Analyzing Data for Patient Health

Print:

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Industry Sector: Healthcare
Content Area: Mathematics
Core Topic: Statistics & Probability - Interpreting Categorical and Quantitative Data

Expand All | Collapse All

Common Core State Standards

HSN-ID.A.1. Represent data with plots on the real number line (dot plots, histograms, and box plots).
HSN-ID.A.2. Use statistics appropriate to the shape of the data distribution to compare center (median, mean) and spread (interquartile range, standard deviation) of two or more different data sets.
HSN-ID.A.3. Interpret differences in shape, center, and spread in the context of the data sets, accounting for possible effects of extreme data points (outliers).

Adult Basic Education Standards

Standard 3S3. Describe data using numerical descriptions, statistics and trend terminology http://www.doe.mass.edu/acls/frameworks/mathnum.pdf p. 52

Industry Overview

Healthcare in America

From neonatal nurses to radiology technologists, medical coders to medical office assistants, health educators to home care aides, the healthcare industry provides a vast and diverse array of services to individuals at every stage of life. Providing nearly 17 million jobs and accounting for an estimated $18 million of the U.S. GDP in 2009, healthcare is the nation's largest industry. In Massachusetts, in particular, healthcare accounts for more than 15% of employment (compared with 12% nationally), accounting for approximately one in six jobs. With an aging baby boomer population that is living longer, there is greater demand for more and higher quality preventative and long-term healthcare across the United States. With eight of the 30 fastest growing occupations, healthcare is predicted to

be one of the fastest growing industries both nationwide and in Massachusetts between now and 2020.

Careers in Healthcare

The healthcare industry includes a vast array of jobs related to planning, managing, and providing therapeutic services, diagnostic services, health informatics, support services, and biotechnology research and development. This industry includes five career pathways:

- therapeutic services, which includes professionals who work directly with patients to improve their health by providing direct care and treatment for patients (for example, a nurse or a physical therapist assistant);
- diagnostic services, which includes professionals who plan and conduct tests to detect and diagnose diseases and injuries, and use test results to plan treatment (for example, a radiologic technologist or a sonographer, who perform diagnostic imaging examinations, such as X-rays or ultrasounds);
- health informatics, which includes professionals who compile and manage health information and records (for example, a medical records and health information technician, who organizes and manages patient databases; higher-level positions, such as administrators of healthcare facilities or departments, are also included in this pathway);
- support services, which includes professionals who provide assistance to other medical professionals, allowing them to do their jobs in diagnosing and treating patients or supporting therapies (for example, food service workers and nutritionists ensure that patients' meals are healthy and meet dietary guidelines); and
- biotechnology research and development, which include careers that involve bioscience research; while many of these professions require doctoral or medical degrees, some entry-level opportunities in the field require only an associate degree (for example, food and agricultural science technicians).

Mathematics and Communication Skills Needed in Healthcare

The growing complexity of the healthcare industry, including changing technologies, requires workers to continuously upgrade their skills. In addition to technical skills specific to their job, mathematics and literacy skills are crucial for success in all occupations across the healthcare industry.

Communication: First and foremost, no matter the job, good healthcare practitioners are committed to giving patients the best care available and keeping abreast of health research and developments in the field. All workers need to be able to read medical journals and understand medical terminology and vocabulary, as well as read and write literate emails to co-workers/supervisors. Many healthcare jobs also require the ability to read and interpret charts and access and interpret electronic medical records in order to provide quality care.

Many health careers, especially—but not exclusively—those in therapeutic services—involve interacting with patients and their families, in some cases working with people who may be sick, disabled, or dying. Even support staff in a medical office or hospital require effective oral communication skills as well as compassionate interpersonal skills such as the ability to listen and talk to patients to assess needs. Effective communication with colleagues as well as patients is crucial. Healthcare is increasingly a group activity, in which a patient's recovery depends on how well all members of a healthcare team perform specific function, and how well they communicate and collaborate with one another.

Mathematics: From reading charts to interpreting data to measuring and administering correct medicine, basic mathematics skills are essential for providing quality care across most healthcare occupations. Nurses, for example, use mathematics for calculations in all areas of their duties. They use mathematics to calculate dosages, caloric requirements for individual patients, calibrate equipment, and interpret lab results. Charts and patient data are often presented as decimals or percentages, and a nurse must be able to convert between the two, thus requiring competency in understanding and using ratios, proportions and percentages.

Much of modern medicine is based on statistics, and all workers in the industry should have a basic understanding of how statistics are used to influence medical trends. Nurses, for example, need to be aware of the statistics behind prescribing medications and possible side effects or complications. They might use statistics to counsel patients on diagnoses or prognoses, or in gathering patient histories.

Career Opportunities in Healthcare with Education from Community Colleges

Massachusetts Community Colleges play a crucial role in preparing students for careers in health sciences across all sectors of the industry—therapeutic services, diagnostic services, informatics, and support services. All 15 community colleges offer pathways to nursing careers, the largest occupation in the healthcare industry. Additionally, Massachusetts Community Colleges offers associate degree and certificate programs that prepare students to enter occupations across all sectors of the industry, for example:

- *Therapeutic services:* registered nurse, practical nurse, nursing assistant, certified nurse's aide, massage therapist, fitness trainer and instructor, dental hygienist, dental assistant, pharmacy technician, physical therapist assistant, occupation therapy assistant, respiratory assistant, medical assistant
- *Diagnostic services:* radiologic technologist and technician, radiographer, surgical technologist, sonographer, phlebotomist, paramedic, polysomnographic technologist and technician, medical and clinical laboratory technician, magnetic resonance imaging technologist, nuclear medicine technologist, veterinary technologist
- *Informatics:* Medical record and health information technician, medical coder, medical interpreter, medical biller, medical transcriptionist, health educator

Recent Career Opportunities in Massachusetts

The following is a sample of healthcare job listings in Massachusetts that require an associate's degree or certificate:

- Registered Nurse (RN), AmeriCare At Home, Boston, MA [show]
- Medical Technologist, Emerson Hospital, Concord, MA [show]
- Ultrasound Technologist, Brockton, MA [show]
- Licensed Practical Nurse, Hologic, East Watertown, MA [show]

Employment Outlook for Healthcare

America's aging population is now nearing or entering retirement (opening new jobs), and will continue to require more services and the increased use of innovative medical technology for diagnosis and treatment. As a result, healthcare is one of the fastest growing industries both nationwide and in Massachusetts, where growth is even higher than nationally. For example, in 2010, Baystate Health of Springfield, which employs more than 10,000 across its Western Massachusetts system, said that it would likely need to hire about 15,000 people between 2010 and 2020 to replace retiring workers and meet increased demand.

One important factor in the healthcare industry is the financial pressure on hospitals to focus on efficiency and profitability, which results in discharging patients as soon as possible. These financial pressures, along with increased healthcare coverage under federal law, will likely result in a growth in out-patient services in the healthcare industry, such as rehabilitation clinics, long-term care facilities, and home care programs. As a result, occupations experiencing the largest growth include home care aides, physical and occupation therapist assistants, dental hygienists, and medical assistants.

Emerging careers in Health/Information Technology (HIT): Estimates based on data from the Bureau of Labor Statistics (BLS), Department of Education, and independent studies indicate a shortfall of approximately 51,000 qualified Health IT (HIT) workers who will be required over the next five years to meet the needs of hospitals and physicians as they move to adopting an electronic healthcare system, facilitated by the Health Information Technology for Economic and Clinical Health (HITECH) Act of 2009. The HITECH Act is a key component of healthcare reform. The Act encompasses interoperable electronic health records (EHRs) including computerized systems to order tests and medications, and support systems to aid clinical decision making and the development of a national health information network to permit the secure exchange of electronic health information among providers. The Congressional Budget Office estimates that the incentive mechanisms in the HITECH Act will increase HIT adoption rates from 45 percent to about 70 percent for hospitals and from 65 percent to approximately 90 percent for physicians. To support job growth in this emerging career field and ensure the adoption of EHRs, new types of workers are needed to facilitate information exchange across healthcare providers and public health authorities, and assist in redesigning workflows within healthcare settings to maximize the quality and efficiency benefits of EHRs, while maintaining privacy and security of health information and records. To that end, the Department of

Health and Human Services has embarked on an initiative to build the HIT workforce with community colleges as the primary training ground for these new workers: (1) Practice workflow and information management redesign specialists; (2) Clinician/practitioner consultants; (3) Implementation support specialists; (4) Implementation managers; (5) Technical/software support staff; and (6) Trainers. The average hourly earnings for community college program graduates are expected to be in the target range of between $12.46/hour to $20.25/hour.

Resources:

Healthcare Employment Outlook:

- Massachusetts Career Information System: Massachusetts-specific information on careers which can be used to look at different industries, occupations within those industries, and the skills and education needed to work in these jobs
- WorkKeys Occupational Profiles
- Bureau of Labor Statistics

Healthcare Career Information:

- Top 5 Reasons to Work in the Healthcare Field, About.com
- Break Into a Healthcare Career, About.com
- Healthcare Initiatives, US Department of Labor
- Six Healthcare Careers that are Booming, Yahoo! Education
- Career Clusters in Health Sciences, National Association of State Directors of Career Technical Education Consortium
- Explore Health Careers, American Dental Education Association

Massachusetts Healthcare Job Listings:

- Massachusetts Healthcare Jobs, Jobs.net
- Healthcare Jobsite, Beyond.com

Workplace Scenario (8th Grade Level)

You are a medical lab technician (MLT). You work in a large regional medical center. You are part of a team of six other medical lab technicians. You receive blood and other samples (sometimes called "specimens"). You must run multiple tests on the samples you've received. MLTs prepare specimens for testing. They also operate computer-based machines that run the tests. Sometimes they manually test the samples. Each test has a different range for normal. You need to compare the results of the test with the normal range. You then record the test results accurately in the computer. You create an alert for the doctor if the results are out of the normal range.

One of the tests a doctor may request is an erythrocyte sedimentation rate. This is also known as ESR or sed rate. Sed rate is a blood test that can reveal the progression of inflammation in the body. Tracking these rates can help diagnose or monitor the progress of disease. For example, it helps in monitoring rheumatoid arthritis. During the test, blood is placed in a thin test tube. The red blood cells gradually settle to the bottom. Inflammation can cause the cells to clump together. These clumps of cells are denser than individual cells. This makes them settle to the bottom of the test tube more quickly. The farther the red blood cells have fallen, the more the immune system response is inflamed. Sed rate is calculated by measuring the distance red blood cells fall each hour. This is measured in millimeters per hour or mm/hr.

Testing sed rates requires strong math skills. Accuracy is essential. You must understand the correct order of operations. You must also have the ability to understand and interpret data. That allows you to compare the results of multiple test results to normal ranges. Then you can make judgments about whether an alert is necessary.

In addition to preparing and testing samples, you have other tasks. You log patient samples in the computer. You set up medical laboratory equipment. You also clean and maintain the lab and equipment. At the beginning of each day, you check the laboratory machines. You must ensure they are operating correctly. You do this by testing a control sample for which you already know the

results. You check to see if your test has the same results as the known value. That is how you know whether the machine is operating correctly.

Workplace Scenario (High School Level)

You are a medical lab technician (MLT) in a large regional medical center where you work with a team of six other medical lab technicians. In your job, you receive blood and other samples (sometimes called "specimens") throughout the day, and you must run multiple tests measuring various things in the samples you've received. MLTs prepare specimens for testing and operate automated analyzers, computer-based machines that run the tests, or manually test the samples. Each test has a different range for normal, and you need to compare the results of the test with the normal range, record the test results accurately in the computer, and create an alert for the doctor if the results are out of the normal range.

One of the tests a doctor may request is an erythrocyte sedimentation rate ESR, also known as ESR or sed rate. Sed rate is a blood test that can reveal the progression of inflammation in the body. Tracking these rates can help initially diagnose or monitor the progress of an inflammatory disease such as rheumatoid arthritis. When blood is placed in a thin test tube, red blood cells (erythrocytes) gradually settle to the bottom. Inflammation can cause the cells to clump together. These clumps of cells are denser than individual cells, so they settle to the bottom of the test tube more quickly. The farther the red blood cells have fallen, the greater the inflammatory response of your immune system. Sed rate is calculated by measuring the distance red blood cells fall in millimeters in an hour or mm/hr.

Testing sed rates requires math skills and accuracy is essential. You must understand the order of operations in order to perform accurate calculations. You must also have the ability to understand and interpret data when you compare the results of multiple test results to normal ranges and make judgments about whether an alert is necessary for those results that fall outside the normal range.

In addition to preparing and testing samples, you also log patient samples in the computer, set up medical laboratory equipment, and clean and maintain the lab and equipment. At the beginning of each day, you check the laboratory machines to be sure they are operating correctly. You do this by testing a control sample for which you already know the results. If your test has the same results as the known value, you know the machine is operating correctly.

Core instructional context

Understanding how to work with groups of numbers is an important workplace skill for healthcare, engineering, personal finance, athletics, and other areas. Being able to calculate mean, median, and mode, and make sense of large numbers of data, is becoming increasingly important as advances in technology have enabled us to obtain huge amounts of data in a wide range of areas, such as the health of a population, technology use, education, and economic trends. For students entering the workforce, learning how to make sense of data is critical.

In healthcare, making sense of data and statistics is crucial—lives depend on healthcare workers paying careful attention to lab results and patient data. In these cases, numbers need to be extremely precise with minimal to no error. From doctors and nurses to medical technicians, data handling skills are absolutely essential. Because of this, employers and certificate programs require strong mathematics skills in candidates.

In the lab, medical lab technicians use their knowledge of units and statistics to calibrate samples.

Testing sed rates requires the ability to conduct manual calculations and comparisons. Accuracy is essential, as well as the ability to interpret what the data means. You regularly note the test results that are normal and those that should be flagged for a doctor's review. When reporting data on multiple patients and looking for trends, it's important to use math terms such as range, mean, median, trend, frequency, mode, and center.

Worked Examples

Note: Problems 1 and 2 can be done as a full class. Problem 3 is much longer multistep problem and can be used in small groups with full class discussions.

1. Calculate maximum normal ESR from age and gender: The sedimentation rate (ESR) is the distance (measured in millimeters) per hour that the clumps of blood cells will fall to the bottom of the test tube. Calculate the maximum normal sedimentation rate for a male and a female, both 55 years old, using the equation below. Remember: The maximum normal sedimentation rate is based on age and gender, so a male and female, even if they are the same age, will have different normal rates. Note: You may find it helpful to show a video of a sed rate test to help provide a visual context for the problems.

Equation:

Emax = (A + G)/2

Where Emax is the maximum normal ESR, A is the age in years, G is 0 for males and 10 for females.

55-year old Male:

Step 1: Emax = (55 + 0)/2

Step 2: Using order of operations, add first (55 + 0) and then divide by 2, so Emax = 55/2

Answer: Emax = 27.5 mm/hr. The maximum normal sedimentation rate for a 55-year old male is 27.5 mm/hr. Anything less than 27.5 mm/hr is in the range of normal. This may also be expressed as:

55-year old Female:

Step 1: Emax = (55 + 10)/2

Step 2: Using the order of operations, add first (55 + 10) and then divide by 2. So, 65/2.

Answer: Emax=32.5 mm/hr. The maximum normal sedimentation rate for a 55-year old female is 32.5 mm/hr. Anything less than 32.5 mm/hr is in the range of normal. This may also be expressed as

2. Calculate ESR from a laboratory test.

a. Blood is drawn into a Westergren-Katz tube to the 200 mm mark. After an hour, red blood cells fall to the 181 mm mark. What is the sedimentation rate in mm/hr?

Step 1: Sedimentation rate is the rate that the clumped red blood cells fall. So, subtract,

200 (the beginning mark in the test tube)
181 (the mark the blood fell after an hour)

19 mm / hr

Answer: sedimentation result for the same is 19 mm/hr.

b. You realize you didn't hear the timer you set for one hour and it is now three hours since you began the test! You look at the Westergren-Katz tube and see that the red blood cells have fallen to the 144 mm mark. What is the sedimentation rate in mm/hr?

Step 1: Subtract

200 (the beginning mark in the test tube)
144 (the mark the blood fell after 3 hours)

56

Step 2: Divide the distance fallen by 3 to get the average distance per hour. So, 56 / 3 hr = 18.66 mm/hr

Answer: 18.66 mm/hr

3. Analyze ESR data from multiple patients. On this particular morning, you are monitoring the tests of seven different patients at the same time. Below is a chart showing how far red blood cells have fallen over the hour for each patient. In each case, the starting point was 200 mm. *Note: This problem can provide an opportunity for students to work in small groups of 2 or 3 to solve and discuss.*

ESR Data from Multiple Patients

Patient	Gender	Height after 1 hour	ESR Value (mm/hr)
1	M	165	
2	F	179	
3	M	181	
4	F	147	
5	F	163	
6	M	143	
7	M	175	

a. Calculate the ESR values and place them in the ESR column of the chart.

Step 1: Subtract the height after 1 hour from 200 mm, the starting point. Answer: Answers appear below in blue.

ESR Data from Multiple Patients

Patient	Gender	Height after 1 hour	ESR Value (mm/hr)
1	M	165	35
2	F	179	21
3	M	181	19
4	F	147	53
5	F	163	37
6	M	143	57
7	M	175	25

b. While you can calculate a more precise maximum average sedimentation rate (ESR) based on gender and age, you know that 0–22 is the normal range for most men and 0–29 is the normal range for most women. Which patients are outside the normal range?

Step 1: Look at each ESR and decide if it falls within the normal range or outside the normal range.

Step 2: In particular, notice the differences in normal ranges for men and women. If patient 7 was a woman instead of a man, she would be considered to be within the normal range because the normal range for women is 0–29.

Answer: Patients 1, 4, 5, 6, and 7 have ESR outside the normal range for their gender.

c. Which two patients are most at risk for having an illness? What is their average ESR?

Answer: Patients 4 and 6, since their ESR values are the highest. Their average ESR would be (57+53)/2 = 55 mm/hr.

d. Researchers at a local university are studying the wellness of people in the local community. Inflammation is a potential marker of disease, so they are gathering data from sed rate tests. They call your lab and ask for the mean, median, and range for the patients you have tested that day to give them a "snapshot" of the community. Using the ESR values you calculated for the seven patients, find the values for mean, median, and range. In your own words, what do the mean, median, and range tell the researchers about the patients you have tested that morning?

Step 1: To find the **median**, place the numbers in sequence. The median is the middle number (35). Follow-up question: How can you change the sed rates of the seven patients so that the median is still 35?
19, 21, 25, 35, 37, 53, 57

Step 2: To find the **mean** ESR, add the values and divide by number of patients. The mean is 35.29. The mean value is what is usually considered the "average," so in this case, the average sed rate for that day is 35.29. Follow-up question: How can you change some or all of the sed rates below so that the mean is still about 35? Explain your strategy and reasoning.

Step 3: To find the **range**, subtract the minimum ESR from the maximum ESR. The range is 38.
57-19 = 38

Step 4: Answers will vary for the explanation of what the data might tell the researchers. It is impossible to test every person in a community for different measurements of wellness, so the researchers are looking for various ways to test samples of that population. In this example, they have called a blood testing lab and are looking specifically at a test for inflammation, a marker of disease, for just one day to provide a snapshot. In the patient sample provided, the mean and median are almost identical. To help students understand how these measurements to express "average" can be used differently, what if students replaced the last number with something much bigger such as 72 or 86? The median would remain the same while the mean would be larger. Help students articulate that the mean includes the outlier data, so a really large or really small number (outlier) can significantly change the average. In this case, researchers would want to look at both the mean and median to get a better idea of the typical patient. The range provides an indication of the distribution of values.

A recently hired research assistant from the local university calls you and asks for your opinion about how to group the patients into three categories of elevated sed rates: mild, moderate, and severe regardless of gender and age. As a reminder, 0–22 is the normal range for most men and 0–29 is the normal range for most women.

Use your understanding of sed rates to identify the sed rate ranges for mild, moderate, and severe. You get to decide which ranges to use, but make sure they are equally balanced (e.g., each category has a 10-point range).

Share your rationale for the ranges you chose for each category.

Answer: Answers will vary; more important than the answer is the rationale for the answers. One possible grouping is shown in the chart below with each category having a 12-point range. Students should be able to understand and apply range to sed rate, understanding that the range is the same for each category and that a higher sed rate means more inflammation. Students should be able to explain how they chose the bottom number of the range for "mild." In the example below, 23 was chosen because it represents the beginning of a mild sed rate elevation for men.

Patient Group	**Range**
Mild	23–35
Moderate	37–49

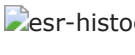
Severe	50–62

(full class discussion) Now that each group has created a way to group the patients by the severity of their sed rate, decide upon one grouping as a class (i.e., what is the sed rate range for mild, moderate, and severe). How can you make this decision using math? We'll use this data to learn about histograms.

> Answer: Use the mean, median, or both to find the average point range, as well as the bottom number of the mild sed rate. This problem gives students practice using mean and median to make decisions with data *they* collect.

A histogram provides a way to graph data with ranges. Each category from our example—mild, moderate, and severe–has a sed rate range instead of just one number. The histogram graphically shows the frequency (how frequently a value in this range occurs, or with this example, how many people) in each category. Begin by sorting the patients into the mild, moderate, and severe groupings. *Note: Work this problem with the full class to introduce histograms.*

Answer: Answers will vary based on class decision about categories. Assuming a 12-point range, one possible solution:



Patient Group	**Range**	**Patients**
Mild	23–35	Patient 1 (35 mm/hr) Patient 7 (25 mm/hr)
Moderate	37–49	Patient 5 (37 mm/hr)
Severe	50–62	Patient 4 (53 mm/hr) Patient 6 (57 mm/hr)

As a class, put a lot of possible sed rates on the board—at least 30 values. In small groups, ask students to create a histogram of this larger patient sample. Ask volunteers to share group work and explain their approach to creating the histogram.

> Answer: Answers will vary. Look for students' ability to explain how they sorted the patient sample into the categories and their understanding of frequency.

Contextualized learning activities

The following activities have been sequenced to best scaffold the understanding of the context and the math presented in the context.

A. Read the Scenario
Ask students to read the scenario in this module. Have students look for unfamiliar words or concepts and write those on the board. Medical Lab Science is a very technical field, so there may be several unfamiliar words.

B. Show videos to provide visual context
As students watch the video, point to the unfamiliar words on the board as they are used.

> Medical Laboratory Technician: In this video (4:46), an MLT discusses her job.

Automated analyzer: This video (3:18) shows a large automated blood analyzer, as well as the technicians who use it.

C. Hands-on activity to simulate sedimentation rate test

The problems in this unit are contextualized around erythrocyte sedimentation rate (ESR or sed rate for short) tests. You can simulate this test with water, red food coloring, a graduated cylinder with a cork, and cooking oil. In an oil and water mixture, the water falls to the bottom over time because it is denser than the oil. In this way, the water is similar to the clumped blood cells that fall in a sed rate test.

Fill about 2/3 of the graduated cylinder with water and add a few drops of red food coloring. Add a few tablespoons of oil and then shake it.
Let students view the simulated blood and identify the measurement.
Let the solution sit for several minutes and then measure where the simulated blood has fallen.
Subtract the two measurements to calculate the sedimentation rate.

D. Worked Examples

Work the three problems in the Core Instructional Context section as a class. Problems 1 and 2 can be worked as a full class. Problem 3 is a much longer multistep problem that can be used in small groups with full class discussions.

E. Contextualized Problems: Independent or Small Group

1. In a sample from a 40-year-old patient, red blood cells fall 7.5 mm in the first 30 minutes. In the second 30 minutes, red blood cells fall another 12.5 mm. What is the sedimentation rate in mm per hour?

7.5 + 12.5 = 20 mm/hr

2. 2 ml of blood are drawn into a Westergren-Katz tube to the 200mm mark. Because of an error, you have to stop the data collection at 30 minutes. At the 30-minute mark, red blood cells have fallen to 190 mm. You are out of samples and the patient does not return for two weeks, so this is the best data you have. Find the ESR in terms of mm/hr.

You only calculated the rate for half an hour, so multiply this distance by 2 to get a value in mm/hr.
(200 mm – 190 mm) x 2 = 10 mm x 2 = 20 mm/hr

3. Another patient had data that was only taken for 30 minutes. However, this patient had data taken every five minutes. Below is data on how far the red blood cells fell in every 5-minute interval. Using this data, calculate ESR.

Time measurement was taken	Measurement (mm)	Distance fallen over 5 min.
0 min.	200	--
5 min.	198	2
10 min.	195	3
15 min.	193	2
20 min.	191	2
25 min.	190	1
30 min.	189	1

(2 + 3 + 2 + 2 + 1 + 1) x 2 = 11 x 2 = 22 mm/hr

or (200 – 189) x 2 = 11 x 2 mm/hr

Now, find the mean sed rate in mm/minute.
(2 + 3 + 2 + 2 + 1 + 1) ÷ 6 = 1.833 is the mean for 5-minute intervals.

Divide by 5 to find the sed rate in mm/min: 1.833 ÷ 5 = .367 mm/min

4. You are working with a medical lab technologist on compiling ESR data over the past week from your clinic. Your group consists of 19 adult female patients, ages ranging from 20 to 50. The list below shows the ESR values of each patient.

12, 14, 15, 16, 17, 19, 19, 19, 20, 21, 22, 22, 23, 25, 26, 28, 31, 47, 51

a. Find the mean, median, mode, and range. Note: Mode is the number that occurs most frequently.

Mean: (12+14+15+16+17+19+19+19+20+21+22+22+23+25+26+28+31+47+51)/19 = 23.5
Median: The middle (10th) number in the series is 21
Mode: The number that occurs most frequently is 19
Range: 51 – 12 = 39

b. Create a histogram using this data. Each range, also called "bin" on histograms, will be 5 mm/hr, starting with a bin of 11–15.

Below shows a table of the values for each bin and the histogram:

Range of ESR values (mm/hr)	Values that fit into this range
11-15	12, 14, 15
16-20	16, 17, 19, 19, 20, 20
21-25>	21, 22, 22, 23, 25
26-30	26, 28
31-35	31
36-40	
41-45	
46-50	47
51-55	51

c. How is the histogram different from a bar graph in terms of how it represents data?

On a bar graph, data is grouped by categories or set numbers. On the histogram, data is grouped by numerical range.

d. Inflammatory clinics see patients with more inflammation than a general practice clinic. Looking at your histogram, do you think this data is most likely from a general practice clinic or an inflammatory clinic? Explain why.

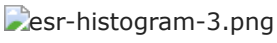
General practice because the mean represents a normal sed rate for women. (normal for women is 0–29 mm/hr)

e. What are the two outliers for this clinic? Why are they outliers?

The patients with sed rates of 47 and 51 are outliers. They are outliers because they are two data points that don't fit with the overall trend of the data set.

Contextualized test items

Use the following histogram to answer questions 1–4.



1. What is the range for this histogram?

Subtract minimum from maximum value; 55 – 10 = 45.

2. What is the range for each bin on the histogram?

5

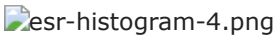
3. Given that five patients had ESR values between 22 and 25 and ten patients had ESR values between 41 and 43, what is the mode ESR value for this histogram?

The mode ESR value is the one that occurs the most often. The bin with the highest frequency is the bin with the range of 21–25. If 5 patients have an ESR between 22 and 25, that leaves 19 patients with an ESR of 21 because 24 (the # of patients in bin 21-25) – 5 (# of patients between 22-25) = 19. Bin 41-45 has 21 patients in it and that could potentially have an ESR with a greater frequency than 19. However, we know that 10 patients have a value between 41 and 43. This means that 11 patients have an ESR value between 44–45, 21–10=11. There is no other bin that contains an ESR with a frequency greater than 19, so the mode is clearly 21.

4. What meaning can you draw from the fact that there are two major peaks on this histogram?

There seem to be a significant group of people that are healthy, and a significant group of people with high ESR values who could potentially have an ESR-related illness.

5. The data in the histogram below was taken from a set of 100 adult female patients at a general clinic. From this sample, what is a likely mean value? Note: This is a challenging, multistep problem.



One strategy is to use the middle value (the median) of each bin and multiply it by that column's frequency (number of patients in that bin). Then you can sum the values and divide by the total number of patients (100) to get the mean.

The middle values are 13, 18, 23, 28, and 33.

Their respective frequencies are 6, 17, 25, 18, and 12.

So (6 x 13 + 17 x 18 + 25 x 23 + 18 x 28 + 12 x 33) / 100

(78 + 306 + 575 + 504 + 396) /100 = 1859/100 = 18.59 which rounds to 19.

http://ajcp.ascpjournals.org/content/135/3/386/F3.expansion.html
http://ajcp.ascpjournals.org/content/135/3/386/F3.expansion.html

Contextualized project

Draw-Pair-Share
Students work with partners. Each student draws a histogram that provides the ESR data for one day at an imaginary clinic. When finished, have the partners swap histograms. Each student should look at their partner's histogram and then provide an oral or written explanation of the data represented in the histogram. How well does the explanation match the original intent?

Describe That Histogram Game Show
Students play a game similar to the Family Feud TV show. Students compete on teams to develop the best story around a histogram in a game. Points are awarded for mathematical accuracy, using mathematical vocabulary, using medical vocabulary, and creativity around the story that is told about the histogram.

Divide students into two teams.
Have each student draw a histogram that provides the ESR data for one day at an imaginary clinic and submit it.
Each team sends one person to the front to take a histogram from the pile of graphs.
The teams are given **two minutes** to huddle, reviewing the graph to decide what the graph means mathematically and to create a scenario that would lead to this histogram.
When time is called, one to two spokespeople for each team will have **two minutes** to tell the story about the histogram.
The professor awards points and declares a winner for each round:
Use and accuracy of math vocabulary words: 1-5 points
Accuracy of interpretation of histogram: 1-5 points
Creativity of narrative: 1-5 points
Play as many rounds as time permits. The winning team wins the most rounds.

Additional or extension activities, multimedia, readings and/or resources

Understanding ESR
http://www.youtube.com/watch?v=Sgsgt93pYZk

This video provides a more thorough and medical explanation of testing and interpreting ESR values. The normal values for females and males in this video are a little different than the ones used in this unit; "normal" values vary by labs and hospitals.

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