Have You Heard About Herd Immunity?

2013 Science Ambassador Workshop
Lesson Plan

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Contents

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Have You Heard About Herd Immunity?

Summary

This lesson demonstrates the concept and importance of herd immunity. It uses hands-on classroom activities to present information on how immunizations protect groups of people from vaccine-preventable diseases and explains the importance of immunizations and why some people are not immunized. The lesson assumes that students have prior knowledge of diseases, vaccines, and the immune system. The concept and activities are appropriate for grades 5-8 but may be used for older students.

Learning Outcomes

The students will be able to:

- Describe the concept of herd immunity using the following terms: disease, immune, vaccine, protect, and susceptible
- List reasons why people should get vaccinated, why herd immunity is important, and why some people cannot or do not get immunized
- Explain what is meant by threshold for herd immunity and, when given the herd immunity threshold for a particular disease, be able to calculate the number of people in a group who need to be immunized in order to prevent transmission of that disease
- Graphically display how the threshold for herd immunity varies among diseases, with both numbers of individuals and percentages

Materials

1. Small red, green and blue items (e.g., index cards, plastic chips, jelly beans or other small items) in a bag. One item for each student in the class. Must include two red (representing people with communicable diseases), and then equal parts green (representing vaccinated people) and blue (representing unvaccinated people) for the rest of the students. For example: in a class of 24 students, there will be 2 red, 11 blue and 11 green items.
2. Colored pencils. Need one red, one blue, and one green for each student. Students may share pencils.
3. "Unvaccinated" cards (Appendix 1) – a set of cards each listing one reason why someone cannot or does not get vaccinated. Need the same amount as there are blue items.
4. Soft squishy balls or stress balls – small and soft enough to be thrown at students without hurting anyone or damaging property. One ball for every two students in the class.
5. Herd Immunity Worksheet (Appendix 2) – need 3 copies per student in the class.
6. Computers with internet access for Illsville interactive game and Herd Immunity YouTube video.

Total Duration

2-3 hours

Procedures

Teacher Preparation

- Ensure Internet access
- Identify and obtain small red, green and blue items and determine how they will be distributed. Red represents sick; blue represents unvaccinated; green represents vaccinated. There should be two red items. There should be an equal number of blue and green items for the remaining students.
- Make enough copies of unvaccinated cards (Appendix 1) for each student with a blue item to have one card.
- Make three copies of Student Worksheet (Appendix 2) for each student.

Resources

- Title: How Vaccines Prevent Diseases
  URL: http://www.cdc.gov/vaccines/parents/vaccine-decision/prevent-diseases.html
  Description: This website targets parents and provides basic information on how vaccines prevent infectious diseases.

- Title: Basics and Common Questions: What You Need to Know.
  URL: http://www.cdc.gov/vaccines/vac-gen/default.htm
  Description: This website is a collection of links to information on the basics of immunizations and answers to common questions about vaccines.

- Title: Herd Immunity: A Rough Guide.
  URL: http://cid.oxfordjournals.org/content/52/7/911.full
  Description: This article in the Oxford Journal, Clinical Infectious Diseases, provides general information about the concept of herd immunity, as well as various threshold rates for different diseases.

- Title: Herd Immunity
  URL: http://www.historyofvaccines.org/content/herd-immunity-0
  Description: This website provides an overview of diseases, immunities, and vaccination, as well as access to the Illsville simulation on the site named in Extension 2.

Activities

Duration: 90 minutes

1. Review these concepts: disease, vaccines, immune system, and immunity

2. Introduce reasons why some people do not or cannot get some vaccines
   - Medical exemptions – some acute illnesses, severe allergy to a vaccine component, compromised immune system (e.g., cancer or immunosuppressive therapy)
   - Religious exemptions
   - Philosophical exemptions

3. Activity to demonstrate herd immunity
   - Have each student in the class randomly pick or receive one of the small red, blue, or green items. Explain that students with red items have a communicable disease that they can spread to other people; students with green have been vaccinated and are protected against infection with the disease; those with blue items have not been vaccinated and are not protected.
   - Give all students with blue items a card from Appendix 1. Each card provides a reason why they were not vaccinated. Ask all unvaccinated students to read their cards to the class. Encourage discussion about the reasons why people do not or cannot get vaccinated.
   - Tell all students with a red item to remain in their seats. Students with green or blue items should stand.
   - Give a squishy ball to the students with a red item. Explain that when you give the word, they are allowed to throw the ball at anyone who is standing. Their goal is to hit the standing students in the torso (front or back). Explain that vaccinated students with green items are protected and allowed to use their hands to deflect the ball to keep from getting hit on their torso. Unvaccinated students with blue items are not protected and must keep their hands by their side. Any unvaccinated student who gets hit in the torso must sit down. They are now sick and should be given a squishy ball to throw. Vaccinated students who get hit should remain standing.
   - Eventually all students who were not vaccinated will get hit and have to sit, at which point they can receive a ball and throw it at anyone who is still standing (because now they are sick and can spread the disease).
   - The number of sick people will be increasing. After each student has had a certain number of throws, the round stops. The number of throws can be varied according to the teacher to reflect disease specifics. A moderately contagious disease such as influenza could be represented by each sick student getting four throws. A highly contagious disease such as measles could be represented by each sick student getting 18 throws.

4. Activity to demonstrate herd immunity.
   - Collect the colored items and reassign them. Again, tell the sick students (those with red items) to sit, while the well students (those with blue or green items) remain standing. This time, all unvaccinated students (those with blue items) stand inside of a circular barricade of vaccinated students (those with green items).
   - The challenge is for the sick kids to hit the torso of the unvaccinated students (within in the circular barricade) with the ball. They will soon discover that they can't because the vaccinated kids are protecting them. This simulates the concept of herd immunity.

- Ask what would happen if there was an increase in the relative proportion of green to blue items so that more vaccinated students are protecting fewer unvaccinated students. Explain that eventually a point would be reached when it would be virtually impossible for a blue item student to get hit. This point represents the threshold for herd immunity.

5. Activity to visualize spread of infection and protection by herd immunity
   - Give each student a copy of the worksheet (Appendix 2) and 3 colored pencils: red, green, and blue. Instruct the students to color any two circles red to represent sick people. Then instruct them to color any 24 circles green to represent people who are vaccinated. Then instruct them to color the remaining blank 24 circles blue to represent the unvaccinated.
   - Ask students to identify any blue circle that is adjacent to (above, below, next to or diagonal) a red circle. Instruct them to outline those blue circles with red because now those people are sick from exposure. Then instruct them to outline with red, any other blue circles that are adjacent to the newly red circles, because those people are sick too. Eventually they will discover that any blue (unvaccinated) that is adjacent to a red (sick), whether the red was originally red or newly outlined, must be outlined in red. This represents the spreading of the disease. We started with two sick people. How many of the 50 are now sick?

6. Activity to calculate the threshold for herd immunity.
   - Explain that the herd immunity threshold for each disease is different. Highly contagious diseases have a higher threshold than less contagious ones. For example, measles is much more contagious and has a higher herd immunity threshold than influenza.
   - Give everyone another copy of the worksheet (Appendix 2). Announce that for everyone to be relatively safe from the flu, 75% of people need to be vaccinated. In a sample of 50 people, how many need to be vaccinated for the population to be safe from the flu? Have students calculate 75% of 50. (Answer: 75% of 50 = 37.5 = 38). Instruct students to write “The Flu” at the top and color 38 circles green. Explain that this is how many people should be vaccinated in order for everyone to be relatively safe. Have students calculate 75% of the total number of students in the class.
   - Give students a third copy of the worksheet (Appendix 2), and have students write “Measles” at the top. For everyone to be relatively safe from the measles, 95% of people need to be vaccinated. In a sample of 50 people, how many need to be vaccinated for the population to be safe from measles? Have students calculate 95% of 50. (Answer 95% of 50 = 48). Instruct students to color 48 circles green. Explain that this is how many people should be vaccinated in order for everyone to be relatively safe. Have students calculate 95% of the total number of students in the class.

Conclusion

Duration: 20 minutes

The teacher will lead a post-activity discussion that reinforces and reviews these concepts:

- Why do we need to get vaccinated?
- What is herd immunity?
- How does herd immunity protect people who are unvaccinated?
- What are the reasons that some people cannot or do not get vaccinations?
- What are the ethical issues of people who take an exemption putting not only themselves but others at risk? (Note: There are parents who actually abuse herd immunity by claiming exemptions simply because they believe they are protecting their children from the possibility of adverse vaccine reactions while benefiting from the immunity of vaccinated children around them. Ironically, this undermines the benefits of herd immunity by increasing the pool of susceptible persons.)

Assessment

Resources

- Title: Illsville: Fight the Disease
  URL: http://www.historyofvaccines.org/content/illsville-fight-disease
  Description: An immersive game that takes players through the historical development of a society as it fights disease and tries to develop vaccines to protect the population.

- Title: Vaccines & Immunizations
  URL: http://www.cdc.gov/vaccines/
  Description: This CDC website contains information on all vaccine preventable diseases.

- Title: Meningitis Immunization for Adolescents
  URL: http://www2c.cdc.gov/podcasts/player.asp?f=9956
  Description: An audio podcast from CDC covering meningitis – especially meningococcal meningitis.

- Title: Meningococcal Disease
  URL: http://www.cdc.gov/meningococcal/about/index.html
  Description: This CDC webpage on meningococcal infections provides information on risk factors, causes and transmission, diagnosis and treatment, signs and symptoms, and prevention. The site also has photos of the bacteria and people with the disease.

- Title: Meningitis Angels
  URL: http://www.meningitis-angels.org/
  Description: This website has stories that share links to personal stories of people affected by bacterial meningitis.

- Title: Meningococcal: Questions and Answers: Information about the disease and vaccines
  URL: http://www.immunize.org/catg.d/p4210.pdf
  Description: This is a three-page fact sheet about meningococcal disease and vaccine.

Activity – Persuasive Letter

Duration: 30 minutes

Teacher Explanation of Activity

Explain to the class that you (the teacher) have received a letter from your doctor stating that you need to make an appointment to receive a meningococcal vaccination to protect against bacterial meningitis.

Tell the class that:

- This type of bacterial meningitis is spread among close contacts
- Approximately one out of every 10 people who develop the disease die
- One out of every five who survive have serious and often permanent complications

Then say that you:

- Don't have time to get the shot
- Hate needles
- Think you will just skip this vaccination

Next, direct students to write a letter to you (the teacher) that explains why vaccinations are important for individuals and public health.

The letters are expected to explain the concepts of immunizations and herd immunity in a way that indicates the students' knowledge of these concepts.

Evaluate the letters on evidence of the students' understanding the concepts and format.

Modifications or Extensions

Modification 1

- Hand out the colored items prior to class, put in envelopes so nobody knows what color they have received. All students with a blue item also receive a card inside the envelope saying why they didn't get vaccinated.
- Let the students mingle prior to taking their seats for class. Ensure that each student has a roster (or some similar list of students in the class). Ask the students to mark the names of everyone they talked to during the mingling, and in what order. [This will work best if students do not know the topic before class]
- After the students sit down, give the introductory materials, and have the students open their envelopes and see what color they have. Identify who would have been infected based on who the students were in contact with while they mingled before taking their seats. [This might be done by depicting each student as a circle on a blackboard and diagramming transmission with arrows. Students can cheer as each new person becomes a victim.]
- As the follow-up exercise, randomly redistribute a new set of envelopes but with more green items and fewer blue items. [Note: It might be best to make sure the same two students get the red items so the index cases will be the same.] Ask students to use their same marked-up rosters. In other words, assume they had the same personal contacts and determine who would have become infected this time—when more people are vaccinated and fewer are susceptible. Ideally, in the second round, fewer people will become infected.

- You can have the students perform a third round. Distribute a higher proportion of green items than you distributed in the follow-up exercise to demonstrate approaching the threshold.

Extension 1: Illsville interactive simulation — Duration: 10-15 minutes

Teacher Preparation
Preview the http://www.historyofvaccines.org website, specifically the Illsville simulation activity which traces the development of modern vaccines from the 1600s to the present day.

Materials
Computers with internet access (≥1)

Resources
- Title: Illsville: Fight the Disease
  URL: http://www.historyofvaccines.org/content/illsville-fight-disease
  Description: An immersive game that takes players through the historical development of a society as it fights a disease and tries to develop vaccines to protect the population.

Activity
Students work individually or in groups (according to internet availability) to act as public health authorities in this town where periodic outbreaks occur. They must make decisions regarding use of resources, technology and various interventions in order to ensure the health of the people in the town.

Science Education Standards

National Science Education Standards

Science as Inquiry Content, Standard A

As a result of activities in grades 5-8, all students should develop the following:

- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

Life Science Content, Standard C

As a result of their activities in grades 5-8, all students should develop understanding of the following:

- Structure and function in living systems
- Regulation and behavior
- Populations and ecosystems
- Diversity and adaptations of organisms

Science in Personal and Social Perspectives, Content Standard F

As a result of activities in grades 5-8, all students should develop understanding of the following:

- Personal health
- Populations, resources, and environments
- Natural hazards
- Risks and benefits
- Science and technology in society

State Science Education Standards – Georgia[1]

Grade 5

- S5CS2. Students will have the computation and estimation skills necessary for analyzing data and following scientific explanations
- S5CS4. Students will use ideas of system, model, change, and scale in exploring scientific and technological matters
- S5CS5. Students will communicate scientific ideas and activities clearly
- S5L4. Students will relate how microorganisms benefit or harm larger organisms

Grade 7

- S7CS2. Students will have the computation and estimation skills necessary for analyzing data and following scientific explanations
- S7CS4. Students will use ideas of system, model, change, and scale in exploring scientific and technological matters.
- S7CS5. Students will communicate scientific ideas and activities clearly
- S7L2. Students will describe the structure and function of cells, tissues, organs, and organ systems

[1] Taken from Georgia Department of Education Science Framework for Middle School Students (https://www.georgiastandards.org/Frameworks/Pages/BrowseFrameworks/Science.aspx)

Glossary

Acute	A short-term, intense illness with sudden onset
Allergic Reaction	A physical reaction by the immune system to a substance that is normally harmless to most people.
Antigen	Foreign substances (e.g., bacteria or viruses) in the body that are capable of causing disease; the presence of antigens in the body triggers an immune response, usually the production of antibodies
Communicable Disease	A disease that can spread from one person to another
Exemption	The right of individuals to refrain from complying with immunization requirements because of medical reasons or their religious or philosophical beliefs
Herd Immunity	Protection from disease in a group, due to a large enough proportion of the population having immunity to prevent the disease from spreading from person to person
Herd Immunity Threshold	Proportion of the population that must be immune in order to prevent the disease from spreading from person to person
Immunization	The process by which a person becomes protected against a disease through receipt of a vaccine, toxoid, antibody, or antitoxin
Immunosuppression	A condition in which the natural immune (protective) response of the body does not work well; can be caused by disease or medication
Immunosuppressive Therapy	Medications or other treatments that impair the natural immune (protective) responses of the body
Susceptible	Someone who is vulnerable to infection or disease; someone who has never had a disease or never been vaccinated against it is susceptible to that disease; opposite of immune
Vaccination	The process of administering a vaccine or toxoid (a toxin that has been modified to make it nontoxic, but which still can stimulate the body to form antibodies) to induce immunity to infection or disease

Appendices: Supplementary Documents

Appendix 1: Unvaccinated Cards

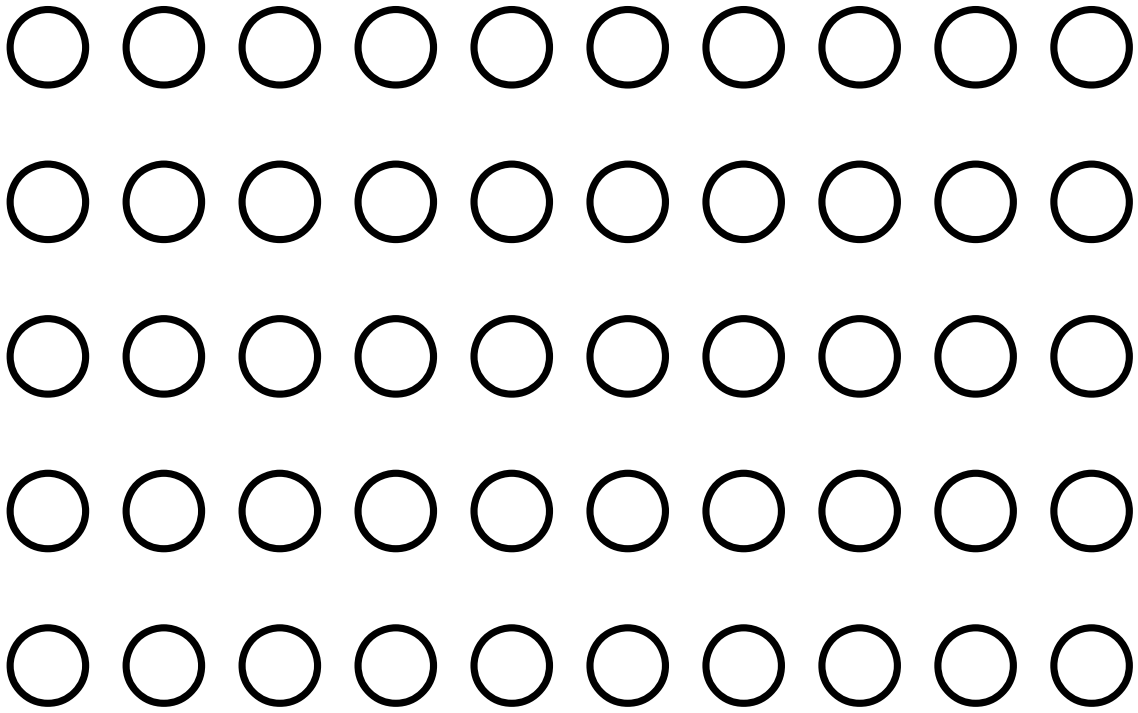
Medical exemption: **Severe allergic reaction to vaccine component** *You had a severe reaction the last time you received this immunization and had difficulty breathing.*	**Medical exemption:** **Acute illness (moderate or severe)** *You have recently been diagnosed with strep throat and are taking medicine for it. This is temporary and your doctor will vaccinate you once you are well.*
Medical exemption: **Compromised immune system** *Your body is weakened from cancer treatment and you cannot be immunized now.*	**Medical exemption:** **Immunosuppressive therapy** *You are taking medicines after an organ transplant and cannot be immunized now.*
Medical exemption: **Age (too young for first immunization)** *You are younger than 2 months.*	**Medical exemption:** **Severe allergic reaction to vaccine component** *You had difficulty breathing and broke out in hives soon after you received this immunization the last time.*
Philosophical exemption in one of the states that permit this: *When you were younger, your parents made the decision not to have you immunized.*	**Religious exemption:** *When you were younger, your parents refused immunization for religious reasons.*

Appendix 2: Worksheet

NAME: _____

Directions

- Pick out 2 circles and mark them red.
- Pick out 12 circles and mark them green.
- Mark the rest blue.
- Wait for further directions.



1. What percentage of this population is vaccinated? Use a proportion to find out.
   36/50 = n/100

2. What percentage of the group is unvaccinated? How can you find the answer?