Elementary Epidemiology: Disease Investigation Using Basic Math Skills

By: Sara Howard, MPH

Grade: 3rd Grade Mathematics

Time Required: 1 hour is suggested. However, the educator should adjust the time and number of activities to best fit the class needs.

Standards *(based on Tennessee Mathematics)*:

- **3.NF.A.3:** Explain equivalence of fractions and compare fractions by reasoning about their size.
- **3. MD.A.1:** Tell and write time to the nearest minute and measure time intervals in minutes. Solve contextual problems involving addition and subtraction of time intervals in minutes.
- **3.MD.B.3:** Draw a scaled pictograph and a scaled bar graph to represent a data set with several categories. Solve one- and two-step "how many more" and "how many less" problems using information presented in scaled graphs.

Lesson Objectives:

The student will:

- Understand the basic principles of epidemiology and how 3rd grade mathematic principles are involved
- Conduct a simulated epidemiologic investigation by integrating epidemiologic principles with 3rd grade mathematic skills

Central Focus:

The main focus of this lesson is to allow students to apply their math skills to a real world problem in epidemiology. After an introduction to the science of epidemiology and an introduction to new terms, students will be work through a disease investigation. Using example data, groups of students (or individual students) will analyze a set of “data” to determine the cause of an infectious disease outbreak. If time permits, the students will also determine how best to communicate their results to others.

Materials:

- *Elementary Epidemiology: Disease Investigation Using Basic Math* (3rd Presentation)
- Example Disease Investigation Data – One set per group
- Disease Investigation Data Worksheet – Optional
- Paper
- Pencil

Background Information:

Epidemiology combines science and mathematics to study the distribution of disease within a population and the factors that influence disease. At its core, epidemiology uses basic math skills to determine the distribution and cause of diseases. This lesson will provide students with an introduction epidemiology while allowing them to apply their skills to a real world problem. To complete the activity, students will need to be familiar with adding, elapsed time, fractions, comparing fractions, and reducing fractions. Additionally, the lesson will introduce the students to new terms that they will need to complete the activity.

Presentation:

Hook:

Who here likes mysteries? Books, movies, or TV shows? Well I do too. What do you like about them?

Allow time for students to answer. Hopefully, some of the students like solving the puzzle of mysteries. Follow with: *Well, today we are going to use similar skills to figure out what food caused a disease outbreak.*

Introduction:

Begin by introducing the lesson. Tell the students that they are going to be learning how the math skills they already know are used by epidemiologists every day to help them understand causes of diseases.

Slide 2:

Introduce epidemiology by stating the definition, which Gordis defines as “the study of how diseases are distributed in a population and the factors that influence or determine the distribution.” In this definition, population means a group of people. This can be a group of people of any size or of any characteristics of your choice. However, this is discussed on a later

slide. Distribution in this definition means how widely spread the disease is among the population.

Ask students:

> *Why would we want to study why diseases occur in a population? Why would we want to study how diseases are spread in a population?*
> *Why do we want to prevent or control the diseases?*

Tell students that epidemiologists are the scientists who do this. They are sometimes referred to as the "detectives of the medical field." The students will get to practice being these medical field detectives today.

Slide 3:

Lead into the next slide by asking:

> *What types of diseases do you think epidemiologists study?*

The answer is every kind of disease of course. Like all sciences, epidemiology has its own specialties. Although the list on the slide is not exhaustive, it shows the most common types of epidemiology. Please clarify each type of epidemiology for the students. Additional information is provided below.

> *<u>Infectious Disease Epidemiology</u>: Infectious diseases are diseases that are caused by other organisms such as bacteria and viruses. Typically, these are passed from person to person or animal/organism to person. Examples would include the flu, strep throat, pneumonia, and HIV.*
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> *<u>Chronic Disease Epidemiology</u>: Chronic diseases are disease that last for an extended period (3 months at least), and they generally do not have a cure. Examples include cancer, diabetes, cardiovascular disease, HIV, Alzheimer's disease, and Parkinson's disease.*
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> *<u>Environmental Epidemiology</u>: This looks at how the environment affects health. Certain diseases can be caused by exposure to things in the environment. This can include second hand smoking, chemical exposures, air quality, or waterborne illnesses. Examples of diseases would be lung cancer, asthma, and anthrax.*
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> *<u>Cancer Epidemiology</u>: Cancer epidemiologists study the causes of different types of cancer and what influences them. For example, the chemicals in cigarette smoke increase the risk for different types of cancer including lung cancer.*

<u>Genetic Epidemiology</u>: Genetic epidemiologists study how diseases are inherited (passed down to family members) and how a person's genes influence disease. Examples of genetic diseases would be Down's syndrome, Muscular Dystrophy, and Cystic Fibrosis.

<u>Occupational Epidemiology</u>: Occupational epidemiologists study diseases that affect groups of workers. Occupations, and even different jobs within those occupations, have different health risks. In this field, epidemiologist work to understand, control, and prevent the diseases from occurring. For examples, occupational epidemiologists may study the effect of pesticide exposure on farmers or how stress levels affect teachers' health.

When reviewing the types of epidemiology, you may want to ask the students if they can provide examples to the different types of diseases that could be in each category. For example, asking if they can name a chronic disease may help them stay engaged with the material.

Lead into the next slide by asking:

What skills do you think are required for this job?

Slide 4:

After you allow a few minutes for the students to answer, go to the next slide. This infographic shows some of the groups of skills need for epidemiology. Explain what each area is and why they are important.

<u>Research Design & Analysis</u>: Epidemiologists need to know how to design a study so that it is ethical and scientifically meaningful. It should also be defensible, meaning that they should be able defend their research against scientific scrutiny.

<u>Medical, Biological, and Mathematical Knowledge</u>: Epidemiologists must have knowledge of medicine, biology, and math. This helps them design their studies, collect their data, and understand the disease processes.

<u>Data Analysis, Presentation, and Communication</u>: Epidemiologist must know different techniques to analyze data both by hand and by software. Then, they need to know how to communicate the result effectively, both visually and orally. Visually here means graphs and figures as well as written documents. Orally in this sense means public speaking as well as one-on-one conversations with people.

<u>Public Policy and Cultural Customs</u>: Epidemiologists need to know the laws that govern the population they are studying as it may influence their health outcomes. For example,

different countries have different healthcare laws. These can influence the health of a population. Epidemiologists also need to know cultural customs because culture will also influence health. For example, the southeastern part of the United States has culture that can be very different from the northeastern part. A strategy to improve health that works well in the northeastern US may not work as well in the southeastern US.

After explaining the infographic, ask students:

What subjects do you study that are used by epidemiologists?

Slide 5:

Now that you have a few basic principles of epidemiology we are going learn some terms that epidemiologists use every day. These terms will be the basis for the group activity. Review the terms with the students and provide examples for each definition. You can use any examples that fit the definitions, but examples are provided below.

<u>Example Population</u>: If we wanted to study everyone in 3rd grade at this school, who would be in our population?

- *Answer: All the students in third grade at this school. We would not include any other 3rd grade students at a different school, and we would not include students at this school who are not in 3rd grade.*

<u>Example Sample</u>: Sometimes it is not possible to study everyone in a population. For example, it would be difficult to study everyone in the United States (It would take too much time & cost too much money.), so epidemiologists will use a sample of the population. If our study population is the students at this school, we may decide to study the people in this classroom as our sample. This means that only the people in the classroom that will be included in the study. If someone is in the hallway, they are not included in the sample.

<u>Example Case & Control</u>: A case can be anyone within your study group who has the disease you are studying. A control is anyone else left in the study group. For example, if our sample is this classroom, we decide that the "disease" we are studying is people wearing classes. Our cases would be people in this classroom who wear glasses, and our controls would be people in this classroom who do not wear glasses. Raise your hand if you are case. Raise your hand if you are a control.

Slide 6:

Use this slide to provide students with another example of population, sample, case, and control. Walk them through the terms using the images in the PowerPoint.

If the population is the entire picture, what would be an example of a sample?

- *People in the left half, right half, top half, or bottom half of the photo.*
- *People in color or people in black & white*

If we make our sample the people on the left side of the page, what could our cases and control be?

- *Cases could be the people in color*
- *Controls could be the people in black and white*

When you click 'enter' on slide, the division line for the sample will appear. Additionally, another click will reveal the cases if the left side of the image is the sample.

Slide 7:

This slide introduces the scenario for the epidemiologic investigation. *Tip: The name of the school in the scenario can be changed to fit your school. If you change the school name, please change slide 11 to match.* Review this slide with the students. This is the basis for the activity.

Slide 8:

This slide has examples of a few items they need to find out during their investigation.

Ask the students:

Based off what you have learned, what are somethings you need to figure out?

- *Number of cases*
- *Number of controls*
- *Who ate the school lunches on Monday*
- *What foods were served on Monday*
- *When did people become sick*
- *What were their symptoms*

Click the space bar the answers to appear on the slide.

Slide 9:

To answer these questions, we need a little more information. We need to define what makes a case, so we need to know the symptoms that are related to *salmonella* and the incubation period. Introduce the term 'incubation period' and its definition.

Incubation period is a new term. Does anyone have any idea what it might be?

The incubation period is the time period from when a person is exposed to an organism to when symptoms are first developed. In this case, the incubation period begins when a person ingested the organism (ate school lunch) to when the person first developed symptoms.

So why do care about the incubation period?

- *Different organisms have different incubation periods, so this can help epidemiologists determine if a person has the illness or not.*

What math skill have we learned this year that we can use to find the incubation period?

- *Elapsed Time*

Once you introduce incubation period, reveal the symptoms and incubation period for *salmonella*.

For the activity, the students will need to find people who are sick within the correct incubation period (Tuesday, Wednesday, or Thursday) and who have at least 3 of the symptoms listed for *salmonella*.

Slide 10:

Epidemiologists use a specific kind of math, called statistics, to help them understand and find the cause of diseases. We are going to use some of those same math skills to help us today. Click to show the statistics they will be using. Go through each of the statistics the students will calculate.

The students will have to use the information they have learned about fractions to create the attack rate and the incident rate. If the students can, they can try to reduce the fraction.

Slide 11:

This slide shows the next steps for the students. Review the information and divide the students into teams. Ideally, the teams will be 3-4 people.

Note: Since each team will receive one set of data, it can be useful to print the data on colored paper (each team gets their own color). This allows the teacher to easily identify that each group received only one set of data.

Slide 12:

Slide 12 shows the main analyses of the activity. Based on the information provided in the presentation, the students should be able develop a strategy to calculate the analyses.

Some classes may need more guidance on where to begin with the investigation. Typically, it is best to start broad with the analysis and work towards more specific information. Thus, students should begin by dividing the data into cases and controls, so they can calculate the incident rate. When the students are dividing the data into cases and controls, they may notice that one food is more common in the cases than others or that a food is more often in the controls. This observation can help guide them when they begin calculating the attack rates.

Disease Investigation Activity:

Instructions:

Before beginning the activity, the students should be familiar with the basic principles of epidemiology that are provided in the presentation. For the activity, the students should be divided into groups, ideally with 3-4 students each. Each group will be given a set of the data, which can be found on the ORISE website, to analyze.

The data are a group of 50 forms that mimic some of the information gathered during a disease investigation. The forms contain name, gender, symptoms, foods eaten at lunch on Monday, and first day symptoms appeared. Some of the items (name and gender) will not be needed by the students; however, students will decide what information is useful and what information is extraneous.

> *Note: The names of the students in the data are all famous scientists. Although this information is not used in the analysis, it may be worth pointing out some of the scientists. An explanation of each scientist is provided in the materials on the ORISE website.*

A worksheet is available for the group activity to help the students work through the disease investigation process. However, this worksheet is not required for the activity. It is merely a tool to provide structure to critical thinking needed for this activity. If not using the worksheet, the students should record the process they used to solve the disease outbreak scenario on another piece of paper. The students should record the number of cases, number of controls, total population, the incident rate, the attack rate for each food.

After the students receive their data, the students should begin sorting their data. Since they need to know how many people are in the sample as well as how many people are cases and how many are controls, the students may want to begin by sorting the data into cases and controls first (cases + controls = sample). They do not necessarily have to start with this step, although it will be more time efficient. Some students may want to begin by counting the total number in the sample. The students should arrive at the same answer either way.

In this lesson, a case is defined as someone who ate the school lunch, has at least 3 of the symptoms of *salmonella*, and became sick 24-72 hours after lunch on Monday. A control is defined as someone who ate the school lunch on Monday but did not get sick within the correct timeframe or did not have at least 3 symptoms.

After the students have found the number of cases, number of controls, and the number in the sample, they can calculate the incident rate. If possible, the students can reduce the fraction. Once the students have calculated the incident rate, they may have made some observations about the data. The students should, then, make a prediction of which food they think could be the culprit.

The students will then calculate the attack rates. Since the attack rates will be calculated by food item, the student may want to start with the food they think is responsible for the outbreak. Regardless of where they start, each student should calculate the attack rate for each food. If possible, they can reduce the fractions.

After the attack rates are calculated, the students should be able to identify which food is responsible for the outbreak. They should also be able to explain why they have selected that food.

The students will then be asked to graph the results of the data analysis. They students have many options for graphs, which include the following:

- Bar Graph – By Attack Rate
- Line Graph – By Number of Cases on Each Day
- Bar Graph – By Number of Cases on Each Day
- Pictograph – By Attack Rate or Number of Cases on Each Day

The types of graphs listed above are certainly not an exhaustive list. The students can choose what type of graph or graphs they would like to use.

Once the students have graphed the results, they need to decide how best to communicate the results of the investigation. Options could include a written report, a presentation to the

community, phone calls to all the parents, press release to the news outlets, and social media posts.

Formulas to Remember:

Incident Rate: number of cases / the total population

Attack Rate: number of people who ate a specific food and became ill / number of people who at the specific food

Closing:

To close the lesson, ask each group to present their findings to the class. The groups should cover which food they think is responsible for the outbreak and how they arrived at that conclusion. If time allows, the students should also present how they graphed the results and how they planned to communicate the results to the community.

Assessment:

To assess the level of understanding among the students during the activity, the teacher could walk around each group and ask questions as they work. Since groups will work at varying paces, the teacher can gage how far along in the activity the students are and address the questions accordingly. For groups that are struggling, the teacher should provide aid to help them better understand. Additionally for students who are struggling with the fractions, modify the activity so they do not have to reduce the fractions.

In the initial walk around, the teacher should check for the understanding of cases and controls. Since the rest of the activity is involves builds on the understanding of cases and controls, the students must understand these concepts to successfully proceed.

For a more formal assessment of understanding, the worksheet is used. If the worksheet is not used for the activity, each group should turn in a sheet of paper documenting their methods for investigating the disease outbreak and the results of the investigation. This should include the statistics they calculated and an explanation as to why they came to their conclusion. An answer key to the worksheet is provided on the ORISE website. If the worksheet is not used in the activity, the teacher can still find the answers to the number of cases and controls, the incident rate, and the attack rates by food in the worksheet answer key.