Bone Fracture Risk and Big Data

Part 1: Predicting Bone Fracture Risk

Your laboratory has been asked to conduct medical tests and collect data to determine if the data could be used to predict a woman's risk for bone fractures (breaks) when she gets older. Four women (1, 2, 3, and 4) have volunteered to be subjects in the research study that will collect data about possible risk factors for bone fractures.

Woman 1
50 years old

Woman 2
55 years old

Woman 3
58 years old

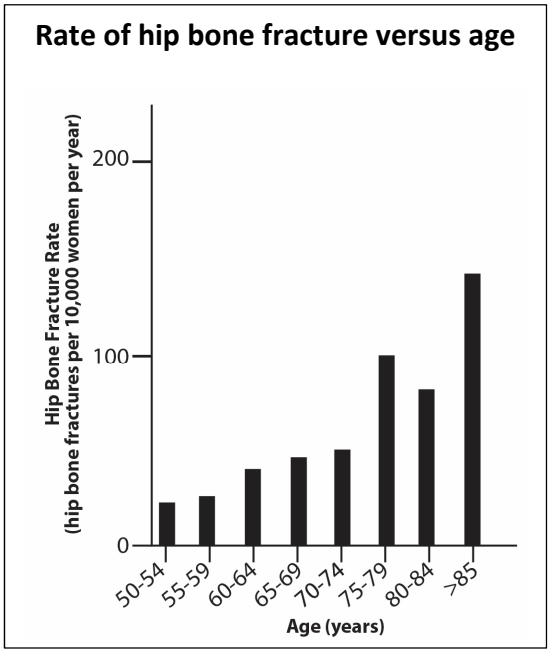
Woman 4
53 years old

1. Describe the association between age and the rate of hip bone fracture shown in the graph on the right.

   _____

   _____

   _____



2. Record the ages of the four women on the **Data Set for Bone Fracture Risk** sheet on the last page of this handout. *You should tear this sheet off to make it easier to record your data.*

3. Which of the four women (1-4) is most at risk for hip bone fractures? Support your conclusion with specific information from the graph.

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A. Bone Density Test

A bone density test uses a low dose X-ray machine and a computer to determine how much calcium and other bone minerals are contained in a segment of bone. The bones that are most commonly tested are in the spine, hip and forearm. Denser bones have higher bone calcium content and are usually stronger.

Bone density test results are reported as "T-scores." Low T-scores indicate bones have low bone density. Bones with low density are porous (have many pores or open spaces). Porous bones are weak and more likely to fracture.

1. Put an X in front of all the characteristic of strong bones that are less likely to fracture.

   ____ High T-Score ____ More porous ____ High bone density ____ Less calcium

2. Use the sheet that shows simulated **Hip Bone X-Ray Images** for the four women. Refer to the **Bone Density T-Scores** sheet**.** Compare the hip bone X-ray images from each of the four women (1, 2, 3 and 4) with the "Standard Scale of Hip Bone Density T-Scores."

3. Record the T-scores for each of the women in the appropriate column on the **Data Set for Bone Fracture Risk** sheet.

4. Based only on the **bone density test results** which woman (1, 2, 3, or 4) would you predict is most at risk for bone fractures when she gets older? Support your conclusion with evidence from the bone density test results data and the "Bone Density and Bone Fracture Probability" graph.

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B. Blood Plasma Tests for Calcium, Vitamin D, and Estrogen

Normal levels of calcium, vitamin D, and estrogen (female sex hormone) are thought to play an important role in a bone health. The levels of these chemicals in the body can be tested in blood plasma (the clear watery part of blood). Because calcium, vitamin D, and estrogen are essential for normal bone health, low levels of these chemicals can lead to decreased bone density and increased fracture risk.

1. Test the blood plasma from each of the four women (1, 2, 3, and 4) by following the **Instructions for Plasma Tests: Estrogen, Vitamin D, and Calcium**.

2. Record the results of the plasma tests for estrogen, vitamin D, and calcium in the appropriate columns on the **Data Set for Bone Fracture Risk** sheet.

3. Based only on the **plasma test results**, which woman (1, 2, 3, or 4) would you predict is most at risk for bone fractures when she gets older? Support your conclusion with evidence from the plasma testing data.

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C. Bone Marker Tests

Bone is living tissue that is constantly being formed (built up) and resorbed (dissolved). Bones are **strong** when:

- F = R Bone **F**ormation is equal to Bone **R**esorption
- F > R Bone **F**ormation is greater than Bone **R**esorption

Bones become **weak** when:

- F < R Bone **F**ormation is less than Bone **R**esorption

Bone markers are substances in blood plasma that indicate the relative activities of bone forming cells and bone resorbing cells. Bone marker tests measure enzymes and proteins released into the blood plasma during bone formation and during bone resorption. Bone marker tests are done to determine if the rates of bone resorption and bone formation make bone stronger or likely to fracture.

1. Test the plasma from the four women (1, 2, 3, and 4) by following the **Instructions for Bone Marker Test.**

2. Record the results of the bone marker tests in the appropriate column on the **Big Data Set for Bone Fracture Risk** sheet by writing "Strong" or "Weak".

3. Based only on the **bone marker test results**, which woman (1, 2, 3, or 4) would you predict is most at risk for bone fractures when she gets older? Support your conclusion with evidence from the bone marker testing data.

_____

_____

_____

4. Can you use the results of a woman's bone marker test to **accurately** predict her bone density? Support your answer.

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Follow your teacher's instructions for clean-up before you go on to the next part.

D. Medical Records Information

The **Graphs: Bone Fracture Risks** sheet summarizes other factors such as exercise, body mass index, smoking, and alcohol consumption that affect a woman's risks for bone fractures.

1. Describe the association between **alcohol consumption** and bone fracture risk.

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   _____

2. Describe the association between **body mass index** and bone fracture risk.

   _____

   _____

3. Describe the association between **exercise** and bone fracture risk.

   _____

   _____

4. Describe the association between **smoking** and bone fracture risk.

   _____

   _____

5. The Medical Records Information for the four women has already been entered on the **Data Set for Bone Fracture Risk** sheet. Circle the data for each factor (alcohol, BMI, exercise, and smoking) that puts women at risk for bone fracture. *See the example for Alcohol Consumption in the data set.*

6. Based only on the **Medical Records Information** and the **Graphs: Bone Fracture Risks**, which woman (1, 2, 3, or 4) would you predict is most at risk for bone fractures when she gets older? Support your conclusion with evidence from the medical records data.

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E. Considering All of the Information

1. Based on **all of the information in the data set**, which woman (1, 2, 3, or 4) is most likely to have a bone fracture during the next 10 years? Support your answer with evidence from all of the information that you collected.

2. Based on **all of the information in the data set**, which woman (1, 2, 3, or 4) is least likely to have a bone fracture during the next 10 years? Support your answer with evidence from all of the information that you collected.

Part 2: "Big Data" to Predict Women's Bone Fracture Risk

It is now 10 years after you collected the original data set from the four women. Since then, additional information (data) that may be related to the women's bone fracture risks has become available from a variety of electronic source such as health records, insurance records, online purchase activity, and social media.

1. Open the envelope labeled "DO NOT OPEN until Part 2". This envelope contains information that may be related to the bone health of the four women 10 years later.

2. According to the **10 Years Later – Additional Data from a Variety of Electronic Sources**, which of the four women had bone fractures? _____ and _____

3. Was the data that you collected and analyzed in Part 1 (on the previous page) accurate in determining which of the four women were likely to have bone fractures when they were 10 years older? Support your answer with evidence.

   _____

   _____

   _____

4. If a researcher conducted the same experiment with four other women, do you think that the results would be similar or different?

   _____

   _____

5. How could the experiment be improved to provide more reliable data?

   _____

   _____

   _____

   _____

The data from a research study is **reliable** if it would yield the same or very similar results when done a second time. One way to increase reliability in an experiment is to increase the number of research subjects.

6. Why is having reliable data from an experiment important if researchers are trying to make accurate predictions about a woman's risk of bone fractures?

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   _____

Imagine what a data table would look like if you combined the data you collected from four women with data collected from thousands of other people. This would create a "**big data"** set that could be analyzed to determine which factors (bone density, bone markers, calcium levels, exercise, etc.) are reliable for predicting bone fractures. The data table would have thousands of rows (one for each person). Computers would be needed to record and analyze the data.

7. Collecting data from thousands of people would be time consuming and expensive. Why is creating a "big data set" from thousands of people worth the effort?

   _____

   _____

Big data research goes beyond simply including a large number of people. A big data research study includes many different **types of data** from many different **data sources**. Analyzing additional types of data increases the likelihood that some of the factors (types of data) might affect bone fracture risk.

Look at the **10 Years Later – Additional Data from a Variety of Electronic Sources.** Notice that most of this data could be "collected" automatically from electronic sources such as phones, computers, medical records, home control devices, and wearable devices. There would be no need to enroll the women in a research study and remain in contact with them over a 10 year period.

8. If you were able use additional factors (types of data), do you think that would improve the ability to predict a woman's bone fracture risk? Explain why or why not.

   _____

   _____

9. List at least 10 other factors (types of data) that <u>might</u> have influenced the women's bone fracture risk.

   - _____
   - _____
   - _____
   - _____
   - _____
   - _____
   - _____
   - _____
   - _____
   - _____

10. What is the advantage to collecting many different types of data for the people in a "big data" research study?

    _____

    _____

It is likely that you are already a part of big data studies without even knowing it. There are many data sources that could already be providing different types of data (information) about you! This data could automatically be added to big data sets without your knowledge.

11. The chart below describes some data sources and examples of types of data from those sources. Complete the chart:
    - Provide two additional examples of **types** of data about you that could be obtained from each source.
    - Suggest another data source, and provide two examples of types of data that could be obtained from this source.

Data Sources	**Types of Data (Factors)**			
Medical records	Birth month	Blood pressure		
Social media	Appearance	Number of friends		
Home monitoring devices (Alexa/Dot)	Time at home	TV shows watched		
Mobile Devices (phone/activity tracker)	Locations visited	Hours of sleep		
Credit card purchases	Medicines purchased	Clothing styles		

12. The types of data in the chart above are not necessarily related to bone density, osteoporosis, or bone fracture risk.
    - Circle three types of data on the chart that might be associated with bone fracture risk.
    - Draw an X over three types of data on the chart that are unlikely to be associated with bone fracture risk.

The data table you used for the four women only included eleven types of data (information) about the four women. Imagine what the "big data" set would look like if you added all of these types of data:

- data from thousands of people
- types of data (factors) listed in question 9
- types of data from the chart in question 11

13. How would the data table from the "big data" set be different from the data table that you made for the four women?

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_____

14. What is meant by the term "big data"?

_____

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15. Why might analysis of "big data" be more effective than traditional controlled experiments in identifying factors that affect women's risk for bone fractures?

_____

_____

16. How is "big data" research different from the controlled experiments typically associated with traditional science research?

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Data Set for Bone Fracture Risk

Woman	Age	Bone Density (T-Score)	Plasma Tests			Bone Marker Test	Medical Records Information			
			Estrogen	Vitamin D	Calcium	Indicates that bones are… (Strong or Weak)	Alcohol Consumed (Drinks per Day)	Exercise Amount	Smoker	BMI (Body Mass Index)
1							1	Little	Yes	30
2							1	Active	No	25
3							3	Average	No	20
4							1	Average	Yes	15