> <ul style="list-style-type: none"><li>→ Teamwork!<ul style="list-style-type: none"><li>◆ The entire premise of the last module is to put heads together and come up with a solution to a pervasive disease issue! Emphasize this as you talk it through with your mentees.</li></ul></li></ul>
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## Background for Mentors

<p><b>Module 1</b></p> <ul style="list-style-type: none"> <li>● Pathogen</li> <li>● Symptoms</li> <li>● Modes of Transmission <ul style="list-style-type: none"> <li>○ Airborne</li> <li>○ Bloodborne</li> <li>○ Foodborne</li> <li>○ Waterborne</li> <li>○ Zoonotic</li> <li>○ Contact</li> </ul> </li> <li>● Pathogen Classification</li> </ul>	<p><b>Pathogen</b></p> <p>A biological agent with a specific <b>classification</b> that causes disease within a host organism.</p> <ul style="list-style-type: none"> <li>- i.e. <i>E. coli</i> or SARS-CoV-2</li> </ul> <p>Such pathogens make their presence within a host known via a plethora of <b>symptoms</b> that mark the specific action of the pathogenic agent within the host. A pathogen's ultimate goal is to be able to proliferate within the body and the population at large. It achieves this with a <b>mode(s) of transmission</b> that propagates its effects and proliferation at the population level.</p> <p><b>Symptoms</b></p> <p>Somatic afflictions or indications of disease experienced by an infected individual.</p> <ul style="list-style-type: none"> <li>- Includes fever, diarrhea, vomiting, etc...</li> </ul> <p><b>Modes of Transmission</b></p> <p>The specific method by which a pathogen is passed from individual to individual. Pathogens can utilize multiple different modes of transmission.</p> <ul style="list-style-type: none"> <li>- <b>Airborne</b> - A pathogen transmitted via air, usually respiratory droplets from sneezing/coughing (Common cold, COVID)</li> <li>- <b>Bloodborne</b> - A pathogen transmitted through direct contact with infected blood or bodily fluids (HIV, HepB/C)</li> <li>- <b>Zoonotic</b> (animal vector) - Diseases transmitted from animal to human (like Rabies, Lyme, COVID).</li> <li>- <b>Foodborne</b> - Diseases related to the consumption of contaminated food (general food poisoning (salmonella, <i>E. coli</i>))</li> <li>- <b>Waterborne</b> - Pathogens transmitted through contaminated water sources (typhoid fever, cholera)</li> <li>- <b>Contact</b> - Transmission of pathogens elicited by direct contact with contaminated surfaces or individuals (Common cold, MRSA)</li> </ul> <p>Among others (you do NOT have to introduce ALL of the modes of transmission to the mentees)</p>
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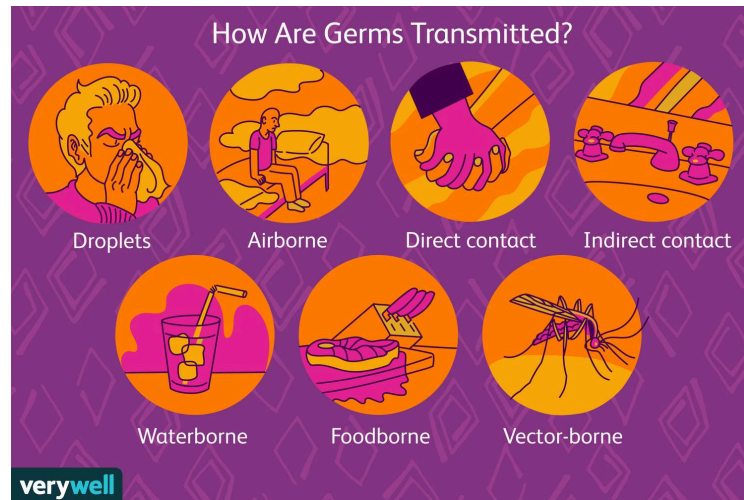


Fig. 1 - Various modes of transmission

### **Pathogen Classification**

The specific biological classification of the pathogen in question. Includes bacterial, fungal, parasitic, viral pathogens.

## Module 2

- Patient Zero
- Disease Transmission
- Pandemic

Disease transmission originates with a single **Patient Zero**, the first individual within the population to be infected with the pathogen. As the pathogen continues to proliferate within the body, it will also initiate **disease transmission**. The aforementioned modes of transmission come into play here, providing a specific means by which the pathogen may spread its parasitic influence. If disease transmission is effective enough, a pathogen and its associated disease condition could become a **pandemic**.

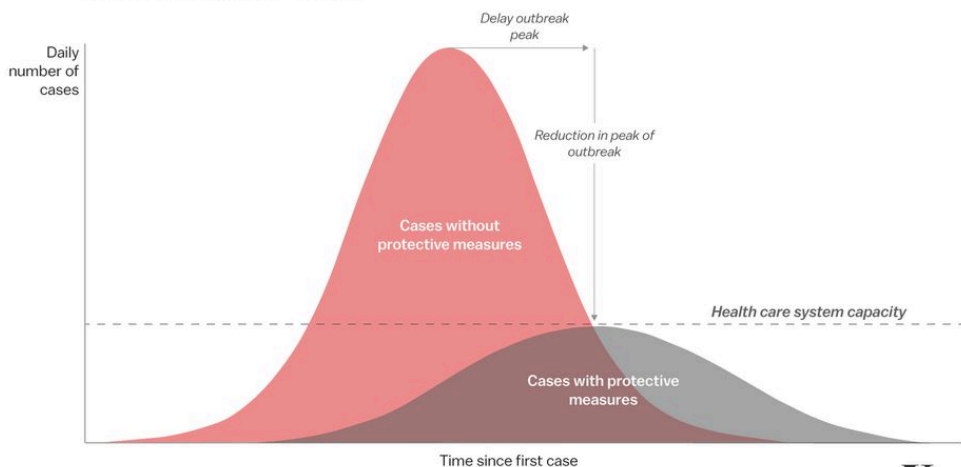
### Patient Zero

The first person within a defined population to have been infected with a specific pathogen.

### Disease Transmission

The process by which a pathogen spreads across a population, from individual to individual. The aforementioned modes of transmission come into play here, providing a specific means by which the pathogen may spread its parasitic influence. Disease transmission generally follows a parabolic trend with time, initially displaying exponential growth that eventually plateaus and falls as individuals recover and gain adaptive immunity.

### Flattening the curve



Source: CDC

Fig. 2 - The transmission curve in cases without protective measures (red) and with (gray). Note that the protective measure curve is significantly less steep than the red curve - a process referred to as "flattening the curve."

### Pandemic

An outbreak of disease on a global scale, spanning countries and continents.

### Module 3

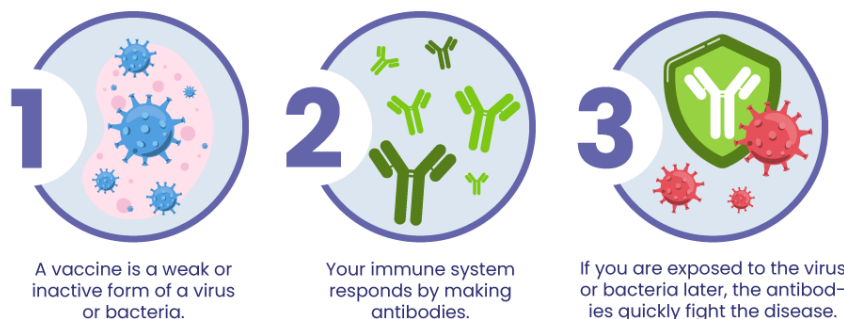
- Vaccines
- Social Distancing
- Quarantine/Isolation
- Hygiene Practices
- Herd Immunity
- [Animal Vector Control](#)

Combating proliferation and spread of pervasive diseases remains a paramount aspect of public health. To do this, epidemiologists and health practitioners stress the utilization/implementation of certain policies. These policies may include:

#### Vaccines

Biological preparations designed to help provide immune defense against certain rampant pathogens. They work by introducing a harmless component of a pathogen to the body and encouraging the development of an immune response.

### HOW DO VACCINES WORK?



LEARN MORE: [PARSEMUS.ORG/NSE](https://www.parsemus.org/nse)



Fig. 3 - Vaccine methodology. Take a harmless aspect of a pathogen, introduce it into the body, and develop an immune response.

#### Social Distancing

The process of intentionally establishing distance between others in certain social settings/situations.

#### Quarantine/Isolation

The process of isolating oneself, infected or not, from the rest of society in an attempt to either contain infection or avoid it altogether.

#### Hygiene Practices

Routine behaviors that are aimed at reducing the spread of harmful pathogens by ensuring cleanliness. May include (but are not limited to) handwashing, bathing, dental care, proper food storage, dishwashing, covering orifices when sneezing/coughing, waste disposal, laundry...

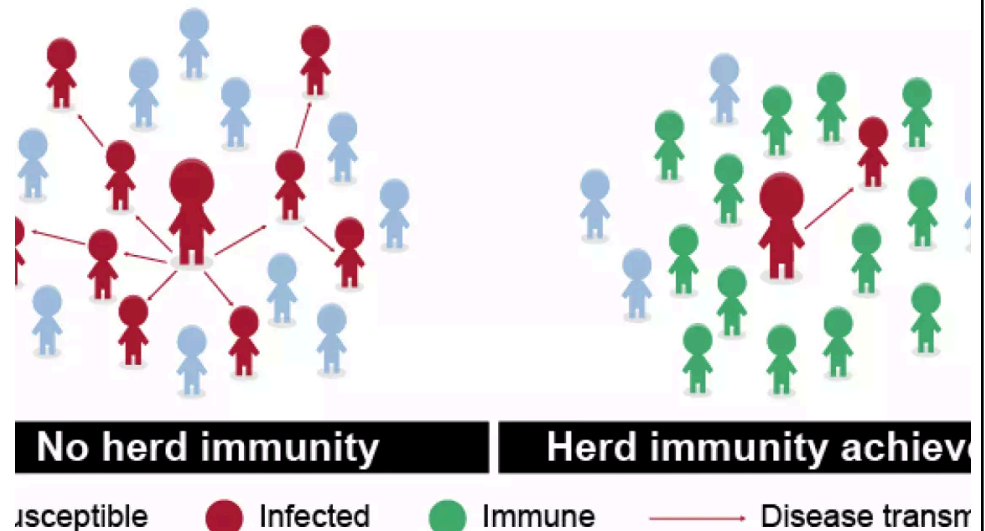
### Animal Vector Control

Various attempts at containing host animals of animal-borne pathogens to reduce risk of transmission to humans. Includes insecticides/fungicides, insect repellents, nets/barriers, introduction of predators.

All of the above teaching goals assist in implementing **herd immunity**, a point at which disease is slow to spread through a population due to a high percentage of individuals within the population being immune.



Fig. 4+5 - Examples of hygiene distancing practices aimed at preventing the spread of disease.



AO adaptation of NIH graphic. | GAO-20-646SP

Fig. 6 - Diagram depicting the principle of herd immunity and its application to disease transmission..

## Introduction

Mentees will get the opportunity to experience, firsthand from the perspective of epidemiologists, the developments and processes involved with combating the spread of disease. Not only is the lesson relevant to current (and past) trends of disease, but also encourages problem-solving thought with regards to threats to public health.

<p><b>Concepts to Introduce</b></p> <ul style="list-style-type: none"> <li>• Modes of Transmission <ul style="list-style-type: none"> <li>◦ Think of the various modes of transmission as different “elements” or “classes” – like in <i>Avatar: the Last Airbender</i> or <i>Percy Jackson</i>. Some really talented pathogens can use multiple different elements to spread!</li> </ul> </li> <li>• Disease <ul style="list-style-type: none"> <li>◦ The game <i>Plague Inc.</i> models module 1 perfectly. Ask mentees if they’ve ever played!</li> </ul> </li> </ul>	<p><b>Questions to Pique Interest</b></p> <ul style="list-style-type: none"> <li>• Ask about your mentees’ experiences with disease, perhaps bringing in the COVID-19 pandemic. <ul style="list-style-type: none"> <li>◦ Many of the policies introduced in the third module will be relevant to this question.</li> </ul> </li> <li>• What image comes to mind when you think of the word “disease?” <ul style="list-style-type: none"> <li>◦ What does the word “disease” mean to you?</li> </ul> </li> <li>• What are some of the ways you know disease can spread?</li> <li>• What do we do in our lives to make sure we don’t get sick?</li> </ul>
<p><b>Scientists, Current and Past Events</b></p> <ul style="list-style-type: none"> <li>• The COVID-19 pandemic is a <i>prime</i> example of the difficulties and conflicts of interest associated with controlling disease outbreaks. With a pattern of transmission exhibiting an extremely sudden onset at the global level, COVID has influenced the everyday lives of virtually every individual residing within afflicted communities. Though efforts to stem the tide of transmission have been largely productive, we still face difficulties regarding control over the disease: <ul style="list-style-type: none"> <li>◦ <a href="https://www.who.int/health-topics/coronavirus#tab=tab_1">https://www.who.int/health-topics/coronavirus#tab=tab_1</a> (general information)</li> <li>◦ <a href="https://covid.cdc.gov/covid-data-tracker/#datatracker-home">https://covid.cdc.gov/covid-data-tracker/#datatracker-home</a> (current COVID data tracker)</li> </ul> </li> </ul>	<p><b>Careers and Applications</b></p> <ul style="list-style-type: none"> <li>• Physician - Utilize and integrate medical knowledge of various fields and specialties to identify prognoses to rampant diseases. Use your platform to encourage good hygiene and disease prevention strategies.</li> <li>• Epidemiologist - Do what we did in this lesson as a job! Compile data and trends from various outbreaks and think of approaches towards disease control.</li> <li>• Public Health Specialist - Advocate for disease prevention policies throughout society. Advise government officials on how best to approach disease.</li> </ul>

## Module 1: Plague Inc.

Individual activity where mentees utilize their learnings from this module to formulate their own pathogen, complete with its mode of transmission, specific symptoms, and type of pathogen (if age group avails). *The mentees are mad scientists in a secret facility that makes pathogens with the aim of ending the world.*

### Teaching Goals

1. **Pathogen** - a biological agent that causes disease within a host organism
2. **Symptoms** - somatic afflictions or indications of disease experienced by an infected individual.
3. **Modes of Transmission** - the specific method by which a pathogen is passed from individual to individual.
  - a. **Airborne** - pathogen spread by respiratory droplets in the air
  - b. **Bloodborne** - pathogen spread by contaminated blood/bodily fluids
  - c. **Zoonotic** - pathogen spread from an animal to a human
  - d. **Contact** - pathogen spread from contact with contaminated surfaces/individuals
  - e. **Foodborne** - pathogen spread from consumption of contaminated food (food poisoning)
  - f. **Waterborne** - pathogen spread from contaminated water sources.
4. **Pathogen Classification** - the biological classification of the pathogen in question (viral, bacterial, fungal, parasitic).

### Materials

- 1 Index card per student
- Writing utensils (one per student (if necessary))
  - Can use markers from module 2
- [Pre-printed document](#)  
*For sites whose students can't read/write (only K/1?)*

### Different Methods for Teaching

1. **Symptoms:** Have mentees list out things they have felt while sick. Explain that all of these examples are symptoms.
2. **Modes of Transmission:** USE A WHITEBOARD (if available). Write out each mode of transmission, fill in one definition (probably zoonotic) and have the mentees infer the definitions of the others. Not all modes of transmission have to be covered, but be mindful that the mentees will be making pathogens based off of what you teach them! Leave the definitions up on the board while the mentees make their pathogen.



## Procedure

### For sites whose students can read/write:

1. Hand out an index card to each mentee.
2. Have mentees create their own pathogen.
  - a. On the blank (unlined) side, have the mentees create a name for their pathogen. *If they would like to draw a picture of their pathogen, they may do so on this side as well.*
  - b. On the lined side, have them write out specific symptoms and the mode of transmission (just one) that the pathogen will utilize.
    - i. If pathogen classification was covered, have them write this on the lined side as well.
3. Encourage presentation (if desired)
4. Have mentees **HOLD ON TO THEIR INDEX CARDS** (keep them at their desks, hold on to them, etc..)

### For sites whose students *can not* read/write:

1. Organize students into groups such that you can designate one mentor per group.
2. Hand each student a [pre-printed document](#).
3. Have each mentor guide their group through filling out the document, writing in pathogen name if needed.
  - a. Each mentee should circle the icon that represents the mode of transmission/symptoms they want their pathogen to have.

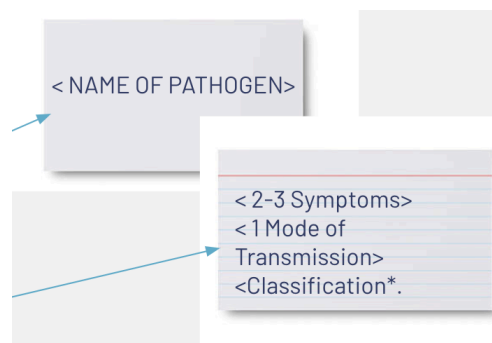


Fig. 1 - Index Card layout for sites whose mentees can read/write.

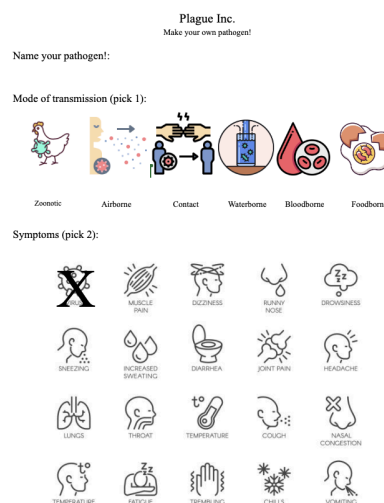


Fig 2. Template for sites whose mentees can NOT read/write.

## Classroom Notes

Both this module and module 3 have rather expansive teaching goals. Using a whiteboard to keep track would be ideal.

## Module 2: ZomBEAMs

*Oh no! One of the lab's newly-developed pathogens manages to escape the secret lab and now looks to wreak havoc on the world! The mentees are now individuals in a small nearby town who do not know anything about this new pathogen.*

Group activity where students model the disease transmission process by interacting with their peers. Infected individuals will be marked, starting with one patient zero.

### Teaching Goals

1. **Patient Zero** - the first person within a defined population to be infected with a pathogen.
2. **Disease Transmission** - The process by which a pathogen spreads across a population. Follows a parabolic trend with transmission being extremely rapid upon onset.
3. **Pandemic** - An outbreak of disease that occurs on a global scale, spanning continents and countries. If disease transmission is effective enough, a disease can be classified as a pandemic.

### Materials

- Small cups
- Baking soda
- Phenolphthalein indicator
- Water
- Plastic Pipettes

### Different Methods for Teaching

3. **Pandemic** - provide a guiding question like: “what do you think of when you think of the word ‘pandemic?’” Try to establish connections to the COVID-19 pandemic when delivering the lesson.

### Procedure

1. Fill enough small cups about halfway with water so that each mentee receives a cup.
2. In ONE of the cups, dissolve a finger-pinch of baking soda. **KEEP TRACK OF THIS CUP AND WHO RECEIVES IT** - This will be the cup given to patient zero!
  - a. Baking soda is basic. Dissolving in water creates a basic solution that is indicated by phenolphthalein turning a deep pink color!
3. Hand out the cups and a plastic pipette to each mentee. Note the mentee whom you give the baking soda cup to.
4. Provide a five-minute period for the following game to progress:



**Figure 1: Phenolphthalein indicator in infected (left) and healthy (right) solutions.**

- Note: due to dilution, the pink color may not be so vibrant.

<ul style="list-style-type: none"> <li>a. Mentees will go around the room and interact with as many of their peers as possible.</li> <li>b. Mentees will take two pipette-fuls of their cup solution and transfer it into the other mentee's cup solution. They will then stir with their pipette to ensure their cups are thoroughly mixed.</li> <li>c. Repeat for each interaction.</li> </ul> <p>5. At the end of the five-minute period, have mentors come around and drop 2-4 drops of phenolphthalein indicator. <b>ENSURE THAT NO ONE DRINKS THE SOLUTION!</b> (phenolphthalein, though not potent, can be toxic when ingested)</p> <p>6. Have mentees stir their solutions once again with their pipettes:</p> <ul style="list-style-type: none"> <li>a. Mentees whose solutions are <i>clear</i> after dropping in phenolphthalein indicator are <i>healthy</i>.</li> <li>b. Mentees whose solutions are <i>light pink</i> after dropping in phenolphthalein indicator are <i>infected</i>.</li> </ul> <p>7. Pull the classroom together and have all infected mentees reveal themselves.</p> <p>8. Discuss the rapid transmission of the disease in question, being sure to note that the infection had initially begun with just a single infected mentee.</p> <p>9. Perform a big reveal uncovering the patient zero selected at the beginning of the game.</p> <p><b>For sites with smaller classroom sizes</b> - have mentors and teachers/classroom aides play the game as well! Site leader should be the moderator in this case.</p> <ul style="list-style-type: none"> <li>- Since the game is unlikely to take up the five-minute interval, play multiple rounds, if needed/desired.</li> <li>- If not, discuss applications to real disease/transmission. Since the population is smaller, have mentees try to identify the patient zero (you may introduce the concept of contact</li> </ul>	
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tracing here, if desired!)	
<b>Cleanup</b> <ul style="list-style-type: none"> <li>- Have mentors consolidate all cups. The solution will be dilute enough to enable safe disposal down a drain with plenty of water. Cups should be rinsed and reused for the third module (fill them less than halfway up with water again)</li> </ul>	

### **Classroom Notes**

- Participation is KEY in this game. If you anticipate it to be difficult to get mentees to participate, put a quota on the amount of peers they need to interact with (each mentee MUST interact with at least five other classmates).
- Preparation for this module (getting water from sink, choosing a cup to be the patient zero cup) can be done during module 1.

## Module 3: Stayin' Alive!

*Yikes...the disease has spread to yet another neighboring town. Luckily, this town had heard of the recent outbreak and tried their best to prepare. The mentees are now residents of this new town, who must now tell the world how to prepare before it's too late!*

Mentees organized in groups will try and create a product to combat the spread of a certain pathogen.

<b>Teaching Goals</b> <ol style="list-style-type: none"><li>1. Vaccines</li><li>2. Social Distancing</li><li>3. Quarantine/Isolation</li><li>4. Hygiene</li><li>5. Herd Immunity</li><li>6. Animal Vector Control</li></ol>	<b>Materials</b> <ul style="list-style-type: none"><li>• <a href="#">template</a></li><li>• Small cups</li><li>• Baking soda</li><li>• Phenolphthalein indicator</li><li>• Water</li><li>• Plastic Pipettes</li><li>• 1 Stamp per site</li></ul>
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### Different Methods for Teaching

Introduce the topic by asking something along the lines of: “what are some things we do in our everyday lives so that we do not get sick?” Fill in the details after examples are taken.

Again, write out definitions and examples on a whiteboard!

### Procedure

1. Have the patient zero from the previous game present on the pathogen they had created in module 1, being sure to note their mode of transmission.
2. Hand each mentee a [template](#) strip. Distribute all of the different prevention tools.
3. Prompt mentees to take a look at their [template](#) strip to note what prevention tool they have.
  - a. Mentees whose prevention tool mode of transmission matches that of the previous patient zero's will be immune from transmission.
    - i. Prior to starting the activity, have these mentees identify



**Figure 1:** Phenolphthalein indicator in infected (left) vs healthy (right) solutions






















- Note: due to dilution, the pink color may not be so vibrant.

themselves and stamp their hand. Again, these individuals are immune.

4. Replay the game from module 2.
5. Have infected mentees reveal themselves. Note how the number of infected individuals is much less than that of the first round (module 2).
  - a. Immune individuals with a stamp are not infected (healthy), even if their solutions are pink in color. Can say something along the lines of: "If you have a stamp, do not raise your hand."
6. Have immune individuals reveal themselves and list the prevention tools they had to protect them from the spread of disease. *Also be sure to note that if mentees decided to interact with less people this round, they were practicing social distancing/isolation!*
7. If time avails, have mentees think of additional solutions to the patient zero's pathogen's mode of transmission and/or have another mentee present on their pathogen, choose another patient zero, and replay w/ immunities for the new pathogen.

**For sites with smaller classroom sizes - have mentors and teachers/classroom aides play the game as well! Site leader should be the moderator in this case.**

- **Play multiple rounds, handing each mentee a new template/prevention tool each time.**
- **Perhaps you could also have mentees think of their own specific prevention tool and use it within a game.**

You have a mask 	→	You are safe from  airborne pathogens.
You have gloves  bloodborne pathogens.	→	You are safe from  contact AND 
You have a filter 	→	You are safe from  waterborne pathogens.
You have a refrigerator 	→	You are safe from  foodborne pathogens.
You have a vaccine 	→	You are safe from ALL pathogens.
You have bug spray  pathogens.	→	You are safe from  zoonotic
You have a bug screen 	→	You are safe from  zoonotic pathogens.
You wash your hands 	→	You are safe from  waterborne pathogens,  contact pathogens, and 
You do your dishes 	→	You are safe from  bloodborne AND  foodborne pathogens.

**Figure 2:** Template sheet/all possible prevention tools and their associated immunities.

### Classroom Notes

Both this module and module 1 have rather expansive teaching goals. Using a whiteboard to keep track would be ideal.

## Conclusion

Have mentees list aspects of disease/epidemiology that they learned! Host a discussion as to how these learnings may apply to real-life applications of public health/disease prevention, the primary example being the COVID-19 pandemic!

## Summary Materials Table

Material	Amount per Site	Expected \$\$	Vendor (or online link)
Writing Utensil (pencils?)	One per mentee (can also be less if it is anticipated that the mentees will have their own writing utensils).		
Index Cards	1 per student	~\$12	<a href="https://www.amazon.com/Oxford-Blank-Index-Cards-30/dp/B002OB49JG/ref=asc_df_B002OB49JG/?hvdid=693071499061&amp;hvdv=c&amp;hvdvcmdl=undefined&amp;hvllocint=undefined&amp;hvllocphy=1013585&amp;hvnetw=g&amp;hvpone=undefined&amp;hvpos=undefined&amp;hvptwo=undefined&amp;hvqmt=undefined&amp;hvrnd=17502215788990378029&amp;hvtargid=pla-351758017673&amp;linkCode=df0&amp;mcid=e74fa0b82a0434a39077ebd5f1dd5a33&amp;tag=hyprod-20&amp;th=1">https://www.amazon.com/Oxford-Blank-Index-Cards-30/dp/B002OB49JG/ref=asc_df_B002OB49JG/?hvdid=693071499061&amp;hvdv=c&amp;hvdvcmdl=undefined&amp;hvllocint=undefined&amp;hvllocphy=1013585&amp;hvnetw=g&amp;hvpone=undefined&amp;hvpos=undefined&amp;hvptwo=undefined&amp;hvqmt=undefined&amp;hvrnd=17502215788990378029&amp;hvtargid=pla-351758017673&amp;linkCode=df0&amp;mcid=e74fa0b82a0434a39077ebd5f1dd5a33&amp;tag=hyprod-20&amp;th=1</a> (1000CT)
Paper (printed <a href="#">template</a> )	Cut into strips - 9 strips on each page. - ~4-5 whole pages per site.	(should have?)	

Stamps	1 per site	~\$17	JOYIN 50 Pieces Halloween Assorted Stamps Kids Self Ink Stamps, 25 Designs Plastic Stamps, Trick Or Treat Stamps, Spooky Stamps for Halloween Party Gifts, Game Prizes, Halloween Goodies Bags <a href="https://a.co/d/8YuSqqU">https://a.co/d/8YuSqqU</a> - something like this is perfect!
Plastic Pipettes	1 per mentee	~\$19	<a href="https://a.co/d/hM3ZhCC">https://a.co/d/hM3ZhCC</a>
Small Clear Plastic Cups	1 per mentee + extra	~\$18	<a href="https://a.co/d/dpoky7m">https://a.co/d/dpoky7m</a> x2
Phenolphthalein Indicator	1 bottle for all sites (divvy up in ziploc/other sealable container)	~\$19	<a href="https://a.co/d/gOeVwPD">https://a.co/d/gOeVwPD</a> - Will it come in time?
Baking Soda	1 box for all sites (divvy up in ziploc bags?)	~\$2	<a href="https://a.co/d/4cmcVGB">https://a.co/d/4cmcVGB</a>