OVERVIEW	
Unit Title: Probability **Lesson Title:** Understanding Risk	**Length of Lesson in # of Hours:** 3-4 **# of Classes:** 2

How does this lesson connect to previous or future work as exemplified by the Standards in your scope and sequence?

This lesson was designed to provide an application lesson for a math unit on probability. Students should have already been exposed to some work with benchmark fractions, decimals and percents, especially 50% and multiples of one quarter. This could be used towards the beginning of a unit on probability because it explores very basic probability concepts and introduces students to a basic probability experiment using a spinner. Follow up lessons include further exploration of the difference between experimental and theoretical probability by running other probability experiments. The conceptual goal of the unit is for students to understand that probability involves randomness in the short term, and predictability over the long run. The application to health literacy allows students to see how this math concept applies to their life and gives them tools for decision-making and advocacy around their own health.

LESSON OBJECTIVES

At the end of this lesson, students will be able to:

- Explain their rights as a patient.
- [More accessible] Connect everyday vocabulary around probability to the probability spectrum and give examples.
- [More advanced] Connect statistical language around probability to the probability spectrum and give examples.
- [More accessible] Visualize percents as greater or less than half using a pie chart and the benchmarks 0%, 50%, and 100%.
- [More advanced] Visualize percents using a pie chart and benchmarks 0%, 25%, 50%, 75%, and 100%.
- Collect and interpret data from simple probability experiments.
- Connect probability to the long term frequency of an event occurring.

STANDARDS

Citation	*[*This portion of the standard will not be explicitly covered in this lesson.]*
7.SP.5	Understand that the probability of a chance event is a number between 0 and 1 that expresses the likelihood of the event occurring.

7.SP.6	Approximate the probability of a chance event by collecting data on the chance process that produces it and observing its long-run relative frequency, and predict the approximate relative frequency given the probability. [This lesson addresses the second part of this standard.]

1 - 3 MATHEMATICAL PRACTICE(S) ADDRESSED IN THIS LESSON	**ELEMENTS OF RIGOR**
MP 4: Model with mathematics.	*Which aspect(s) of Rigor do the targeted Standard(s) require?* ☒ Conceptual understanding of key concepts ☐ Procedural skill and fluency ☒ Rigorous application of mathematics in real-world contexts

ESSENTIAL QUESTIONS

What are my rights as a patient? How can I be informed about my options?

What does it mean if a certain treatment has a *x* percent chance of success?

EVIDENCE OF LEARNING

Ways I and my students will know the extent to which the objectives have been met.

Students will complete an exit ticket reflecting on the meaning of a treatment's success rate and considering what other factors would help them make treatment decisions.

LEARNING PLAN - Vocabulary

Vocabulary that may come up when discussing patients' rights and treatment options:

Risk

Consequences

Diagnosis

Treatment

Options
Second opinion
Cure/curable
Chronic
Survival rate
Mortality rate
Informed consent
Outcome
Side effect

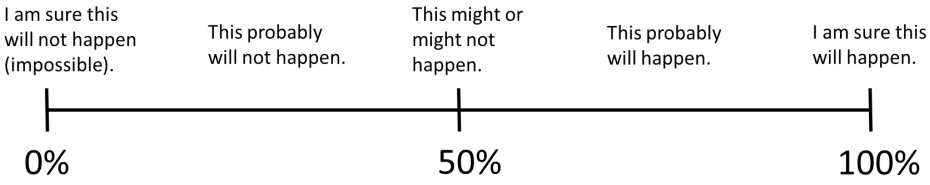
Math vocabulary:
Probability/chance/likelihood
Likely/unlikely
Impossible/certain
Percent
Possible/possibly
Probable/probably

LEARNING PLAN - Introduction	MATERIALS	TIME
Hand out *Your Rights as a Patient (True/False)*. Use this to start the discussion about what rights we have as a patient and to discuss some of the vocabulary below, as it comes up. If you want to discuss more about Patients' Rights, hand out a copy of Patients' Rights from the American Medical Association (available at https://www.ama-assn.org/delivering-care/ethics/patient-rights). Students can read and paraphrase the rights listed here in the AMA's Code of Ethics.	Copies of *Your Rights as a Patient (True/False)* Copies of "Patients' Rights" from the AMA	30 mins

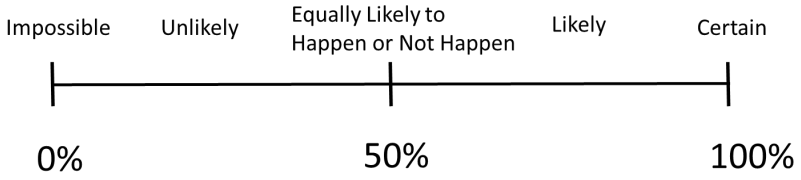
LEARNING PLAN – Body of the Lesson	MATERIALS	TIME
What is risk?		
1. Show video from the FDA: *Do Teething Babies Need Medicine on their Gums? No.* https://youtu.be/kddC8kEm4-I, also can be found on FDA's website at https://www.fda.gov/ForConsumers/ConsumerUpdates/ucm385817.htm 2. Based on what you saw in the video, why is the medication used on baby's gums considered risky? *Note to teacher: The data can be found here https://www.fda.gov/Drugs/DrugSafety/ucm608265.htm. It is interesting to note that there is only one recorded infant fatality, and 11 cases of methemoglobinemia in children under 2. However, that is only what has been reported.* 3. Discuss the idea of risk, which is based on two factors: how bad the possible outcome could be and how likely a bad outcome is. 		15 mins

4. Have the class generate examples of things that fall into each category. 5. How does risk affect decision making? Share.		
Probability Spectrum and Vocabulary		
1. The words and concepts of *probability, likelihood,* or *chance* of something occurring can be challenging for native and non-native speakers alike (especially "likelihood," which is often incorrectly interpreted as "likeableness"). Start by assessing students understanding of more common words for these concepts (possibly, probably, probably not, certain / sure, impossible) by posing questions: • Name one thing you will probably (possibly, probably not) do tomorrow. • Name one thing you are sure that you will do tomorrow. • Name something that you are sure will not happen tomorrow (impossible). (If these more common phrases for probability are unfamiliar to your students, you may want to focus just on these for now, with some sentence starters, role plays, or other activities to practice their use. If students are already fluent with these everyday ways of talking about probability, you can use these concepts as a jumping off point to connect to the terms *likely*, *unlikely*, *likelihood*, etc.) Collect different student examples on the board for each level of probability. 2. Explain that all of these words or phrases describe the *probability* of something happening. Create a class definition for probability. The definition should mention something about what we expect to happen, or how confident we are that something will happen or not happen. 3. Draw a probability spectrum on the board, like the one below, and have students label their own on a copy of *Probability Spectrum*. Use the terms that are appropriate for your learners. Sort the student examples that (subjectively) match these different probabilities. Have students rate for themselves the probability of different things happening (What will happen tomorrow? on the *Probability Spectrum* handout).	Copies of *Probability Spectrum*	45 mins

Everyday language:



Statistical language:



4. Explain that we can put numbers to probabilities between 0% and 100% and add numbers (with percent and fraction/decimal equivalents) to the spectrum for 0%, 50%, and 100%. (If students are unfamiliar with percents, define percent as "per hundred" and give examples.)

Making Sense of Percent Chance

Visualizing percents with a pie chart:

1. Using two paper plates of different colors, cut each paper plate to the center and fit together (see photo). If you don't have paper plates, you can have students use mini whiteboards to draw pie charts. It helps to have them create something large enough that you can look around the class quickly to see who understands.

Paper plates in two contrasting colors to make pie chart makers, one set per student or pair

60 mins

2. Give each student or pair of students a set of plates. Using the plates, ask students to show you:
   - 50% red [or other color]
   - 0% red
   - 100% red

   Make sure students understand that 0% means none or 0, and that 100% means the whole, or 1.

3. Next, ask students to show you:
   - More than 1/2 red
   - Less than 1/2 red
   - Almost 100% red
   - A little more than 0% red
   - A little more than 50% red

Ask students to estimate what percent red they think their pie might be for each one.

4. If students are comfortable with the language and concept of ½ (50%), you can also introduce the benchmarks ¼ (25%) and ¾ (75%) in a similar way, and ask them to use the pie plates to show you things like:
   - 1/4 red
   - 25% red (Follow with, *What percent would be blue?*)
   - 75% red (Ask those who show this correctly how they know.)
   - A little less than 25% red
   - More than 50% red but less than 75% red

5. Next, distribute the handout *Treatment Options*. Review with students approximately what percent of each circle is shaded (more than 50%? close to 75%?, etc.). Now explain how to create a spinner with a pencil tip and a bobby pin (paper clips work, too, but are slightly less precise). Explain that each circle represents a treatment option for a medical condition. If the spinner lands on "Works," then the treatment works and the patient gets better. If the spinner lands on "Does not work," then the treatment does not work and the patient does not get better. Have them spin a few times on each of the first four treatments and interpret the results (did the treatment work or not?)

Copies of *Treatment Options*

Sharpened pencils

Bobby pins (or paper clips)

6. Using whatever level of vocabulary is appropriate for your students (Everyday language or Statistical language), help them to connect the circle graphs to the probability spectrum by asking questions like:
   - Which treatment are you sure/certain will work?
   - Which treatment are you sure/certain will not work?
   - Which treatment will probably work (is more likely to work)?
   - Which treatment probably will not work (is unlikely to work)?
   - Which treatment has an equal chance of working or not working?

   Have students spin ten times on the last spinner (50% success rate). Did the treatment work half of the times? Have pairs share data and reflect on why some of the groups had more or less than half successful treatments. What does this tell us about probability?

Collecting Data and Final Discussion

1. Give the class the following final "treatment" from the *Treatment Options* handout:

   Medication Treatment: 70% success rate.

   Have pairs sketch a spinner for this treatment. Go around and check spinners before collecting data.

2. Ask the class to make predictions based on the following questions: *If we spin the spinner ten times, how many times do you think the treatment will be successful? Why? What if we spin it 100 times? Why?* Collect predictions on board.
3. Have each pair spin ten times and record their results. Share results with the class. How closely did they match predictions?
4. Have each pair collect a few more sets of ten spins. Collect all class data on a poster or board.
5. Ask, *How closely did the sets of ten match the predictions?* Compile all the data together. Then ask, *How closely does the larger set match the prediction? How closely does the actual success rate match the given 70% success rate of the treatment?*

20 mins

6. Discuss results. Ask, *Why does a larger set of data generally get closer to the given success rate?* ***Note to teacher:*** *Push for an understanding that probability predicts the outcome in the long run, over many trials. For any small group of trials, we can and will see fluctuations, because outcomes are random in the short term. Probability: Short term randomness, long term predictability.* 7. [Optional] Give groups prompts to discuss (*Discussion Cards*), or discuss one or more of these prompts as a class. How does the discussion relate to probability and risk?	Copies of *Discussion Cards*	
Digital Literacy Extension		
1. Use an online probability simulator to run more trials. One that uses a spinner and is fairly easy to use is http://www.shodor.org/interactivate/activities/AdjustableSpinner/ 2. Show students how to use the interface. Give out copies of *More Trials* and have students work with a partner to complete. 3. Bring the class together to debrief. Relate the trials back to the context: each trial would be one person who received the treatment. **What happened as the number of trials increased?** **Why did the results get closer to the predicted success rate with more trials?** 4. [Optional Extension] Give out *Medical Researcher*, and have students discuss the questions with a partner. Encourage them to use the simulator to run 10 or 500 trials to help in their discussion.	Access to computers and internet Copies of *More Trials* [Optional] Copies of *Medical Researcher*	45 mins
LEARNING PLAN – Closure / Conclusion	**MATERIALS**	**TIME**
Exit ticket prompt: Your doctor gives you a diagnosis and explains that surgery has a 50% success rate. What does that mean? What else would you want to know in order to make a decision?		10 mins

Suggestions for Differentiation	MATERIALS
More accessible: • Use everyday language for the probability spectrum. • Reference only probably/probably not by comparing to the benchmark of ½ (50%). When students are collecting data on the "Medication Treatment," use a success rate of 75%. More challenging: • Use statistical language for the probability spectrum. • Groups who need an extra challenge can work on *Treatments and Risk*, which involves three possible outcomes and requires a more sophisticated use of benchmark percents.	Copies of *Treatments and Risk*

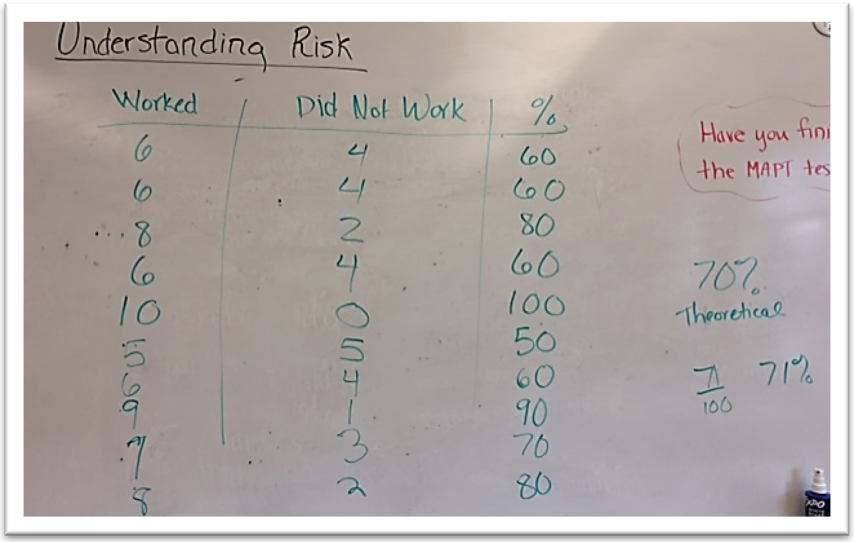
Additional Resources

Think it Through: Managing the Benefits and Risks of Medicines, available at: https://www.fda.gov/Drugs/ResourcesForYou/Consumers/ucm143558.htm

Lesson in Action: Teacher Reflection - Melissa Braaten, *Haitian Multi-Services Center, Catholic Charities,* Dorchester, MA

I piloted this lesson in a science class with a group of five ABE students with varying levels of math ability. I taught the lesson over two classes of 90 mins each, and we were able to engage in all the main activities, but did not have time for the discussion cards or the *Medical Researcher* handout.

My pilot group had more background information than I had anticipated, and they were familiar with both benchmark fractions and most of the vocabulary (statistical and health related). They had no problem connecting the spinners to simulating whether a treatment worked or not. We actually went through the first part of the lesson quickly. When we ran the trials for the 50% and 70%, there was some variation in the groups of ten trials (see photo on following page), while the percentage for 100 trials was pretty close to the theoretical. I introduced the terms subjective probability, theoretical probability, and experimental probability since the group was not struggling with the other vocabulary.



In the second class, the whole group worked on *Treatment and Risk*, since they seemed to need more challenge. This activity went well. (Side note: I definitely recommend the bobby pins for the spinners. They worked great.) We collected 100 spins for each of the treatments, and students were excited that our experimental percentages closely matched the theoretical. I deliberately chose to use groups of ten and a total of 100 so that the percentages would be easy to understand. Given the math background of the group, I didn't want to spend time on calculating percentages beyond the basic benchmarks, as I was worried it would take too much focus away from the probability concepts at the center of the lesson.

The activity *More Trials* using on online spinner was especially effective. Even before they started the activity, one student said they wondered if the percentages will get closer to the theoretical as we did more spins. At the end, we shared our experimental percentages for ten, one hundred, and one thousand spins, and students agreed that with more spins, our experimental results got closer and closer to the theoretical. This allowed us to wrap up the lesson by defining probability as the prediction of what will happen in the long run, even if the short term results are random. I ended by mentioning that this idea is what allows for research: in the real world, we often don't know the theoretical probability (such as, what are the chances that a woman will develop breast cancer in her lifetime?). So, we collect lots of data about what actually happens, with the idea that after enough "trials," the percentages we observe in the real world will get closer and closer to the actual, underlying probability. If I taught this lesson again, or had more time, I would have liked to investigate together some actual medical research and look at how it is conducted to drive the last point home.

Your Rights as a Patient

True or False?

You have the right to refuse treatment, even if your doctor recommends it.

Doctors only have to provide you with information in English. It is your job to make sure you can understand it.

You have the right to ask for a second opinion (to have another doctor examine you).

Doctors don't have to show you your medical records or test results.

Doctors are required to explain everything about your diagnosis and treatment options and to make sure that you understand them.

Family members can access your medical information without written permission.

Your Rights as a Patient

True or False? Answer Key

You have the right to refuse treatment, even if your doctor recommends it.

TRUE – In most cases. There are a few exceptions, such as if the patient is of "altered mental state" (from drugs or mental illness).

Doctors only have to provide you with information in English. It is your job to make sure you can understand it.

FALSE – You have the right to request translation into another language.

You have the right to ask for a second opinion (to have another doctor examine you).

TRUE

Doctors don't have to show you your medical records or test results.

FALSE – You have the right to get all of your medical records.

Doctors are required to explain everything about your diagnosis and treatment options and to make sure that you understand them.

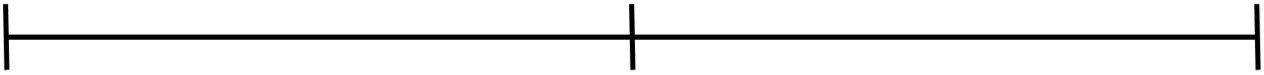
TRUE – This is called "Informed Consent."

Family members can access your medical information without permission.

FALSE – Under HIPPA, family members cannot access your information without your explicit consent (unless they have been appointed to represent you by the state).

Sources:
https://www.verywellhealth.com/do-patients-have-the-right-to-refuse-treatment-2614982
https://www.hhs.gov/answers/health-care/what-are-my-health-care-rights/index.html
https://www.hhs.gov/answers/hipaa/index.html
https://www.mass.gov/service-details/learn-about-your-right-to-an-interpreter

Probability Spectrum



What will happen tomorrow?

Write the letter of each statement where it would fall on the probability spectrum for you.

A) I will come to class tomorrow.

B) I will wake up in another country tomorrow.

C) I will win money in the lottery tomorrow.

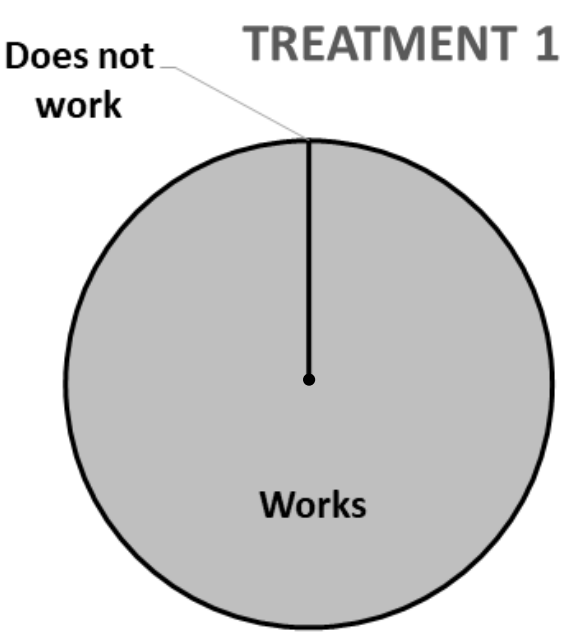
D) I will eat breakfast tomorrow.

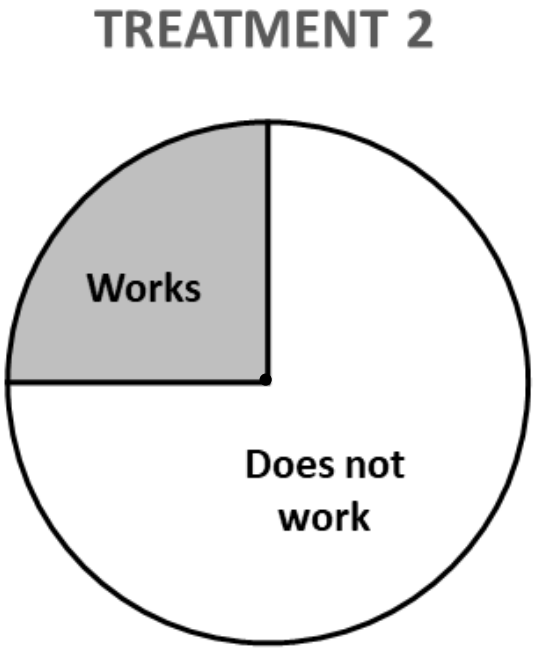
E) I will drink coffee tomorrow.

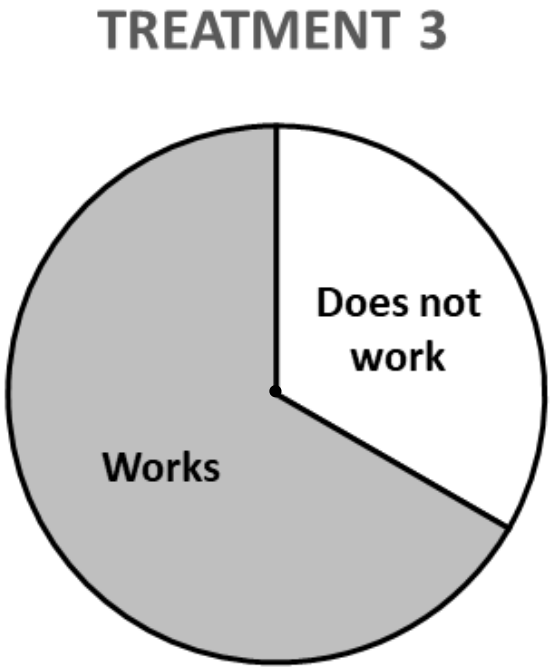
F) I will read a book to my child tomorrow.

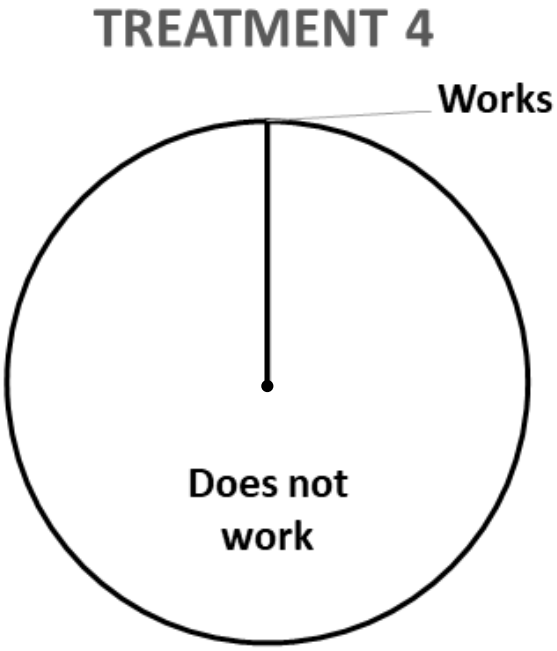
Treatment Options

If the spinner lands on "Works," the treatment works and the patient gets better. If the spinner lands on "Does not work," the treatment does not work and the patient does not get better.



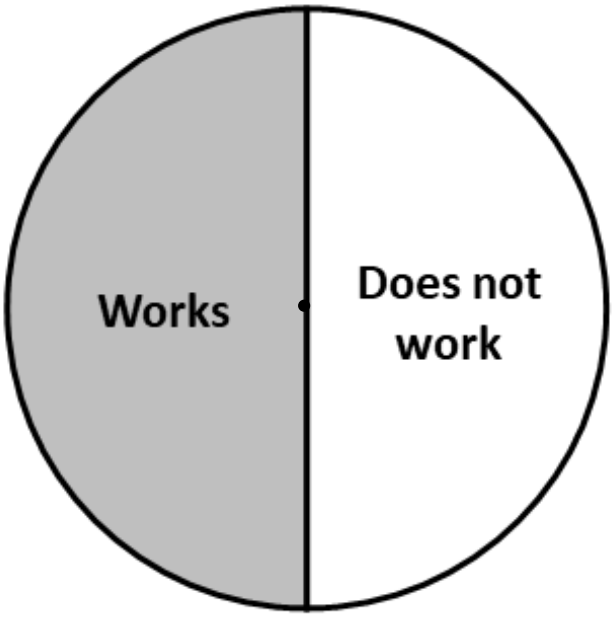






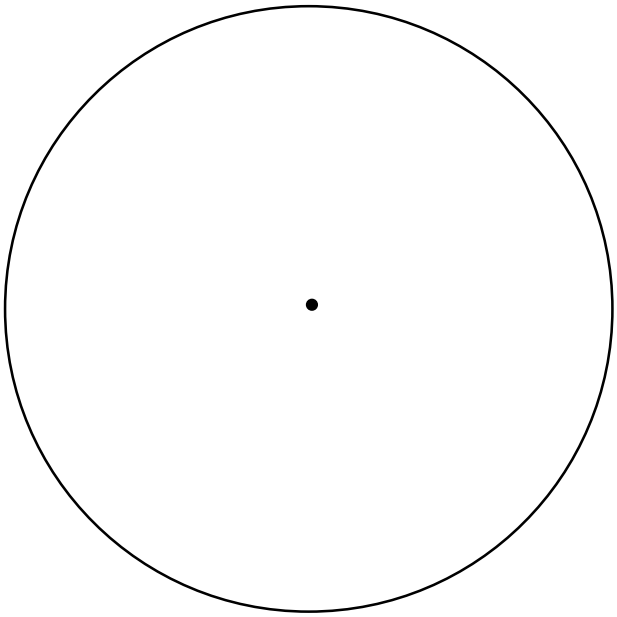
Spin ten times. Record your results below.

TREATMENT 5



Works	Does not work

Medication Treatment: 70% success rate



Works	Does not work

Discussion Cards

You are offered a treatment with a high success rate (90%), but there is a very small chance of serious side effects (1 out of every 10,000 people who receive the treatment go blind).

Another treatment option has a lower success rate (75%), but no chance of side effects.

Which would you choose and why? What else would influence your decision?

You have a choice between two treatments. Both are almost certain to work (close to 100% success rate).

The first treatment has a small chance of a serious side effect (1% of people who receive the treatment develop serious migraines).

The second treatment has a moderate chance of a milder side effect (30% of people who receive the treatment experience nausea).

Which would you choose and why? What else would influence your decision?

Your doctor recommends a treatment that she says has a 60% success rate. You know two people who have had the treatment, and it did not work for either of them.

How would this influence your decision?

Discuss a time when you had to make a decision based on probability and risk. It does not have to be health-related.

More Trials

Each time we spin the spinner is called a "trial." We can think of each trial as one patient who was given the treatment.

1. Go to http://www.shodor.org/interactivate/activities/AdjustableSpinner/

2. Click on -1 to reduce the number of sectors to 2.

3. The pink will mean that the treatment works, the blue will mean that the treatment does not work.

   Adjust the blue and pink so that you have a 70% success rate (70% pink, 30% blue).

4. Start with 10 spins. Click "Spin." Your results will appear in the box on the right.

   "Count" refers to how many of each color were spun.
   "Experimental" refers to the percent of each color that were spun.
   "Theoretical" is how you set up the spinner (it should say 70% pink, 30% blue).

   Record your results below.

Count (10 spins)	**Experimental %**
Pink (Treatment works)	Pink (Treatment works)
Blue (Treatment does not work)	Blue (Treatment does not work)

5. Click on "New Experiment." Now set the spinner to 100 spins. Click "Spin." Record the results below.

Count (100 spins)	Experimental %
Pink (Treatment works)	Pink (Treatment works)
Blue (Treatment does not work)	Blue (Treatment does not work)

6. This time, don't click on "New Experiment"; just click "Spin" again. The computer will add another 100 spins to your results, so you now have 200 spins total. Spin a few more times. **How do the experimental percents change as you have more spins?**

7. Click "New Experiment" to clear your results. Now have it run 1,000 spins. Record the results below.

Count (1,000 spins)	Experimental %
Pink (Treatment works)	Pink (Treatment works)
Blue (Treatment does not work)	Blue (Treatment does not work)

What happens to the experimental percent as you have more spins? What does this tell us about probability?

Medical Researcher

You are told that a certain treatment has an 80% success rate. You collect data about patients that were given the treatment and whether the treatment worked.

HOSPITAL 1:

10 patients were given the treatment.

The treatment worked for 6 patients (60%).

The treatment did not work for 4 patients (40%).

Based on this data, do you think the given success rate for the treatment (80%) is accurate? Why or why not?

Now you collect more data on the same treatment (80%).

HOSPITAL 2:

500 patients were given the treatment.

The treatment worked for 350 patients (70%).

The treatment did not work for 150 patients (30%).

Based on this new data, do you think the given success rate for the treatment (80%) is accurate? Why or why not?

Treatments and Risk

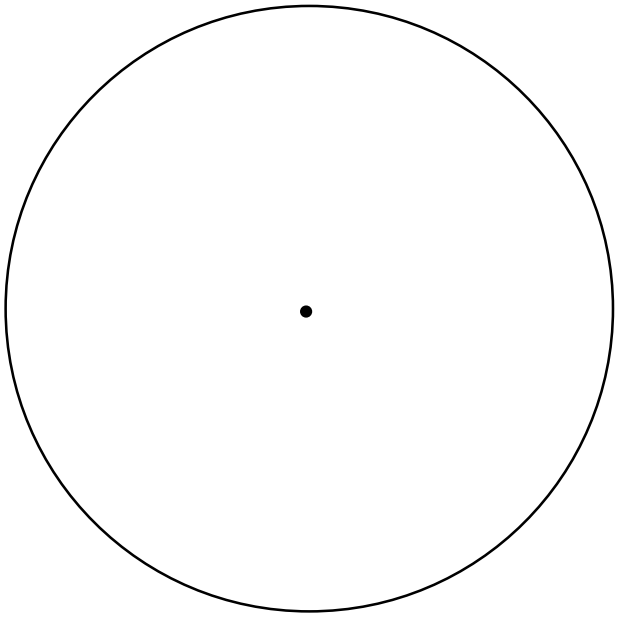
Some treatments also have a risk of side effects. Sketch a spinner for each treatment described below. Then spin on each spinner 10 times and record your results.

Treatment 1:

50% chance it will work with no side effects

25% chance it will work, but will cause nausea

25% chance it will not work and will cause nausea



Spin ten times. Record your results below.

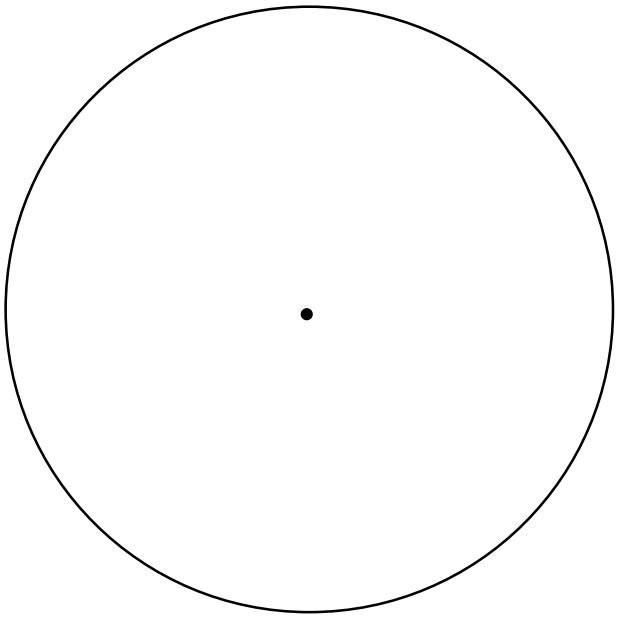
Works, no side effects	Works, causes nausea	Does not work, and causes nausea

Treatment 2:

30% chance it will work with no side effects

50% chance it will not work and will have no side effects (does nothing)

20% chance it will not work and will cause nausea



Spin ten times. Record your results below.

Works, no side effects	Does not work, and has no side effects	Does not work, and causes nausea

If you had to make a choice, which treatment would you choose? What would you consider? What other information would you want to know?