A Guide to Numeracy in Nursing

A Guide to Numeracy in Nursing

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The web version of this resource has been designed to meet Web Content Accessibility Guidelines 2.0, level AA. In addition, it follows all guidelines in Appendix A: Checklist for Accessibility of the *Accessibility Toolkit – 2nd Edition*. It includes:

- **Easy navigation**. This resource has a linked table of contents and uses headings in each chapter to make navigation easy.
- **Accessible math equations**. Many of the equations in this resource have been written in LaTeX and rendered with MathJax, which makes them accessible to people using screen readers that are set up to read MathML. The rest of the equations are rendered as images with appropriate alternative text.
- **Accessible images**. All images in this resource that convey information have alternative text. Images that are decorative have empty alternative text.
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Tables	Tables do not have merged or split cells.	Yes
Tables	Tables have adequate cell padding.	Yes
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Links	Links do not open new windows or tabs. If they do, a textual reference is included in the link text.	Yes
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EPUB	No	Computer, tablet, phone	An eReader app	Option to enlarge text, change font style, size, and colour.	Unsure
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A Guide to Numeracy in Nursing by Julia Langham was funded by BCcampus Open Education.

BCcampus Open Education began in 2012 as the B.C. Open Textbook Project with the goal of making post-secondary education in British Columbia more accessible by reducing students' costs through the use of open textbooks and other OER. BCcampus supports the post-secondary institutions of British Columbia as they adapt and evolve their teaching and learning practices to enable powerful learning opportunities for the students of B.C. BCcampus Open Education is funded by the Ministry of Post-Secondary Education and Future Skills and the Hewlett Foundation.

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Introduction

Welcome to *A Guide to Numeracy in Nursing*. This workbook was created to help students learn how to make sense of numerical information in health care with the undergraduate nursing student in mind. I chose to publish this workbook with an open license as I strongly believe everyone should have access to tools to help them learn. If you are interested in sharing feedback or additional practice questions I would love to hear from you as your feedback is valuable for improving and expanding future versions.

Acknowledgements

I give my sincere appreciation to the following people for support in creating this workbook:

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- Susan Burr, Jocelyn Schroeder, Alyssa Franklin, and Lindsay Hewson for providing peer feedback and copy editing.

Workbook Layout

This workbook is divided into multiple parts, with each part containing chapters related to a particular theme. Several box types have been used to organize information within the chapters. Some chapters may be broken into multiple sections, visible in the online format when the heading title is clicked. Generally, these sections are the lesson, followed by one or more sets of practice questions.

Learning Outcomes

Learning outcomes will be included at the beginning of the chapter, within a green shaded box.

Sample Exercises

Sample exercises will be included within a purple shaded box.

Practice Sets

Practice sets will be included within a teal shaded box.

Key Takeaways

Key takeaways will be included within an orange shaded box.

Critical Thinking Questions

Critical thinking questions will be included within a red shaded box.

References and copyright information for open source components adapted for this book will be included in a grey shaded box.

Tips for Working Towards Correct Answers

When completing practice questions you should focus on reading each question carefully and reducing any distractions around you. Check your work after completing questions and try to determine where your mistakes are coming from if you get the wrong answer. Answers to sample exercises and practice questions have steps in solving shown to help you identify where you are making mistakes. You can compare your work to the work shown in the answers. Ask yourself the following questions to help you to understand why you are not getting the right answer:

- Did I understand what the question was asking?
- Did I set up the equation correctly?
- Did I make a mistake when using the calculator or doing mental math?
- Is there a difference between my answer and the provided answer because of the method I used when rounding?

Always check in with your instructor or tutor if you continue to make mistakes.

I

Foundational Math Skills

In this section of the book, chapters will focus on helping you to practice basic arithmetic skills and the use of scientific notation. You will draw upon these skills as you begin to use math to calculate drug doses, set up intravenous infusions and interpret laboratory results.

When completing practice questions, read each question carefully and reduce any distractions around you. Check your work after completing questions and try to determine where your mistakes are coming from if you get the wrong answer. Continue to practice until you feel confident with basic arithmetic skills.

1.

Basic Arithmetic

Proficiency with basic arithmetic (adding, subtracting, multiplication, and division) is generally mandatory for admission to nursing programs. Therefore, lessons of basic arithmetic will not be discussed in this text.

Included in this chapter are several quizzes to practice basic arithmetic skills. Although calculators are often available to assist with tasks requiring arithmetic in the workplace, practice without a calculator is beneficial. It is a great exercise for your brain health and you may find your speed of mental calculations improving with repeated practice. To improve your ability to do mental math, you can practice these questions with pencil and paper, double-checking your answers with a calculator if you like.

Check out Calculator Soup , created by Edward Furey, for a variety of free calculators built for specific functions.

Click the start button to generate quiz questions. The quiz will count down and then begin to provide randomly generated questions. Each quiz will generate ten multiple choice questions each time you click the start button. You will be able to view one question at a time. When ready, click on the answer you think is correct. If it is the correct answer, the box changes to green and you will hear a sound indicating a correct answer. If it is not the correct answer, the box you click changes to a darker shade of blue and the correct answer is highlighted in green. You can track self improvement by the number of correctly answered questions and/or by the amount of time you take to complete the quiz.

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2.

Ratios and Proportions

Lesson

Learning Outcomes

By the end of this chapter, learners will be able to:

- define the terms ratio and proportion,
- write ratios and proportions in numerical format using a colon and using fractions, and
- describe how to solve for an unknown amount in a proportion equation.

Ratios

You have likely used ratios in many ways in everyday life, but perhaps you are not sure how to define a **ratio**. A ratio is a numerical expression which shows the connection between two or more numbers. These numbers must be related in some way; we do not use ratios to compare unrelated numbers. Most often, you will see a ratio using just two whole numbers.

When writing a ratio, the numbers are written in a particular order. For instance, if I was writing a ratio of how many nursing students were in one clinical practice group, I would write $8:1$.

In healthcare, we use ratios in a variety of situations. For instance, when describing safe staffing levels, reviewing morbidity and mortality data, or while carrying out medication administration.

Examples of Ratios in Healthcare

When identifying staffing levels, a ratio is used to clearly indicate the number of patients a nurse can safely provide nursing care for on a particular unit:

- In an intensive care unit, you may see a ratio of one nurse for one intubated, acute patient. This is written in numerical form as $1:1$.
- In a surgical unit, you may see a ratio of one nurse for four patients. This is written as $1:4$.
- On a medical unit where care is provided by teams of two nurses (a licensed practical nurse and a registered nurse) for every ten patients, you may see a ratio written as $2:10$, or $1:1:10$ if they are separating the types of nurses within this example.

Mortality rates may also be expressed as ratios:

- An infant mortality rate of four deaths in every one thousand births is written as $4:1000$.

The quantity of medication in a unit measure can also be expressed as a ratio:

- A tablet of acetaminophen containing 325 mg of drug is written as $1:325$.

Sample Exercise 2.1

1. How would you write the ratio of thirty two students in one classroom?

Answer:

$$32:1$$

A ratio can also be expressed as a fraction, with the two numbers acting as the **numerator** and **denominator**. The numerator is always from the left of the colon, the denominator is from the right. For example, an infant mortality rate of $4:1000$ can be expressed as:

$$\frac{4}{1000}$$

Sample Exercise 2.2

1. How would you write the ratio of the amount of one tablet contains 325 mg of

acetaminophen, or $1:325$ as a fraction?

Answer:

$$\frac{1}{325}$$

Proportions

A proportion is an equation of two ratios of equivalent amounts. The terms of the first ratio are related to the terms of the second ratio. This means you should ensure the numbers of each ratio are written in the same order.

Example of a Proportion

$$1:325 = 2:650$$

In this case, the proportion is comparing the amount of 1 tablet containing 325 mg of acetaminophen with 2 tablets containing 650 mg of acetaminophen. Both ratios have equivalent amounts of acetaminophen per tablet.

As with ratios, you can write proportions in fraction form:

$$\frac{1}{325} = \frac{2}{650}$$

Both ways mean the same thing: 1 tablet is to 325 mg, just as 2 tablets are to 650 mg.

Sample Exercise 2.3

How would you write a proportion equation in fraction format which compares how 1 cup of apple juice (of a particular brand) contains 24 g of sugar to 4 cups of the same brand apple juice containing 96 g of sugar?

Answer:

$$\frac{1}{24} = \frac{4}{96}$$

You can confirm if two ratios make a proportion equation by reducing the fractions to see if they reduce to the same amount. It is not likely you will come across a problem like this very often in the practice setting, but you may use it to confirm there is the same amount of drug in different brands of tablets when engaging in medication reconciliation with patients.

Verifying Proportions

If 4 tablets contain a total of 200 mg of prednisone, do 8 tablets containing a total of 400 mg reduce to the same amount?

$$\frac{4}{200} = \frac{8}{400}$$

Recall to reduce a fraction, you need to divide each numerator and denominator by the same amount. In this example, we can divide by 4.

$$\frac{1}{50} = \frac{2}{100}$$

A fraction is not reduced if it can still be simplified further. In this case, the fraction to the right can be reduced further by dividing the numerator and denominator by 2.

$$\frac{1}{50} = \frac{1}{50}$$

Now you can see these ratios do indeed have the same proportions because the fractions are equal once they have been reduced.

Unknown Amounts Within a Proportion Equation

Sometimes we are presented with an unknown amount in one of the ratios in a proportion equation. This is where the short cut of “cross multiply and divide” is often used to solve for the unknown amount. We can do this when we know that the ratios presented are related to each other and have equivalent proportions. For instance, we can solve for an unknown amount when comparing two ratios with units of minutes and hours.

Solving for an Unknown Amount in a Proportion Equation

Here is an example of two ratios depicting the relationship between minutes and hours, one with an unknown amount of minutes. In this case the ratio reads as 120 minutes to 2 hours and x minutes in 8 hours.

$$120 : 2 \text{ and } x : 8$$

Step 1: Set up your equation

To solve for x, the unknown amount, you first need to set up the formula. It is helpful to write it as a fraction to see how the process works.

$$\frac{x}{8} = \frac{120}{2}$$

Step 2: Cross multiply opposing numerators and denominators

$$(2)(x) = (8)(120)$$

*Numbers next to each other in brackets indicates they are being multiplied, so the letter x is not confused with x as a multiplication symbol.

You can see x was the numerator of the first ratio and 2 the denominator from the other ratio. Likewise, eight was the denominator and 120 the numerator.

$$2x = 960$$

Step 3: Simplify the equation (get x by itself!)

To simplify the equation, divide both sides by the same amount. In this case, dividing by $2x$ by 2 simplifies to $1x$, or just x. Now we know what x equals.

$$\frac{(x)(2)}{2} = \frac{960}{2}$$

$$x = 480$$

Key Takeaways

- A ratio is used to express the relationship between numbers.
- A ratio can be written as numbers separated by a colon or as a fraction.
- A proportion is an equation of two ratios of equal values.
- A proportion can be written with ratios written as numbers separated by a colon or as a fraction.
- Use the “cross multiply and divide” process to solve for an unknown amount in a proportion equation.

Practice Set 2.1: Ratios

Practice Set 2.1: Ratios

Complete the following questions and click on the word **Answers** to check your work.

1. Write a ratio using a colon expressing the relationship between three computers to a nursing station on a hospital ward.
2. Write a ratio using a colon expressing the relationship between one hundred ibuprofen tablets per bottle.
3. Write a ratio using a colon expressing how one tablet contains fifty mg of dimenhydrinate.
4. Write a ratio using a colon expressing the staffing ratio of one pediatric nurse to four stable patients.
5. Write a ratio as a fraction expressing four out of five people of a particular country have blue eyes.
6. Write a ratio as a fraction expressing in two nebules there are 500 mcg of ipratropium.
7. Write a ratio as a fraction expressing there is one dean representing each nursing school in Canada.
8. If one cup of water is the same as 250 mL, how would you write the ratio?
9. If there are 500 mg of ciprofloxacin in one tablet, how would you write the ratio?
10. If two out of every thirty nursing students receive an entrance scholarship over $1,000, how would you write this ratio?

Answers:

1. $3 : 1$
2. $100 : 1$
3. $1 : 50$
4. $1 : 4$
5. $\frac{4}{5}$
6. $\frac{2}{500}$
7. $\frac{1}{1}$

8. $1 : 250$ or $\frac{1}{250}$
9. $1 : 500$ or $\frac{1}{500}$
10. $2 : 30$ or $\frac{2}{30}$, or $1 : 15$ or $\frac{1}{15}$

Practice Set 2.2: Proportions

Practice Set 2.2: Proportions

Complete the following questions and click on the word **Answers** to check your work.

1. Write a proportion equation comparing the ratios of 500mcg ipratropium per two nebules to 250 mcg ipratropium per one nebule in fraction form.
2. Write a proportion equation comparing the ratios of one crash cart per nursing ward to five crash carts in five wards.
3. Write a proportion equation comparing the ratio of twenty five mg of sertraline per capsule to seventy five mg of sertraline per three capsules in fraction form.
4. Write a proportion equation comparing the ratios of sixty minutes in one hour to 320 minutes in four hours.
5. Write a proportion equation expressing the rate of five infant births per month is equivalent to sixty infant births per year at a small hospital. Hint: Ensure the units are the same.

Answers:

1. $\frac{500}{2} = \frac{250}{1}$
2. $1 : 1 = 5 : 5$
3. $\frac{25}{1} = \frac{75}{3}$ or $25 : 1 = 75 : 3$
4. $\frac{60}{1} = \frac{320}{4}$ or $60 : 1 = 320 : 4$

5. $5:1 = 60:12$ (Convert units first: One year = 12 months)

Practice Set 2.3: Solving for Unknown Amounts in Proportions

Practice Set 2.3: Solving for Unknown Amounts in Proportions

Use the cross multiply and divide method to solve for the unknown amount in each of the following proportions. Click on the word **Answers** to check your work.

1. $3:4 = x:12$
2. $x:10 = 1:2$
3. $\frac{x}{6} = \frac{75}{3}$
4. $\frac{225}{1} = \frac{x}{3}$
5. $\frac{800}{4} = \frac{200}{x}$
6. $\frac{4}{13} = \frac{12}{x}$
7. $\frac{24}{x} = \frac{8}{3}$
8. $4:8 = x:6$
9. $\frac{x}{150} = \frac{5}{2}$
10. $x:12 = 18:3$

Answers:

1. x = 9

$$\frac{3}{4} = \frac{x}{12}$$

$$(3)(12) = (4)(x)$$

$$36 = 4x$$

$$9 = x$$

2. x = 5

$$\frac{x}{10} = \frac{1}{2}$$

$$(2)(x) = (10)(1)$$

$$2x = 10$$

$$x = 5$$

3. x = 150

$$(3)(x) = (6)(75)$$

$$3x = 450$$

$$x = 150$$

4. x= 675

$$(1)(x) = (225)(3)$$

$$x = 675$$

5. x = 1

$$(800)(x) = (4)(200)$$

$$800x = 800$$

$$x = 1$$

6. x = 39

$$4x = 156$$

$$x = 39$$

7. x = 9

$$72 = 8x$$

$$9 = x$$

8. x = 3

$$\frac{4}{8} = \frac{x}{6}$$

$$(4)(6) = (8)(x)$$

$$24 = 8x$$

$$3 = x$$

9. x = 375

$$2x = 750$$

$$x = 375$$

10. x = 12

$$\frac{x}{2} = \frac{18}{3}$$

$$(x)(2) = (18)(3)$$

$$3x = 36$$

$$x = 12$$

Practice Set 2.4: Solving for Unknown Amounts in Proportions

Practice Set 2.4: Solving for Unknown Amounts in Proportions

Use the cross multiply and divide method to solve for the unknown amount in each of the following proportions. Click on the word **Answers** to check your work.

1. $6 : x = 9 : 32$
2. $\frac{135}{x} = \frac{20}{5}$

3. $\frac{x}{13} = \frac{17}{2}$
4. $13 : 7 = x : 3$
5. $x : 2 = 14 : 7$
6. $\frac{200}{12} = \frac{x}{4}$
7. $\frac{28}{8} = \frac{3}{x}$
8. $\frac{x}{3} = \frac{12}{72}$
9. $6 : 4 = 22 : x$
10. $\frac{2}{19} = \frac{x}{27}$

Answers:

1. $x = 21.3$

$$\frac{6}{x} = \frac{9}{32} = \frac{9}{32}$$

$$9x = 192$$

$$x = 21.3$$

2. $x = 33.75$

$$675 = (20)(x)$$

$$33.75 = x$$

3. $x = 110.5$

$$(2)(x) = 221$$

$$x = 110.5$$

4. $x = 5.6$

$$\frac{13}{7} = \frac{x}{3}$$

$$39 = (7)(x)$$

$$5.6 = x$$

5. $x = 4$

$$\frac{x}{2} = \frac{14}{7}$$

$$(7)(x) = 28$$

$$x = 4$$

6. $x = 66.7$

$$800 = (12)(x)$$

$$66.7 = x$$

7. $x = 0.86$

$$(28)(x) = 24$$

$$x = 0.86$$

8. $x = 0.5$

$$(72)(x) = 36$$

$$x = 0.5$$

9. $x = 14.7$

$$\frac{6}{4} = \frac{22}{x}$$

$$(6)(x) = 88$$

$$x = 14.7$$

10. $x = 2.8$

$$54 = (19)(x)$$

$$2.8 = x$$

Practice Set 2.5: Solving for Unknown Amounts in Proportions

Practice Set 2.5: Solving for Unknown Amounts in Proportions

Use the cross multiply and divide method to solve for the unknown amount in each of the following proportions. Unless the answer is a whole number, round to the second decimal place. Click on the word **Answers** to check your work.

1. $\frac{4}{x} = \frac{125}{20}$
2. $\frac{x}{17} = \frac{7}{2}$
3. $3 : x = 8 : 12$
4. $1200 : 2 = x : 20$
5. $\frac{490}{14} = \frac{72}{x}$
6. $397 : 17 = 3 : x$
7. $\frac{x}{19} = \frac{7}{325}$
8. $\frac{13}{3} = \frac{x}{2}$
9. $12 : x = 17 : 19$
10. $x : 4 = 2 : 5$

Answers:

1. $x = 0.64$
   $80 = (125)(x)$

   $0.64 = x$
2. $x = 59.5$
   $(2)(x) = 119$

   $x = 59.5$
3. $x = 4.5$
   $$\frac{3}{x} = \frac{8}{12}$$

   $36 = (8)(x)$

   $4.5 = x$

4. $x = 12000$

$$\frac{1200}{2} = \frac{x}{20}$$

$$24000 = (2)(x)$$

$$12000 = x$$

5. $x = 2.06$

$$(490)(x) = 1008$$

$$x = 2.06$$

6. $x = 0.13$

$$\frac{397}{17} = \frac{3}{x}$$

$$(397)(x) = 51$$

$$x = 0.13$$

7. $x = 0.41$

$$(325)(x) = 133$$

$$x = 0.41$$

8. $x = 8.67$

$$26 = (3)(x)$$

$$8.67 = x$$

9. $x = 13.41$

$$\frac{12}{x} = \frac{17}{19}$$

$$228 = (17)(x)$$

$$13.41 = x$$

10. $x = 1.60$

$$\frac{x}{4} = \frac{2}{5}$$

$$(5)(x) = 8$$

$$x = 1.6$$

3.

Fractions

Lesson

Learning Outcomes

By the end of this chapter, learners will be able to:

- define fraction, improper fraction and mixed fraction,
- simplify fractions,
- add and subtract fractions, and
- multiply and divide fractions.

Defining Fractions

Fractions

Fractions are useful when describing information which relates to parts of a whole. A fraction is a way of documenting the amount of parts present out of the total number of parts of a thing. They are also used when writing **ratios** and proportion equations, using algebra and determining percentages.

Fractions always have a minimum of two parts, a **numerator** and a **denominator**:

$$\frac{\text{numerator}}{\text{denominator}}$$

Sometimes, a whole number may precede a fraction. We see this often in baking recipes. For instance, you might see a recipe require $1\frac{1}{4}$ cups of sugar.

Consider a package of a dozen assorted doughnuts. If 3 of the 12 doughnuts were raisin bran, the fraction would read as follows:

$$\frac{3}{12}$$

The numerator is the portion present and the denominator are the number of parts in the whole (12 parts in a dozen).

Sample Exercise 3.1

How would you write a fraction if a pizza, with a total of 10 slices, had 5 slices with pineapple added on?

Answer:

$$\frac{5}{10}$$

Fraction Types

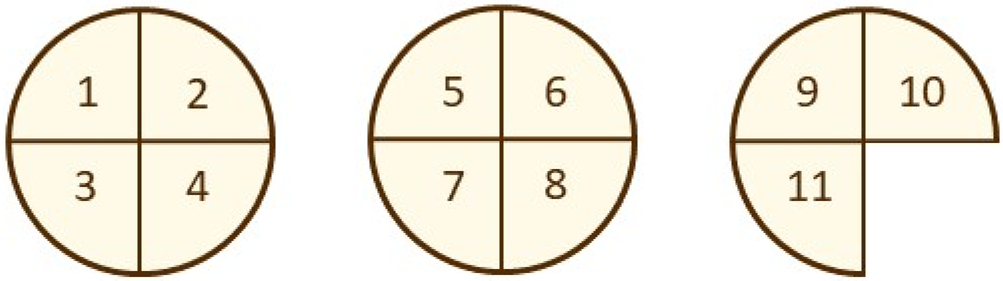
Fractions	$\frac{7}{8}$	$\frac{2}{15}$	$\frac{1}{3}$
Improper fractions	$\frac{9}{8}$	$\frac{6}{3}$	$\frac{12}{5}$
Mixed fractions	$2\frac{3}{4}$	$4\frac{5}{8}$	$1\frac{2}{5}$

Improper Fractions

Improper fractions are simply fractions which have a larger numerator than denominator. If you think about a proper fraction as representing a portion of a whole, an improper fraction would be representing a value greater than one. It represents more pieces than are available in one whole item.

For instance, we could use an improper fraction to describe the total number of pizza slices. The image below represents three personal pizzas, each cut into four pieces. There is one piece missing from the last pizza. The fraction to describe this situation is:

$$\frac{11}{4}$$



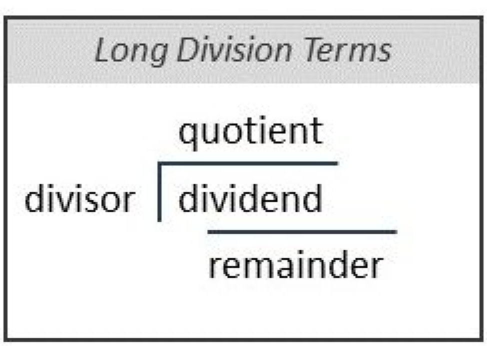
Mixed Fractions

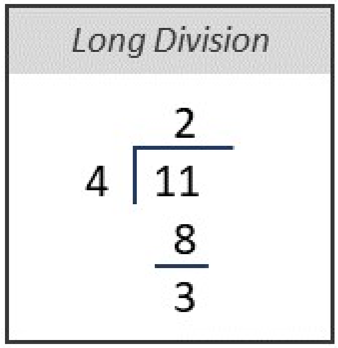
Mixed fractions also represent a value that is greater than one whole. Instead of the numerator being larger than the denominator, the fraction is written with the amount of whole portions before the fraction. If you look at the pizza picture above, there are 2 whole pizzas plus 3 pieces left out of the four pieces which make up a whole pizza. Written as a fraction it looks like this:

$$2\frac{3}{4}$$

Converting Improper Fractions to Mixed Fractions

In order to write an improper fraction as a mixed fraction, we need to know how many whole units there are. You can determine how many whole units there are by dividing the numerator by the denominator. Long division works well for this process, as the remainder becomes the numerator and the quotient becomes the whole number to the left of the fraction. Let's start by looking at the improper fraction $\frac{11}{4}$ from the example above.





Now to write as a mixed fraction the quotient (2) is the whole number written to the left of the fraction. The remainder (3) is the numerator and the divisor (4) is the denominator.

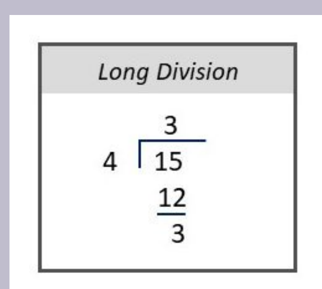
$$2\frac{3}{4}$$

Sample Exercise 3.2

Convert $\frac{15}{4}$ into a mixed fraction.

Answer:

$3\frac{3}{4}$



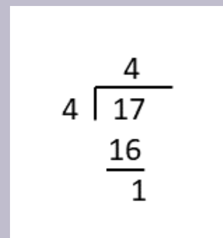
Sample Exercise 3.3

Convert $\frac{17}{4}$ to a mixed fraction.

Answer:

Using long division:

$4\frac{1}{4}$



Alternately:

First, divide the numerator by the denominator to find out how many whole units there are.

$$17 \div 4 = 4.25$$

The denominator stays the same.

The numerator is the portion of the whole: 0.25, or $\frac{1}{4}$.

$$4\frac{1}{4}$$

Converting Mixed Fractions to Improper Fractions

When converting a mixed fraction to an improper fraction, the denominator always stays the same, as the number of parts in a whole item is not changing. To determine the numerator, you first multiply the whole number and denominator from the mixed fraction. This step determines how many pieces are in the number of whole items. Then add number of pieces represented by the numerator of the mixed fraction to this am

ount to calculate the total number of pieces. This number is now the new numerator of the improper fraction.

- $2\frac{3}{4}$
- $2 \times 4 = 8$
- $8 + 3 = 11$
- $\frac{11}{4}$

Sample Exercise 3.4

Convert $3\frac{7}{8}$ to an improper fraction.

Answer:
The denominator stays the same. 8.

To find the numerator, first multiply the whole number and denominator:

$$3 \times 8 = 24$$

Add this number to the current numerator:

$$24 + 7 = 31$$

Write the improper fraction:

$$\frac{31}{8}$$

Simplifying Fractions

It is common practice to write fractions using the smallest numbers possible, as it is easier to conceptualize what the fraction represents when the numbers are small. This is also called reducing fractions. When we simplify a fraction, it does not change the size of the portion we are referring to because the relationship between the numerator and denominator does not change. For instance, try to picture $\frac{2}{4}$ of an orange. Now try to picture $\frac{1}{2}$ of an orange. They still refer to the same amount of the orange, even though the numbers of the fractions are different.

To simplify a fraction, you must divide the numerator and the denominator by the same number. If you are able to find the largest number you can divide both the numerator and denominator by, the fraction will be in simplified (or reduced) form. These numbers are also called the **largest common factor**.

As long as you divide by the same number, you do not change the relationship between the numerator and denominator. Fractions with small numbers, like $\frac{2}{4}$, can often be simplified with just one step, as it is easier to identify the largest common factor.

Fractions with larger numbers, like $\frac{362}{900}$ may take you a couple of steps, depending on your knowledge related to topics like multiplication tables and **prime numbers** Prime numbers have only two common factors, 1 and the number itself. If you spot a prime number in a fraction, you cannot simplify it any further. To reduce large numbers you cannot identify the largest common factor of, try dividing by 2 if they are both even numbers, by 5 if they end in a 5, or by 10 if they end in zeros.

$$\frac{362}{900}$$

In this case, it's not clear what the largest common factor is. Since they are both even, they can be divided by 2.

$$\frac{362 \div 2}{900 \div 2}$$

$$\frac{181}{450}$$

181 is a prime number, so this fraction is now reduced.

Sample Exercise 3.5

Simplify the following fraction:

$$\frac{440}{1200}$$

Answer:

$$\frac{440 \div 10}{1200 \div 10} = \frac{44}{120}$$

$$\frac{44 \div 4}{120 \div 4} = \frac{11}{30}$$

11 is a prime number, so now this fraction is reduced.

Adding and Subtracting Fractions

To add and subtract fractions, fractions must share the same denominator. When the denominators are the same, you can simply add or subtract the numerators as indicated in the math problem. Simplify the new fraction if possible.

Sample Addition of Fractions

$$\frac{1}{3}+\frac{3}{5}$$

First, convert fractions as needed so they end up with the same denominator. In this case, we can make the common denominator 15.

$$\frac{1}{3}\times\frac{5}{5}=\frac{5}{15}$$

$$\frac{3}{5}\times\frac{3}{3}=\frac{9}{15}$$

Second, add the numerators.

$$\frac{5}{15}+\frac{9}{15}=\frac{14}{15}$$

Third, simplify if possible.

$\frac{14}{15}$ is in the simplest form.

Sample Exercise 3.6

$$\frac{8}{12}-\frac{1}{6}$$

Answers:

Find common denominator and convert fractions, subtract second numerator, simplify.

$$\frac{8}{12}-\left(\frac{1}{6}\times\frac{2}{2}\right)$$

$$\frac{8}{12}-\frac{2}{12}=\frac{6}{12}$$

$$\frac{6\div 6}{12\div 6}=\frac{1}{2}$$

Multiplying Fractions

To multiply fractions, all you need to do is multiply the numerators together and then multiply the denominators together to determine the numerator and denominator of the new fraction. You will need to convert any mixed fractions to improper fractions before multiplying the numerators together. Simplify your answer as needed.

Sample Multiplication of Fractions

$$\frac{5}{7} \times \frac{2}{6}$$

First, check to see if there are mixed fractions which need to be converted to improper fractions. In this question, there is not.

Second, multiply the numerators and then the denominators.

$$\frac{5 \times 2}{7 \times 6} = \frac{10}{42}$$

Third, simplify.

$$\frac{10 \div 2}{42 \div 2} = \frac{5}{21}$$

Sample Exercise 3.7

$\frac{3}{4} \times 1\frac{1}{2}$

Answer:
Convert to an improper fraction:

$$\frac{3}{4} \times \frac{3}{2}$$

Multiply numerators then denominators:

$$\frac{3 \times 3}{4 \times 2} = \frac{9}{8}$$

Simplify:

$$1\frac{1}{8}$$

Dividing Fractions

To divide fractions, start by converting any mixed fractions to improper fractions. To divide a fraction, you will actually multiply the first fraction by the reciprocal of the second. To create the **reciprocal of a fraction**, all you need to do is switch the places of the numerator and denominator.

Reciprocal Fractions

$$\frac{2}{3} = \frac{3}{2}$$

Sample Division of Fractions

$$1\frac{7}{8} \div \frac{2}{3}$$

First, convert any mixed fractions to improper fractions.

$$\frac{15}{8} \div \frac{2}{3}$$

Second, invert the second fraction to its reciprocal and change your symbol.

$$\frac{15}{8} \times \frac{3}{2}$$

Third, multiply across.

$$\frac{15}{8} \times \frac{3}{2} = \frac{45}{16}$$

Simplify.

$$\frac{45}{16} = 2\frac{13}{16}$$

Sample Exercise 3.8

$$\frac{3}{12} \div \frac{2}{3}$$

Answer:
Multiply the first fraction by the reciprocal of the second.

$$\frac{3}{12} \times \frac{3}{2} = \frac{9}{24}$$

Divide the numerator and denominator by 3 to simplify.

$$\frac{3}{8}$$

Key Takeaways

- Fractions are comprised of a numerator and denominator.
- Mixed fractions have a whole number to the left of the fraction.
- Improper fractions have a numerator larger than the denominator.
- To simplify fractions, divide the numerator and the denominator by the largest common factor.
- To add and subtract fractions, add or subtract the numerators of fractions with the same denominator.
- To multiply fractions, multiply the numerators and then multiply the denominators.
- To divide fractions, multiply the first fraction by the reciprocal of the second.
- Always simplify fractions when able.

Practice Set 3.1: Simplifying Fractions

Practice Set 3.1: Simplifying Fractions

Simplify the following fractions. Click the word **Answers** to check your work.

1. $\frac{6}{16}$
2. $\frac{3}{9}$
3. $\frac{10}{25}$
4. $\frac{32}{56}$
5. $\frac{22}{44}$
6. $\frac{14}{21}$
7. $\frac{13}{13}$
8. $\frac{30}{24}$
9. $\frac{66}{14}$
10. $\frac{70}{15}$

Answers:

1. $\frac{6 \div 2}{16 \div 2} = \frac{3}{8}$
2. $\frac{3 \div 3}{9 \div 3} = \frac{1}{3}$
3. $\frac{10 \div 5}{25 \div 5} = \frac{2}{5}$
4. $\frac{32 \div 8}{56 \div 8} = \frac{4}{7}$
5. $\frac{22 \div 22}{44 \div 22} = \frac{1}{2}$
6. $\frac{14 \div 7}{21 \div 7} = \frac{2}{3}$
7. $\frac{13 \div 13}{13 \div 13} = \frac{1}{1} = 1$
8. $\frac{30 \div 6}{24 \div 6} = \frac{5}{4} = 1\frac{1}{4}$
9. $\frac{66 \div 2}{14 \div 2} = \frac{33}{7} = 4\frac{5}{7}$
10. $\frac{70 \div 5}{15 \div 5} = \frac{14}{3} = 4\frac{2}{3}$

Practice Set 3.2: Adding and Subtracting Fractions

Practice Set 3.2: Adding and Subtracting Fractions

Add or subtract the following fractions. Click the word **Answers** to check your work.

1. $\frac{1}{3}+\frac{1}{3}$
2. $\frac{9}{10}-\frac{1}{5}$
3. $\frac{1}{4}+\frac{2}{3}$
4. $\frac{3}{4}-\frac{1}{7}$
5. $\frac{1}{2}+\frac{1}{4}$
6. $\frac{2}{3}-\frac{1}{9}$
7. $\frac{2}{5}+\frac{1}{6}$
8. $\frac{2}{3}+\frac{5}{6}$
9. $\frac{7}{8}-\frac{1}{2}$
10. $\frac{5}{6}-\frac{1}{10}$

Answers:

1. $\frac{2}{3}$
2. $\frac{9}{10}-\left(\frac{1}{5}\times\frac{2}{2}\right)=\frac{9}{10}-\frac{2}{10}=\frac{7}{10}$
3. $\left(\frac{1}{4}\times\frac{3}{3}\right)+\left(\frac{2}{3}\times\frac{4}{4}\right)=\frac{3}{12}+\frac{8}{12}=\frac{11}{12}$
4. $\left(\frac{3}{4}\times\frac{7}{7}\right)-\left(\frac{1}{7}\times\frac{4}{4}\right)=\frac{21}{28}-\frac{4}{28}=\frac{17}{28}$

5. $\left(\frac{1}{2} \times \frac{2}{2}\right) + \frac{1}{4} = \frac{2}{4} + \frac{1}{4} = \frac{3}{4}$

6. $\left(\frac{2}{3} \times \frac{3}{3}\right) - \frac{1}{9} = \frac{6}{9} - \frac{1}{9} = \frac{5}{9}$

7. $\left(\frac{2}{5} \times \frac{6}{6}\right) + \left(\frac{1}{6} \times \frac{5}{5}\right) = \frac{12}{30} + \frac{5}{30} = \frac{17}{30}$

8. $\left(\frac{2}{3} \times \frac{2}{2}\right) + \frac{5}{6} = \frac{4}{6} + \frac{5}{6} = \frac{9}{6} = 1\frac{3}{6} = 1\frac{1}{2}$

9. $\frac{7}{8} - \left(\frac{1}{2} \times \frac{4}{4}\right) = \frac{7}{8} - \frac{4}{8} = \frac{3}{8}$

10. $\left(\frac{5}{6} \times \frac{5}{5}\right) - \left(\frac{1}{10} \times \frac{3}{3}\right) = \frac{25}{30} - \frac{3}{30} = \frac{22}{30} = \frac{22 \div 2}{30 \div 2} = \frac{11}{15}$

Practice Set 3.3: Multiplying and Dividing Fractions

Practice Set 3.3: Multiplying and Dividing Fractions

Multiply or divide the following. Be sure to simplify all answers and write them as a mixed fraction when possible. Click on the word **Answers** to check your work.

1. $\frac{7}{10} \times \frac{1}{5}$
2. $\frac{2}{4} \times \frac{1}{2}$
3. $\frac{3}{7} \times \frac{5}{12}$
4. $3\frac{2}{3} \times \frac{7}{8}$

5. $1\frac{3}{5} \times 4\frac{5}{6}$
6. $\frac{4}{9} \div \frac{1}{2}$
7. $\frac{2}{3} \div \frac{6}{10}$
8. $\frac{3}{5} \div \frac{4}{7}$
9. $\frac{6}{13} \div \frac{4}{5}$
10. $\frac{1}{4} \div \frac{3}{9}$

Answers:

1. $\frac{7}{50}$
2. $\frac{2}{8} = \frac{1}{4}$
3. $\frac{3}{7} \times \frac{5}{12} = \frac{15}{84} = \frac{5}{28}$
4. $\frac{11}{3} \times \frac{7}{8} = \frac{77}{24} = 3\frac{5}{24}$
5. $\frac{8}{5} \times \frac{29}{6} = \frac{232}{30} = 7\frac{22}{30} = 7\frac{11}{15}$
6. $\frac{4}{9} \times \frac{2}{1} = \frac{8}{9}$
7. $\frac{2}{3} \times \frac{10}{6} = \frac{20}{18} = 1\frac{2}{18} = 1\frac{1}{9}$
8. $\frac{3}{5} \times \frac{7}{4} = \frac{21}{20} = 1\frac{1}{20}$
9. $\frac{6}{13} \times \frac{5}{4} = \frac{30}{52} = \frac{15}{26}$

10. $\frac{1}{4} \times \frac{9}{3} = \frac{9}{12} = \frac{3}{4}$

4.

Algebra

Lesson

Learning Outcomes

By the end of this chapter, learners will be able to:

- describe how algebra can be used in the process of medication administration, and
- solve linear equations with whole numbers and fractions.

What is Algebra?

Algebra is the branch of mathematics which uses symbols (also known as variables) to represent numbers which do not have a known amount. Letters are often used as the symbols for variables to represent values which are unknown in an equation. To determine the actual value of the variable(s) is called "solving the equation". Practicing how to solve for variables can support the development of your ability to calculate medication dosages safely as the preparation of medication often requires you to solve for an unknown amount.

Solving Equations

It is important to note the total value on each side of the equals sign is the same. You may recall that before solving an equation you may need to simplify it by combining all like terms together and then solving for the unknown variable(s). The majority of problems you must solve in medication administration will only require you to use basic math skills (adding, subtracting, multiplying and/or dividing) with real numbers and fractions.

Points to remember:

- Each side of the equation is equal.
- Simplify the problem by combining all like terms together.
- Use order of operations when solving the equation.

- If you do something to one side of the equation to simplify, you must do it to the other in order to keep both sides of the equation equal.

Solve the following equation:

$$2x + 4 = 12$$

First, let's get all the like terms together. Terms in this equation are 2x, 4 and 12. 4 and 12 are like terms because they are whole numbers. 2x does not have another like term. To get 4 and 12 together, we need to do something to both sides of the equation to cancel the 4 on the left side and bring it to the right side of the equals symbol.

$$2x + 4 - 4 = 12 - 4$$
$$2x = 8$$

Now get x by itself. To do this we must cancel out the 2, which we can do if we divide both sides by 2.

$$\frac{2x}{2} = \frac{8}{2}$$
$$x = 4$$

*In a shortened form of this process, this means when joining like terms that are being added or subtracted, you can just move the term across the equals sign and do the opposite function. Similarly, when moving terms that are being multiplied or divided, you can do the opposite function if it crosses the equals sign.

In the next section, you can practice solving randomly generated equations. You may want to have something to write on as you are solving these questions. You can practice questions with and without a calculator.

If you would like to review algebra in more detail, refer to Introductory Algebra by Izabela Mazur.[1]

Practice Set 4.1: Solving Equations

Included in this chapter are two quizzes to practice basic algebra equations (more precisely, linear equations). Start with the first quiz which includes equations with only whole numbers. For an additional challenge, try without a calculator! Although calculators are often available to assist with tasks requiring arithmetic in the workplace, practice without a calculator is also beneficial. It is a great exercise for your brain health and you may find your speed of mental calculations improving with repeated practice.

The second quiz is extra challenging, with the addition of fractions in most questions. Practicing these questions will help you consolidate your understanding of how to simplify, add, subtract, multiply and

1. Mazur, I. (2021). Introductory algebra. BCcampus. https://opentextbc.ca/introalgebra/

divide fractions. You will not need to be proficient in these questions to be able to understand most numerical information found in the field of nursing.

Click the start button to generate quiz questions. The quiz will count down and then begin to provide randomly generated questions. Each quiz will generate ten multiple choice questions each time you click the start button. You will be able to view one question at a time. When ready, click on the answer you think is correct. If it is the correct answer, the box changes to green and you will hear a sound indicating a correct answer. If it is not the correct answer, the box you click changes to a darker shade of blue and the correct answer is highlighted in green. You can track self improvement by the number of correctly answered questions and/or by the amount of time you take to complete the quiz.

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://opentextbc.ca/nursingnumeracy/?p=45#h5p-5

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://opentextbc.ca/nursingnumeracy/?p=45#h5p-6

5.

Scientific Notation

Lesson

Learning Outcomes

By the end of this chapter, learners will be able to

- explain the use of exponents,
- describe the system of scientific notation, and
- convert numbers from scientific form to standard form.

Exponents

You will see exponents being used in various ways related to health care topics. For instance, it might be for very large, or very small, amounts of medication or diagnostic test values. You may also come across exponents when reading statistical information in journal articles.

Exponents are numbers written in superscript, to the right of a number, called the base. Exponents can be positive or negative. A positive exponent is used to identify how may times the base number should be multiplied by itself. This number is referred to as the power. A negative exponent is the reciprocal of the number with a positive exponent. In general, positive exponents are related to large numbers while negative exponents are related to small numbers. While it is unlikely you will need to calculate what the power of a number equals, the following practice questions may help you to gain an appreciation for how the values of numbers change in size depending on the size of the base number and the size of the exponent.

$\text{Base}^{\text{Exponent}}$	Positive Exponent

For example: 2^6 or $2 \times 2 \times 2 \times 2 \times 2 \times 2 = 64$

This can be read aloud as “two to the sixth power.”

Negative Exponent

$$\begin{aligned} 2^{-6} &= \frac{1}{2^6} \\ &= \frac{1}{2 \times 2 \times 2 \times 2 \times 2 \times 2} \\ &= \frac{1}{64} \\ &= 0.015625 \end{aligned}$$

Sample Exercise 5.1

1. Write five to the power of three.
2. What does five to the power of three equal?

Answers:

1. 5^3
2. $5 \times 5 \times 5 = 125$

Sample Exercise 5.2

What number is represented by 6^{-4}?

Answers:

$$6^{-4} = \frac{1}{6^4}$$

$$= \frac{1}{1296}$$

$$= 0.0007716049382716$$

Scientific Notation

Scientific notation is a special way of concisely expressing very large and very small numbers. You can think of it like an abbreviation of a number. When a number is not abbreviated, it is known as a number in standard form. When numbers are written in scientific notation, the base number is multiplied or divided by a power of 10 to make the number large or small. When the exponent is positive, the base number is multiplied by 10, a number of times equal to the number of the exponent. When the exponent is negative, the base number is divided by 10, a number of times equal to the number of the exponent.

Positive Exponents

number x 10^n

$$\text{a. } 3.4 \times 10^5 = 3.4 \times 10 \times 10 \times 10 \times 10 \times 10$$

$$= 340000$$

$$\text{b. } 2.7 \times 10^3 = 2.7 \times 10 \times 10 \times 10$$

$$= 2700$$

$$\text{c. } 7.1 \times 10^8 = 7.1 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10$$

$$= 710000000$$

Negative Exponents

number × 10−^{n}

$$\text{a. } 4.2 \times 10^{-3} = 4.2 \times \frac{1}{10^3}$$

$$= 4.2 \times \frac{1}{10 \times 10 \times 10}$$

$$= \frac{4.2}{1000}$$

$$= 0.0042$$

$$\text{b. } 9.3 \times 10^{-5} = 9.3 \times \frac{1}{10^5}$$

$$= 9.3 \times \frac{1}{10 \times 10 \times 10 \times 10 \times 10}$$

$$= \frac{9.3}{10 \times 10 \times 10 \times 10 \times 10}$$

$$= \frac{9.3}{10000}$$

$$= 0.00093$$

Here you can see in scientific notation, the number is divided by 10 the same number of times as the number of the exponent.

When determining what the number is which is represented by scientific notation, you can easily do this just by moving the decimal place over by the number of spaces equal to the exponent. The decimal place will move to the right with positive exponents, making the number larger, and to the left for negative exponents, making the number smaller.

Positive Exponents

Move the decimal to the right to make the number larger.
In this example, the exponent, or the power, is 5. Move the decimal five places to the right.
(The numbers in subscript show the number of places the decimal is moving.)

eg. 3.4×10^5 = $3.4_1 0_2 0_3 0_4 0_5$ = 340000

Negative Exponents

Move the decimal to the left to make the number smaller.
In this example, the exponent, or the power, is 3. Move the decimal three places to the right.

eg. 4.2×10^{-3} = $_3 0_2 0_1 4 . 2$ = 0.0042

Sample Exercise 5.3

Write 1.7×10^6 in standard form.

Answers:
1700000
Move the decimal to the right six places. (1.7×10^6 = $1.7_1 0_2 0_3 0_4 0_5 0_6$= 1700000)

Key Takeaways

- Exponents are helpful when writing very large and very small numbers.

- Numbers with positive exponents will be greater or equal to one.
- Numbers with negative exponents will be less than one.
- When determining the value of a number written in scientific notation, if the power of 10 is positive you move the decimal to the right.
- When determining the value of a number written in scientific notation, if the power of 10 is negative you move the decimal to the left.

Practice Set 5.1: Determining the numerical value of numbers with positive exponents

Practice Set 5.1: Determining the numerical value of numbers with positive exponents

Calculate the value of the following numbers with exponents:

1. 5^4
2. 2^7
3. 4^2
4. 8^3
5. 6^6
6. 12^4
7. 3^{15}
8. 9^5
9. 10^3
10. 3^8

Answers:

1. 625
2. 128
3. 16
4. 512
5. 46656
6. 20736
7. 14348907
8. 59049
9. 1000
10. 6561

Practice Set 5.2: Determining the numerical value of numbers with negative exponents

Practice Set 5.2: Determining the numerical value of numbers with negative exponents

Calculate the value of the following numbers with exponents:

1. 2^{-4}
2. 10^{-2}
3. 4^{-3}
4. 7^{-4}
5. 32^{-1}
6. 5^{-5}
7. 3^{-5}
8. 7^{-3}
9. 8^{-2}
10. 3.3^{-4}

Answers:

1. 0.0625
2. 0.01
3. 0.015625
4. 0.00041649312786339
5. 0.03125
6. 0.00032
7. 0.0041152263374486
8. 0.0029154518950437
9. 0.015625
10. 0.0084322648810503

Practice Set 5.3: Determining the value of numbers written in scientific notation

Practice Set 5.3: Determining the value of numbers written in scientific notation

Convert each number to standard form.

1. 2.8×10^{4}
2. 7.34×10^{-6}
3. 4.9×10^{7}
4. 5.2×10^{3}
5. 1.54×10^{-4}
6. 6.241×10^{-8}

7. 5.9×10^5
8. 3.278×10^{-5}
9. 4.4×10^2
10. 8.623×10^6

Answers:

1. 28000
2. 0.00000734
3. 49000000
4. 5200
5. 0.000154
6. 0.00000006241
7. 590000
8. 0.0000327
9. 440
10. 8623000

II

Measuring

In this section of the book, chapters outline a variety of measurement systems which are used in healthcare settings. Practice questions are provided to help consolidate your understanding of each topic. When completing practice questions, read each question carefully and reduce any distractions around you. Check your work after completing questions and try to determine where your mistakes are coming from if you get the wrong answer. Continue to practice until you feel confident with the content in each chapter.

6.

Common Units in Nursing

Lesson

Learning Outcomes

By the end of this chapter, learners will be able to:

- identify common units of measurement for amount, mass and liquid volume in the metric system, and
- identify the correct abbreviations for common units of measure.

Understanding the Metric System

Types of Units

It's likely you have learned about the metric system (also known as The International System of Units) at some point in your past education, but perhaps some of the details are a little fuzzy. There are seven basic types of measure, which relate to quantities of time, length, mass, electric current, thermodynamic temperature, amount of substance and luminous intensity (National Institute of Standards and Technology, 2020). However, we will focus on only four types, as they are the measurements most commonly used in nursing. The mole, grams, metres and litres. Respectively, these units measure amount of a substance, mass (weight), length and volume (capacity).

Difference Between Volume and Capacity

You might think of litres as a way to measure the volume of a liquid, but it's not the most precise definition. Volume is a measure of how much space an object takes up, always measured in cubic units, such as cubic centimetres. Can you remember calculating the volume of objects in high school geometry? Multiplying the height, width and length of an object would give the volume of the object. Capacity is the measurement of how much of a substance can be inside an object, which could be matter existing in any state. Although there are many units to measure capacity, litre is most commonly used unit for measuring liquid matter. For use in nursing work, litre is commonly referred to as a measure of volume.

Base Units and Sizes of Measurements

When units of measure go up and down in size, they do so by a power of ten. A prefix is added to the base unit to indicate the size of the unit. For instance, a unit ten times larger than a gram is a decagram. You will not often see all of the possible units of measure being used in nursing work, so for the purposes of this text we will focus on the units you will use most often.

Table 6.1 Common Base Units

Metric Prefix	Symbol	Power of 10	Meaning	Multiply By
tera	T	10^{12}	one trillion	1,000,000,000,000
giga	G	10^{9}	one billion	1,000,000,000
mega	M	10^{6}	one million	1,000,000
kilo	k	10^{3}	one thousand	1,000
hecto	h	10^{2}	one hundred	100
deca	da	10^{1}	ten	10
deci	d	10^{-1}	one tenth	1/10
centi	c	10^{-2}	one hundredth	1/100
milli	m	10^{-3}	one thousandth	1/1,000
micro	μ	10^{-6}	one millionth	1/1,000,000
nano	n	10^{-9}	one billionth	1/1,000,000,000
pico	p	10^{-12}	one trillionth	1/ 1,000,000,000,000

Commonly Used Units

The following table outline units which are commonly used in medication orders and in medication administration in Canada. You should understand what these units measure and how to convert from one unit of measure to another. Occasionally, you will see measurements given using the US customary system of measure, derived from the British imperial system of measure. You may need to convert between units of the metric and imperial systems of measurement. Refer to the conversion table in this textbook for commonly used conversion factors.

Table 6.2 Common Units

Quantity	Abbreviation	Measure
Amount	i.u.	**international unit**
Amount	mEq	**milliequivalent**
Amount	mmol	**millimole**
Volume	mL	**millilitre**
Volume	L	**litre**
Mass	mcg	**microgram**
Mass	mg	**milligram**
Mass	g	**gram**
Mass	kg	**kilogram**
Length	cm	**centimetre**
Length	m	**metre**

Defining Units

Within the table above, each unit of measure is defined in the glossary of this textbook. Click on the word to view the definition if you are unable to define the unit of measure in your own words. If using this book in another format, you can find the glossary at the back of the book.

National Institute of Standards and Technology. (2020, January). *SI units*. https://www.nist.gov/si-redefinition/definitions-si-base-units

Practice Set 6.1: Unit Abbreviations

Practice Set 6.1: Unit Abbreviations

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://opentextbc.ca/nursingnumeracy/?p=51#h5p-7

7.

Converting Units for Medication Amounts

Lesson

Learning Outcomes

By the end of this chapter, learners will be able to:

- identify when units require conversion when comparing between the medication order and medication supply, and
- convert between common units of measure.

Determining When to Convert Units

When an order for medication is supplied in an amount with a different unit of measure than the order, you will need to convert units so they match in order to ensure you are giving the correct dose of medication. Not all orders will require unit conversion.

Sample Exercise 7.1

Which of the following orders require unit conversion before medication administration?

Order A:

- **Medication Order:** prednisone 25 mg PO once daily
- **Medication Supply:** prednisone 5 mg tablets

Order B:

- **Medication Order:** acetaminophen 1 g PO QID prn
- **Medication Supply:** acetaminophen 500 mg tablets

Answer:

Order B requires unit conversion as the order is given in grams and the supply is provided in milligrams. Order A and the supply are both provided in milligrams.

Converting Units

To convert from one unit of measure to another, you need to know how many of a particular unit is equal to a single unit of the other type of measure. You can refer to the conversion table for quick reference if you are unfamiliar with how many of one unit would be in another for the units commonly used in medication administration. These amounts are called **conversion factors**. You will then set up an algebraic equation to convert between units, with the conversion factor written as a fraction.

Let's say we need to give 0.5 grams (g) of a medication and the supply is in milligrams (mg). How many mg are equal to 0.5 g?

$$? \text{ mg} = 0.5 \text{ g}$$

Start the equation with what you need to know, in this case, how many mg. We use **"x"** to represent the unknown amount of mg. Then, we need to use the conversion factor of **1000 mg = 1 g.** When you set up the formula, put the type of units on top which matches the unit you are looking for. In this example, we are trying to find mg, so write in $\frac{1000 \text{ mg}}{1 \text{ g}}$.

Finally, we multiply by the known amount. The formula would look like this:

$$x \text{ mg} = \frac{1000 \text{ mg}}{1 \text{ g}} \times 0.5 \text{ g}$$

To solve this equation, complete the calculation using the standard **order of operations**. Some people use the acronym **BEDMAS** to help them remember the order of operations: **B**rackets, **E**xponents, **D**ivision or **M**ultiplication, **A**ddition or **S**ubtraction.

You can always check to see if you are ending up with the correct units by cancelling out units which match in the numerator and denominator of the equation. In this case, grams in the numerator and denominator cancel out, leaving us with just an amount of mgs, which is exactly what we want!

$$x \text{ mg} = \frac{1000\text{mg}}{1 \cancel{\text{g}}} \times 0.5 \cancel{\text{g}}$$

$$x = 500 \text{ mg}$$

Sample Exercise 7.2

Sample Medication Order to Convert

Medication Order: pulmicort 500 mcg twice a day via nebulizer

Medication Supply: pulmicort 0.25 mg/mL nebule

You can see that the order is written as **mcg** and the supply is measured in **mg/mL.**

First, decide what type of unit you are converting to. This is what you will use to start the set up of your formula. In this example, we need to find out how many milligrams are in 500 micrograms because our supply is available in milligrams.

$$x \text{ mg} =$$

Second, start with what you know-the conversion factor:

$$x \text{ mg} = \frac{1 \text{ mg}}{1000 \text{ mcg}}$$

Third, multiply by the amount you need to convert:

$$x \text{ mg} = \frac{1 \text{ mg}}{1000 \text{ mcg}} \times 500 \text{ mcg}$$

You can see the units of mcg cancel out as there is one in the numerator and the denominator:

$$x \text{ mg} = \frac{1 \text{ mg}}{1000 \cancel{\text{ mcg}}} \times 500 \cancel{\text{ mcg}}$$

Now, complete the calculation:

$$\frac{500}{1000} = 0.5 \text{ mg}$$

Sample Exercise 7.3

How many milligrams of ciprofloxacin must be administered?

Medication Order: Ciprofloxacin 0.75 g PO once daily

Medication Supply: Ciprofloxacin 250 mg tablets

Answer:
Set up the formula. Start with what you need to know (x mg). Use the conversion factor, with number on top in the same units (mg). Multiply by amount in the order.

$$x \text{ mg} = \frac{1000 \text{ mg}}{1 \text{ g}} \times 0.75 \text{ g}$$

Cancel out units to ensure the formula is set up correctly.

$$x \text{ mg} = \frac{1000 \text{ mg}}{1 \cancel{\text{g}}} \times 0.75 \cancel{\text{g}}$$

Calculate.

$$1000 \text{ mg} \times 0.75 \text{ g} = 750 \text{ mg}$$

Practice Set 7.1: When to Convert

Practice Set 7.1: When to Convert

In the following exercises, identify if any units need to be converted (yes/no answer) and what unit to convert to.

1. A medication is ordered at a single dose of 500 mg. The capsules provided by the pharmacy are 250 mg each.
2. A medication is ordered at a single dose of 1 g. The tablets provided by the pharmacy are 500 mg each.
3. A medication is ordered at 0.15 mg BID. The tablets provided by the pharmacy are 0.75 mcg each.
4. A medication is ordered at 750 mg TID. The tablets provided by the pharmacy are 250 mg each.
5. A medication is ordered at 500 mcg BID. The tablets provided are 1 mg each.

6. A medication is ordered for a single dose of 500 mg at 1,000. The tablets provided are 1,000 mg each.
7. A medication is ordered at 1 g TID. The capsules provided are 500 mg each.
8. A medication is ordered at 500 mcg BID. The capsules provided by pharmacy are 1 g each.
9. A medication is ordered at a single dose of 150 mg. The tablets provided are 750 mcg each.
10. A medication is ordered at 300 mcg QID. The capsules provided are 200 mcg each.

Answers:

1. No.
2. Yes. Convert 1 g to mg.
3. Yes. Convert 0.15 mg to mcg.
4. No.
5. Yes. Convert 500 mcg to mg.
6. No.
7. Yes. Convert 1 g to mg.
8. Yes. Convert 500 mcg to g.
9. Yes. Convert 150 mg to mcg.
10. No.

Practice Set 7.2: Converting Mass

Practice Set 7.2: Converting Mass

In each of the following practice questions you will be given a medication order and a supply provided with an alternate unit of measurement. Convert the order amount so it matches the unit of measurement of the supply.

The answers to this problem set are visible when you click the drop down button below. When you click the word "Answers" you will see the answers for all ten questions with the answer listed first, followed by how to set up the formula. It is worth mentioning this is not the only way to solve this type of problem, and it is acceptable to use another method to convert between units if you are comfortable with a different method.

Questions:

1. Order: acetaminophen 1 g PO QID
Supply 500 mg tablets
2. Order: ipratropium 0.5 mg via nebulizer q6h
Supply 250 mcg nebules
3. Order: lorazepam 500 mcg SL BID prn
Supply 0.5 mg tablets
4. Order: cloxacillin 0.5 g PO q4h
Supply 250 mg tablets
5. Order: digoxin 250 mcg PO once daily
Supply 0.125 mg tablets
6. Order: azithromycin 2 g PO once daily
Supply 500 mg tablets
7. Order: budesonide 0.4 mg inhaled BID
Supply 200 mcg per metered dose
8. Order: synthroid 0.15 mg PO once daily
Supply 75 mcg tablets
9. Order: ciprofloxacin 0.75 g PO q12h
Supply 500 mg tablets
10. Order: metronidazole 1.5 g PO
Supply 500 mg tablets

Answers:

1. 1,000 mg $$x \text{ mg} = \frac{1000 \text{ mg}}{1 \text{ g}} \times 1 \text{ g}$$
2. 500 mcg $$x \text{ mcg} = \frac{1000 \text{ mcg}}{1 \text{ mg}} \times 0.5 \text{ mg}$$
3. 0.5 mg $$x \text{ mg} = \frac{1 \text{ mg}}{1000 \text{ mcg}} \times 500 \text{ mcg}$$
4. 500 mg $$x \text{ mg} = \frac{1000 \text{ mg}}{1 \text{ g}} \times \text{x}0.5 \text{ g}$$

5. 0.25 mg $$x \text{ mg} = \frac{1 \text{ mg}}{1000 \text{ mcg}} \times 250 \text{ mcg}$$
6. 2,000 mg $$x \text{ mg} = \frac{1000 \text{ mg}}{1 \text{ g}} \times 2 \text{ g}$$
7. 400 mcg $$x \text{ mcg} = \frac{1000 \text{ mcg}}{1 \text{ mg}} \times 0.4 \text{ mg}$$
8. 150 mcg $$x \text{ mcg} = \frac{1000 \text{ mcg}}{1 \text{ mg}} \times 0.15 \text{ mg}$$
9. 750 mg $$x \text{ mg} = \frac{1000 \text{ mg}}{1 \text{ g}} \times 0.75 \text{ g}$$
10. 1,500 mg $$x \text{ mg} = \frac{1000 \text{ mg}}{1 \text{ g}} \times 1.5 \text{ g}$$

Practice Set 7.3: Converting Mass

Practice Set 7.3: Converting Mass

In each of the following practice questions you will be given a weight which needs to be converted to an alternate unit of measure, which may be metric or imperial.

1. A baby weighs 2,347 grams. A medication is ordered and the amount is based on how heavy a child is in kilograms. How many kilograms is this baby?
2. A child weighs 35 kilograms. The parent asks how much the child weighs in pounds. How many pounds is this child?
3. A nurse is on light work duty only after returning to work post injury. Worksafe requirements state they can lift a maximum of 10 kilograms. A box of IV bags is labelled 25 lbs. How many kilograms is this?

4. A baby weighs 1.27 kilograms. How many grams is this?
5. A person weighs 87.5 kilograms. How many pounds is this?
6. A child weighs 32 pounds. How many kilograms is this?
7. A wheelchair is rated for use for a person up to 400 pounds. The person you would like to transfer using the wheelchair is 167 kilograms. How many pounds is this equivalent to?
8. A premature infant weighs 477 grams. How many kilograms is this?
9. An infant warmer in the hospital neo-natal intensive care unit has a maximum patient weight of 30 pounds. The baby you are caring for was born weighing 11.8 kilograms. How many pounds is this?
10. A newborn weighs 6 pounds and 4 ounces. How many grams is this?

Answers:

1. 2.35 kg $$x \text{ kg} = \frac{1 \text{ kg}}{1000 \text{ g}} \times 2347 \text{ g}$$
2. 77 lb $$x \text{ lbs} = \frac{2.2 \text{ lbs}}{1 \text{ kg}} \times 35 \text{ kg}$$
3. 11.36 kg $$x \text{ kg} = \frac{1 \text{ kg}}{2.2 \text{ lbs}} \times 25 \text{ lbs}$$
4. 1,270 g $$x \text{ g} = \frac{1000 \text{ g}}{1 \text{ kg}} \times 1.27 \text{ kg}$$
5. 192.5 lb $$x \text{ lbs} = \frac{2.2 \text{ lbs}}{1 \text{ kg}} \times 87.5 \text{ kg}$$
6. 14.54 kg $$x \text{ kg} = \frac{1 \text{ kg}}{2.2 \text{ lbs}} \times 32 \text{ lbs}$$
7. 367.4 lb $$x \text{ lbs} = \frac{2.2 \text{ lbs}}{1 \text{ kg}} \times 167 \text{ kg}$$

8. 0.477 kg $x \text{ kg} = \dfrac{1 \text{ kg}}{1000 \text{ g}} \times 477 \text{ g}$
9. 25.96 $x \text{ lbs} = \dfrac{2.2 \text{ lbs}}{1 \text{ kg}} \times 11.8 \text{ kg}$
10. 2,840.9 grams.

If you use the method demonstrated in this textbook, but you do not have the conversion factor between grams and pounds, you can answer this question using this method:

1. Convert ounces to pounds $x \text{ lbs} = \dfrac{1 \text{ lb}}{16 \text{ oz}} \times 4 \text{ oz}$ = 0.25
2. Add converted ounces (0.25 lbs) to the known amount of pounds (6) from the question. =6.25
3. Convert pounds to grams: $x \text{ g} = \dfrac{1000 \text{ g}}{1 \text{ kg}} \times \dfrac{1 \text{ kg}}{2.2 \text{ lbs}} \times 6.25 \text{ lbs}$

Alternately, you could use the conversion factor for pounds and grams: 1 lb = 454 g, which would give you a slightly different answer due to rounding error as both conversion factors have been rounded from the most precise conversion amount: 2,837.5 g

Practice Set 7.4: Converting Volume

Practice Set 7.4: Converting Volume

In each of the following practice questions you will be given a measurement which needs to be converted to an alternate unit of measure, which may be metric or imperial.

1. Convert 1.15 litres to millilitres.
2. Convert 237 millilitres to litres.
3. Convert 5,819 millilitres to litres.
4. A medication requires you to mix a package of powdered medication into 1.5 cups of

water. How many millilitres is this?

5. Before an ultrasound, the radiology department calls and asks you to have the patient drink 2 cups of water. How many millilitres is this?

6. At the end of your shift, the charge nurse asks you how many litres of intake your patient had today. When you check the fluid balance record you see they have received 1,875 mL of intravenous fluid and 680 mL of fluid from their meal trays.

7. You are recording fluid intake for a client. They report in the afternoon they had 2.5 cans of flavoured soda water. Each can holds 355 ml. How many mL is this?

8. When caring for a pediatric client, the guardian informs you they gave the child 2.5 teaspoons of children's Tylenol. You weigh the child and determine the appropriate dose based on their weight is 15 mL. Presuming her teaspoon measurements were precise, was the amount given correct?

9. A client has a new prescription for eye drops: One drop in each eye once a day. The client is curious how long the bottle might last and so you help them out with the math. The bottle contains 2.5 mL of fluid. A standard eye drop dispenser releases drops approximately 50 microlitres each. How many days will the bottle likely last for, if the client takes the medication as prescribed and does not waste any drops?

10. While discussing effective treatments for constipation on night shift, a senior nurse describes their previous success with milk and molasses enemas to you. While you are researching literature to find out if their anecdotal findings have been experienced by others, you come across a recipe for the treatment: Mix 8-16 oz milk with 8-16 oz molasses and instill slowly. Knowing that a large volume enema can be given safely at a volume of 500-1,000 mL, would this recipe fall in the safe range?

Answers:

1. 1,150 mL
   $$x \text{ mL} = \frac{1000 \text{ mL}}{1 \text{ L}} \times 1.15 \text{ L}$$

2. 0.237 L
   $$x \text{ L} = \frac{1 \text{ L}}{1000 \text{ mL}} \times 237 \text{ mL}$$

3. 5.819 L
   $$x \text{ L} = \frac{1 \text{ L}}{1000 \text{ mL}} \times 5819 \text{ mL}$$

4. 375 mL

$$x \text{ mL} = \frac{250 \text{ mL}}{1 \text{ cup}} \times 1.5 \text{ cups}$$

5. 500 mL

$$x \text{ mL} = \frac{250 \text{ mL}}{1 \text{ cup}} \times 2 \text{ cups}$$

6. 2.555 L
Calculate in two steps:
    1. $1875 \text{ mL} + 680 \text{ mL} = 2555 \text{ mL}$
    2. $x \text{ L} = \dfrac{1 \text{ L}}{1000 \text{ mL}} \times 2555 \text{ mL}$

7. 887.5 mL

$$x \text{ mL} = \frac{355 \text{ mL}}{1 \text{ can}} \times 2.5 \text{ cans}$$

8. No, not quite enough. She likely gave 12.5 mL.

$$x \text{ mL} = \frac{5 \text{ mL}}{1 \text{ tsp}} \times 2.5 \text{ tsp}$$

9. 25 days

$$x \text{ days} = \frac{1 \text{ day}}{2 \text{ gtts}} \times \frac{1 \text{ gtt}}{50 \mu\text{L}} \times \frac{1000 \mu\text{L}}{1 \text{ mL}} \times 2.5 \text{ mL}$$

10. Yes, it would be a minimum of 480 mL if 8 oz of milk and 8 oz of molasses was used and a maximum of 960 mL if 16 oz of each were used.

$$x \text{ mL} = \frac{30 \text{ mL}}{1 \text{ oz}} \times 16 \text{ oz} x \text{ mL} = \frac{30 \text{ mL}}{1 \text{ oz}} \times 32 \text{ oz}$$

8.

Conversion Table

The following tables outline common conversion amounts used in nursing.

Table 8.1 Common Metric Conversions for Weight

Weight Measurements in Metric	Equivalent Amount in Metric
1,000 microgram (mcg)	1 milligram (mg)
1,000 milligram (mg)	1 gram (g)
1,000 gram (g)	1 kilogram (kg)

Table 8.2 Common Metric Conversions for Volume

Volume Measurements in Metric	Equivalent Amount in Metric
1,000 millilitre (mL)	1 litre (L)
1,000 milliunits (no official abbreviation)	1 unit (U*)
1 cubic centimetre (cc*)	1 millilitre (mL)
1 milliquivalent (mEq)	1 millimole (mmol)

Table 8.3 Conversions Between Metric and Imperial Measurement of Weight

Weight Measurement in Metric	Equivalent Amount in Imperial
1 kilogram (kg)	2.2 pounds
28.35 grams	1 ounces (oz)

Table 8.4 Additional Common Conversions

Additional Measures	Equivalent Amount
1 milliquivalent (mEq)	1 millimole (mmol)
30 centimetres	1 foot (ft or ‘)
2.54 centimetres	1 inch (in or “)
16 ounces	1 pound (lb)
1 millilitre (mL)	1 gram (g)

*symbol denotes a dangerous abbreviation which should not be used. This abbreviation is included in this text as it is possible you may see this abbreviation in the health care setting. Clarification of the order is required to ensure patient safety.

9.

Roman Numerals

Lesson

Learning Outcomes

By the end of this chapter, learners will be able to:

- describe the Roman numeral system,
- convert Roman numerals to Arabic numbers, and
- convert Arabic numbers to Roman numerals.

The Roman Numeral System

The basic Roman numeral system is made up of seven letters which represent numerical values. Either upper or lowercase letters can be used. Although not used extensively in the healthcare system, there are situations which arise where Roman numerals are used instead of typical Arabic numbers. Can you think of any instances where you have seen Roman numerals used in healthcare?

Table 9.1 Roman Numeral Values

Roman Numeral	Arabic Number
I	1
V	5
X	10
L	50
C	100
D	500
M	1,000

Interpreting Values of Roman Numerals

Numbers outside of the values above are represented by using these letters in combination. The combinations can have multiple letters in a row, but always follow a particular pattern.

- You add the values of the letters together when they are the same letter or the letter values are in descending order.
    - This pattern is used for all numbers except those including 4 and 9.
    - Examples:
        - XX (10+10) = 20
        - MCCLXXXVIII (1000+100+100+50+10+10+10+5+1+1+1) = 1,288
- For values that include 4 and 9, one must use subtraction of values to determine the number being represented.
    - When a lower value letter is to the left of a higher value letter, subtract it from the letter to the right.
    - If a lower value letter is between two large value letters, subtract it from the letter to the right.
    - Examples:
        - IV (5-1) = 4
        - XLIV [(50-10)+(5-1)] = 44
- If a line is drawn above a letter, multiply the numeral by 1,000, however it is very unlikely you will see any Roman numerals written in this form in the context of nursing work.

What is the numerical value of XXI?

First, determine each of the letter values: 10 , 10 , 1

Second, determine if the letters should be added or subtracted. To do this, identify if a lower value letter is to the left of any of the values. If it is, subtract the lower value from the value to the right, then add the remaining values.

In this case, all values to the left of 1 are higher, therefore you can just add all the values together.

10 + 10 + 1 = 21
XXI = 21

Sample Exercise 9.1

What is the numerical value of XXIV?

Answer:
XXIV = 24

1. Determine the values of each letter: 10, 10, 1, 5
2. Identify if a lower value is to the left of a larger value: 1 is to the left of 5.
3. Subtract the lower value from the larger value: 5 – 1 = 4
4. Add this number to the remaining numbers: 10 + 10 + 4 = 24

Writing Arabic Numbers as Roman Numerals

When writing numbers, you should follow the rules written in the section above and also note there should never be more than three of the same letter in a row.

How do you write the Arabic number 71 as a Roman numeral?

Generally*, start by using the biggest value Roman numeral without going over the Arabic number: L = 50

Next, add additional letters until the values add up to the correct numerical value: LXXI (50+10+10+1=71)

Sometimes it can be helpful to count as you add the letters in a row: L 50, LX 60, LXX 70, LXXI 71

*Note that in some cases, particularly with numbers ending in 9, you may start with a numeral with a value greater than the final Arabic number.

Sample Exercise 9.2

How do you write the Arabic number 53 as a Roman numeral?

Answer:
LIII

1. Identify the Roman numeral with the biggest value without going over: L
2. Add additional letters to obtain the correct numerical value: 50 + 1 + 1 + 1 = 53

Practice Set 9.1: Converting Roman Numerals to Arabic Numbers

Practice Set 9.1: Converting Roman Numerals to Arabic Numbers

Convert the following Roman numerals into Arabic numbers.

1. XX
2. VI
3. VIII
4. IV
5. IX
6. XXVII
7. II
8. M
9. LV
10. CXXV

Answers:

1. 20
2. 6
3. 8
4. 4
5. 9
6. 27
7. 2
8. 1,000
9. 55
10. 125

Practice Set 9.2: Converting Arabic Numbers to Roman Numerals

Practice Set 9.2: Converting Arabic Numbers to Roman Numerals

Convert the following Arabic numbers to Roman numerals.

1. 36
2. 21
3. 7
4. 18
5. 14
6. 49
7. 86
8. 35
9. 3
10. 12

Answers:

1. XXXVI
2. XXI
3. VII
4. XVIII
5. XIV
6. IL
7. LXXXVI
8. XXXV
9. III
10. XII

10.

The 24-Hour Clock

Lesson

Learning Outcomes

By the end of this chapter, learners will be able to:

- describe the difference between the ante meridiem (a.m.) and post meridiem (p.m) system of time (12 hour clock) and the 24-hour clock,
- convert time between the 12 and 24-hour clocks, and
- identify the time on an analog clock.

The 24-Hour Clock

In healthcare, the 24-hour clock is often used instead of the Latin system using **ante meridiem** (a.m.) and **post meridiem** (p.m.). Using the a.m. and p.m. notation when communicating about time can be confusing and lead to errors in places that function during the night and day. Instead of having time be broken into two periods of 12 hours each, each hour of the day is noted with it's own number-hence the clock being a 24-hour clock. The 24-hour clock starts counting at 12 a.m., or midnight, at 0000. 1 a.m. is written as 0100, 2 a.m. is written as 0200, 1 p.m. is written as 1300. To determine how to write p.m. times, all you need to do is add 1200 to any notation of p.m. time.

3:00 p.m. = 1500 hours

Eventually, using the 24-hour clock will become habitual, and you will not have to think about how to convert between the two systems at all. You can also refer to the table below as a quick reference to see what each hour of p.m. time is in the 24-hour system. You never have to change how minutes are recorded. Some professions continue to use a colon when writing times using the 24-hour system, but in handwritten healthcare charting the colons are generally left out to keep charting entries clear. Computer systems will often use colons, especially if there are seconds also being recorded.

Table 10.1 Converting P.M. Time to 24-Hour Time

Post Meridiem Time	24-Hour Time
1:00 p.m.	1300 hours
2:00 p.m.	1400 hours
3:00 p.m.	1500 hours
4:00 p.m.	1600 hours
5:00 p.m.	1700 hours
6:00 p.m.	1800 hours
7:00 p.m.	1900 hours
8:00 p.m.	2000 hours
9:00 p.m.	2100 hours
10:00 p.m.	2200 hours
11:00 p.m.	2300 hours
12:00 p.m.	2400 or 0000 hours

Sample Exercise 10.1

How you write 9:45 p.m. using the 24-hour clock format?

Answer:
945 + 1200 = 2145 hours
You could also use the table and see 9 p.m. = 2100 hours to change the 9 to 21, keeping the minutes the same.

Key Takeaways

- When converting a.m. and p.m. time to the 24-hour system, add 1200 to any p.m. time.
- Notation of minutes remain the same in the 12 and 24-hour systems.

Practice Set 10.1: Converting a.m. and p.m. time to the 24-hour clock

Practice Questions Set 10.1: Converting a.m. and p.m. time to the 24-hour clock

Convert the following times from the a.m. and p.m. system to the 24-hour clock.

1. 6:15 a.m.
2. 9:30 p.m.
3. 4:00 p.m.
4. 7:25 p.m.
5. 11:15 p.m.
6. 2:10 p.m.
7. 3:54 a.m.
8. 5:05 p.m.
9. 1:38 p.m.
10. 6:45 p.m.
11. 8:45 p.m.
12. 9:36 a.m.
13. 2:44 p.m.
14. 5:12 p.m.
15. 10:00 p.m.
16. 6:18 p.m.
17. 3:48 p.m.
18. 11:15 p.m.
19. 7:27 p.m.
20. 4:20 a.m.

Answers:

1. 0615 hours
2. 2130 hours
3. 1600 hours
4. 1925 hours
5. 2315 hours
6. 1410 hours
7. 0354 hours
8. 1705 hours
9. 1338 hours
10. 1845 hours
11. 2045 hours
12. 0936 hours
13. 1444 hours
14. 1712 hours
15. 2200 hours
16. 1818 hours
17. 1548 hours
18. 2315 hours
19. 1927 hours
20. 0420 hours

Practice Set 10.2: Converting from the 24-hour system to a.m. and p.m. time

Practice Set 10.2: Converting from the 24-hour system to a.m. and p.m. time

Convert the following times from the 24-hour system to a.m. and p.m. time.

1. 1915
2. 1435
3. 0642
4. 1724
5. 2317
6. 1604
7. 1303
8. 2159
9. 1522
10. 2220

Answers:

1. 7:15 p.m.
2. 2:35 p.m.
3. 6:42 a.m.
4. 5:24 p.m.
5. 11:17 p.m.
6. 4:04 p.m.
7. 1:03 p.m.
8. 9:59 p.m.
9. 3:22 p.m.
10. 10:20 p.m.

Practice Set 10.3: Converting time on analog clocks to the 24-hour clock

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://opentextbc.ca/nursingnumeracy/?p=60#h5p-8

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://opentextbc.ca/nursingnumeracy/?p=60#h5p-9

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://opentextbc.ca/nursingnumeracy/?p=60#h5p-10

11.

Reading Syringes

Lesson

Learning Outcomes

By the end of this chapter, learners will be able to:

- identify the volume of liquid in a syringe, and
- select the most appropriate syringe to draw up a volume of liquid.

Syringe Units of Measure

Syringes come in a variety of sizes and are most often labelled for measurement in millilitres (mL) of liquid. It is possible you may see some syringes measuring cubic centimeters (cm^3), but most large companies use only mL. 1 cm^3 is equivalent to 1 mL. Insulin syringes, used only in drawing up insulin, measure units of insulin — not millilitres of insulin. Less commonly, you will see some syringes packaged with particular medications labelled in imperial units, such as teaspoons or tablespoons. For instance, a liquid antibiotic for pediatric patients may be packaged with a syringe measuring teaspoons of liquid.

Three samples of syringes with difference measurements are included below:

1 mL syringe

100 Unit Insulin Syringe

3 mL syringe

Reading Syringe Volumes

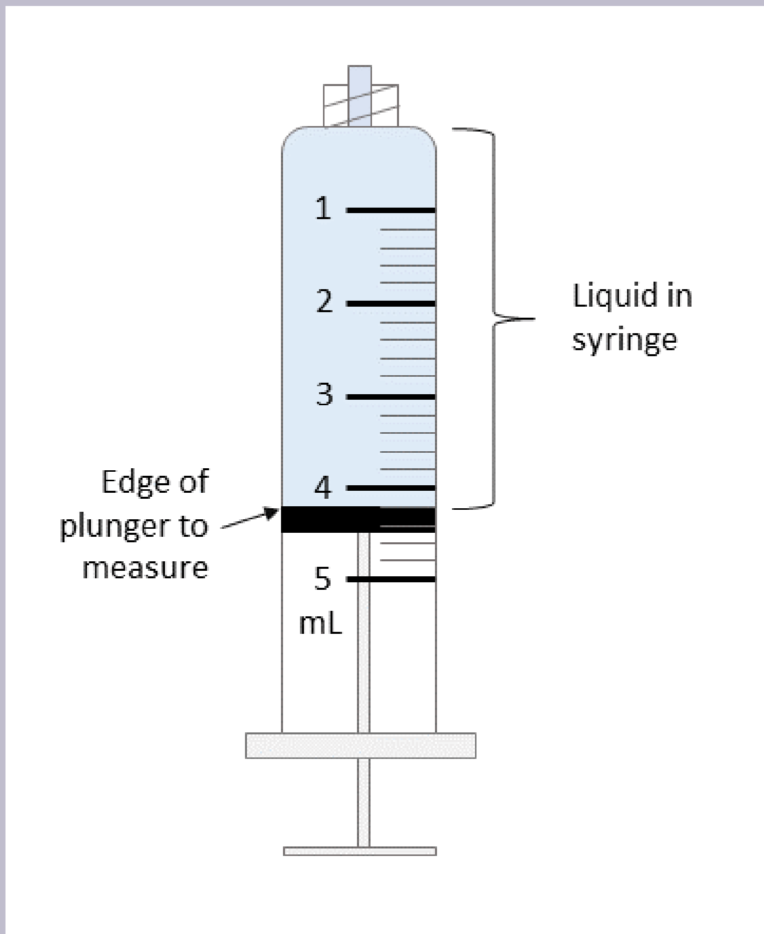
Attention to detail is required to read syringe volumes accurately.

1. Identify the unit of measure for the syringe you are using.
    a. The barrel of the syringe is marked with graduated measurements of a particular unit of measure. Long or possibly bold lines mark whole units, with whole numbers often marked on the syringe barrel.
2. Identify the size of graduated measurements.
    a. Depending on the total capacity of the syringe, the space between each line on syringes will vary in volume. For instance, in a 3 mL syringe, each space between lines is equal to 0.1 mL. In a 5 mL syringe, each space is equal to 0.2 mL.
3. Identify where the end of the plunger is.
    a. The liquid inside the syringe will take up space up to the edge of the plunger inside the syringe. This edge is what should be compared to the graduated measurements to determine how much liquid is inside the syringe. The plunger inside the syringe is large and usually shows two sharp edges where the rubber is touching the inside of the syringe barrel. The edge you are looking at is always going to be the edge closed to the tip of the syringe, not the edge close to where your fingers are holding the flanges and plunger rod.
4. Determine if the volume is accurate.
    a. If bubbles are present, the measurement of volume will not be accurate. Remove the bubbles before reading the volume of liquid.
5. Determine the volume of liquid present.

a. Now you are ready to read the volume of liquid in the syringe. Compare the edge of the plunger to the graduated markings to determine how much liquid is in the syringe.

Sample Exercise 11.1

Use the image below to answer the questions and click on “Answers” to check your work.



Questions:

1. What is the capacity of the syringe?
2. How much volume is between each graduated measure on the syringe?
3. Identify the volume of liquid in the pictured syringe.

Answers:

1. 5 mL

The capacity is the total volume the syringe can measure. This is represented by the largest number on the scale, and will be closest to the flange of the syringe.

2. 0.2 mL

   On this scale, 1 mL is broken up into 5 parts. $\frac{1}{5} = 0.2 \text{ mL}$

3. 4.2 mL

   Make sure to take the measurement from the side of the plunger closest to the syringe tip. You can see liquid represented by the shaded portion from this plunger edge to the tip of the syringe.

Choosing Syringe Sizes

There are multiple syringes which can measure 1 mL of liquid. You will use critical thinking to determine which is the most appropriate syringe to use when drawing up medication. Factors you can consider when choosing a syringe include, but are not limited to:

1. Policy requirements.
   a. Be aware of policy requirements related to equipment you are using. In particular situations you will need to select a specific size of syringe.
2. The total volume of liquid required.
   a. You should use a syringe which can draw up the total amount of liquid required whenever possible. Choose a syringe which can hold all of the volume of liquid required.
3. The precision required for the context of the situation.
   a. There are a variety of factors which impact how precise you must be when measuring liquid medications. For instance, the effect of medications on a premature infant versus an adult patient can be much more pronounced, and thus require a smaller syringe allowing measurements of volume to additional decimal places.
4. The pressure which will be created when delivering the liquid.
   a. In general, smaller syringes created higher pressure than larger syringes when liquid is delivered from the syringe. Pressure may or may not be a factor which needs to be considered in the particular situation you are working in.
5. The supply available.
   a. What is available for use at the time you are drawing up liquid? If the syringe you were going to choose is not available, you will need to determine if it is safe to replace with an alternate syringe type.

Key Takeaways

When determining the volume of liquid in a syringe, keep the following in mind:

- Note the unit of measure of the syringe.
- Ensure you are measuring from the correct side of the plunger.
- Remove all bubbles before determining the volume.

Practice Set 11.1: Reading Syringe Volumes

Practice Set 11.1: Reading syringe volumes

An interactive H5P element has been excluded from this version of the text. You can view it online here: https://opentextbc.ca/nursingnumeracy/?p=66#h5p-11

Practice Set 11.2: Reading Syringe Volumes

Practice Set 11.2: Reading syringe volumes

An interactive H5P element has been excluded from this version of the text. You can view it online here: https://opentextbc.ca/nursingnumeracy/?p=66#h5p-12

Practice Set 11.3: Reading Syringe Volumes

Practice Set 11.3: Reading Syringe Volumes

An interactive H5P element has been excluded from this version of the text. You can view it online here: https://opentextbc.ca/nursingnumeracy/?p=66#h5p-13

Practice Set 11.4: Reading Syringe Volumes

Practice Set 11.4: Reading Syringe Volumes

An interactive H5P element has been excluded from this version of the text. You can view it online here: https://opentextbc.ca/nursingnumeracy/?p=66#h5p-14

Practice Set 11.5: Choosing Syringes

Practice Set 11.5: Choosing Syringes

Identify the type of syringe you would select to draw up the following volumes of liquid medication.

1. 4.2 mL
2. 0.22 mL

3. 1.6 mL
4. 0.75 mL
5. 3.0 mL
6. 0.1 mL
7. 2.6 mL
8. 1 mL
9. 2.3 mL
10. 7.8 mL

Answers:

1. 5 mL syringe
2. 1 mL syringe
3. 3 mL syringe (5 mL is also possible)
4. 1 mL syringe
5. 3 mL or 5 mL syringe
6. 1 mL syringe
7. 3 mL or 5 mL syringe
8. 3 mL syringe. (1 mL also works, but can be tricky to clear air bubbles as the plunger is pulled almost all the way back.)
9. 3 mL syringe (a 5 mL syringe has measurements in 0.2 mL increments so is not the best choice as odd measurements fall midway between the measurement lines)
10. 10 mL syringe

III

Math for Medication Administration

In this section of the book, chapters will focus on helping you to develop skills essential for the correct preparation of medication. When completing practice questions you should focus on reading each question carefully and reducing any distractions around you. Check your work after completing questions and try to determine where your mistakes are coming from if you get the wrong answer. Answers to sample exercises and practice questions have steps in solving shown to help you identify where you are making mistakes.

- Did you understand the question?
- Did you set up the equation correctly?
- Did you make a mistake when using the calculator or doing mental math?
- Is there a difference because of the method you used when rounding?

12.

Understanding Medication Labels

Lesson

Learning Outcomes

By the end of this chapter, learners will be able to:

- describe the key components of a medication label, and
- identify key information on sample medication labels.

Medication Labels

Medication containers are labelled with various types of information about the particular medication inside. When administering medications, it is essential you understand what the numbers on the label represent in order to determine the correct amount of medication to give. Medication labels may be formatted differently, but contain particular types of information about the medication. This chapter reviews the components of the label you should be familiar with when determining how much of a medication to give.

When you read the information on the medication label, be sure to note the medication name, the quantity of medication in the container and the expiry date. The quantity of medication may be measured using a variety of units, such as milligrams (mg), grams (g), or international units (IU). For liquid medications, the total volume and concentration of medication in the container will also be written on the label. It is important not to confuse the concentration with the total amount of medication in the vial. Concentration is often given as a quantity of medication in a particular volume, which is often only part of the total volume in the container. For example, the concentration of a liquid medication could be 5 mg/1 mL. This would indicate there are 5 mg of medication in every 1 mL of liquid.

In addition to numerical information related to dose, the package may include numbers representing the expiry date, reconstitution information, lot number, and non medicinal ingredients. Other key information includes the medication name, which may be listed with both the generic and trade name in some cases, what route the medication may be used for, and the pharmaceutical company name.

Alternately, some of this information may be included on the box or wrapper the medication was packaged in or on an information sheet inside the package.

In the image below, note the generic name, the milligrams of medication (amount) per tablet and the total number of tablets in the package.

Sample Exercise 12.1

Answer the questions related to the image of the package containing salbutamol nebules below.

1. What is the volume of a single nebule?
2. What dose of salbutamol is one nebule?
3. What is the concentration of salbutamol?
4. How many nebules are inside the package?

Answers:

1. 2.5 mL. This is written on the upper left corner of the package.
2. 2.5 mg. This is the amount of medication inside the total volume of one nebule. Sometimes, students mix up the total amount of medication with the amount related to the information about concentration. The total amount will always be the amount related to the information listed with the largest volume (the total volume in the container).
3. 1 mg/mL
4. 20. This is written on the upper left corner of the package.

Sample Exercise 12.2

Answer the questions related to the image of the heparin vial below.

1. What is the volume of liquid in the vial?
2. What is the total amount of heparin in the vial?
3. What is the concentration of heparin?

Answers:

1. 0.5 mL. This is seen at the top left corner of the vial.
2. 5 000 USP units. There is only 0.5 mL of fluid, therefore 5000 USP units.
3. 10 000 USP units/mL. This is written below the quantity of the vial, in a smaller font.

Critical Thinking Question

When administering liquid medications, should you calculate the volume of liquid (eg. mL) or the amount of medication (eg. mg) first?

Answer:
Amount. The amount of medication is constant. The volume of liquid may change depending on the concentration of solution you are administering. It is important to know the volume you will administer as well, but it is based on the amount of medication you are giving. Ensure you know the amount of medication first, and then calculate the volume to administer, based on the concentration of the medication in the available supply.

Key Takeaways

Key components of medication labels when preparing a medication dose:

- medication name
- quantity of medication

- volume of liquid (for liquid medications)
- concentration (for liquid medications)
- expiry date

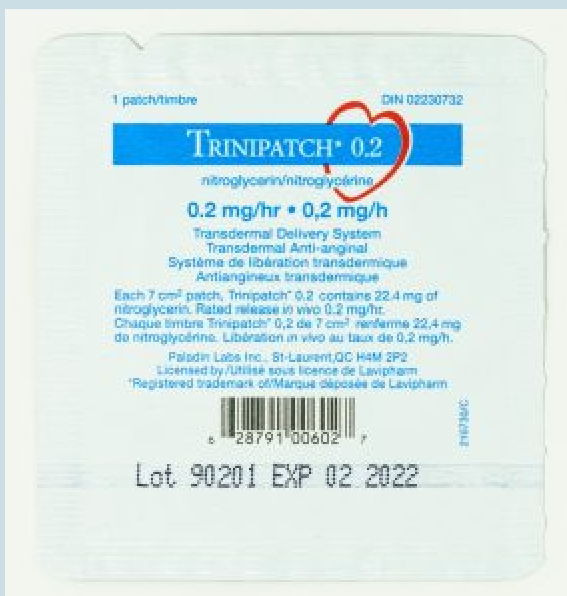
Practice Set 12.1: Reading Medication Labels

Practice Set 12.1: Reading Medication Labels

Answer the following questions for each image included in this practice set. To check on the answers for a particular image, click on the word **Answers** below the image.

1. What is the generic name of the medication in the image?
2. What is the total amount in one dose of the medication?

Questions:



Answers:

1. nitroglycerin
2. 22.4 mg

Answers:

1. dimenhydrinate
2. 50 mg

Answers:

1. beclomethasone dipropionate
2. 50 micrograms (µg)

Answers:

1. cholecalciferol – it is not visible on this bottle
2. 1000 IU (in each tablet)

Answers:

1. budesonide
2. 0.5 mg. The total amount in one whole ampoule is 0.5 mg, as there is 2 mL in one ampoule.

Practice Set 12.2: Reading Medication Labels

Practice Set 12.2: Reading Medication Labels

Answer the following questions for each image included in this practice set. To check on the answers for a particular image, click on the word **Answers** below the image.

1. What is the volume of liquid in the vial?
2. What is the total amount of medication in the vial?
3. What is the concentration of liquid?

Questions:

1. methylprednisolone

Answers:

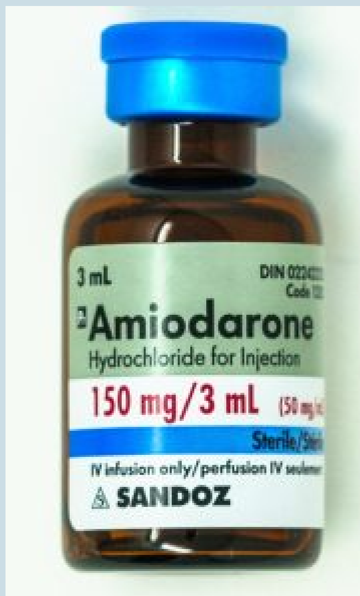
1. 2 mL (once the fluid above the rubber stopper is pushed into the main chamber of the vial)
2. 125 mg
3. 62.5 mg/mL

2. tobramycin

Answers:

1. 2 mL
2. 80 mg
3. 40 mg/mL

3. amiodarone



Answers:

1. 3 mL
2. 150 mg
3. 50 mg/mL. The concentration is in brackets to the right of the total amount, it is hard to read in the image but you can also calculate the number of mg in each mL as you know the total volume and the total amount (in mg) of medication.

4. phenytoin

Answers:

1. 2 mL
2. 100 mg
3. 50 mg/mL

5. metoclopramide

Answers:

1. 2 mL
2. 10 mg
3. 5 mg/mL

13.

Reconstituting Medications

Lesson

Learning Outcomes

By the end of this chapter, the learner will be able to:

- define reconstitution,
- identify the correct amount of liquid to be added to dried medications, and
- identify the final concentration of medication.

Reconstituting Medications

Many medications are packaged as a dried powder inside a vial or bottle. In order to administer these medications **parenterally** or as an oral liquid medication, liquid must be added to the powder which then dissolves into the liquid. Instructions supplied with the medication will direct exactly how much liquid should be added to the container to give a specific concentration of medication. The instructions might be found on the container, on the packaging, on a paper inside the package or in information sent by pharmacy. In addition, directions as to the specific type of liquid to be used will also be present, most often **normal saline** or sterile water. Careful reading of instructions and use of equipment is required to ensure the right amount of liquid measured out and added to the container. Additional considerations for safe preparation of medications such as proper labelling, avoidance of contamination, etc. will not be discussed in the context of this manual. Seek out additional information in a nursing skills textbook, such as Clinical procedures for safer patient care. by Doyle and McCutcheon, 2015.

Practice questions will focus on the following steps in reconstituting a medication:

1. Identifying the amount and type of liquid to reconstitute the powdered

medication with.

2. Identifying the final concentration of medication.
3. Calculating the correct volume of medication for a single dose.

Sample Exercise 13.1: Reconstituting clindamycin

Refer to the images below of a bottle of clindamycin and two sides of the packaging to answer the questions in this example.

A full transcribed label is provided at the end of the chapter for readability. Click this link to go there: Clindamycin transcribed label.

Questions:

1. What type of liquid is used for reconstitution?
2. How much of this liquid should be added to the container for reconstitution?
3. What is the total volume in the container once reconstituted?
4. What is the concentration of the reconstituted medication?
5. What volume of medication would be poured from the bottle to give a dose of 90 mg?

Answers:

1. demineralized or distilled water (this is found on the side of the package)
2. 75 mL (this is found on the side of the package)
3. 100 mL (this is found on the bottle and the front of the package)

4. 75 mg/5 mL (this is found on the bottle and the front of the package)
5. 6 mL

$$mL = \frac{75\ mg}{5\ mL} \times 90\ mg$$

$$mL = 6$$

Practice Sets 13.1-13.6: Reconstituting Medications

Practice Set 13.1: Reconstituting clarithromycin

Refer to the images below, of a bottle of clarithromycin and two sides of the packaging, to answer the questions in this example.

A full transcribed label is provided at the end of the chapter for readability. Click this link to go there: [Clarithromycin transcribed label](#).

Questions:

1. What type of liquid is used for reconstitution?
2. How much of this liquid should be added to the bottle for reconstitution?
3. What is the total volume in the container once reconstituted?
4. What is the concentration of the reconstituted medication?
5. What volume of medication would be poured from the bottle to give a dose of 50 mg?

Answers:

1. water (this is found on the side of the package)
2. 29 mL (this is found on the side of the package)
3. 55 mL (this is found on the bottle and both sides of the package)
4. 125 mg/5 mL (this is found on the bottle and both sides of the package)
5. 2 mL

$$\text{mL} = \frac{5\ \text{mg}}{125\ \text{mL}} \times 50\ \text{mg}$$

$$\text{mL} = 2$$

Practice Set 13.2: Reconstituting amoxicillin + clavulanate

Refer to the images below, of a bottle of amoxicillin + clavulanate and two sides of the packaging, to answer the questions in this example.

A full transcribed label is provided at the end of the chapter for readability. Click this link to go there: *Amoxicillin + clavulanate transcribed label*.

Questions:

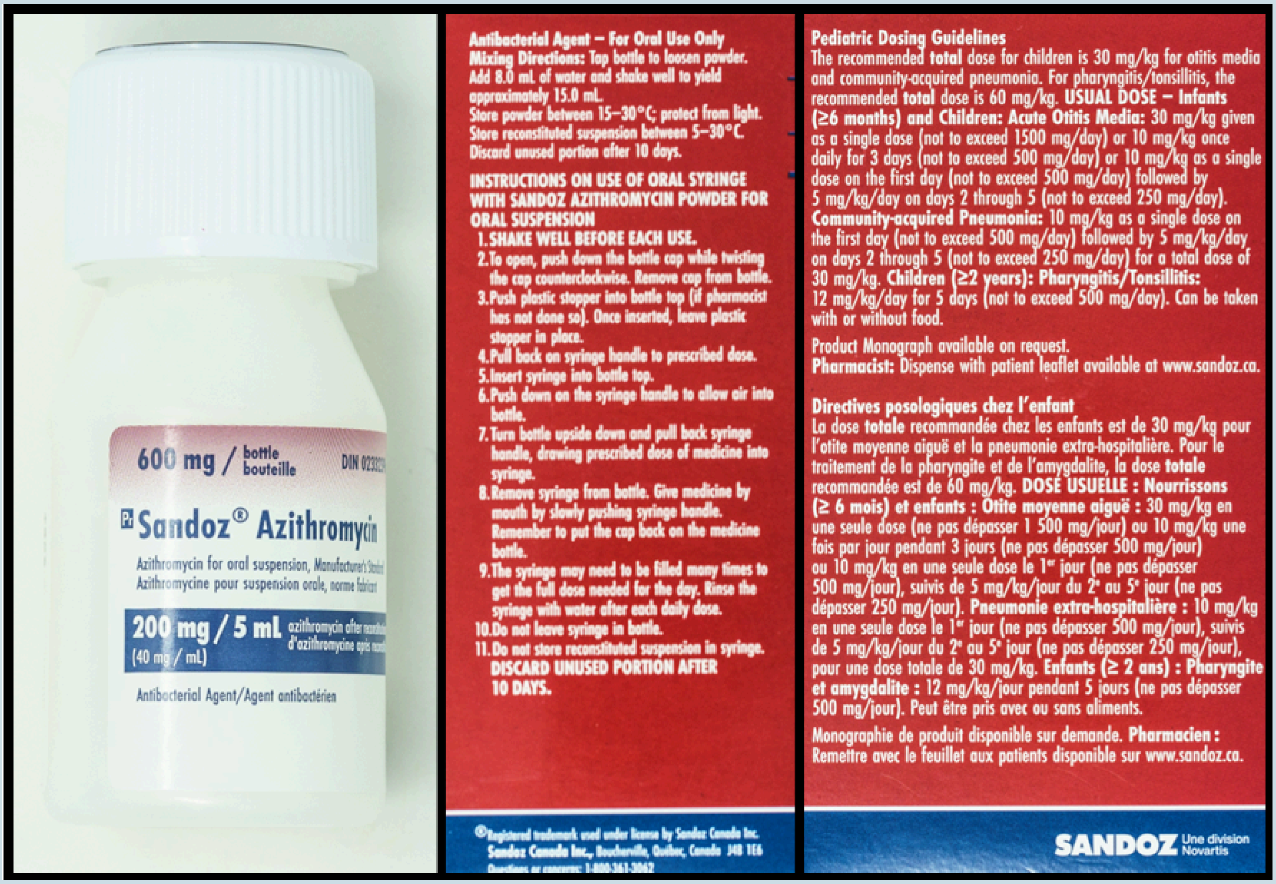
1. How much water should be added to the container for reconstitution?
2. What is the total volume in the container once reconstituted?
3. What is the concentration of the reconstituted medication?

Answers:

1. 92 mL (this is found on the front of the bottle and the package)
2. 100 mL (this is found on the bottle and the front of the package)
3. 125 amoxicillin + 31.25 mg clavulanate/5 mL (this is found on the bottle and the front of the package)

Practice Set 13.3: Reconstituting azithromycin

Refer to the images below, of a bottle of azithromycin and two sides of the packaging, to answer the questions in this example.



A full transcribed label is provided at the end of the chapter for readability. Click this link to go there: *[Azithromycin transcribed label](#)*.

Questions:

1. How much water should be added to the container for reconstitution?
2. What is the total volume in the container once reconstituted?
3. What is the concentration of the reconstituted medication?
4. What volume of medication would be poured from the bottle to give a dose of 72 mg?

Answers:

1. 8 mL (this is found on the skinny side of the package)
2. 15 mL (this is found on the skinny side of the package)
3. 200 mg/5 mL or 40 mg/mL (this is found on the bottle label)

4. 1.8 mL

$$\text{mL} = \frac{40 \text{ mg}}{1 \text{ mL}} \times 72 \text{ mg}$$

$$\text{mL} = 1.8$$

Practice Set 13.4: Reconstituting cefixime

Refer to the images below, of a bottle of cefixime and two sides of the packaging, to answer the questions in this example.

A full transcribed label is provided at the end of the chapter for readability. Click this link to go there: *Cefixime transcribed label*.

Questions:

1. How much water should be added to the bottle for reconstitution?
2. What is the total volume in the container once reconstituted?
3. What is the concentration of the reconstituted medication?
4. What volume of medication would be poured from the bottle to give a dose of 400 mg?

Answers:

1. 33 mL total, split into two portions of 16 and 17 mL (this is found on the side of the package)
2. 50 mL (this is found on the side of the package)
3. 100 mg/5 mL (this is found on the bottle and the front of the package)
4. 20 mL

$$mL = \frac{100\ mg}{5\ mL} \times 400\ mg$$

$$mL = 20$$

Practice Set 13.5: Reconstituting cefprozil

Refer to the images below, of the front and side labels of a bottle of cefprozil, to answer the questions in this example.

A full transcribed label is provided at the end of the chapter for readability. Click this link to go there: [Cefprozil transcribed label](#).

Questions:

1. What volume of water should be added to the container for reconstitution?
2. What is the total volume in the container once reconstituted?
3. What is the concentration of the reconstituted medication?
4. What volume of medication would be poured from the bottle to give a dose of 250 mg?

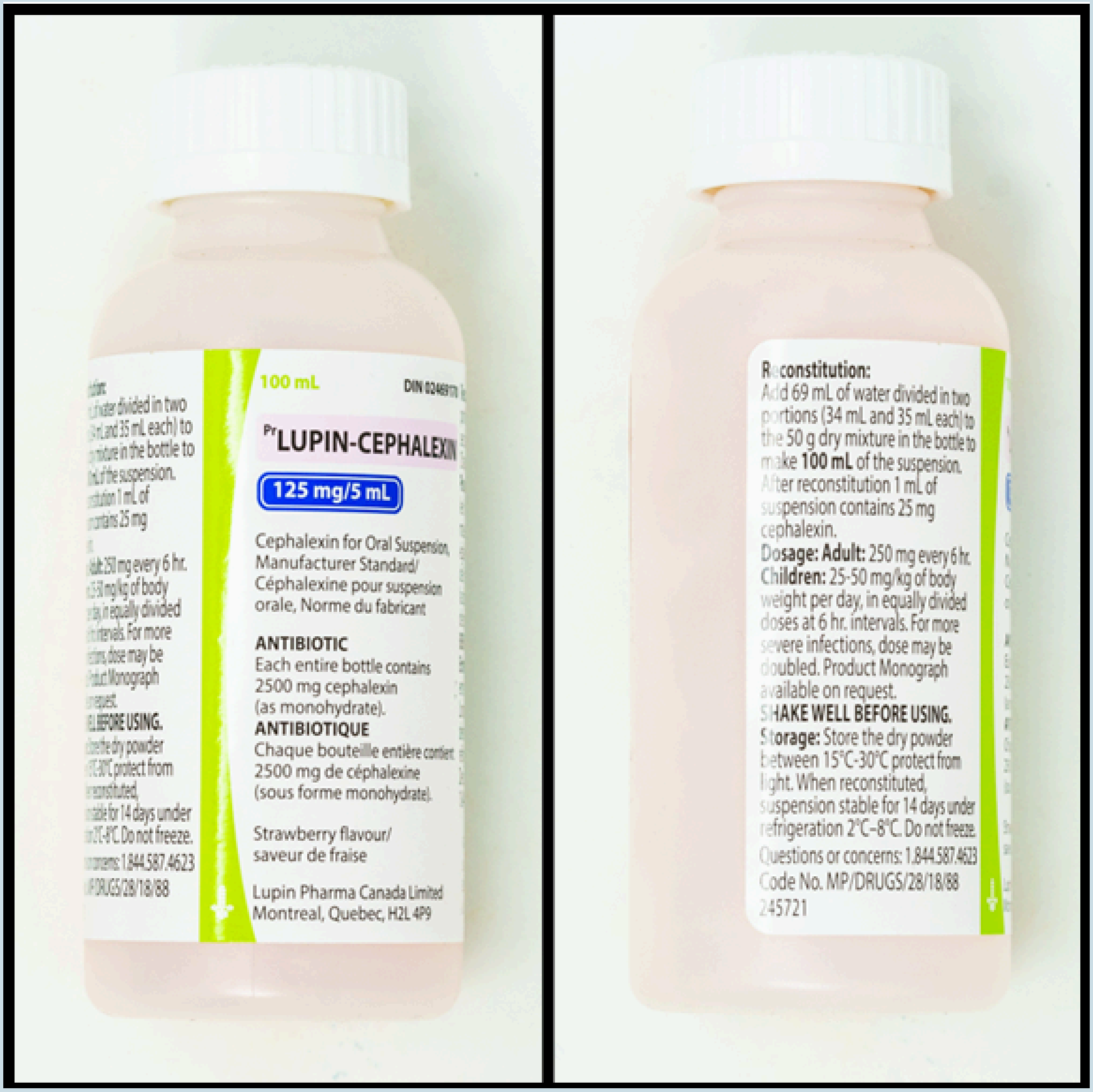
Answers:

1. 60 mL (this is found on the side of the bottle)
2. 75 mL (this is found on the front of the bottle)
3. 125 mg/5 mL (this is found on the front and side of the bottle
4. 10 mL

$$\text{mL} = \frac{125\text{ mg}}{5\text{ mL}} \times 250\text{ mg}$$
$$\text{mL} = 10$$

Practice Set 13.6: Reconstituting cephalexin

Refer to the images below, of the front and side labels of a bottle of cephalexin to answer the questions in this example.



A full transcribed label is provided at the end of the chapter for readability. Click this link to go there: Cephalexin transcribed label.

Questions:

1. What volume of water should be added in the first step of mixing?
2. What is the concentration of the reconstituted medication?
3. What volume of medication would be poured from the bottle to give a dose of 87.5 mg?

Answers:

1. 34 mL (this is found on the side of the bottle)
2. 125 mg/5 mL (this is found on the front of the bottle) or 25 mg/mL (side of bottle)
3. 3.5 mL

$$\text{mL} = \frac{25 \text{ mg}}{1 \text{ mL}} \times 87.5 \text{ mg}$$
$$\text{mL} = 3.5$$

Transcribed Labels

Sample Exercise 13.1: Clindamycin label

- Front of label:
    - Dalacin C. Flavoured granules.
    - Clindamycin palmitate hydrochloride for oral solution USP.
    - 75 mg clindamycin per 5 mL when reconstituted as directed.
    - 100 mL when reconstituted.
- Side of label:
    - Oral antibiotic.
    - Dosage: Children (over 1 month of age): 8 to 25 mg per kg per day in 3 to 4 divided doses.
    - For prevention of endocarditis:
        - Adult: 300 mg orally, 1 hour before procedure; then 150 mg, 6 hours after initial dose.
        - Children: 10 mg per kg (not to exceed 300 mg) orally, 1 hour before procedure; then 5 mg per kg 6 hours after initial dose.
    - Reconstitute with a total of 75 mL demineralized or distilled water. Add water in two potions. Mix well after each addition of water.
    - Store power or solution at room temperature (20-25°C). Discard solution after 14 days.

[Return to Sample Exercise 13.1]

Practice Set 13.1: Clarithromycin label

- Front of label:
    - Pediatric Biaxin.
    - 125 mg per 5 mL.
    - Clarithromycin for oral suspension USP.
    - Fruit punch flavour.
    - 55 mL after reconstitution.

- Side of label:
    - Antibiotic
    - To the Pharmacist: Add 29 mL of water and shake well to yield approximately 55 mL.
    - Each 5 mL contains: Clarithromycin 125 mg.
    - Usual dose (infants and children): 15 mg per kg per day, in divided doses every 12 hours, not to exceed 1000 mg per day for 5 to 10 days.
    - Shake well before use.
    - Do not refrigerate reconstituted suspension. Discard unused medication after 14 days.
    - Storage: Store granules between 15 and 30°C in a tightly closed bottle. Protect from light.

[Return to Practice Set 13.1]

Practice Set 13.2: Amoxicillin + clavulanate label

- Front of label:
    - Clavulin. Amoxicillin and clavulanate potassium for oral suspension.
    - 100 mL bottle.
    - 125 mg amoxicillin (as trihydrate) and 31.25 mg clavulanic acid (as clavulanate potassium) per 5 mL when reconstituted with 92 mL water.
- Side of label:
    - Bottle contains: 2642.5 mg amoxicillin and 693.7 mg clavulanic acid. Sugar free, contains aspartame.
    - Storage: Store powder in a dry place at room temperature (15-25°C); use only if white to off-white. Refrigerate reconstituted suspension; use within 10 days. Keep bottle tightly closed. Keep out of reach and sight of children.
    - Dosage and other information: See enclosed leaflet and product monograph available at www.gsk.ca.
    - Shake well before use.

[Return to Practice Set 13.2]

Practice Set 13.3: Azithromycin label

- Front of label
    - Sandoz® Azithromycin
    - 600 mg per bottle
    - Azithromycin for oral suspension

  - 200 mg per 5 mL (40 mg per mL)
  - Antibacterial agent
- Side 1 of label:
  - Antibacterial agent – for oral use only.
  - Mixing directions: Top bottle to loosen powder. Add 8.0 mL of water and shake well to yield approximately 15.0 mL.
  - Store powder between 15-30°C. Protect from light. Store reconstituted suspension between 5-30°C. Discard unused potion after 10 days.
  - INSTRUCTIONS ON USE OF ORAL SYRINGE WITH SANDOZ AZITHROMYCIN POWDER FOR ORAL SUSPENSION.
    1. SHAKE WELL BEFORE EACH USE.
    2. To open, push down the bottle cap while twisting the cap counterclockwise. Remove cap from bottle.
    3. Push plastic stopper into bottle top (if pharmacist has not done so). Once inserted, leave plastic stopper in place.
    4. Pull back on syringe handle to prescribed dose.
    5. Insert syringe into bottle top.
    6. Push down in the syringe handle to allow air into bottle.
    7. Turn bottle upside down and pull back syringe handle, drawing prescribed dose of medicine into the syringe.
    8. Remove syringe from bottle. Give medicine by mouth by slowly pushing syringe handle. Remember to put the cap back on the medicine bottle.
    9. The syringe may need to be filled may times to get the full dose needed for the day. Rinse the syringe with water have each daily dose.
    10. Do not leave syringe in bottle.
    11. Do not store reconstituted suspension in syringe. DISCARD UNUSED PORTION AFTER 10 DAYS.
- Side 2 of label: Pediatric dosing guidelines:
  - The recommended total dose for children is 30 mg per kg for otitis media and community-aquired pneumonia. For pharyngitis/tonsillitis, the recommended total dose is 60 mg per kg.
  - Usual dose – infants (≥6 months) and children: Acute otitis media: 30 mg per kg given as a single dose (not to exceed 1500 mg per day) or 10 mg per kg once daily for 3 days (not to exceed 500 mg per day) or 10 mg per kg as a single dose on the first day (not to exceed 500 mg per day) followed by 5 mg per kg per day on days 2 through 5 (not to exceed 250 mg per day).
  - Community-aquired pneumonia: 10 mg per kg as a single dose on the first day (not

to exceed 500 mg per day) followed by 5 mg per kg per day on days 2 through 5 (not to exceed 250 mg per day) for a total dose of 30 mg per kg.

- Children (≥2 years): Pharyngitis/tonsillitis: 12 mg per kg per day for 5 days (not to exceed 500 mg per day). Can be taken with or without food.

[Return to Practice Set 13.3]

Practice Set 13.4: Cefixme label

- Front of label
    - Suprax. Cefixime for oral suspension, Mfr. Std.
    - 100 mg per 5 mL when reconstituted
    - Antibiotic
    - 50 mL
- Side of label:
    - Shake well before use.
    - The bottle contains cefixime as trihydrate, corresponding to 1 g cefixime anhydrous.
    - Dosage – adults: 400 mg once daily. If necessary, 200 mg twice daily. Urinary tract infections: 400 mg once daily.
    - Children: 8 mg per kg per day once daily. If necessary, 4 mg per kg twice daily. Urinary tract infections: 8 mg per kg per day once daily.
    - Reconstitution: Tap bottle several times to loosen powder contents prior to reconstitution. Add a total volume of 33 mL of water split in TWO POTIONS. Mix well after each addition. Provides 20 mg per mL.
    - Suspension may be kept for 14 days at room temperature or under refrigeration. Discard unused potion. Store powder at controlled room temperature between 15 and 30°C.

[Return to Practice Set 13.4]

Practice Set 13.5: Cefprozil label

- Front of label:
    - Cefprozil
    - 75 mL
    - Cefprozil for oral suspension USP
    - 125mg/5mL
    - Antibiotic
    - Ranbaxy pharmaceuticals

- Side of label:
  - Each: 5 mL of reconstituted suspension contains 125 mg of cefprozil.
  - Directions for use: Reconstitute with 54 mL of water. Shake well prior to use.

[Return to Practice Set 13.5]

Practice Set 13.6: Cephalexin label

- Front of label:
  - Lupin-Cephalexin
  - 100 mL
  - 125 mg per 5 mL.
  - Cephalexin for Oral Suspension, manufacturer standard.
  - Antibiotic.
  - Each bottle contains 25000 mg cephalexin (as monohydrate).
  - Strawberry flavour.
- Side of label:
  - Reconstitution: Add 69 mL of water divided in two potions (34 mL and 35 mL each) to the 50 g dry mixture in the bottle to make 100 mL of the suspension. After reconstitution, 1 mL of suspension contains 25 mg cephalexin.
  - Dosage – adults: 250 mg every 6 hr.
  - Children: 25-50 mg per kg of body weight per day in equally divided doses at 6 hr intervals. For more severe infections, dose may be doubled.
  - SHAKE WELL BEFORE USING.
  - Storage: Store the dry powder between 15-30°C. Protect from light. When reconstituted, suspension stable for 14 days under refrigeration 2-8°C. Do not freeze.

[Return to Practice Set 13.6]

14.

Calculating Medication Dosage

Lesson

Learning Outcomes

By the end of this chapter, learners will be able to:

- explain a method for solving medication dose problems, and
- correctly solve medication dose problems.

There are often multiple ways to solve problems involving math. In this workbook, the process of dimensional analysis is presented as one way to solve all types of medication related problems. You can continue to use this process when solving practice problems presented in this chapter. Using this form of problem solving can help you reduce errors if you struggle to remember formulas or figure out which formula to use as you can learn just one method to approach all the calculations.

Steps to Calculate Medication Amounts

1. Read the information carefully. Avoid distractions when preparing medications so you can focus on the problem at hand. What information are you trying to calculate?
2. Set up the formula. When beginning to calculate medication amounts it is helpful to always write down your work so you can check your work and so others can help you find errors if you have made a mistake.
3. Calculate the answer by using a calculator or mental math.
4. Check your work. Always double check your answer. Does it make sense? If you have determined you need to give 20 tablets for one dose this would be a red flag-an unlikely situation and indicates an error has probably been made. As a student, you should always have a supervising nurse check your math. After you graduate, there are specific high risk medications (like insulin) which must be double checked by another nurse. You may also decide that specific situations warrant asking someone to check, such as if you have been feeling tired or if there are distractions during your process of medication administration.

Sample Exercise 14.1: Determining the number of tablets required when the dose is more than the supply

How many tablets would you administer for the following medication order?

Order: prednisone 20 mg PO OD
Supply: prednisone 5 mg tablets

Answer:
4 tablets.

$$\text{x tablets} = \frac{\text{1 tablet}}{\text{5 mg}} \times \text{20mg}$$

$$\text{x tablets} = \frac{\text{1 tablet}}{5\ \cancel{\text{mg}}} \times 20\ \cancel{\text{mg}}$$

$$\text{x tablets} = \frac{\text{20 tablet}}{5}$$

$$\text{x tablets} = 4$$

Alternate Formula for Solving Medication Dose Problems

$$\frac{\text{Desired amount}}{\text{Amount in supply}} \times \text{Volume of supply} = \text{Quantity for dose}$$

This may also be written as:

$$\frac{\text{Desired Amount}}{\text{Dose on hand}} \times \text{Volume} = \text{Dose}$$

Or abbreviated as:

$$\frac{\text{D}}{\text{H}} \times \text{V} = \text{Dose}$$

Regardless of the words or letters chosen to represent numbers in the formula, the numbers related to the medication problem are always in the same place.

Here is the same problem from the sample exercise above, using this formula:

Order: prednisone 20 mg PO OD
Supply: prednisone 5 mg tablets

$$\frac{\text{Desired amount}}{\text{Amount in supply}} \times \text{Volume of supply} = \text{Quantity for dose}$$

$$\frac{20\ \text{mg}}{5\ \text{mg}} \times 1\ \text{tablet} = \text{Quantity for dose}$$

$$\frac{20\ \cancel{\text{mg}}}{5\ \cancel{\text{mg}}} \times 1\ \text{tablet} = \text{Quantity for dose}$$

$$4\ \text{tablets}$$

Make sure to check your work:

- First, check your formula and make sure it has been set up correctly.
- Do all of the units cancel out based on the way you have set up the formula? If you are not left with units matching on both sides of the equals sign, this is a clue information has been put into the formula incorrectly.
- Next, look for calculation errors by doing the math again to see if you get the same answer.
- Lastly, have a supervising nurse confirm you have calculated the correct amount.

Sample Exercise 14.2: Determining the number of tablets required when the dose is less than the supply

How many tablets would you administer for the following medication order?

Order: metoprolol 12.5 mg PO BID
Supply: metoprolol 50 mg tablets

Answers:
0.25 of one tablet, or

$$\frac{1}{4}$$

$$\text{x tablets} = \frac{1\ \text{tablet}}{50\ \text{mg}} \times 12.5\text{mg}$$

$$\text{x tablets} = \frac{1\ \text{tablet}}{50\ \cancel{\text{mg}}} \times 12.5\ \cancel{\text{mg}}$$

$$\text{x tablets} = \frac{12.5\ \text{tablet}}{50}$$

$$\text{x tablets} = 0.25$$

Sample Exercise 14.3: Determining the volume of medication required

What volume needs to be drawn up to administer the following medication?

Order: dimenhydrinate 25 mg SC prn q6h
Supply: dimenhydrinate 50 mg/mL

Answers:
0.5 mL

$$x \text{ mL} = \frac{1 \text{ mL}}{50 \text{ mg}} \times 25 \text{ mg}$$

$$x \text{ mL} = \frac{1 \text{ mL}}{50 \cancel{\text{mg}}} \times 25 \cancel{\text{mg}}$$

$$x \text{ mL} = \frac{25 \text{ mL}}{50}$$

$x \text{ mL} = 0.5$

Key Takeaways

When calculating dosages, follow the following steps:

- Read the information presented carefully
- Set up the formula
- Ensure units cancel out
- Calculate the amount required
- Check your work

Practice Set 14.1: Calculating the Number of Tablets

Practice Set 14.1: Calculating the number of tablets to administer

Calculate how many tablets would you administer for the following medication orders. Click on the word answers to check your work.

Questions:

1. Order: acetaminophen 650 mg PO QID
   Supply: acetaminophen 325 mg tablets
2. Order: sertraline 75 mg PO OD
   Supply: sertraline 25 mg capsules
3. Order: ibuprofen 400 mg PO QID prn
   Supply: ibuprofen 200 mg tablets
4. Order: dimenhydrinate 12.5 mg PO QID prn
   Supply: dimenhydrinate 50 mg tablets
5. Order: gabapentin 300 mg PO OD
   Supply: gabapentin 100 mg capsules
6. Order: azithromycin 1 g PO
   Supply: azithromycin 250 mg tablets
7. Order: digoxin 250 mcg PO OD
   Supply: digoxin 0.5 mg tablets
8. Order: furosemide 80 mg PO OD
   Supply: furosemide 40 mg tablets
9. Order: glyburide 10 mg PO BID
   Supply: glyburide 5 mg tablets
10. Order: diltiazem 45 mg PO BID
    Supply: diltiazem 90 mg tablets

Answers:

1. 2 tablets

$$\text{x tablets} = \frac{1 \text{ tablet}}{325 \text{ mg}} \times 650\text{mg}$$

$$\text{x tablets} = \frac{1 \text{ tablet}}{325 \;\cancel{\text{mg}}} \times 650 \;\cancel{\text{mg}}$$

$$\text{x tablets} = \frac{650 \text{ tablet}}{325}$$

$$\text{x tablets} = 2$$

2. 3 capsules

$$\text{x tablets} = \frac{1 \text{ capsule}}{25 \text{ mg}} \times 75 \text{ mg}$$

$$\text{x tablets} = \frac{1 \text{ capsule}}{25 \;\cancel{\text{mg}}} \times 75 \;\cancel{\text{mg}}$$

$$\text{x tablets} = \frac{75 \text{ capsule}}{25}$$

$$\text{x tablets} = 3$$

3. 2 tablets

$$\text{x tablets} = \frac{1 \text{ tablet}}{200 \text{ mg}} \times 400\text{mg}$$

$$\text{x tablets} = \frac{1 \text{ tablet}}{200 \;\cancel{\text{mg}}} \times 400 \;\cancel{\text{mg}}$$

$$\text{x tablets} = \frac{400 \text{ tablet}}{200}$$

$$\text{x tablets} = 2$$

4. 0.25 tablet

$$\text{x tablets} = \frac{1 \text{ tablet}}{50 \text{ mg}} \times 12.5 \text{ mg}$$

$$\text{x tablets} = \frac{1 \text{ tablet}}{50 \;\cancel{\text{mg}}} \times 12.5 \;\cancel{\text{mg}}$$

$$\text{x tablets} = \frac{12.5 \text{ tablet}}{50}$$

$$\text{x tablets} = 0.25$$

5. 3 capsules

$$\text{x tablets} = \frac{1 \text{ capsule}}{100 \text{ mg}} \times 300 \text{ mg}$$

$$\text{x tablets} = \frac{1 \text{ capsule}}{100 \;\cancel{\text{mg}}} \times 300 \;\cancel{\text{mg}}$$

$$\text{x tablets} = \frac{300 \text{ capsule}}{100}$$

$$\text{x tablets} = 3$$

6. 4 tablets

$$\text{x tablets} = \frac{1\text{ tablet}}{250\text{ mg}} \times \frac{1000\text{ mg}}{1\text{ g}} \times 1\text{ g}$$

$$\text{x tablets} = \frac{1\text{ tablet}}{250\ \cancel{\text{mg}}} \times \frac{1000\ \cancel{\text{mg}}}{\cancel{1\text{ g}}} \times \cancel{1\text{ g}}$$

$$\text{x tablets} = \frac{1000\text{ tablet}}{250}$$

$\text{x tablets} = 4$

7. 0.5 tablet

$$\text{x tablets} = \frac{1\text{ tablet}}{0.5\text{ mg}} \times \frac{1\text{ mg}}{1000\text{ mcg}} \times 250\text{ mcg}$$

$$\text{x tablets} = \frac{1\text{ tablet}}{0.5\ \cancel{\text{mg}}} \times \frac{1\ \cancel{\text{mg}}}{1000\ \cancel{\text{mcg}}} \times 250\ \cancel{\text{mcg}}$$

$$\text{x tablets} = \frac{250\text{ tablet}}{500}$$

$\text{x tablets} = 0.5$

8. 2 tablets

$$\text{x tablets} = \frac{1\text{ tablet}}{40\text{ mg}} \times 80\text{ mg}$$

$$\text{x tablets} = \frac{1\text{ tablet}}{40\ \cancel{\text{mg}}} \times 80\ \cancel{\text{mg}}$$

$$\text{x tablets} = \frac{80\text{ tablet}}{40}$$

$\text{x tablets} = 2$

9. 2 tablets

$$\text{x tablets} = \frac{1\text{ tablet}}{5\text{ mg}} \times 10\text{ mg}$$

$$\text{x tablets} = \frac{1\text{ tablet}}{5\ \cancel{\text{mg}}} \times 10\ \cancel{\text{mg}}$$

$$\text{x tablets} = \frac{10\text{ tablet}}{5}$$

$\text{x tablets} = 2$

10. 0.5 tablet

$$\text{x tablets} = \frac{1\text{ tablet}}{90\text{ mg}} \times 45\text{ mg}$$

$$\text{x tablets} = \frac{1\text{ tablet}}{90\ \cancel{\text{mg}}} \times 45\ \cancel{\text{mg}}$$

$$\text{x tablets} = \frac{45\text{ tablet}}{90}$$

$$x \text{ tablets} = 0.5$$

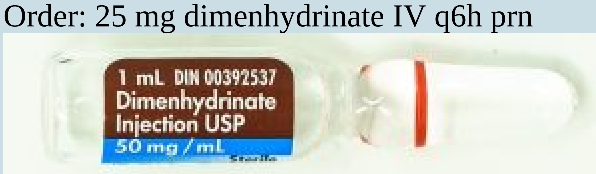
Practice Set 14.2: Calculating the Volume of a Medication Dose

Practice Set 14.2: Calculating the volume of a medication dose

Calculate the volume of liquid you would draw up for the following medication orders. Click on the word answers to check your work.

Questions:

1. Order: 25 mg dimenhydrinate IV q6h prn



2. Order: hydromorphone 1.5 mg SC q4h prn

3. Order: 7 mg diazepam IM now

4. Order: gentamycin 112 mg IV q8h

5. Order: hydromorphone 0.5 mg SC q4-6 h prn

6. Order: 50 mcg cyanocobalamin SC OD x 7 days

7. Order: digoxin 10 mcg/kg IV total loading dose; administer 50% initially; then give ¼ the loading dose q8hr twice. Client weighs 74 kg
How much would you draw up for the first dose of digoxin?

Answers:

1. 0.5 mL

$$\text{x mL} = \frac{1\text{ mL}}{50\text{ mg}} \times 25\text{ mg}$$

$$\text{x mL} = \frac{1\text{ mL}}{50\ \cancel{\text{mg}}} \times 25\ \cancel{\text{mg}}$$

$$\text{x mL} = \frac{25\text{ mL}}{50}$$

$$\text{x mL} = 0.5$$

2. 0.75 mL

$$\text{x mL} = \frac{1\text{ mL}}{2\text{ mg}} \times 1.5\text{ mg}$$

$$\text{x mL} = \frac{1\text{ mL}}{2\ \cancel{\text{mg}}} \times 1.5\ \cancel{\text{mg}}$$

$$\text{x mL} = \frac{1.5\text{ mL}}{2}$$

$$\text{x mL} = 0.75$$

3. 1.4 mL

$$x\ \text{mL} = \frac{2\ \text{mL}}{10\ \text{mg}} \times 7\ \text{mg}$$

$$x\ \text{mL} = \frac{2\ \text{mL}}{10\ \cancel{\text{mg}}} \times 7\ \cancel{\text{mg}}$$

$$x\ \text{mL} = \frac{15\ \text{mL}}{10}$$

$$x\ \text{mL} = 1.4$$

4. 2.8 mL

$$x\ \text{mL} = \frac{1\ \text{mL}}{40\ \text{mg}} \times 112\ \text{mg}$$

$$x\ \text{mL} = \frac{1\ \text{mL}}{40\ \cancel{\text{mg}}} \times 112\ \cancel{\text{mg}}$$

$$x\ \text{mL} = \frac{112\ \text{mL}}{40}$$

$$x\ \text{mL} = 2.8$$

5. 0.25 mL

$$x\ \text{mL} = \frac{1\ \text{mL}}{2\ \text{mg}} \times 0.5\ \text{mg}$$

$$x\ \text{mL} = \frac{1\ \text{mL}}{2\ \cancel{\text{mg}}} \times 0.5\ \cancel{\text{mg}}$$

$$x\ \text{mL} = \frac{0.5\ \text{mL}}{2}$$

$$x\ \text{mL} = 0.25$$

6. 0.05 mL

$$x\ \text{mL} = \frac{1\ \text{mL}}{1000\ \text{mcg}} \times 50\ \text{mcg}$$

$$x\ \text{mL} = \frac{1\ \text{mL}}{1000\ \cancel{\text{mg}}} \times 50\ \cancel{\text{mg}}$$

$$x\ \text{mL} = \frac{50\ \text{mL}}{1000}$$

$$x\ \text{mL} = 0.05$$

7. 1.48 mL
First, calculate the total loading dose based on the client's weight.

$$x\ \text{mcg} = \frac{10\ \text{mcg}}{1\ \text{kg}} \times 74\ \text{kg}$$

$$x\ \text{mL} = \frac{10\ \text{mcg}}{1\ \cancel{\text{kg}}} \times 74\ \cancel{\text{kg}}$$

$$x\ \text{mL} = 740\ \text{mcg}$$

Second, calculate the amount of the first portion of the loading dose. (50% = half of the total)

$740 \text{ mcg} \div 2$

$= 370 \text{ mcg}$

Third, calculate the volume to draw up from the medication supply.

$$\text{x mL} = \frac{1 \text{ mL}}{0.25 \text{ mg}} \times \frac{1 \text{ mg}}{1000 \text{ mcg}} \times 370 \text{ mcg}$$

$$\text{x mL} = \frac{1 \text{ mL}}{0.25 \ \cancel{\text{mg}}} \times \frac{1 \ \cancel{\text{mg}}}{1000 \ \cancel{\text{mcg}}} \times 370 \ \cancel{\text{mcg}}$$

$$\text{x mL} = \frac{370 \text{ mL}}{250}$$

$\text{x mL} = 1.48 \text{ mL}$

Practice Set 14.3: Calculating the Volume of a Medication Dose and Selecting the Correct Syringe Size

Practice Set 14.3: Calculating the Volume of a Medication Dose and Selecting the Correct Syringe Size

Calculate the volume of liquid you would draw up for the following medication orders. Look at the images and drag and drop an image of a syringe filled with the correct volume into the empty rectangle on the right. Click on the word **check** to see if you have selected a syringe with the correct volume. Click on the word **answers** to check your work for the medication math.

Questions:

1. *An interactive H5P element has been excluded from this version of the text. You can view it online here: https://opentextbc.ca/nursingnumeracy/?p=100#h5p-15*

2. *An interactive H5P element has been excluded from this version of the text. You can view it online here:* *https://opentextbc.ca/nursingnumeracy/?p=100#h5p-16*

3. *An interactive H5P element has been excluded from this version of the text. You can view it online here:* *https://opentextbc.ca/nursingnumeracy/?p=100#h5p-17*

4. *An interactive H5P element has been excluded from this version of the text. You can view it online here:* *https://opentextbc.ca/nursingnumeracy/?p=100#h5p-18*

5. *An interactive H5P element has been excluded from this version of the text. You can view it online here:* *https://opentextbc.ca/nursingnumeracy/?p=100#h5p-19*

6. *An interactive H5P element has been excluded from this version of the text. You can view it online here:* *https://opentextbc.ca/nursingnumeracy/?p=100#h5p-20*

7. *An interactive H5P element has been excluded from this version of the text. You can view it online here: https://opentextbc.ca/nursingnumeracy/?p=100#h5p-21*

8. *An interactive H5P element has been excluded from this version of the text. You can view it online here: https://opentextbc.ca/nursingnumeracy/?p=100#h5p-22*

9. *An interactive H5P element has been excluded from this version of the text. You can view it online here: https://opentextbc.ca/nursingnumeracy/?p=100#h5p-23*

10. *An interactive H5P element has been excluded from this version of the text. You can view it online here: https://opentextbc.ca/nursingnumeracy/?p=100#h5p-24*

Answers:

1. 0.65 mL

$$\frac{65}{x} = \frac{100}{1}$$

$$65 = (100)(\mathrm{x})$$

$$0.65 = \mathrm{x}$$

2. 1.2 mL

$$\frac{120}{x} = \frac{300}{3}$$

$$360 = (300)(\mathrm{x})$$

$$1.2 = \mathrm{x}$$

3. 0.5 mL

$$\frac{0.5}{x} = \frac{1}{1}$$

$$0.5 = (1)(\mathrm{x})$$

$$0.5 = \mathrm{x}$$

4. 2.25 mL

$$\frac{4.5}{x} = \frac{2}{1}$$

$$4.5 = (2)(\mathrm{x})$$

$$2.25 = \mathrm{x}$$

5. 0.7 mL

$$\frac{35}{x} = \frac{50}{1}$$

$$35 = (50)(\mathrm{x})$$

$$0.7 = \mathrm{x}$$

6. 0.7 mL

$$\frac{3.5}{x} = \frac{5}{1}$$

$$3.5 = (5)(\mathrm{x})$$

$$0.7 = \mathrm{x}$$

7. 0.35 mL

$$\frac{1.4}{x} = \frac{4}{1}$$

$$1.4 = (4)(\mathrm{x})$$

$$0.35 = \mathrm{x}$$

8. 0.53 mL

$$\frac{1.6}{x} = \frac{6}{2}$$

$$3.2 = (6)(\mathrm{x})$$

$$0.53 = \mathrm{x}$$

9. 1.8 mL

$$\frac{7.2}{x} = \frac{4}{1}$$

$$7.2 = (4)(\mathrm{x})$$

$$1.8 = \mathrm{x}$$

10. 1.7 mL

$$\frac{0.17}{x} = \frac{0.1}{1}$$

$$0.17 = (0.1)(\mathrm{x})$$

$$1.7 = \mathrm{x}$$

Practice Set 14.4: Calculating the Volume of a Medication Dose and Selecting the Correct Syringe Size

Practice Set 14.4: Calculating the Volume of a Medication Dose and Selecting the Correct Syringe Size

Calculate the volume of liquid you would draw up for the following medication orders. Look at the images and determine which syringes filled with liquid represent the correct volume of medication. There may be more than one correct syringe size option. Drag and drop all syringes with correct volumes into the open rectangle on the right. Click on the word **check** to see if your selection is correct. Click on the word **answers** to see the work for the medication math.

Questions:

1. *An interactive H5P element has been excluded from this version of the text. You can view it online here: https://opentextbc.ca/nursingnumeracy/?p=100#h5p-25*

2. *An interactive H5P element has been excluded from this version of the text. You can view it online here: https://opentextbc.ca/nursingnumeracy/?p=100#h5p-26*

3. *An interactive H5P element has been excluded from this version of the text. You can view it online here: https://opentextbc.ca/nursingnumeracy/?p=100#h5p-27*

4. *An interactive H5P element has been excluded from this version of the text. You can view it online here: https://opentextbc.ca/nursingnumeracy/?p=100#h5p-28*

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16. *An interactive H5P element has been excluded from this version of the text. You can view it online here: https://opentextbc.ca/nursingnumeracy/?p=100#h5p-30*

17. *An interactive H5P element has been excluded from this version of the text. You can view it online here: https://opentextbc.ca/nursingnumeracy/?p=100#h5p-31*

18. *An interactive H5P element has been excluded from this version of the text. You can view it online here: https://opentextbc.ca/nursingnumeracy/?p=100#h5p-32*

19. *An interactive H5P element has been excluded from this version of the text. You can view it online here: https://opentextbc.ca/nursingnumeracy/?p=100#h5p-33*

20. *An interactive H5P element has been excluded from this version of the text. You can view it online here: https://opentextbc.ca/nursingnumeracy/?p=100#h5p-34*

Answers:

1. 2 mL
$$\frac{0.4}{x} = \frac{0.2}{1}$$
$$0.4 = (0.2)(\text{x})$$
$$2 = \text{x}$$
2. 0.2 mL
$$\frac{20}{x} = \frac{300}{3}$$
$$60 = (300)(\text{x})$$
$$0.2 = \text{x}$$
3. 0.4 mL
$$\frac{50}{x} = \frac{125}{1}$$
$$50 = (125)(\text{x})$$
$$0.4 = \text{x}$$
4. 0.6 mL
$$\frac{24}{x} = \frac{40}{1}$$
$$24 = (40)(\text{x})$$
$$0.6 = \text{x}$$
5. 0.75 mL

$$\frac{3}{x} = \frac{4}{1}$$

$$3 = (4)(\mathrm{x})$$

$$0.75 = \mathrm{x}$$

6. 0.27 mL

$$\frac{0.27}{x} = \frac{1}{1}$$

$$0.27 = (1)(\mathrm{x})$$

$$0.27 = \mathrm{x}$$

7. 0.8 mL

$$\frac{4}{x} = \frac{5}{1}$$

$$4 = (5)(\mathrm{x})$$

$$0.8 = \mathrm{x}$$

8. 2.5 mL

$$\frac{300}{x} = \frac{120}{1}$$

$$300 = (120)(\mathrm{x})$$

$$2.5 = \mathrm{x}$$

9. 2.6 mL

$$\frac{5.2}{x} = \frac{2}{1}$$

$$5.2 = (2)(\text{x})$$

$$2.6 = \text{x}$$

10. 2 mL

$$\frac{25}{x} = \frac{12.5}{1}$$

$$25 = (12.5)(\text{x})$$

$$2 = \text{x}$$

Practice Set 14.5: Calculating the Volume of a Medication Dose and Selecting the Correct Syringe Size

Practice Set 14.5: Calculating the Volume of a Medication Dose and Selecting the Correct Syringe Size

Calculate the volume of liquid you would draw up for the following medication orders. Look at the images and determine which syringes filled with liquid represent the correct volume of medication. There may be more than one correct syringe size option. Drag and drop all syringes with correct volumes into the open rectangle on the right. Click on the word **check** to see if your selection is correct. Click on the word **answers** to see the work for the medication math.

Questions:

1. A patient exposed to an STI receives an order of ceftriaxone.

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https://opentextbc.ca/nursingnumeracy/?p=100#h5p-35

2. A pediatric patient is requiring a dose of glycopyrrolate.

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https://opentextbc.ca/nursingnumeracy/?p=100#h5p-36

3. A patient with an infection requires a dose of ampicillin.

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https://opentextbc.ca/nursingnumeracy/?p=100#h5p-37

4. A pediatric patient has an anaphylactic reaction to a medication and pre-filled syringes are out of stock. Draw up the ordered dose of epinephrine. After the patient stabilizes, draw up diphenhydramine for IM injection.

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https://opentextbc.ca/nursingnumeracy/?p=100#h5p-38

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://opentextbc.ca/nursingnumeracy/?p=100#h5p-39

5. A physician has ordered dexamethasone for you to draw up and administer for a pediatric patient with cerebral edema.

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https://opentextbc.ca/nursingnumeracy/?p=100#h5p-40

6. You are drawing up heparin for a pediatric patient's loading dose for heparinization.

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https://opentextbc.ca/nursingnumeracy/?p=100#h5p-41

7. A prophylactic dose of gentamicin is required for a pre-surgical adult patient weighing 53 kg.

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https://opentextbc.ca/nursingnumeracy/?p=100#h5p-42

8. A child arrives to the emergency department with a fractured arm and requires morphine for acute pain.

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https://opentextbc.ca/nursingnumeracy/?p=100#h5p-43

9. A 45-year-old with right-sided flank pain requires analgesic.

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https://opentextbc.ca/nursingnumeracy/?p=100#h5p-44

10. You are caring for a 73-year-old with pulmonary edema.

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https://opentextbc.ca/nursingnumeracy/?p=100#h5p-45

Answers:

1. 2.2 mL

$$\frac{785}{x} = \frac{250}{0.7}$$

$$549.5 = (250)(\mathrm{x})$$

$$2.2 = \mathrm{x}$$

2. 1.8 mL

$$x \text{ mg} = \frac{1 \text{ mg}}{1000 \cancel{\text{ mcg}}} \times 360 \cancel{\text{ mcg}}\, x \quad = 0.36 \text{ mg}$$

$$\frac{0.36}{x} = \frac{0.2}{1}$$

$$0.36 = (0.2)(\text{x})$$

$$1.8 = \text{x}$$

3. 1.7 mL

$$\frac{425}{x} = \frac{500}{2}$$

$$850 = (500)(\text{x})$$

$$1.7 = \text{x}$$

4. 0.45 mL

$$\frac{0.45}{x} = \frac{1}{1}$$

$$0.45 = (1)(\text{x})$$

$$0.45 = \text{x}$$

0.7 mL

$$\frac{35}{x} = \frac{50}{1}$$

$$35 = (50)(\text{x})$$

$$0.7 = \text{x}$$

5. 1.5 mL

$$\frac{6}{x} = \frac{4}{1}$$

$$6 = (4)(\text{x})$$

$$1.5 = \text{x}$$

6. 1.3 mL
$$\frac{1300}{x} = \frac{1000}{1}$$
$$1300 = (1000)(\mathrm{x})$$
$$1.3 = \mathrm{x}$$
7. 1.9 mL
$$\frac{76}{x} = \frac{40}{1}$$
$$76 = (40)(\mathrm{x})$$
$$1.9 = \mathrm{x}$$
8. 1.1 mL
$$\frac{2.2}{x} = \frac{2}{1}$$
$$2.2 = (2)(\mathrm{x})$$
$$2.2 = \mathrm{x}$$
9. 0.45 mL
$$\frac{13.5}{x} = \frac{30}{1}$$
$$13.5 = (30)(\mathrm{x})$$
$$0.45 = \mathrm{x}$$
10. 4 mL

$$\frac{40}{x} = \frac{10}{1}$$

$$40 = (10)(\mathrm{x})$$

$$4 = \mathrm{x}$$

15.

Calculating Medication Doses Based on Weight

Lesson

Learning Outcomes

By the end of this chapter, learners will be able to:

- calculate medication doses when the quantity is based on client weight,
- calculate minimum and maximum medication doses when the quantity is based on client weight and a dose range is given, and
- verify safe doses for weight based medication recommendations.

Calculating Weight Based Doses

Some medications require the dose to be determined based on the weight of the client. Orders are written indicating how much medication should be given for each kilogram (kg) the client weighs. You will need to calculate this amount to ensure you are administering the correct amount to the client. You may see weight based orders written in different ways, for example:

morphine 0.2 mg/kg po q4h

morphine 0.1 – 0.5 mg/kg po q4h

Note in the first example only one dose will be calculated, whereas in the second example there is a range of doses which are possible. If the client's weight has been recorded in pounds or ounces, you must convert the client's weight into kilograms or grams, as weight based drug dosages are always given in an amount per kilogram or gram (for some neonatal dosages). When a range is given in the order, you will calculate the smallest and largest amounts which can be given, based on the client's weight.

Sample Exercise 15.1

An order is written for a child to receive 0.2 mg/kg of morphine PO q4h prn. The child weighs 14 kg. Calculate the prn dose for this child.

Answer:

$$x \text{ mg} = \frac{0.2 \text{ mg}}{1 \cancel{\text{kg}}} \times 14 \cancel{\text{kg}}$$

$$x \text{ mg} = \frac{2.8 \text{ mg}}{1}$$

$$\text{mg} = 2.8$$

Sample Exercise 15.2

An order is written for a child to receive morphine 0.1 – 0.5 mg/kg PO q4h prn. The child weighs 24 kg. Calculate the range of prn doses for this child.

Answer:
The range is 2.4-12 mg of morphine per dose. These represent the smallest and largest doses the child should receive.

$$x \text{ mg} = \frac{0.1 \text{ mg}}{1 \cancel{\text{kg}}} \times 24 \cancel{\text{kg}}$$

$$x \text{ mg} = \frac{2.4 \text{ mg}}{1}$$

$$\text{mg} = 2.4$$

$$x \text{ mg} = \frac{0.5 \text{ mg}}{1 \cancel{\text{kg}}} \times 24 \cancel{\text{kg}}$$

$$x \text{ mg} = \frac{12 \text{ mg}}{1}$$

$$\text{mg} = 12$$

You might have noticed there is a step we can take out of the calculation above. Whenever we are calculating a dose where the amount per dose and the weight of the client have the same unit for weight, the following formula can be used:

$$\text{mg} = \text{amount per dose} \times \text{weight of client}$$

Sample Exercise 15.3

An order is written for a child to receive 25 mg/kg of cephazolin IV q12h. The child weighs 37 kg. Calculate the dose for this child.

Answer:

$$\text{mg} = \text{amount per dose} \times \text{weight of client}$$

$$\text{mg} = 25 \times 37$$

$$\text{mg} = 925$$

Verifying Dosage Safety

Recommended Dosage

To verify if a medication dose is safe for a client, the ordered dose must be compared with the recommended dosage information published by the manufacturer or within a reference manual (drug guide, pharmacy documents, etc).

You will need to read carefully to ensure you are following the recommendations for categories relevant to your client, as there may be recommended dosages for multiple circumstances. For instance, the type of client (often based on age and/or weight) or the reason the medication is being prescribed for.

Sample Recommended Dose

The World Health Organization recommends the following dosage options for children ages 2 months to 12 years:

Meropenem 60 mg/kg/day IV divided in 3 doses

or

Meropenem 120 mg/kg/day IV divided in 3 doses (in severe infection)

In this example, the difference in the two doses is related to the reason the medication being administered for.

Antibiotic Dosing for Children: Draft expert Recommendations for the 2017 Essential Medicines List for Children (EMLc) [PDF]

Critical Thinking Questions

1. What is the risk to the client if the dose is higher than the recommended range?
2. What is the risk to the client if the dose is lower than the recommended range?

Answers:

1. There is risk of the client receiving a toxic dose if a dose of the medication is given above the recommended range. Adverse reactions may also worsen or occur, with the severity depending on the amount of extra medication.
2. There is risk of the medication not having any, or reduced effect. The client's condition could worsen.

Safe Dosage for Weight Based Medications

In order to determine if the ordered dose is appropriate for the client, you need to compare the medication order to the information in the reference guide. Often, the recommended dose is given as a total daily amount with a range of possible frequencies, rather than the amount for a single dose. If this is the case, you will need to calculate the recommended doses for the low and high end of the range. It is important you ensure you are using the right information from the drug reference manual when determining which numbers to use in your calculations. You will determine which information is important by referring back to the information about the client. Relevant information may include:

- client age
- client weight
- route
- frequency
- reason
- presence of kidney or liver disease
- pregnancy status

- other diagnostic results

Determine if the following medication order is safe:

vancomycin 500 mg IV q12h

Drug guide information: vancomycin
Children:
IV: 10-15 mg/kg q6-12h
PO: 40 mg/kg
Adults:
IV: 500-2,000mg q12-24h
PO: 125-500 mg q6-8h

Client information:
11 year old with severe staphylococcal infection, weight 38kg

To solve the problem:
Step 1: Determine which information in the drug guide is relevant to the client.
In this case, the relevant information is **IV: 10-15 mg/kg q6-12h**
This is the dose for the **age** of the client and matches the **route** in the medication order.
Step 2: Calculate the minimum and maximum recommended doses.

$$\text{min dose} = \frac{10\text{ mg}}{1\text{ }\cancel{\text{kg}}} \times 38\text{ }\cancel{\text{kg}} = 380\text{ mg}$$

$$\text{max dose} = \frac{15\text{ mg}}{1\text{ }\cancel{\text{kg}}} \times 38\text{ }\cancel{\text{kg}} = 570\text{ mg}$$

Step 3: Compare the dose in the order to the minimum and maximum recommended doses.
Does the dose fall between these numbers? Yes, 500 mg falls between 380 and 570mg.

Sample Exercise 15.4

Order: amoxicillin 250 mg PO TID

Reference manual states: Safe dosage is 20 to 40 mg/kg/day

Client weighs: 20 kg

Problem: Based on the client’s weight, is this a safe dose?

Answer:
Yes, this is a safe dose. 250 mg is in the safe range of 133-267 mg per dose.

Since the reference manual gives you a total daily amount, you must calculate the total daily range first, then divide by the order frequency to see if the dose is safe.

$$\text{min daily amount} = \frac{20 \text{ mg}}{1 \text{ kg}} \times 20 \text{ kg} = 400 \text{ mg}$$

$$\text{max daily amount} = \frac{40 \text{ mg}}{1 \text{ kg}} \times 20 \text{ kg} = 800 \text{ mg}$$

$$\text{min dose} = \frac{400 \text{ mg}}{1 \text{ day}} \times \frac{1 \text{ day}}{3 \text{ doses}} = 133 \text{ mg/dose}$$

$$\text{max dose} = \frac{800 \text{ mg}}{1 \text{ day}} \times \frac{1 \text{ day}}{3 \text{ doses}} = 267 \text{ mg/dose}$$

Administering Doses from a Range

When a weight based medication order includes a range of dose options, you will need to use critical thinking to determine what dose of medication to give after completing a thorough assessment with the client.

Critical Thinking Questions

What factors might impact the dose you choose to give?

Answer:
You may need to consider factors such as:

- has the client has received this medication before?
- if given previously, was the medication effective when it was last given?
- does the client experience adverse effects with this medication?
- are there other diagnostic tests you need to review when selecting the dose (creatinine, INR, ptt, etc.)?
- what is the patient's preference?

As a novice student, you will make decisions about what particular dose to give in partnership with the client's primary nurse and/or your nursing instructor.

Practice Set 15.1: Calculating weight based doses

Practice Set 15.1: Calculating weight based doses

Calculate the dose for each of the following medication orders:

1. vancomycin 15 mg/kg IV TID, child weighs 32 kg
2. nitrofurantoin 1mg/kg PO q6h, child weighs 44 lb
3. acetaminophen 10-15 mg/kg PO q4h prn, child weighs 16 kg
4. piperacillin-tazobactam 90mg/kg IV q8h, child weighs 27 kg
5. ibuprofen 4-10 mg/kg PO q4-6h prn, child weighs 19 kg
6. clindamycin 2-5 mg/kg PO q6h, child weighs 17 kg
7. meropenem 20 mg/kg IV q8h, child weighs 38.5 lb
8. clarithromycin 7.5mg/kg PO BID, child weighs 12 kg
9. cefotaxime 50 mg/kg IV q8h, child weighs 36 kg
10. ketorlac 0.5 mg/kg IV q6-8h prn, child weighs 70 kg

Answers:

1. 480 mg/dose $\dfrac{15 \text{ mg}}{1 \text{ kg}} \times 32 \text{ kg}$
2. 20 mg/dose $\dfrac{1 \text{ kg}}{2.2 \text{ lbs}} \times 44 \text{ lbs} = 20 \text{ kg}, \text{ dose} = \dfrac{1 \text{ mg}}{1 \text{ kg}} \times 20 \text{ kg}$
3. 160-240 mg/dose $\dfrac{10 \text{ mg}}{1 \text{ kg}} \times 16 \text{ kg}, \dfrac{15 \text{ mg}}{1 \text{ kg}} \times 16 \text{ kg}$
4. 2430 mg/dose $\dfrac{90 \text{ mg}}{1 \text{ kg}} \times 27 \text{ kg}$

5. 76-190 mg/dose $\frac{4\text{ mg}}{1\text{ kg}} \times 19\text{ kg}, \frac{10\text{ mg}}{1\text{ kg}} \times 19\text{ kg}$

6. 34-85 mg/dose $\frac{2\text{ mg}}{1\text{ kg}} \times 17\text{ kg}, \frac{5\text{ mg}}{1\text{ kg}} \times 17\text{ kg}$

7. 350 mg/dose $\frac{1\text{ kg}}{2.2\text{ lbs}} \times 38.5\text{ lbs} = 17.5\text{ kg}$, dose $= \frac{20\text{ mg}}{1\text{ kg}} \times 17.5\text{ kg}$

8. 90 mg/dose $\frac{7.5\text{ mg}}{1\text{ kg}} \times 12\text{ kg}$

9. 1800 mg/dose $\frac{50\text{ mg}}{1\text{ kg}} \times 36\text{ kg}$

10. 35 mg/dose $\frac{0.5\text{ mg}}{1\text{ kg}} \times 70\text{ kg}$

Practice Set 15.2: Calculating weight based doses

Practice Set 15.2: Calculating weight based doses

Calculate the dose for each of the following medication orders:

1. amoxicillin 50 mg/kg PO BID, child weighs 43 kg
2. diphenhydramine 1-2 mg/kg IM q4-8h prn, child weighs 15 kg
3. cephalexin 12.5 mg/kg PO q6h, child weighs 23 kg
4. ketorlac 0.5 mg/kg IV q6-8h prn, child weighs 47 lb
5. ciprofloxacin 15 mg/kg PO q12h, child weighs 31 kg
6. acetaminophen 10-15 mg/kg PO q4h prn, child weighs 35 kg

7. ceftriaxone 80 mg/kg IV once daily, child weighs 92 lb
8. gentamycin 7 mg/kg IV once daily, child weighs 29 kg
9. dimenhydrinate 12.5-25 mg/kg PO q6-8h prn, child weighs 73 lb
10. codeine 0.5-1 mg/kg q4-6h PO prn, child weighs 19 kg

Answers:

1. 2150 mg/dose $$\frac{50\text{ mg}}{1\text{ kg}} \times 43\text{ kg}$$
2. 15 – 30 mg/dose $$\frac{1\text{ mg}}{1\text{ kg}} \times 15\text{ kg}, \frac{2\text{ mg}}{1\text{ kg}} \times 15\text{ kg}$$
3. 287.5 mg/dose $$\frac{12.5\text{ mg}}{1\text{ kg}} \times 23\text{ kg}$$
4. 10.7 mg/dose $$\frac{1\text{ kg}}{2.2\text{ lbs}} \times 47\text{ lbs} = 21.4\text{ kg},\ \text{dose} = \frac{0.5\text{ mg}}{1\text{ kg}} \times 21.4\text{ kg}$$
5. 465 mg/dose $$\frac{15\text{ mg}}{1\text{ kg}} \times 31\text{ kg}$$
6. 350 – 525 mg/dose $$\frac{10\text{ mg}}{1\text{ kg}} \times 35\text{ kg}, \frac{15\text{ mg}}{1\text{ kg}} \times 35\text{ kg}$$
7. 3344 mg/dose $$\frac{1\text{ kg}}{2.2\text{ lbs}} \times 92\text{ lbs} = 41.8\text{ kg},\ \text{dose} = \frac{80\text{ mg}}{1\text{ kg}} \times 41.8\text{ kg}$$
8. 203 mg/dose $$\frac{7\text{ mg}}{1\text{ kg}} \times 29\text{ kg}$$
9. 415 – 830 mg/dose $$\frac{1\text{ kg}}{2.2\text{ lbs}} \times 73\text{ lbs} = 33.2\text{ kg},$$ $$\text{dose} = \frac{12.5\text{ mg}}{1\text{ kg}} \times 33.2\text{ kg}, \text{dose} = \frac{25\text{ mg}}{1\text{ kg}} \times 33.2\text{ kg}$$

10. 9.5 – 19 mg/dose $\frac{0.5 \text{ mg}}{1 \text{ kg}} \times 19 \text{ kg}, \frac{1 \text{ mg}}{1 \text{ kg}} \times 19 \text{ kg}$

Practice Set 15.3: Calculating weight based doses

Practice Set 15.3: Calculating weight based doses

Calculate the dose for each of the following medication orders:

1. atropine 0.02 mg/kg/dose IV Q5 min x 2 doses prn, child weighs 15 kg
2. morphine 0.08 mg/kg/dose PO Q3-4H PRN, child weighs 22 lbs
3. naproxen 7 mg/kg/dose PO Q8-12H, child weighs 82 lbs
4. digoxin 10 mcg/kg/24 hr PO once daily, child weighs 31 lbs
5. octreotide 2 mcg/kg/dose IV bolus over 2-5 min, child weighs 25 kgs
6. adenosine initial dose 0.1 mg/kg rapid IV within 1-2 sec, child weighs 16 lbs
7. meropenem 20 mg/kg/dose IV Q8H, child weighs 13 kgs
8. prednisone 0.25 mg/kg/dose PO BID, child weighs 48 lbs
9. piperacillin-tazobactam 75 mg/kg/dose IV Q6H, child weighs 24 kg
10. norepinephrine 0.1 mcg/kg/min, child weighs 14 kgs

Answers:

1. 0.3 mg/dose
$$\frac{0.02 \text{ mg}}{1 \text{ kg}} \times 15 \text{ kg} = 0.3 \text{ mg/dose}$$
2. 0.79 mg/dose

$$\frac{1 \text{ kg}}{2.2 \text{ lbs}} \times 22 \text{ lbs} = 9.97 \text{ kg} \frac{0.08 \text{ mg}}{1 \text{ kg}} \times 9.97 \text{ kg} = 0.79 \text{ mg/dose}$$

3. 260 mg/dose
$$\frac{1 \text{ kg}}{2.2 \text{ lbs}} \times 82 \text{ lbs} = 37.19 \text{ kg} \frac{7 \text{ mg}}{1 \text{ kg}} \times 37.19 \text{ kg} = 260 \text{ mg/dose}$$

4. 140.1 mcg/dose
$$\frac{1 \text{ kg}}{2.2 \text{ lbs}} \times 31 \text{ lbs} = 14.01 \text{ kg} \frac{10 \text{ mcg}}{1 \text{ kg}} \times 14.01 \text{ kg} = 140.1 \text{ mcg/dose}$$

5. 50 mcg/dose
$$\frac{2 \text{ mcg}}{1 \text{ kg}} \times 25 \text{ kg} = 50 \text{ mcg/dose}$$

6. 0.73 mg/dose
$$\frac{1 \text{ kg}}{2.2 \text{ kgs}} \times 16 \text{ lbs} = 7.25 \text{ kg} \frac{0.1 \text{ mg}}{1 \text{ kg}} \times 7.25 \text{ kg} = 0.73 \text{ mg/dose}$$

7. 260 mg/dose
$$\frac{20 \text{ mg}}{1 \text{ kg}} \times 13 \text{ kg} = 260 \text{ mg/dose}$$

8. 5.45 mg/dose
$$\frac{1 \text{ kg}}{2.2 \text{ lbs}} \times 48 \text{ lbs} = 21.8 \text{ kg} \frac{0.25 \text{ mg}}{1 \text{ kg}} \times 21.8 \text{ kg} = 5.45 \text{ mg/dose}$$

9. 1800 mg/dose
$$\frac{75 \text{ mg}}{1 \text{ kg}} \times 24 \text{ kg} = 1800 \text{ mg/dose}$$

10. 1.4 mcg/min
$$\frac{0.1 \text{ mcg}}{1 \text{ kg}} \times 14 \text{ kg} = 1.4 \text{ mcg/min}$$

Practice Set 15.4: Calculating weight based doses with ranges

Practice Set 15.4: Calculating weight based doses with ranges

Calculate the dose for each of the following medication orders:

1. amoxicillin/clavulanic acid 10-15 mg/kg/dose PO TID, child weighs 39 kg
2. cefazolin 35–50 mg/kg/dose IV Q8H, child weighs 48 kg
3. clopidogrel 0.2-1 mg/kg/dose PO once daily, child weighs 27 lbs
4. haloperidol 0.01-0.02 mg/kg/dose PO BID, child weighs 84 lbs
5. diazepam 0.04-0.2 mg/kg/dose PO Q6-8H, child weighs 37 kg
6. ibuprofen 5-10 mg/kg/dose PO Q6-8H, child weighs 72 lbs
7. ketorolac 0.2-0.5 mg/kg/dose IV/IM Q6-8H PRN, child weighs 49 kg
8. metoprolol 0.5-1 mg/kg/dose PO BID, child weighs 49 lbs
9. mannitol 0.25-1 g/kg IV over 20-30 min repeat Q4-8H PRN, child weighs 33 lbs
10. spironolactone 1-1.5 mg/kg/dose BID, child weighs 83 lbs

Answers:

1. 390-585 mg/dose

$$\frac{10 \text{ mg}}{1 \text{ kg}} \times 39 \text{ kg} = 390 \text{ mg/dose}$$

$$\frac{15 \text{ mg}}{1 \text{ kg}} \times 39 \text{ kg} = 585 \text{ mg/dose}$$

2. 1680-2400 mg/dose

$$\frac{35 \text{ mg}}{1 \text{ kg}} \times 48 \text{ kg} = 1680 \text{ mg/dose}$$

$$\frac{50 \text{ mg}}{1 \text{ kg}} \times 48 \text{ kg} = 2400 \text{ mg/dose}$$

3. 2.45-12.25 mg/dose

$$\frac{1\text{ kg}}{2.2\text{ lbs}} \times 27\text{ lbs} = 12.25\text{ kg}$$

$$\frac{0.2\text{ mg}}{1\text{ kg}} \times 12.25\text{ kg} = 2.45\text{ mg/dose}$$

$$\frac{1\text{ mg}}{1\text{ kg}} \times 12.25 = 12.25\text{ mg/dose}$$

4. 0.38-0.76 mg/dose

$$\frac{1\text{ kg}}{2.2\text{ lbs}} \times 84\text{ lbs} = 38.1\text{ kg}$$

$$\frac{0.01\text{ mg}}{1\text{ kg}} \times 38.1\text{ kg} = 0.38\text{ mg/dose}$$

$$\frac{0.02\text{ mg}}{1\text{ kg}} \times 38.1\text{ kg} = 0.76\text{ mg/dose}$$

5. 1.48-7.4 mg/dose

$$\frac{0.04\text{ mg}}{1\text{ kg}} \times 37\text{ kg} = 1.48\text{ mg/dose}$$

$$\frac{0.2\text{ mg}}{1\text{ kg}} \times 37\text{ kg} = 7.4\text{ mg/dose}$$

6. 163.3-326.6 mg/dose

$$\frac{1\text{ kg}}{2.2\text{ lbs}} \times 72\text{ lbs} = 32.66\text{ kg}$$

$$\frac{5\text{ mg}}{1\text{ kg}} \times 32.66\text{ kg} = 163.3\text{ mg/dose}$$

$$\frac{10\text{ mg}}{1\text{ kg}} \times 32.66\text{ kg} = 326.6\text{ mg/dose}$$

7. 9.8-24.5 mg/dose

$$\frac{0.2\text{ mg}}{1\text{ kg}} \times 49\text{ kg} = 9.8\text{ mg/dose}$$

$$\frac{0.5\text{ mg}}{1\text{ kg}} \times 49\text{ kg} = 24.5\text{ mg/dose}$$

8. 11.15-22.3 mg/dose

$$\frac{1\text{ kg}}{2.2\text{ lbs}} \times 49\text{ lbs} = 22.3\text{ kg}$$

$$\frac{0.5\text{ mg}}{1\text{ kg}} \times 22.3\text{ kg} = 11.15\text{ mg/dose}$$

$$\frac{1\ \text{mg}}{1\ \text{kg}} \times 22.3\ \text{kg} = 22.3\ \text{mg/dose}$$

9. 3.75-15 g/dose

$$\frac{1\ \text{kg}}{2.2\ \text{lbs}} \times 33\ \text{lbs} = 15\ \text{kg}$$

$$\frac{0.25\ \text{g}}{1\ \text{kg}} \times 15\ \text{kg} = 3.75\ \text{g/dose}$$

$$\frac{1\ \text{g}}{1\ \text{kg}} \times 15\ \text{kg} = 15\ \text{g/dose}$$

10. 37.7-56.55 mg/dose

$$\frac{1\ \text{kg}}{2.2\ \text{lbs}} \times 83\ \text{lbs} = 37.7\ \text{kg}$$

$$\frac{1\ \text{mg}}{1\ \text{kg}} \times 37.7\ \text{kg} = 37.7\ \text{mg/dose}$$

$$\frac{1.5\ \text{mg}}{1\ \text{kg}} \times 37.7\ \text{kg} = 56.55\ \text{mg/dose}$$

Practice Set 15.5: Verifying Dosage Safety

Practice Set 15.5: Verifying Dosage Safety – acetaminophen

All of the questions in this practice set use the following dosage information for acetaminophen. For each question, determine if the ordered dose is safe.

Drug guide dosage information:

1-3 months:
10 mg/kg/dose PO Q4H PRN (max 60 mg/kg/day)
20 mg/kg/dose PR Q6H PRN (max 80 mg/kg/day)

3 months of age to adolescents:
10 to 15 mg/kg/dose PO Q4H PRN (max 75 mg/kg/day)
20 mg/kg/dose PR Q6H PRN (max 80 mg/kg/day)

Usual adult dose:
325 to 650 mg/dose PO Q4 to 6H PRN (max 4 g/24 hr)

Questions:

1. **Client information:** 12 year old weighing 41 kg
   Ordered dose: 500 mg PO Q4H prn
2. **Client information:** 2 year old weighing 12 kg
   Ordered dose: 250 mg PO Q4H prn
3. **Client information:** 1 month old weighing 4 kg
   Ordered dose: 80 mg PR Q6H prn
4. **Client information:** 7 year old weighing 23 kg
   Ordered dose: 300 mg PO Q4H prn
5. **Client information:** 4 year old weighing 16 kg
   Ordered dose: 125 mg PO Q4H prn

Answers:

1. Yes, this is a safe dose. 500 mg is in the safe range of 410-615 mg.
   $$\text{min dose} = \frac{10 \text{ mg}}{1 \text{ kg}} \times 41 \text{ kg} = 410 \text{ mg}$$
   $$\text{max dose} = \frac{15 \text{ mg}}{1 \text{ kg}} \times 41 \text{ kg} = 615 \text{ mg}$$
2. No, this is not a safe dose. 250 mg is above the safe range of 120-180 mg.
   $$\text{min dose} = \frac{10 \text{ mg}}{1 \text{ kg}} \times 12 \text{ kg} = 120 \text{ mg}$$
   $$\text{max dose} = \frac{15 \text{ mg}}{1 \text{ kg}} \times 12 \text{ kg} = 180 \text{ mg}$$
3. Yes, this is a safe dose. 80 mg is the correct dose when given rectally (PR).
   $$\text{dose} = \frac{20 \text{ mg}}{1 \text{ kg}} \times 4 \text{ kg} = 80 \text{ mg}$$
4. Yes, this is a safe single dose. 300 mg is in the safe range of 230-345 mg.
   $$\text{min dose} = \frac{10 \text{ mg}}{1 \text{ kg}} \times 23 \text{ kg} = 230 \text{ mg}$$
   $$\text{max dose} = \frac{15 \text{ mg}}{1 \text{ kg}} \times 23 \text{ kg} = 345 \text{ mg}$$
5. No, this is not a safe dose. 125 mg is below the safe range of 160-240 mg.
   $$\text{min dose} = \frac{10 \text{ mg}}{1 \text{ kg}} \times 16 \text{ kg} = 160 \text{ mg}$$
   $$\text{max dose} = \frac{15 \text{ mg}}{1 \text{ kg}} \times 16 \text{ kg} = 240 \text{ mg}$$

Practice Set 15.6: Verifying Dosage Safety

Practice Set 15.6: Verifying Dosage Safety – phenoxymethyl penicillin

All of the questions in this practice set use the following dosage information for phenoxymethyl penicillin (Penicillin V). For each question, determine if the ordered dose is safe.

Drug guide dosage information:

Children:
8-17 mg/kg/dose PO Q8H OR 6-13 mg/kg/dose PO Q6H (max: 3 g/day).

Adults:
300-600 mg/dose PO Q6-8H.

Prophylaxis for Asplenia:
>3 months to 5 years old: 150 mg PO BID.
>5 years old: 300 mg PO BID.

Questions:

1. **Client information:** 6 year old weighing 22 kg
   Ordered dose: 300 mg PO Q8H
2. **Client information:** 16 year old weighing 63 kg
   Ordered dose: 600 mg PO Q6H
3. **Client information:** 8 year old weighing 25 kg
   Ordered dose: 600 mg PO Q8H
4. **Client information:** 1 year old weighing 9 kg with asplenia
   Ordered dose: 300 mg PO BID
5. **Client information:** 4 year old weighing 13 kg
   Ordered dose: 150 mg PO Q6H

Answers:

1. Yes, this is a safe dose. 300 mg is in the safe range of 176-374 mg.
   $$\text{min dose} = \frac{8 \text{ mg}}{1 \text{ kg}} \times 22 \text{ kg} = 176 \text{ mg}$$
   $$\text{max dose} = \frac{17 \text{ mg}}{1 \text{ kg}} \times 22 \text{ kg} = 374 \text{ mg}$$
2. Yes, this is a safe dose. 600 mg is in the safe range of 378-819 mg.

$$\text{min dose} = \frac{6\text{ mg}}{1\text{ kg}} \times 63\text{ kg} = 378\text{ mg}$$

$$\text{max dose} = \frac{13\text{ mg}}{1\text{ kg}} \times 63\text{ kg} = 819\text{ mg}$$

3. No, this is not a safe dose. 600 mg is above the safe range of 200-425 mg.

$$\text{min dose} = \frac{8\text{ mg}}{1\text{ kg}} \times 25\text{ kg} = 200\text{ mg}$$

$$\text{max dose} = \frac{17\text{ mg}}{1\text{ kg}} \times 25\text{ kg} = 425\text{ mg}$$

4. No, this is not a safe dose. The dose for a 1 year old is 150 mg BID.
5. Yes, this is a safe dose. 150 mg is in the safe range of 78-169 mg.

$$\text{min dose} = \frac{6\text{ mg}}{1\text{ kg}} \times 13\text{ kg} = 78\text{ mg}$$

$$\text{max dose} = \frac{13\text{ mg}}{1\text{ kg}} \times 13\text{ kg} = 169\text{ mg}$$

Practice Set 15.7: Verifying Dosage Safety

Practice Set 15.7: Verifying Dosage Safety – metoclopramide

All of the questions in this practice set use the following dosage information for metoclopramide. For each question, determine if the ordered dose is safe.

Drug guide dosage information:

GI Hypomotility and GE Reflux:
Children: 0.1-0.2 mg/kg/dose PO/IV/IM up to QID (Maximum: 0.5 mg/kg/24 hr).
Adults: 10-15 mg/dose PO/IV/IM QID.

Chemotherapy Induced Nausea and Vomiting (N&V)*
1mg/kg/dose IV/PO prior to chemotherapy, then 0.04 mg/kg/dose IV/PO Q6H (Maximum: 10 mg/dose).
Alternate dosing: 1 mg/kg IV/PO Q6H*

Post-Op or Opioid-Induced Nausea and Vomiting:
Children: 0.1-0.2 mg/kg/dose IV Q6-8H PRN. (Maximum 0.5 mg/kg/24 hr)
Children > 14 years and Adults: 10 mg/dose IV Q6-8H PRN

Questions:

1. **Client information:** 15 year old weighing 50 kg with GE reflux.
   Ordered dose: 5 mg PO QID prn

2. **Client information:** 46 year old weighing 88 kg with GI hypomotility.
   Ordered dose: 15 mg PO QID

3. **Client information:** 7 year old weighing 23 kg with post op N&V.
   Ordered dose: 2.5 mg IV Q8H prn

4. **Client information:** 6 year old weighing 20 kg with chemo induced N&V.
   Ordered dose: 0.8 mg PO Q6H

5. **Client information:** 12 year old weighing 41 kg with post op N&V.
   Ordered dose: 2.5 mg IV Q6-8H prn

Answers:

1. Yes, this is a safe dose. 5 mg is in the safe range of 5-10 mg and does not exceed the daily maximum if all 4 prn doses were given.
   $$\text{min dose} = \frac{0.1 \text{ mg}}{1 \text{ kg}} \times 50 \text{ kg} = 5 \text{ mg}$$
   $$\text{max dose} = \frac{0.2 \text{ mg}}{1 \text{ kg}} \times 50 \text{ kg} = 10 \text{ mg}$$
   Max daily total 25mg/day

2. Yes, this is a safe dose for an adult with GI hypomotility as it is in the range of 10-15 mg/dose. This dose is not calculated by weight.

3. Yes, this is a safe dose as 2.5 mg is in the safe range of 2.3-4.6 mg and does not exceed the daily maximum if all 3 prn doses were given.
   $$\text{min dose} = \frac{0.1 \text{ mg}}{1 \text{ kg}} \times 23 \text{ kg} = 2.3 \text{ mg}$$
   $$\text{max dose} = \frac{0.2 \text{ mg}}{1 \text{ kg}} \times 23 \text{ kg} = 4.6 \text{ mg}$$
   Max daily total 11.6 mg/day.

4. Yes, this is a safe dose and does not exceed the maximum single dose.
   $$\text{min dose} = \frac{0.04 \text{ mg}}{1 \text{ kg}} \times 20 \text{ kg} = 0.8 \text{ mg}$$

5. No, this is not a safe dose. 2.5 mg is below the safe range of 4.1-8.2 mg and therefore the drug will not be in therapeutic range and the child's N&V would persist.

$$\text{min dose} = \frac{0.1 \text{ mg}}{1 \text{ kg}} \times 41 \text{ kg} = 4.1 \text{ mg}$$

$$\text{max dose} = \frac{0.2 \text{ mg}}{1 \text{ kg}} \times 41 \text{ kg} = 8.2 \text{ mg}$$

Practice Set 15.8: Verifying Dosage Safety

Practice Set 15.8: Verifying Dosage Safety – fentanyl

All of the questions in this practice set use the following dosage information for fentanyl. For each question, determine if the ordered dose is safe.

Drug guide dosage information:

Intermittent Dosing:
Infants: 1 to 2 mcg/kg/dose IV Q2-4H PRN (usual max 4 mcg/kg/dose)
Children: 1 to 2 mcg/kg/dose IV Q30-60 minutes PRN (usual adolescent starting dose: 25-50 mcg)
1 to 2 mcg/kg/dose buccal Q30-60 min. PRN. Maximum initial dose 50 mcg

Continuous IV infusion (by Acute Pain Service, ICU or Palliative Care Specialists only):
Usual dose: 1 -4 mcg/kg/hr. Higher doses may be required in palliative care or end of life symptom management with monitored titration.

Intubation Dosage:
2 to 5 mcg/kg/dose IV over 1-2 min.

Questions:

1. **Client information:** 2 year old weighing 14 kg.
   Ordered dose: 20 mcg IV q30-60min prn (IV intermittent).

2. **Client information:** 6 year old weighing 38 kg.
   Ordered dose: 190 mcg/hour IV (continuous infusion).

3. **Client information:** 4 year old weighing 65 lbs.
   Ordered dose: 120 mcg IV over 1-2 min (intubation dose).

4. **Client information:** 7 month old weighing 9 kgs.
   Ordered dose: 9 mcg IV Q2-4h prn (IV intermittent).

5. **Client information:** 4 month old weighing 10 lbs.
   Ordered dose: 16 mcg IV Q2-4h prn (IV intermittent).

Answers:

1. Yes, this is a safe dose. 20 mcg is in the safe range of 14-28 mcg.

$$\text{min dose} = \frac{1 \text{ mcg}}{1 \text{ kg}} \times 14 \text{ kg} = 14 \text{ mcg/dose}$$

$$\text{max dose} = \frac{2 \text{ mcg}}{1 \text{ kg}} \times 14 \text{ kg} = 28 \text{ mcg/dose}$$

2. No, this is a safe dose. 190 mcg is not in the safe range of 14.5-29 mcg.

$$\text{min dose} = \frac{1 \text{ mcg}}{1 \text{ kg}} \times 38 \text{ kg} = 38 \text{ mcg/dose}$$

$$\text{max dose} = \frac{4 \text{ mcg}}{1 \text{ kg}} \times 38 \text{ kg} = 152 \text{ mcg/dose}$$

3. Yes, this is a safe dose. 120 mcg is in the safe range of 59-147.5 mcg.

$$\text{weight conversion} = \frac{1 \text{ kg}}{2.2 \text{ lbs}} \times 65 \text{ lbs} = 29.5 \text{ kg}$$

$$\text{min dose} = \frac{2 \text{ mcg}}{1 \text{ kg}} \times 29.5 \text{ kg} = 59 \text{ mcg/dose}$$

$$\text{max dose} = \frac{5 \text{ mcg}}{1 \text{ kg}} \times 29.5 \text{ kg} = 147.5 \text{ mcg/dose}$$

4. Yes, this is a safe dose. 9 mcg is in the safe range of 9-18 mcg.

$$\text{min dose} = \frac{1 \text{ mcg}}{1 \text{ kg}} \times 9 \text{ kg} = 9 \text{ mcg/dose}$$

$$\text{max dose} = \frac{2 \text{ mcg}}{1 \text{ kg}} \times 9 \text{ kg} = 18 \text{ mcg/dose}$$

5. Yes, this is a safe dose. 16 mcg is in the safe range of 14.5-29 mcg and does not exceed the maximum initial dose for children.

$$\text{weight conversion} = \frac{1 \text{ kg}}{2.2 \text{ lbs}} \times 10 \text{ lbs} = 4.5 \text{ kg}$$

$$\text{min dose} = \frac{1 \text{ mcg}}{1 \text{ kg}} \times 4.5 \text{ kg} = 4.5 \text{ mcg/dose}$$

$$\text{max dose} = \frac{2 \text{ mcg}}{1 \text{ kg}} \times 4.5 \text{ kg} = 9 \text{ mcg/dose}$$

Practice Set 15.9: Verifying Dosage Safety and Checking Orders

Practice Set 15.9: Verifying Dosage Safety and Checking Orders – furosemide

All of the questions in this practice set use the following dosage information for infants and children receiving furosemide. For each question, determine if the ordered dose is safe as well as checking the orders compared to the drug guide dosage information as you go.

Drug guide dosage information:

Oral Dose
Initial: 0.5-2 mg/kg/dose PO Q6H–Q24H
Maximum PO dose 4 mg/kg/dose

Parenteral Dose:
0.5-2 mg/kg/dose /IV Q6-24H PRN
Usual: 1 mg/kg/dose IV Q6-24H
Maximum single dose is 2 mg/kg/dose IV

Continuous IV Infusion in Critical Care areas:
0.1-0.5 mg/kg/hr

Questions:

1. **Client information:** 3 year old weighing 43 lbs needing continuous IV infusion of furosemide in the PICU.
   Ordered dose: 9.75 mg/hour continuous IV infusion.
2. **Client information:** 7 year old weighing 40 kgs, needing oral dosing of furosemide.
   Ordered dose: 20.4 mg/dose IV Q6h.
3. **Client information:** 15 month old weighing 12 kgs, needing intermittent parenteral dosing of furosemide.
   Ordered dose: 18 mg/dose IV Q8h PRN.
4. **Client information:** 4 year old weighing 38 lbs, needing oral dosing of furosemide.
   Ordered dose: 76 mg/dose PO Q6h.
5. **Client information:** 3 month old weighing 9.7 lbs, needing continuous IV infusion of furosemide in the Emergency Department.
   Ordered dose: 2.2 mg/dose IV Q24h.

Answers:

1. Yes, this is a safe dose. 9.75 mg/hr is in the safe range of 1.95-9.75 mg/hr with continuous infusion.

$$\text{weight conversion} = \frac{1\text{ kg}}{2.2\text{ lbs}} \times 43\text{ lbs} = 19.5\text{ kg}$$

$$\text{min dose} = \frac{0.1\text{ mg}}{1\text{ kg}} \times 19.5\text{ kg} = 1.95\text{ mg/hour}$$

$$\text{max dose} = \frac{0.5\text{ mg}}{1\text{ kg}} \times 19.5\text{ kg} = 9.75\text{ mg/dose}$$

2. No, this is a safe dose but the route of what was ordered does not match what the patient needs. 20.4 mg is in the safe range of 20-80 mg/dose.

$$\text{min dose} = \frac{0.5\text{ mg}}{1\text{ kg}} \times 40\text{ kg} = 20\text{ mg/dose}$$

$$\text{max dose} = \frac{2\text{ mg}}{1\text{ kg}} \times 40\text{ kg} = 80\text{ mg/dose}$$

3. Yes, this is a safe dose. 18 mg is in the safe range of 6-24 mg/dose.

$$\text{min dose} = \frac{0.5\text{ mg}}{1\text{ kg}} \times 12\text{ kg} = 6\text{ mg/dose}$$

$$\text{max dose} = \frac{2\text{ mg}}{1\text{ kg}} \times 12\text{ kg} = 24\text{ mg/dose}$$

4. No, this is not a safe dose. 76 mg is not in the safe range of 8.65-34.6 mg/dose.

$$\text{weight conversion} = \frac{1\text{ kg}}{2.2\text{ lbs}} \times 38\text{ lbs} = 17.3\text{ kg}$$

$$\text{min dose} = \frac{0.5\text{ mg}}{1\text{ kg}} \times 17.3\text{ kg} = 8.65\text{ mg/dose}$$

$$\text{max dose} = \frac{2\text{ mg}}{1\text{ kg}} \times 17.3\text{ kg} = 34.6\text{ mg/dose}$$

5. No, 2.2 mg/dose would be correct dosing for continuous IV furosemide. The order is wrong because it is for intermittent IV dosing when the child needs continuous dosing of furosemide.

$$\text{weight conversion} = \frac{1\text{ kg}}{2.2\text{ lbs}} \times 9.7\text{ lbs} = 4.4\text{ kg}$$

$$\text{min dose} = \frac{0.1\text{ mg}}{1\text{ kg}} \times 4.4\text{ kg} = 0.44\text{ mg/dose}$$

$$\text{max dose} = \frac{0.5\text{ mg}}{1\text{ kg}} \times 4.4\text{ kg} = 2.2\text{ mg/dose}$$

Practice Set 15.10: Verifying Dosage Safety and Checking Orders

Practice Set 15.10: Verifying Dosage Safety and Checking Orders – methotrimeprazine

All of the questions in this practice set use the following dosage information for methotrimeprazine. For each question, determine if the ordered dose is safe as well as checking the orders compared to the drug guide dosage information as you go.

Drug guide dosage information:

Agitation, Aggression, Psychosis:
Children (<12 yrs):
Initial: 0.125 mg/kg/dose PO BID Increase gradually as needed to control agitation/psychosis.
IM: 0.06-0.125 mg/kg/dose IM once daily or div. TID.
Maximum: 40 mg/24 hr.

Adolescents/Adults:
Initial: 2.5-10 mg PO BID-TID Increase gradually as needed to control agitation/psychosis. In severe cases may start with 25 mg PO BID-TID, IM: 25 mg IM BID-QID

Pain, Agitation, Delirium (Palliative Care):
0.05-0.2 mg/kg/dose PO/IV Q6-8H PRN. When titrating IV doses, may give Q30-60 min until stable dose is reached.
Maximum 0.5 mg/kg/dose (50 mg/dose)

Questions:

1. **Client information:** 10 year old weighing 74.5 lbs, needing intermittent IV administration of methotrimeprazine for delirium symptoms during palliation.
   Ordered dose: 3.7 mg/hour IV, after titration.

2. **Client information:** 5 year old weighing 18 kgs, needing oral dosing of methotrimeprazine for agitation and aggression.
   Ordered dose: 1.1 mg/dose PO BID.

3. **Client information:** 14 year old weighing 120 lbs, needing oral dosing of methotrimeprazine to control psychosis and agitation symptoms.
   Ordered dose: 96 mg/dose PO BID.

4. **Client information:** 3 year old weighing 32 lbs, needing intramuscular dosing of methotrimeprazine for agitation.
   Ordered dose: 1.5 mg/dose IM once daily.

5. **Client information:** 17 month old weighing 22 lbs, needing intermittent IV administration of methotrimeprazine for pain and delirium symptoms during palliation.
   Ordered dose: 1.5 mg/dose PO Q6h PRN.

Answers:

1. No, this is a safe dose. 3.7 mg is in the safe range of 1.68-6.72 mg but the timing is off. The order is for continuous IV dosing when the patient needs intermittent IV administration.

$$\text{weight conversion} = \frac{1\text{ kg}}{2.2\text{ lbs}} \times 74\text{ lbs} = 33.6\text{ kg}$$

$$\text{min dose} = \frac{0.05\text{ mg}}{1\text{ kg}} \times 33.6\text{ kg} = 1.68\text{ mg/dose}$$

$$\text{max dose} = \frac{0.2\text{ mg}}{1\text{ kg}} \times 33.6\text{ kg} = 6.72\text{ mg/dose}$$

2. No, this would be a safe but ineffective dose, it is too low. There is no range, you would start at 2.25 mg/dose. The rest of the order is correct.

$$\text{dose} = \frac{0.125\text{ mg}}{1\text{ kg}} \times 18\text{ kg} = 2.25\text{ mg/dose}$$

3. No, the weight does not matter, 2.5-10 mg PO BID-TID is the generic range.

4. Yes, this is a safe dose. 1.5 mg is in the safe range of 0.87-1.81 mg/dose.

$$\text{weight conversion} = \frac{1\text{ kg}}{2.2\text{ lbs}} \times 32\text{ lbs} = 14.5\text{ kg}$$

$$\text{min dose} = \frac{0.06\text{ mg}}{1\text{ kg}} \times 14.5\text{ kg} = 0.87\text{ mg/dose}$$

$$\text{max dose} = \frac{0.125\text{ mg}}{1\text{ kg}} \times 14.5\text{ kg} = 1.81\text{ mg/dose}$$

5. No, the patient needs intermittent IV not oral, like what was ordered. Though 1.5 mg is within the safe range of 0.5-2 mg/dose and Q6-8h PRN is corrent.

$$\text{weight conversion} = \frac{1\text{ kg}}{2.2\text{ lbs}} \times 22\text{ lbs} = 10\text{ kg}$$

$$\text{min dose} = \frac{0.05\text{ mg}}{1\text{ kg}} \times 10\text{ kg} = 0.5\text{ mg/dose}$$

$$\text{max dose} = \frac{0.2\text{ mg}}{1\text{ kg}} \times 10\text{ kg} = 2\text{ mg/dose}$$

16.

IV Flow Rates

Lesson

Learning Outcomes

By the end of this chapter, learners will be able to:

- define the terms rate, drop factor, and drop rate,
- distinguish between micro and macro drip tubing,
- calculate infusion rate,
- calculate drop rate, and
- calculate infusion time.

When administering intravenous (IV) fluids, you will come across a variety of ways prescribers write IV orders. You will need to be familiar with the types of information presented in the order, how to use this information correctly when administering IV fluid and how to make this information meaningful when discussing the IV treatment with the client. Much of this information is related to the amount of fluid they will receive, either the total amount or the amount infused each hour. The type of equipment you have available will impact how the IV infusion is set up, so it is important to understand how the equipment works and how it can impact how fluid is infused.

Calculating the IV Infusion Rate

The term rate refers to an amount over a period of time. When we consider intravenous (IV) fluid treatments, the rate is typically measured in millilitres/hour (mL/hr). Most of the time, IV pumps will be set to infuse IV fluids in mL/hr as well, but there are some exceptions when we are infusing IV medications. Just like other med math questions, you need to make sure you are always considering the type of units written in the order and what you have available in your supply when preparing medications as you may need to convert units before completing your calculation.

$$\text{rate} = \frac{\text{total volume}}{\text{time in hours}}$$

You can use the formula above to help you quickly calculate a rate if the rate is not specifically written in the order. You can also use dimensional analysis to calculate rate when unit conversion is necessary.

Sample Exercise 16.1

IV infusion order: Run 500 mL of normal saline over 4 hours. What rate would this IV run at?

Answer:

$$\text{rate} = \frac{\text{total volume}}{\text{time in hours}}$$

$$\text{rate} = \frac{500 \text{ mL}}{4 \text{ hours}}$$

$$\text{rate} = 125 \text{ mL/hr}$$

Sample Exercise 16.2

IV infusion order: Run 1 L of D5W over 4 hours. What rate would this IV run at?

Answer:

$$\text{rate} = \frac{\text{total volume}}{\text{time in hours}}$$

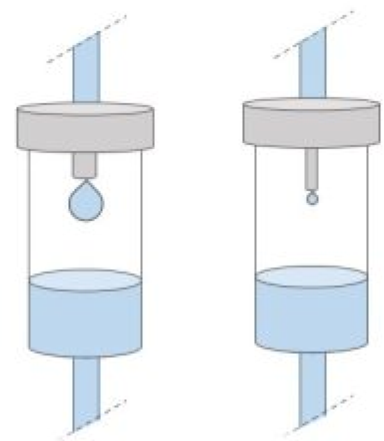
$$\frac{\text{mL}}{\text{hr}} = \frac{1000 \text{ mL}}{1 \text{ L}} \times \frac{1 \text{ L}}{4 \text{ hours}}$$

$$\frac{\text{mL}}{\text{hr}} = \frac{1000 \text{ mL}}{1 \cancel{\text{L}}} \times \frac{1 \cancel{\text{L}}}{4 \text{ hours}}$$

$$\frac{\text{mL}}{\text{hr}} = 250 \text{ mL/hr}$$

Calculating the IV Drop Rate

When you watch an IV infuse, you can see drops falling from where the IV tubing enters the drop chamber. The **drop rate** refers to how fast the IV fluid is dripping, measured in drops/minute (gtts/min). When there is no pump available, you must set the rate manually by using the roller clamp to control the flow and watching how quickly the drops are dripping in the drip chamber. In order to determine exactly how fast we should let the IV drip, we need to consider how big each drop is, and count how many drops are falling in a minute. Each IV set you use has a specific size drop it produces, some large, others small. The size of drop is reflected in the **drop factor** which is identified on the IV set packaging. The drop factor tells you how many drops are in 1 mL of fluid, which you can use to help calculate the rate the IV should run. In the image below, you can see the size difference between a large drop of a macro set and a small drop of a micro set.



Macro vs. Micro Drip

Note the drop rate is measured in gtts/min, versus the infusion rate which is measured in mL/hr. To calculate the drop rate you must know the infusion rate and the drop factor of the IV tubing. You can use the formula below, but only if you convert the rate of mL/hr to mL/min. As IV rates are usually given in mL/1 hr, you should be able to use 60 minutes as the denominator in most cases.

Drop Rate = Infusion Rate x Drop Factor

You can see how this works using dimensional analysis:

Consider an IV running at 125mL/hr, using a standard tubing set with a drop factor of 10 gtts/mL. What is the drop rate in gtts/min?

$$\frac{\text{gtts}}{\text{min}} = \frac{10\text{ gtts}}{1\text{ mL}} \times \frac{125\text{ mL}}{1\text{ hr}} \times \frac{1\text{hr}}{60\text{ min}}$$

$$\frac{\text{gtts}}{\text{min}} = \frac{10\text{ gtts}}{1\ \cancel{\text{mL}}} \times \frac{125\ \cancel{\text{mL}}}{1\ \cancel{\text{hr}}} \times \frac{1\ \cancel{\text{hr}}}{60\text{ min}}$$

$$\frac{\text{gtts}}{\text{min}} = \frac{10\text{ gtts x }125}{60\text{ min}}$$

$$\frac{\text{gtts}}{\text{min}} = \frac{1250\text{ gtts}}{60\text{ min}}$$

$$\frac{\text{gtts}}{\text{min}} = 20.83$$

$$\frac{\text{gtts}}{\text{min}} = 21$$

*round to the whole number as you cannot count a portion of a drop

Critical Thinking Questions

1. If an IV set creates a large drop, will the patient finish the infusion more quickly than an IV set which creates a small drop?
2. If the drop rate is calculated at 15.5, what do you set the drop rate at when administering the IV?

Answers:

1. If the rate is set in mL/hr, then both infusions should finish at the same time. Macro drips will take less drops to fill 1 mL than a micro drip set, so if you compare the drops falling in the drop chamber, the drops per minute in the IV set with small drops will be running at a faster rate (drops/min). If we compare two infusions with the same drop rate, then the infusion running with the macro set would finish faster as more volume per drop is being infused, however IV infusions are not ordered with a drop/minute rate because of this variability.
2. Drops must be rounded up or down, as you cannot count a portion of a drop. So do you choose 15 or 16? The actual difference of fluid administered in one hour between a drop rate of 15 and 16 is only 6 mL. When the IV infusion is running by gravity, there are fluctuations in the actual rate of the IV infusion and you will need to keep readjusting the drop rate to keep the IV running at the appropriate rate. So, it is likely

that you can choose either drop rate, knowing that you will be frequently readjusting the drop rate to ensure the fluid infuses in the correct amount of time. However, if the extra 6 mL/hour of fluid would be detrimental to your client, then you should find a pump and ensure a more exact rate is delivered to the client. Instances where the infusion is a medication or the client is at risk for fluid overload may be circumstances which require the pump versus gravity.

Sample Exercise 16.3

Calculate the drop rate for the following order:

Give NS IV 70 mL/hr.

The IV set has a drop factor of 10 gtts/min.

Answer:

$$\frac{\text{gtts}}{\text{min}} = \frac{\text{10 gtts}}{\text{1 mL}} \times \frac{\text{70 mL}}{\text{1 hr}} \times \frac{\text{1hr}}{\text{60 min}}$$

$$\frac{\text{gtts}}{\text{min}} = \frac{\text{10 gtts x 70}}{\text{60 min}}$$

$$\frac{\text{gtts}}{\text{min}} = \frac{\text{700 gtts}}{\text{60 min}}$$

$$\frac{\text{gtts}}{\text{min}} = 11.66$$

$$\frac{\text{gtts}}{\text{min}} = 12$$

Calculating IV Infusion Time

In some cases, you may want to know how long an IV infusion is going to take. Perhaps you need to know how long the IV will take to infuse in order to inform the patient how long it will be until they take a shower, or to be discharged home. Most IV pumps will display the remaining time of the infusion, but you may need this information before you have programmed infusion details into the IV pump. Understanding how to calculate infusion time can help you be prepared to plan timing of infusions and answer questions about the infusion time promptly.

$$\text{infusion time} = \frac{\text{total volume}}{\text{rate}}$$

Sample Exercise 16.4

A client has the following order: Infuse 1 L NS at 125 mL/hr.
How long will this take to infuse?

Answer:

$$\text{infusion time} = \frac{\text{total volume}}{\text{rate}}$$

$$\text{infusion time} = \frac{1000}{125}$$

$$\text{infusion time} = 8$$

Here is the same question showing how dimensional analysis is used, and where the units will cancel out:

$$\text{infusion time} = \frac{1\ \text{hr}}{125\ \text{mL}} \times 1000\ \text{mL}$$

$$\text{infusion time} = \frac{1\ \text{hr}}{125\ \cancel{\text{mL}}} \times 1000\ \cancel{\text{mL}}$$

$$\text{infusion time} = 8\ \text{hrs}$$

Critical Thinking Questions

A patient asks you how much longer their IV will run for. You manually calculate the remaining amount of time and determine the answer is 1.66 hours. How could you communicate this information to the client in a way that is easier to understand?

Answer:
You could report the remaining amount of time in hours and minutes. First, convert 0.66 into minutes (39.6 mins) and then inform the patient the infusion will run for about 1 hour and 40 minutes.

You could inform the client what time the infusion will finish. For instance, if it was 0800 hours, you could report the infusion will be finished around 0940 hours if the infusion is uninterrupted.

Key Takeaways

- Infusion rate is measured in mL/hr.
- Drop rate is measured in gtts/hr.
- Micro drip tubing has a drop factor of 60 gtts/mL.
- Standard tubing has a drop factor of 10 gtts/mL.
- Drop rate = Infusion Time x Drop Factor

Practice Set 16.1-16.3: Calculating IV Flow Rate

Practice Set 16.1: Calculating IV Flow Rate

Calculate the IV flow rate for the following IV infusion orders:

1. Run 500 mL of normal saline over 2 hours.
2. Give 1 L of Ringer’s lactate over 12 hours.
3. Run 1 L of normal saline over 4 hours.
4. Administer 1 L bolus of NS over 2 hours.
5. Give 250 ml of 3% sodium chloride over 30 minutes.
6. Run 1 L D5 0.45% NS over 5 hours.
7. Infuse 500 mL D10W over 4 hours.
8. Give 1,000 mL of D5W over 8 hours.
9. Administer 750 mL of Ringer’s lactate over 8 hours.

10. Give a 500 mL bolus of NS over an hour and a half.

Answers:

Answers should be in mL/hr. Use dimensional analysis or the formula $\text{rate} = \dfrac{\text{total volume}}{\text{total time}}$.

1. $\text{rate} = \dfrac{500 \text{ mL}}{2 \text{ hours}} = 250 \text{ mL/hr}$
2. $\text{rate} = \dfrac{1000 \text{ mL}}{12 \text{ hours}} = 83 \text{ mL/hr}$
3. $\text{rate} = \dfrac{1000 \text{ mL}}{4 \text{ hours}} = 250 \text{ mL/hr}$
4. $\text{rate} = \dfrac{1000 \text{ mL}}{2 \text{ hours}} = 500 \text{ mL/hr}$
5. $\text{rate} = \dfrac{250 \text{ mL}}{30 \text{ minutes}} = \dfrac{250 \text{ mL}}{0.5 \text{ hours}} = 500 \text{ mL/hr}$
6. $\text{rate} = \dfrac{1000 \text{ mL}}{5 \text{ hours}} = 200 \text{ mL/hr}$
7. $\text{rate} = \dfrac{500 \text{ mL}}{4 \text{ hours}} = 125 \text{ mL/hr}$
8. $\text{rate} = \dfrac{1000 \text{ mL}}{8 \text{ hours}} = 125 \text{ mL/hr}$
9. $\text{rate} = \dfrac{750 \text{ mL}}{8 \text{ hours}} = 94 \text{ mL/hr}$
10. $\text{rate} = \dfrac{500 \text{ mL}}{1.5 \text{ hours}} = 333 \text{ mL/hr}$

Practice Set 16.2: Calculating IV Flow Rates

Calculate the IV flow rate for the following IV infusion orders:

1. Give 600 mL over 120 minutes.
2. Administer 1 L of NS over 8 hours.
3. Run 750 mL over 4 hours.
4. Run 500 mL over 210 minutes.
5. Give a 1 L Ringer's Lactate bolus over 90 minutes.
6. Administer 800 mL over 6 hours.
7. Administer 500 mL over 2 hours.
8. Run 800 mL NS over 4 hours.
9. Give a 250 mL bolus over 30 minutes.
10. Run 500 mL over 6 hours.

Answers:

1. $$\text{rate} = \frac{600 \text{ mL}}{120 \text{ minutes}} = \frac{600 \text{ mL}}{2 \text{ hours}} = 300 \text{ mL/hr}$$
2. $$\text{rate} = \frac{1000 \text{ mL}}{8 \text{ hours}} = 125 \text{ mL/hr}$$
3. $$\text{rate} = \frac{750 \text{ mL}}{4 \text{ hours}} = 187.5 \text{ mL/hr}$$
4. $$\text{rate} = \frac{500 \text{ mL}}{210 \text{ minutes}} = \frac{500 \text{ mL}}{3.5 \text{ hours}} = 143 \text{ mL/hr}$$
5. $$\text{rate} = \frac{1000 \text{ mL}}{90 \text{ minutes}} = \frac{1000}{1.5 \text{ hours}} = 666 \text{ mL/hr}$$

6. $\text{rate} = \dfrac{800 \text{ mL}}{6 \text{ hours}} = 133 \text{ mL/hr}$

7. $\text{rate} = \dfrac{500 \text{ mL}}{2 \text{ hours}} = 250 \text{ mL/hr}$

8. $\text{rate} = \dfrac{800 \text{ mL}}{4 \text{ hours}} = 200 \text{ mL/hr}$

9. $\text{rate} = \dfrac{250 \text{ mL}}{30 \text{ minutes}} = \dfrac{250}{0.5 \text{ hours}} = 500 \text{ mL/hr}$

10. $\text{rate} = \dfrac{500 \text{ mL}}{6 \text{ hours}} = 83 \text{ mL/hr}$

Practice Set 16.3: Calculating Infusion Rate

Calculate the infusion rate for the following IV orders:

1. You need to administer 10,800 mL of Ringer's lactate over 24 hours to a patient with burns to 45% of their total body surface area. How many mL/hour will you program on the IV pump and how many 1 L bags of Ringer's lactate will you go through in the first 24 hours?

2. A person arrives to the emergency room in hemorrhagic shock. The physician prescribes 1 unit of packed red blood cells (PRBC) to be given over 20 minutes and the unit you collect from blood services has 346 mL of PRBC. What would you program as the infusion rate on the pump?

3. A person is severely hypokalemic but is NPO and cannot take oral potassium. Your order is to give 40 mEq of potassium in 1L lactated Ringer's over 4 hours. What would your infusion rate be?

4. You are working on the surgical floor and one of your patients is having severe postoperative nausea after hip replacement surgery. The physician has ordered 4 mg of ondansetron to help with this nausea. Using the parenteral manual you have decided to dilute the medication in a 50 mL minibag and give over 15 minutes because your patient is over 65 years old but has been tolerating fluids well. What will your infusion rate be?

5. You have a patient on the medical floor who is having an allergic reaction to one of the medications that the doctor has ordered. The doctor has now ordered 50 mg diphenhydramine which you have diluted in a 50 mL minibag that you are going to run over 20 minutes. What will your infusion rate be?

6. A patient comes into the emergency room with the flu severely dehydrated and unable to tolerate fluids by mouth. The physician orders 1 L of Ringer's lactate over four and a half hours. What will your infusion rate be?

7. You have a child who came into the hospital in ventricular fibrillation. The doctor has ordered 160 mg of amiodarone which you have diluted in a 50 mL minibag of D5W and you choose to give this dose over 30 minutes. What will your infusion rate be?

8. A woman who is 26 weeks pregnant was admitted for hyperemesis gravidarum treatment. The midwife has ordered 100 mg diphenhydrinate IV. You have diluted this in 1 L of D5W and are going to give over 10 hours. What will your infusion rate be?

9. You are receiving a postoperative patient from the PAR who is on a ketorolac infusion that is almost complete. The surgeon wants another 10 mg hung and you add the medication into a 50 mL bag to run over 30 minutes. What will your infusion rate be?

10. Your patient has been NPO for a couple of days as their surgery has been postponed. In the meantime, the physician has ordered 1 L over 4 hours. What will the infusion rate be?

Answers:

1. $\text{rate} = \dfrac{10800 \text{ mL}}{24 \text{ hours}} = 450 \text{ mL/hr}$

2. $\text{rate} = \dfrac{346 \text{ mL}}{20 \text{ minutes}} = \dfrac{346 \text{ mL}}{0.33 \text{ hours}} = 1048 \text{ mL/hr}$

3. $\text{rate} = \dfrac{1000 \text{ mL}}{4 \text{ hours}} = 250 \text{ mL/hr}$

4. $\text{rate} = \dfrac{50 \text{ mL}}{15 \text{ minutes}} = \dfrac{50 \text{ mL}}{0.25 \text{ hours}} = 200 \text{ mL/hr}$

5. $\text{rate} = \dfrac{50 \text{ mL}}{20 \text{ minutes}} = \dfrac{50 \text{ mL}}{0.33 \text{ hours}} = 151 \text{ mL/hr}$

6. $\text{rate} = \dfrac{1000 \text{ mL}}{4.5 \text{ hours}} = 222.2 \text{ mL/hr}$

7. $\text{rate} = \dfrac{50 \text{ mL}}{30 \text{ minutes}} = \dfrac{50 \text{ mL}}{0.5 \text{ hours}} = 100 \text{ mL/hr}$

8. $\text{rate} = \dfrac{1000 \text{ mL}}{10 \text{ hours}} = 100 \text{ mL/hr}$

9. $\text{rate} = \dfrac{50 \text{ mL}}{30 \text{ minutes}} = \dfrac{50 \text{ mL}}{0.5 \text{ hours}} = 100 \text{ mL/hr}$

10. $\text{rate} = \dfrac{1000 \text{ mL}}{4 \text{ hours}} = 250 \text{ mL/hr}$

Practice Set 16.4-16.6: Calculating IV Drop Rate

Practice Set 16.4: Calculating IV Drop Rate

Calculate the drop rate for the following IV orders:

1. IV NS 125 ml/hr using standard tubing
2. IV D5W 80 ml/hr using standard tubing
3. IV RL 150 ml/hr using standard tubing
4. IV NS 25 ml/hr using microdrip tubing
5. IV RL 35 ml/hr using microdrip tubing
6. IV 0.45% NS 100 ml/hr using standard tubing
7. IV NS 130 ml/hr using standard tubing
8. IV D5W 15 ml/hr using microdrip tubing
9. IV NS 55 ml/hr using standard tubing
10. IV NS 200 ml/hr using standard tubing

Answers:

1. $\frac{\text{gtts}}{\text{min}} = \frac{\text{10 gtts x 125}}{\text{60 min}} = 21$
2. $\frac{\text{gtts}}{\text{min}} = \frac{\text{10 gtts x 80}}{\text{60 min}} = 13$
3. $\frac{\text{gtts}}{\text{min}} = \frac{\text{10 gtts x 150}}{\text{60 min}} = 25$
4. $\frac{\text{gtts}}{\text{min}} = \frac{\text{60 gtts x 25}}{\text{60 min}} = 25$
5. $\frac{\text{gtts}}{\text{min}} = \frac{\text{60 gtts x 35}}{\text{60 min}} = 35$
6. $\frac{\text{gtts}}{\text{min}} = \frac{\text{10 gtts x 100}}{\text{60 min}} = 17$
7. $\frac{\text{gtts}}{\text{min}} = \frac{\text{10 gtts x 130}}{\text{60 min}} = 22$
8. $\frac{\text{gtts}}{\text{min}} = \frac{\text{60 gtts x 15}}{\text{60 min}} = 15$
9. $\frac{\text{gtts}}{\text{min}} = \frac{\text{10 gtts x 55}}{\text{60 min}} = 9$
10. $\frac{\text{gtts}}{\text{min}} = \frac{\text{10 gtts x 200}}{\text{60 min}} = 33$

Practice Set 16.5: Calculating IV Drop Rate

Calculate the drop rate for the following IV orders:

1. Run 1L NS over 4 hours, standard tubing

2. IV RL 70 ml/hr, macro drip tubing 20 gtts/min
3. IV NS 25 ml/hr, micro drip tubing
4. IV D5W 175 ml/hr, standard tubing
5. IV RL 76 ml/hr, standard tubing
6. Infuse 500 ml NS over 2 hours, standard tubing
7. IV NS 135 ml/hr, standard tubing
8. Give 1L RL over 8 hours, standard tubing
9. IV NS 40 ml/hr, macro drip tubing 15 gtts/min
10. IV D5W 60ml/hr, standard tubing

Answers:

1. $\text{rate} = \frac{1000\text{ mL}}{4\text{ hours}} = 250\text{ mL/hr} = \frac{10\text{ gtts x }250}{60\text{ min}} = 42$
2. $\frac{\text{gtts}}{\text{min}} = \frac{20\text{ gtts x }70}{60\text{ min}} = 23$
3. $\frac{\text{gtts}}{\text{min}} = \frac{60\text{ gtts x }25}{60\text{ min}} = 25$
4. $\frac{\text{gtts}}{\text{min}} = \frac{10\text{ gtts x }175}{60\text{ min}} = 29$
5. $\frac{\text{gtts}}{\text{min}} = \frac{10\text{ gtts x }75}{60\text{ min}} = 12$
6. $\text{rate} = \frac{500\text{ mL}}{2\text{ hours}} = 250\text{ mL/hr} = \frac{10\text{ gtts x }250}{60\text{ min}} = 42$
7. $\frac{\text{gtts}}{\text{min}} = \frac{10\text{ gtts x }135}{60\text{ min}} = 22$

8. $\text{rate} = \dfrac{1000 \text{ mL}}{8 \text{ hours}} = 125 \text{ mL/hr} = \dfrac{10 \text{ gtts x } 125}{60 \text{ min}} = 21$

9. $\dfrac{\text{gtts}}{\text{min}} = \dfrac{15 \text{ gtts x } 40}{60 \text{ min}} = 10$

10. $\dfrac{\text{gtts}}{\text{min}} = \dfrac{10 \text{ gtts x } 60}{60 \text{ min}} = 10$

Practice Set 16.6: Calculating IV Drop Rate

Calculate the drop rate for the following IV orders:

1. IV RL 50 mL/hr using standard tubing.
2. IV NS 175 mL/hr using microdrip tubing.
3. IV D5W 500 mL over 3 hours using microdrip tubing.
4. IV RL 250 mL/hr using standard tubing.
5. IV NS 1L over 6 hours using standard tubing.
6. IV RL 75 mL/hr using standard tubing.
7. IV D5W 250 mL over 3 hours using standard tubing.
8. IV D5W 100 mL/hr using macrodrip tubing 20 gtts/min.
9. IV NS 30 mL/hr using microdrip tubing.
10. IV NS 50 mL over 30 minutes using macrodrip tubing 15 gtts/min.

Answers:

1. $\text{rate} = 50 \text{ mL/hr} = \dfrac{10 \text{ gtts x } 50}{60 \text{ min}} = 8.3$

2. $\text{rate} = 175 \text{ mL/hr} = \dfrac{60 \text{ gtts x } 175}{60 \text{ min}} = 175$

3. $\text{rate} = \dfrac{500 \text{ mL}}{3 \text{ hours}} = 166 \text{ mL/hr} = \dfrac{60 \text{ gtts x } 166}{60 \text{ min}} = 166$

4. $\text{rate} = 250 \text{ mL/hr} = \dfrac{10 \text{ gtts x } 250}{60 \text{ min}} = 41.6$

5. $\text{rate} = \dfrac{1000 \text{ mL}}{6 \text{ hours}} = 166.6 \text{ mL/hr} = \dfrac{10 \text{ gtts x } 166.6}{60 \text{ min}} = 27.2$

6. $\text{rate} = 75 \text{ mL/hr} = \dfrac{10 \text{ gtts x } 75}{60 \text{ min}} = 12.5$

7. $\text{rate} = \dfrac{250 \text{ mL}}{3 \text{ hours}} = 83.3 \text{ mL/hr} = \dfrac{10 \text{ gtts x } 83.3}{60 \text{ min}} = 13.8$

8. $\text{rate} = 100 \text{ mL/hr} = \dfrac{20 \text{ gtts x } 100}{60 \text{ min}} = 33.3$

9. $\text{rate} = 30 \text{ mL/hr} = \dfrac{60 \text{ gtts x } 30}{60 \text{ min}} = 30$

10. $\text{rate} = \dfrac{50 \text{ mL}}{30 \text{ min}} = 100 \text{ mL/hr} = \dfrac{15 \text{ gtts x } 100}{60 \text{ min}} = 25$

Practice Set 16.7-16.8: Calculating Infusion Time

Practice Set 16.7: Calculating Infusion Time

Calculate the infusion time for the following problems:

1. A client has an IV infusing at 70 mL/hr. There is 140 mL left to be infused. How long will it take to infuse the rest of the fluid?

2. A client has an IV infusing at 125 ml/hr. There is 587 mL left to be infused. How long will it take to infuse the rest of the fluid?
3. A client has an IV infusing at 150 mL/hr. There is 225 mL left to be infused. How long will it take until the IV fluid has infused?
4. A client has an IV infusing at 100 mL/hr. There is 850 mL left to be infused. How long will it take until the IV fluid has infused?
5. A client has an IV infusing at 80 mL/hr. There is 320 mL left to be infused. How long will it take until the IV fluid has infused?
6. A client has an IV infusing at 125 mL/hr. There is 725 mL left to be infused. How long will it take until the IV infusion is complete?
7. A client has an IV infusing at 80 mL/hr. There is 409 mL left to be infused and it is currently 1945. What time should you expect to change the IV bag?
8. A client has an IV infusing at 125 mL/hr. They can be discharged when the IV bag is empty. There is currently 340 mL of fluid remaining. How long will it be until they can be discharged?
9. A client has an IV infusing at 100 mL/hr. There is 385 mL left to be infused and it is currently 0735. What time should you expect to change the IV bag?
10. A client has an IV bolus running at 500 mL/hr, with 200 mL already infused. It is currently 1425. When the bolus is complete they will be taken for a CT scan. What time should you ask the porter to pick up the client?

Answers:

1. $\text{infusion time} = \dfrac{140}{70} = 2 \text{ hrs}$
2. $\text{infusion time} = \dfrac{587}{125} = 4.696 \text{ hr} = 4 \text{ hr } 42 \text{ min}$
3. $\text{infusion time} = \dfrac{225}{150} = 1.5 \text{ hr} = 1 \text{ hr } 30 \text{ min}$
4. $\text{infusion time} = \dfrac{850}{100} = 8.5 \text{ hrs} = 8 \text{ hr } 30 \text{ min}$
5. $\text{infusion time} = \dfrac{320}{80} = 4 \text{ hrs}$

6. $\text{infusion time} = \frac{725}{125} = 5.8 \text{ hrs} = 5 \text{ hr } 48 \text{ min}$

7. $\text{infusion time} = \frac{409}{80} = 5.1125 \text{ hrs} = 5 \text{ hr } 7\text{min} = 0052 \text{ hours}$

8. $\text{infusion time} = \frac{340}{125} = 2.72 \text{ hrs} = 2 \text{ hr } 43 \text{ min}$

9. $\text{infusion time} = \frac{385}{100} = 3.85 \text{ hrs} = 3 \text{ h } 51 \text{ min hrs} = 1126 \text{ hours}$

10. $\text{infusion time} = \frac{300}{500} = 0.6 \text{ hrs} = 36 \text{ min} = 1501 = 1500 \text{ hours}$

*to easily convert a portion of an hour to minutes, multiply 60 by the portion of the hour.

2.35 hours converts to 2 hours and 21 minutes

$0.35 \times 60 = 21$

Practice Set 16.8: Calculating Infusion Time

Calculate the infusion time for the following problems:

1. A client has an IV infusing at 75 mL/hr. There is 346 mL left to be infused. How long until you will need to change the IV bag?
2. A client has an IV infusing at 250 mL/hr. There is 115 mL left to be infused. The patient will be discharged when the infusion is finished, how long until the patient can be discharged?
3. A client has an IV infusing at 33 mL/hr. There is 453 mL left to be infused. It is 0945, at what time should you change the IV bag next?
4. A client has an IV infusing at 80 mL/hr. There is 235 mL left to be infused. How long until you change to the next IV bag?
5. A client has an IV infusing at 125 mL/hr. There is 167 mL left to be infused. It is 1000, when can you change the IV bag next?

6. A client has an IV infusing at 100 mL/hr. There is 245 mL left to be infused. It is 1635, when should the IV bag be changed next?
7. A client has an IV infusing at 55 mL/hr. There is 374 mL left to be infused. It is 0745, the patient will be going to physio after their infusion is complete, when will physio expect them for?
8. A client has an IV infusing at 500 mL/hr. There is 238 mL left to be infused. When the bolus is completed, the patient is to go to have an MRI, when should you tell the MRI staff to expect the patient?
9. A client has an IV infusing at 200 mL/hr. There is 784 mL left to be infused. How long until you change the IV bag?
10. A client has an IV infusing at 83 mL/hr. There is 675 mL left to be infused. Your patient can be discharged when the infusion finishes, how long until the patient can be discharged?

Answers:

1. $\text{infusion time} = \dfrac{346}{75} = 4.613 \text{ hrs} = 4 \text{ hr } 37 \text{ min}$
2. $\text{infusion time} = \dfrac{115}{250} = 0.46 \text{ hr} = 28 \text{ min}$
3. $\text{infusion time} = \dfrac{453}{33} = 13.7 \text{ hr} = 13 \text{ hr } 44 \text{ min}$
4. $\text{infusion time} = \dfrac{253}{80} = 2.94 \text{ hrs} = 2 \text{ hr } 56 \text{ min}$
5. $\text{infusion time} = \dfrac{167}{125} = 1.336 \text{ hrs} = 1 \text{ hr } 20 \text{ min}$
6. $\text{infusion time} = \dfrac{245}{100} = 2.45 \text{ hrs} = 2 \text{ hr } 27 \text{ min}$
7. $\text{infusion time} = \dfrac{374}{55} = 6.8 \text{ hrs} = 6 \text{ hr } 48 \text{ min}$
   $07{:}45 + 6 \text{ hr} = 13{:}45 + 48 \text{ min} = 14{:}33$ is when physio should expect the patient
8. $\text{infusion time} = \dfrac{238}{500} = 0.476 \text{ hrs} = 29 \text{ min}$

9. $\text{infusion time} = \dfrac{784}{200} = 3.92 \text{ hrs} = 3 \text{ h } 55 \text{ min hrs}$

10. $\text{infusion time} = \dfrac{675}{83} = 8.1325 \text{ hrs} = 8 \text{ hr } 8 \text{ min}$

17.

Administering Medications IV Direct

Lesson

Learning Outcomes

By the end of this chapter, learners will be able to:

- identify factors which affect the rate of administration of IV direct medications,
- create a dose, volume, time table for use in administration of IV direct medications, and
- label a syringe to help keep track of medication delivery rate.

IV Direct Administration Rates

It is essential for medications administered directly into an IV line to be given at the correct rate to prevent complications. Information describing the appropriate rate will be available in the health agency's drug reference manual. Ensure all factors about the patient's context are considered when reviewing rate information in the reference manual. For instance, the rate may be different for a neonate versus an adult. In some cases, a variable rate is given and you will need to use critical thinking skills to determine the most appropriate rate, often in discussion with your nursing instructor or the most responsible nurse for the patient.

To determine how fast to administer an IV direct medication, you will need the following information:

- the medication order
- information about the patient's context (eg. age, reason for medication order, hepatic function…)
- the administration information from the drug reference manual
- the total volume of medication to be administered

Once the rate of administration of the drug is determined, the actual administration of the drug must be timed to ensure it is given at the correct rate. In order to administer the drug evenly over a particular period of time, nurses often calculate a volume of medication to be given over specific time intervals (for example, every 15 seconds) during the administration period. The drug information in the text box below will be used to exemplify this process. It is important to note the information presented here should not be used for direct patient care, always review your agency's drug reference manual for up to date information regarding the drug and the administration policy of your institution.

> diazepam
>
> Status Epilepticus: 5-10 mg IV/IM q5-10min; not to exceed 30 mg, OR 0.5 mg/kg PR (using parenteral solution), THEN 0.25 mg/kg in 10 minutes PRN
> IV Direct: Administer undiluted over 3 min; no more than 5 mg/min
>
> https://reference.medscape.com/drug/valium-diastat-diazepam-342902

1. Gather the information which will affect the rate of administration.

Medication order: diazepam 10 mg
Rate information: over 3 min; no more than 5mg/min
Supply: the concentration of diazepam in a vial is 5 mg : 1 mL
Calculate the total volume to be administered:

$$x \text{ mL} = \frac{1 \text{ mL}}{5 \text{ mg}} \times 10 \text{ mg}$$

$$x \text{ mL} = \frac{1 \text{ mL}}{5 \cancel{\text{mg}}} \times 10 \cancel{\text{mg}}$$

$$x \text{ mL} = \frac{1 \text{ mL} \times 10}{5}$$

$$x \text{ mL} = 2 \text{ mL}$$

2. Determine what volume of medication will be given in each time interval:

When beginning to administer IV direct medications, it can be hard to ensure you are maintaining an even speed of delivery
over the whole time period. To stay within a consistent delivery speed, you can create a table to determine how much of the syringe volume should be given over smaller time intervals to ensure you have an even speed over the duration of the injection. This can be called a dose, volume, time table. Including the amount, volume and time interval in the table is helpful when checking to ensure you are meeting the criteria as laid out in the drug reference manual as rate information is often given in an amount (usually mg or mcg) per time interval (usually min or sec).
In this dose, volume and time table, the total amount, volume and time period is entered into the second row. Each subsequent value has been cut in half from the value above.

Amount (mg)	**Volume (mL)**	**Time Interval**
10	*2*	*3 min (180 sec)*
5	*1*	*90 sec*
2.5	*0.5*	*45 sec*
1.25	*0.25*	*22.5 sec*

This is not the only way to set up the table. Here is an alternate table in which each value has been divided by 3:

Amount (mg)	**Volume (mL)**	**Time Interval**
10	*2*	*3 min*
3.33	*0.66*	*1 min (60 sec)*
1.11	*0.22*	*20 sec*

And finally, a table where each value has been divided by 5:

Amount (mg)	**Volume (mL)**	**Time Interval**
10	*2*	*3 min (180 sec)*
2 mg	*0.4*	*36 sec*
1 mg	*0.2*	*18 sec*

In this example, clinical judgement must be used to determine which one will give a volume and time interval easiest for a nurse to follow. The middle table might be the easiest to use in practice, as watching a timer and noting how much you have given every 20 seconds is easier to follow than watching for every 22.5 or 18 seconds. You may also find any number you divide by gives a difficult number to measure with the available syringes. In this case, you will need to round the number so the volume can be measured easily on the syringe. For example, if you calculated the final volume to be 1.08 mL you could round to 1 mL. If you are rounding down, you are giving slightly less volume over the allotted time and should be safe for the client to receive. You must be very cautious about rounding up, as the medication would be given slightly faster. Make sure to discuss rationale for rounding with your preceptor or instructor to ensure you are making appropriate decisions.

Sample Exercise 17.1

Complete a dose, volume, time table when administering the following medication:

Medication Order: ketorlac 30 mg IV prn q8h
Rate Information: undiluted over 1-2 minutes
Supply: ketorlac 30 mg/mL

Answer:

Amount (mg)	**Volume (mL)**	**Time Interval**
30	1	2 min
15	0.5	1 min
7.5	0.25	30 sec

Sample Exercise 17.2

Create a dose, volume, time chart for the following medication order.

Medication Order: furosemide 40 mg IV BID
Rate Information: administer undiluted at a rate of 20 mg/min
Supply: 20 mg/1 mL ampule

Answer:
First, calculate the total volume of the injection.

$$x \text{ mL} = \frac{1 \text{ mL}}{20 \text{ mg}} \times 40 \text{ mg}$$

$$x \text{ mL} = \frac{1 \text{ mL}}{20 \cancel{\text{ mg}}} \times 40 \cancel{\text{ mg}}$$

$$x \text{ mL} = \frac{40 \text{ mL}}{20}$$

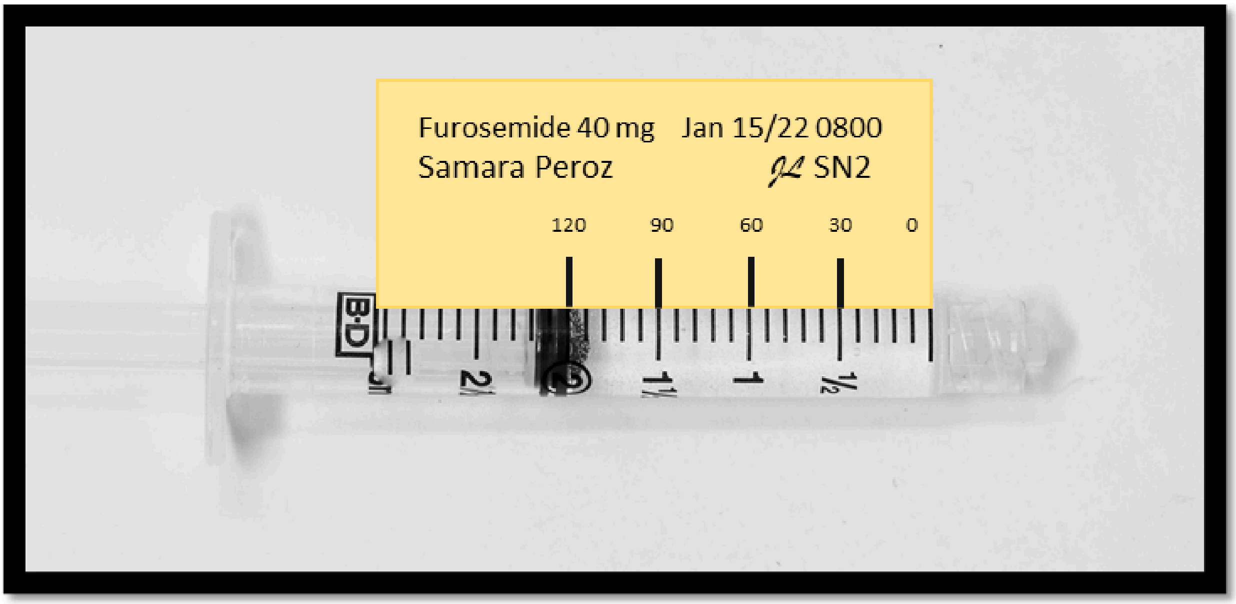
$x \text{ mL} = 2 \text{ mL}$

Enter the total amount, volume and period of time in the first row. In this case, the recommended rate of 20 mg/min is represented in the third row of the chart, and thus meets criteria for safe administration.
Next, choose an amount to divide each value by. In this answer, each value has been divided by 2.

Amount (mg)	**Volume (mL)**	**Time Interval**
40	2	2 min
20	1	1 min
10	0.5	30 sec

Syringe Labels for IV Direct Administration

It can be challenging for some people to focus on the amount of volume being administered in each short time interval while in the practice setting, even while watching a timer. Distractions such as alarms, conversation and/or questions from the patient or family and other interruptions can break the focus of the nurse during this process. When beginning to administer IV direct medications, it may be helpful to add a visual cue to the syringe label to help keep on track. In the image below, two components have been added to a syringe label for administration of furosemide. Lines to indicate every 0.5 mL on the syringe and numbers representing the seconds remaining at each interval are added. These correspond to the dose, volume, time table created in the sample exercise above, in which 0.5 mL is given every 30 seconds.



Critical Thinking Question

When comparing the same dose of a particular medication given by IV direct versus an intermittent IV infusion, do you anticipate any differences in the onset, peak and duration of the medication?

Answer:

The onset occurs when the medication enters the bloodstream and is able to take effect in the body. It varies with mechanism of action, dosage, and individual patient factors. The IV direct route is often delivered over a total shorter time than the intermittent IV route. If the medication is delivered into the vein more quickly, it is likely the onset will be earlier for IV direct than IV intermittent. It may effect the peak for some medications as well. The duration of effect is more variable. It's possible the duration of IV intermittent is longer, especially for infusions which are given over longer periods of time. If you think variations in onset, peak and duration of various routes will affect the choice of route given to a patient, you should check the parenteral manual for guidelines on specific medications when preparing the medication.

Practice Set 17.1: Creating Dose, Volume, Time Tables

Practice Set 17.1: Creating Dose, Volume, Time Tables

Create a dose, volume, time table for the following scenarios.

1. Medication Order: dexamethasone 4 mg IV q6h
   Rate Information: administer undiluted, no more than 8mg/min
   Supply: 20 mg/5 mL vial
2. Medication Order: pantoprazole 40 mg IV OD
   Rate Information: administer over 2 minutes
   Supply: 40 mg powder in medication vial, to be reconstituted with 10 mL NS
3. Medication Order: benzotropine 2 mg IV now
   Rate Information: administer undiluted over 1 minute
   Supply: 2 mg/2 mL ampule
4. Medication Order: morphine 2 mg IV q2h prn
   Rate Information: dilute with 9 mL NS or SW for injection to give 1 mg/mL and give at a maximum rate of 2 mg/min
   Supply: 10 mg/mL ampule
5. Medication Order: digoxin 0.25 mg IV once daily
   Rate Information: dilute each 1 mL with at least 4 mL NS and give over at least 5 minutes
   Supply: 0.25 mg/mL ampule
6. Medication Order: furosemide 40 mg IV once daily
   Rate Information: give undiluted; doses 120 mg or less over 1-2 minutes
   Supply: 10 mg/mL ampule
7. Medication Order: lorazepam 3 mg IV 20 minutes prior to surgery
   Rate Information: dilute with equal volume D5W, NS, or SW; give over 1 minute, max of 2 mg/min
   Supply: 4 mg/mL vial

8. Medication Order: naloxine 0.2 mg IV q2-3 minutes until respiratory rate depression is resolved
   Rate Information: give undiluted over 30-60 seconds
   Supply: 0.4 mg/mL

9. Medication Order: oxytocin 8 units once postpartum bolus
   Rate Information: may dilute with 3 mL NS, given slowly over at least 1 minute
   Supply: 10 units/mL vial

10. Medication Order: haloperidol 2 mg IV push PRN.
    Rate Information: dilute with 5 mL SW and give rapid IV push over at least 1 minute.
    Supply: 5 mg/mL (1 mL) ampule.

Answers:

1. First, calculate the total volume of the injection.

$$x \text{ mL} = \frac{5 \text{ mL}}{20 \text{ mg}} \times 4 \text{ mg}$$

$$x \text{ mL} = \frac{5 \text{ mL}}{20 \cancel{\text{mg}}} \times 4 \cancel{\text{mg}}$$

$$x \text{ mL} = \frac{20 \text{ mL}}{20}$$

$$x \text{ mL} = 1 \text{ mL}$$

   Enter the total amount, volume and period of time in the first row. Choosing to give 4 mg in 1 minute is giving the medication slower than the maximum rate of 8 mg/min, and meets criteria for safe administration.
   Next, choose an amount to divide each value by. In this answer, each value has been divided by 2.

Amount (mg)	Volume (mL)	Time Interval
4	1	1 min
2	0.5	30 sec
1	0.25	15 sec

2. First, note the total volume of the injection (40 mg in 10 mL).
   Enter the total amount, volume and period of time in the first row.
   Next, choose an amount to divide each value by. In this answer, each value has been divided by 2.

Amount (mg)	**Volume (mL)**	**Time Interval**
40	10	2 min
20	5	1 min
10	2.5	30 sec
5	1.25	15 sec

3. First, note the total volume of the injection (2 mg in 2 mL).
Enter the total amount, volume and period of time in the first row.
Next, choose an amount to divide each value by. In this answer, each value has been divided by 2.

Amount (mg)	**Volume (mL)**	**Time Interval**
2	2	1 min
1	1	30 sec
0.5	0.5	15 sec

4. First, calculate the total volume of the injection.

$$x \text{ mL} = \frac{10 \text{ mL}}{10 \text{ mg}} \times 2 \text{ mg}$$

$$x \text{ mL} = \frac{10 \text{ mL}}{10 \cancel{\text{ mg}}} \times 2 \cancel{\text{ mg}}$$

$$x \text{ mL} = \frac{20 \text{ mL}}{10}$$

$$x \text{ mL} = 2 \text{ mL}$$

Enter the total amount, volume and period of time in the first row. Safety note: In this situation, you may have recognized the morphine is supplied in an ampule. Morphine is diluted by drawing up 9 ml of NS in a 10 mL syringe and then the 1 mL of morphine from the ampule. Before administering, the extra volume in the syringe must be wasted so only the calculated volume of 2 mL remains.
Next, choose an amount to divide each value by. In this answer, each value has been divided by 2.

Amount (mg)	Volume (mL)	Time Interval
2	2	1 min (60 sec)
1	1	30 sec
0.5	0.5	15 sec

Alternately, if the decision is made to administer the morphine slower than the maximum rate, the following table could be set up:

Amount (mg)	Volume (mL)	Time Interval
2	2	2 min (120 sec)
1	1	1 min (60 sec)
0.5	0.5	30 sec
0.25	0.25	15 sec

5. First, calculate the total volume of the injection.

$$x \text{ mL} = \frac{1 \text{ mL}}{0.25 \text{ mg}} \times 0.25 \text{ mg}$$

$$x \text{ mL} = \frac{1 \text{ mL}}{0.25 \cancel{\text{mg}}} \times 0.25 \cancel{\text{mg}}$$

$$x \text{ mL} = \frac{0.25 \text{ mL}}{0.25}$$

$$x \text{ mL} = 1 \text{ mL}$$

Enter the total amount, volume and period of time in the first row.
Next, choose an amount to divide each value by. In this answer, each value has been divided by 5 to start and then by 2 to get down to 15 second increments.

Amount (mg)	Volume (mL)	Time Interval
0.25	1	5 min
0.05	0.2	1 min
0.025	0.1	30 sec

6. First, calculate the total volume of the injection.

$$x \text{ mL} = \frac{1 \text{ mL}}{10 \text{ mg}} \times 40 \text{ mg}$$

$$x \text{ mL} = \frac{1 \text{ mL}}{10 \cancel{\text{mg}}} \times 40 \cancel{\text{mg}}$$

$$x \text{ mL} = \frac{40 \text{ mL}}{10}$$

$$x \text{ mL} = 4 \text{ mL}$$

Enter the total amount, volume and period of time in the first row.
Next, choose an amount to divide each value by. In this answer, each value has been divided by 2.

Amount (mg)	Volume (mL)	Time Interval
40	4	2 min
20	2	1 min
10	1	30 sec
5	0.5	15 sec

7. First, calculate the total volume of the injection.

$$x \text{ mL} = \frac{1 \text{ mL}}{4 \text{ mg}} \times 3 \text{ mg}$$

$$x \text{ mL} = \frac{1 \text{ mL}}{4 \cancel{\text{mg}}} \times 3 \cancel{\text{mg}}$$

$$x \text{ mL} = \frac{3 \text{ mL}}{4}$$

$$x \text{ mL} = 0.75 \text{ mL}$$

Due to how this medication needs to be diluted, the total volume that will be give needs to be doubled.

$0.75 \text{ mL} \times 2 = 1.5 \text{ mL}$

Enter the total amount, volume and period of time in the first row.
Next, choose an amount to divide each value by. In this answer, each value has been divided by 2.

Amount (mg)	Volume (mL)	Time Interval
3	1.5	1 min
1.5	0.75	30 sec

8. First, calculate the total volume of the injection.

$$x \text{ mL} = \frac{1 \text{ mL}}{0.4 \text{ mg}} \times 0.2 \text{ mg}$$

$$x \text{ mL} = \frac{1 \text{ mL}}{0.4 \cancel{\text{mg}}} \times 0.2 \cancel{\text{mg}}$$

$$x \text{ mL} = \frac{0.2 \text{ mL}}{0.4}$$

$$x \text{ mL} = 0.5 \text{ mL}$$

Enter the total amount, volume and period of time in the first row.
Next, choose an amount to divide each value by. In this answer, each value has been divided by 2.

Amount (mg)	**Volume (mL)**	**Time Interval**
0.2	0.5	60 sec
0.1	0.25	30 sec

9. First, calculate the total volume of the injection.

$$x \text{ mL} = \frac{1 \text{ mL}}{10 \text{ units}} \times 8 \text{ units}$$

$$x \text{ mL} = \frac{1 \text{ mL}}{10 \cancel{\text{units}}} \times 8 \cancel{\text{units}}$$

$$x \text{ mL} = \frac{8 \text{ mL}}{10}$$

$$x \text{ mL} = 0.8 \text{ mL}$$

Enter the total amount, volume and period of time in the first row.
Next, choose an amount to divide each value by. In this answer, each value has been divided by 2.

Amount (units)	**Volume (mL)**	**Time Interval**
8	0.8	1 min
4	0.4	30 sec
2	0.2	15 sec

10. First, calculate the total volume of the injection.

$$x \text{ mL} = \frac{6 \text{ mL}}{5 \text{ mg}} \times 2 \text{ mg}$$

$$x \text{ mL} = \frac{6 \text{ mL}}{5 \cancel{\text{mg}}} \times 2 \cancel{\text{mg}}$$

$$x \text{ mL} = \frac{12 \text{ mL}}{5}$$

$$x \text{ mL} = 2.4 \text{ mL}$$

Enter the total amount, volume and period of time in the first row.
Next, choose an amount to divide each value by. In this answer, each value has been divided by 2.

Amount (mg)	**Volume (mL)**	**Time Interval**
2	2.4	1 min
1	1.2	30 sec
0.5	0.6	15 sec

Practice Set 17.2: Creating Dose, Volume, Time Tables

Practice Set 17.2: Creating Dose, Volume, Time Tables

Create a dose, volume, time table for the following scenarios. Identify the final volume and time interval you would use when administering the medication.

1. Medication Order: dexamethasone 15 mg IV once
   Rate Information: max rate of 8 mg/min
   Supply: 4 mg/mL vial
2. Medication Order: diphenhydrinate 35 mg IV push q4h.
   Rate Information: dilute every 50 mg with 10 mL NS and administer over 2-4 minutes.
   Supply: 50 mg/mL (1 mL) vial.
3. Medication Order: meropenum 600 mg IV q8h.
   Rate Information: reconstitute with 20 mL NS or D5W and give over 3-5 minutes.
   Supply: 1 g (powdered) vial.
4. Medication Order: thiamine 100 mg IV push once daily for 5 days.
   Rate Information: give undiluted over 1 minute.

Supply: 100 mg/mL (1 mL) vial.

5. Medication Order: morphine 2.5 mg IV push q4h.
Rate Information: max rate of 2 mg/mL, diluted to 1 mg/mL with NS (10 mL of fluids).
Supply: 10 mg/mL

6. Medication Order: flumezanil 0.2 mg for suspected benzo overdose, possibly giving additional doses if inadequate results.
Rate Information: give over 30 seconds.
Supply: 0.1 mg/mL (5 mL) vial.

7. Medication Order: ampicillin 25 mg/kg/dose, for a 15 kg child, IV push for a mild infection.
Rate Information: give over 4 minutes at a max rate of 100 mg/minute, diluted to 250 mg/2.5 mL.
Supply: 250 mg (powdered) vial.

8. Medication Order: ketorolac 20 mg q4h IV push.
Rate Information: give over 1-2 minutes undiluted.
Supply: 30 mg/mL (1 mL) vial.

9. Medication Order: diazepam 8 mg q3h.
Rate Information: give undiluted 2-5 mg/minute.
Supply: 5 mg/mL (2 mL) ampule.

10. Medication Order: midazolam 0.2 mg/kg IV push loading dose, repeating q5 minute until seizure stops. This is for a 65 kg adult.
Rate Information: given at a rate of 2 mg/minute.
Supply: 1 mg/mL

Answers:

1. First, calculate the total volume of the injection.

$$x \text{ mL} = \frac{1 \text{ mL}}{4 \text{ mg}} \times 15 \text{ mg}$$

$$x \text{ mL} = \frac{1 \text{ mL}}{4 \cancel{\text{mg}}} \times 15 \cancel{\text{mg}}$$

$$x \text{ mL} = \frac{15 \text{ mL}}{4}$$

$$x \text{ mL} = 3.75 \text{ mL}$$

In this answer, in the table set up, each value has been divided by 2.
When you calculate a volume that is not a round decimal number, round to the the number that you can measure in the syringe that you are using.

Amount (mg)	**Volume (mL)**	**Rounded Volume (mL)**	**Time Interval**
15	3.75	3.8	2 min
7.5	1.875	1.9	1 min
3.75	0.9375	1.0	30 sec
1.875	0.46875	0.5	15 sec

2. First, calculate the total volume of the injection.

$$x \text{ mL} = \frac{10 \text{ mL}}{50 \text{ mg}} \times 35 \text{ mg}$$
$$x \text{ mL} = \frac{10 \text{ mL}}{50 \cancel{\text{ mg}}} \times 35 \cancel{\text{ mg}}$$
$$x \text{ mL} = \frac{350 \text{ mL}}{50}$$
$$x \text{ mL} = 7 \text{ mL}$$

Enter the total amount, volume and period of time in the first row.
Next, choose an amount to divide each value by. In this answer, each value has been divided by 2.

Amount (mg)	**Volume (mL)**	**Time Interval**
35	7	4 min
17.5	3.5	2 min
8.7	1.75	1 min
4.4	0.88	30 sec
2.2	0.44	15 sec

From the table, 0.44 is not an easy volume to track over 15 seconds when giving a direct IV. Instead, you can round this number to 0.4 to track the volume your are giving better.

3. First, calculate the total volume of the injection.

$$x \text{ mL} = \frac{10 \text{ mL}}{500 \text{ mg}} \times 600 \text{ mg}$$
$$x \text{ mL} = \frac{10 \text{ mL}}{500 \cancel{\text{ mg}}} \times 600 \cancel{\text{ mg}}$$

$$x \text{ mL} = \frac{6000 \text{ mL}}{500}$$
$$x \text{ mL} = 12 \text{ mL}$$

Enter the total amount, volume and period of time in the first row.
Next, choose an amount to divide each value by. In this answer, each value has been divided by 5 to start and then by 2 to get to 15 second increments.

Amount (mg)	**Volume (mL)**	**Time Interval**
600	12	5
120	2.4	1
60	1.2	30 sec
30	0.6	15 sec

4. First, we know the volume of the dose due to the supply and we will enter the total amount, volume and period of time in the first row.
Next, choose an amount to divide each value by. In this answer, each value has been divided by 2.

Amount (mg)	**Volume (mL)**	**Time Interval**
100	1	1 min
50	0.5	30 sec
25	0.25	15 sec

5. First, calculate the total volume of the injection.

$$x \text{ mL} = \frac{1 \text{ mL}}{1 \text{ mg}} \times 2.5 \text{ mg}$$
$$x \text{ mL} = \frac{1 \text{ mL}}{1 \cancel{\text{mg}}} \times 2.5 \cancel{\text{mg}}$$
$$x \text{ mL} = \frac{2.5 \text{ mL}}{1}$$
$$x \text{ mL} = 2.5 \text{ mL}$$

Enter the total amount, volume and period of time in the first row.
Next, choose an amount to divide each value by. In this answer, each value has been divided by 3 to start and then divided by 2 to get to 15 second increments.

Amount (mg)	Volume (mL)	Time Interval
2.5	2.5	1.5 min
0.8	0.8	30 sec
0.4	0.4	15 sec

6. First, calculate the total volume of the injection.

$$x \text{ mL} = \frac{1 \text{ mL}}{0.1 \text{ mg}} \times 0.2 \text{ mg}$$

$$x \text{ mL} = \frac{1 \text{ mL}}{0.1 \cancel{\text{mg}}} \times 0.2 \cancel{\text{mg}}$$

$$x \text{ mL} = \frac{0.2 \text{ mL}}{0.1}$$

$$x \text{ mL} = 2 \text{ mL}$$

Enter the total amount, volume and period of time in the first row.
Next, choose an amount to divide each value by. In this answer, each value has been divided by 2.

Amount (mg)	Volume (mL)	Time Interval
0.2	2	30 sec
0.1	1	15 sec

7. First, calculate the dose in mg from the weight of the patient given.
$25 \text{ mg} \times 15 \text{ kg} = 375 \text{ mg/dose}$
Then, calculate the total volume of the injection.

$$x \text{ mL} = \frac{2.5 \text{ mL}}{250 \text{ mg}} \times 375 \text{ mg}$$

$$x \text{ mL} = \frac{2.5 \text{ mL}}{250 \cancel{\text{mg}}} \times 375 \cancel{\text{mg}}$$

$$x \text{ mL} = \frac{937.5 \text{ mL}}{250}$$

$$x \text{ mL} = 3.75 \text{ mL}$$

Enter the total amount, volume and period of time in the first row.
Next, choose an amount to divide each value by. In this answer, each value has been divided by 4 to start and then by 2 to get to 15 second increments.

Amount (mg)	Volume (mL)	Time Interval
375	3.75	4 min
93.75	0.94	1 min
46.9	0.47	30 sec
23.4	0.23	15 sec

From the table, 0.23 is not an easy volume to track over 15 seconds when giving a direct IV. Instead, you can round this number to 0.2 to track the volume your are giving better.

8. First, calculate the total volume of the injection.

$$x\text{ mL} = \frac{1\text{ mL}}{30\text{ mg}} \times 20\text{ mg}$$

$$x\text{ mL} = \frac{1\text{ mL}}{30\ \cancel{\text{mg}}} \times 20\ \cancel{\text{mg}}$$

$$x\text{ mL} = \frac{20\text{ mL}}{30}$$

$$x\text{ mL} = 0.67\text{ mL}$$

Enter the total amount, volume and period of time in the first row.
Next, choose an amount to divide each value by. In this answer, each value has been divided by 2.

Amount (mg)	Volume (mL)	Rounded Volume (mL)	Time Interval
20	0.67	0.7	2 min
10	0.33	0.3	1 min
5	0.16	0.2	30 sec
2.5	0.08	0.1	15 sec

9. First, calculate the total volume of the injection.

$$x\text{ mL} = \frac{1\text{ mL}}{5\text{ mg}} \times 8\text{ mg}$$

$$x\text{ mL} = \frac{1\text{ mL}}{5\ \cancel{\text{mg}}} \times 8\ \cancel{\text{mg}}$$

$$x\text{ mL} = \frac{8\text{ mL}}{5}$$

$$x \text{ mL} = 1.6 \text{ mL}$$

Enter the total amount, volume and period of time in the first row.
Next, choose an amount to divide each value by. In this answer, each value has been divided by 2.

Amount (mg)	Volume (mL)	Time Interval
8	1.6	2 min
4	0.8	1 min
2	0.4	30 sec
1	0.2	15 sec

10. First, calculate the dose in mg from the weight of the patient given.
$0.2 \text{ mg} \times 65 \text{ kg} = 13 \text{ mg/dose}$
Then, calculate the total volume of the injection.

$$x \text{ mL} = \frac{1 \text{ mL}}{1 \text{ mg}} \times 13 \text{ mg}$$

$$x \text{ mL} = \frac{1 \text{ mL}}{1 \cancel{\text{mg}}} \times 13 \cancel{\text{mg}}$$

$$x \text{ mL} = \frac{13 \text{ mL}}{1}$$

$$x \text{ mL} = 13 \text{ mL}$$

Enter the total amount, volume and period of time in the first row.
Next, choose an amount to divide each value by. In this answer, each value has been divided by 13 to start and then by 2 to get to 15 second increments.

Amount (mg)	Volume (mL)	Time Interval
13	13	6.5 min
1	1	30 sec
0.5	0.5	15 sec

Practice Set 17.3: Creating Dose, Volume, Time Tables

Practice Set 17.3: Creating Dose, Volume, Time Tables

Create a dose, volume, time table for the following scenarios. Identify the final volume and time interval you would use when administering the medication.

1. Medication Order: diltiazem 0.25 mg/kg IV direct for a 55kg adult.
   Rate Information: give undiluted over 2 minutes.
   Supply: 5 mg/mL (10 mL) vial.

2. Medication Order: hydromorphone 0.5 mg IV direct q6h.
   Rate Information: dilute to 5 mL with NS administer slowly over 2 minutes.
   Supply: 2 mg/mL vial.

3. Medication Order: labetalol 7 mg IV initial dose in a hypertensive emergency.
   Rate Information: give over 2 minutes.
   Supply: 5 mg/mL (20 mL) vial.

4. Medication Order: propofol 18 mg IV direct bolus.
   Rate Information: given over 3 minutes.
   Supply: 10 mg/mL (20 mL) ampule.

5. Medication Order: metoclopramide 10 mg IV for prophylactic postoperative vomiting.
   Rate Information: given over 2 minutes.
   Supply: 5 mg/mL (2 mL) vial.

6. Medication Order: hydrocortisone 200 mg IV direct.
   Rate Information: dilute with 2 mL SW (diluted to 125 mg/mL), given over 1.5 minutes.
   Supply: 250 mg vial.

7. Medication Order: ephedrine 20 mg IV repeat q5-10 minutes according to blood pressure response.
   Rate Information: given over 10 mg/minute as a max rate.
   Supply: 50 mg/mL (1 mL) vial.

8. Medication Order: meperidine 15 mg IV direct q4h PRN for severe pain.
   Rate Information: diluted to 10 mg/mL, given over 5 minutes.
   Supply: 50 mg/mL (1 mL) ampule.

9. Medication Order: fentynal 75 mcg intrapartum q30 minutes IV direct.
   Rate Information: given undiluted over 2 minutes.
   Supply: 50 mcg/mL (5 mL) ampule.

10. Medication Order: octreotide 2 mg/kg/dose IV direct bolus for a 20 kg toddler with a severe gastrointestinal bleed.
Rate Information: given undiluted over 2 minutes.
Supply: 100 mcg/mL (1 mL) ampule.

Answers:

1. First, calculate the dose in mg from the weight of the patient given.
$0.25 \text{ mg} \times 55 \text{ kg} = 13.75 \text{ mg}$
Then, calculate the total volume of the injection.

$$x \text{ mL} = \frac{1 \text{ mL}}{5 \text{ mg}} \times 13.75 \text{ mg}$$

$$x \text{ mL} = \frac{1 \text{ mL}}{5 \cancel{\text{mg}}} \times 13.75 \cancel{\text{mg}}$$

$$x \text{ mL} = \frac{13.75 \text{ mL}}{5}$$

$$x \text{ mL} = 2.75 \text{ mL}$$

Enter the total amount, volume and period of time in the first row.
Next, choose an amount to divide each value by. In this answer, each value has been divided by 2.

Amount (units)	**Volume (mL)**	**Rounded Volume (mL)**	**Time Interval**
13.75	2.75	2.75	2 min
6.875	1.37	1.4	1 min
3.437	0.68	0.7	30 sec
1.718	0.34	0.3	15 sec

2. First, calculate the total volume of the injection.

$$x \text{ mL} = \frac{5 \text{ mL}}{2 \text{ mg}} \times 0.5 \text{ mg}$$

$$x \text{ mL} = \frac{5 \text{ mL}}{\cancel{2 \text{ mg}}} \times 0.5 \cancel{\text{mg}}$$

$$x \text{ mL} = \frac{2.5 \text{ mL}}{2}$$

$$x \text{ mL} = 1.25 \text{ mL}$$

Enter the total amount, volume and period of time in the first row.
Next, choose an amount to divide each value by. In this answer, each value has been divided by 2.

Amount (units)	**Volume (mL)**	**Time Interval**
0.5	1.25	2 min
0.25	0.63	1 min
0.125	0.31	30 sec
0.0625	0.16	15 sec

From the table, 0.16 is not an easy volume to track over 15 seconds when giving a direct IV. Instead, you can round this number to 0.2 to track the volume your are giving better.

3. First, calculate the total volume of the injection.

$$x \text{ mL} = \frac{1 \text{ mL}}{5 \text{ mg}} \times 7 \text{ mg}$$

$$x \text{ mL} = \frac{1 \text{ mL}}{5 \cancel{\text{ mg}}} \times 7 \cancel{\text{ mg}}$$

$$x \text{ mL} = \frac{7 \text{ mL}}{5}$$

$$x \text{ mL} = 1.4 \text{ mL}$$

Enter the total amount, volume and period of time in the first row.
Next, choose an amount to divide each value by. In this answer, each value has been divided by 2.

Amount (units)	**Volume (mL)**	**Time Interval**
7	1.4	2 min
3.5	0.7	1 min
1.75	0.35	30 sec
0.875	0.175	15 sec

From the table, 0.175 is not an easy volume to track over 15 seconds when giving a direct IV. Instead, you can round this number to 0.2 to track the volume your are giving better.

4. First, calculate the total volume of the injection.

$$x \text{ mL} = \frac{1 \text{ mL}}{10 \text{ mg}} \times 18 \text{ mg}$$

$$x \text{ mL} = \frac{1 \text{ mL}}{10 \cancel{\text{ mg}}} \times 18 \cancel{\text{ mg}}$$

$$x \text{ mL} = \frac{18 \text{ mL}}{10}$$

$$x \text{ mL} = 1.8 \text{ mL}$$

Enter the total amount, volume and period of time in the first row.
Next, choose an amount to divide each value by. In this answer, each value has been divided by 3 to start and then divided by 2 to reach 15 second increments.

Amount (units)	**Volume (mL)**	**Time Interval**
18	1.8	3 min
3	0.6	1 min
3	0.3	30 sec
1.5	0.15	15 sec

5. First, calculate the total volume of the injection.

$$x \text{ mL} = \frac{1 \text{ mL}}{5 \text{ mg}} \times 10 \text{ mg}$$

$$x \text{ mL} = \frac{1 \text{ mL}}{5 \cancel{\text{ mg}}} \times 10 \cancel{\text{ mg}}$$

$$x \text{ mL} = \frac{10 \text{ mL}}{5}$$

$$x \text{ mL} = 2 \text{ mL}$$

Enter the total amount, volume and period of time in the first row.
Next, choose an amount to divide each value by. In this answer, each value has been divided by 2.

Amount (units)	**Volume (mL)**	**Time Interval**
10	2	2 min
5	1	1 min
2.5	0.5	30 sec
1.25	0.25	15 sec

6. First, calculate the total volume of the injection.

$$x \text{ mL} = \frac{2 \text{ mL}}{250 \text{ mg}} \times 200 \text{ mg}$$

$$x \text{ mL} = \frac{2 \text{ mL}}{250 \cancel{\text{mg}}} \times 200 \cancel{\text{mg}}$$

$$x \text{ mL} = \frac{400 \text{ mL}}{250}$$

$$x \text{ mL} = 1.6 \text{ mL}$$

Enter the total amount, volume and period of time in the first row.
Next, choose an amount to divide each value by. In this answer, each value has been divided by 2 and then divided by 3 to reach 15 second increments.

Amount (units)	**Volume (mL)**	**Time Interval**
200	1.6	1.5 min
100	0.8	45 sec
33.3	0.27	15 sec

From the table, 0.27 is not an easy volume to track over 15 seconds when giving a direct IV. Instead, you can round this number to 0.3 to track the volume your are giving better.

7. First, calculate the total volume of the injection.

$$x \text{ mL} = \frac{1 \text{ mL}}{50 \text{ mg}} \times 20 \text{ mg}$$

$$x \text{ mL} = \frac{1 \text{ mL}}{50 \cancel{\text{mg}}} \times 20 \cancel{\text{mg}}$$

$$x \text{ mL} = \frac{20 \text{ mL}}{50}$$

$$x \text{ mL} = 0.4 \text{ mL}$$

Enter the total amount, volume and period of time in the first row.
Next, choose an amount to divide each value by. In this answer, each value has been divided by 2.

Amount (units)	Volume (mL)	Time Interval
20	0.4	2 min
10	0.2	1 min
5	0.1	30 sec
2.5	0.05	15 sec

8. First, calculate the total volume of the injection.

$$x \text{ mL} = \frac{1 \text{ mL}}{10 \text{ mg}} \times 15 \text{ mg}$$

$$x \text{ mL} = \frac{1 \text{ mL}}{10 \cancel{\text{mg}}} \times 15 \cancel{\text{mg}}$$

$$x \text{ mL} = \frac{15 \text{ mL}}{10}$$

$$x \text{ mL} = 1.5 \text{ mL}$$

Enter the total amount, volume and period of time in the first row.
Next, choose an amount to divide each value by. In this answer, each value has been divided by 5 to start and then divided by 2 to reach 15 second increments.

Amount (units)	Volume (mL)	Time Interval
15	1.5	5 min
3	0.3	1 min
1.5	0.15	30 sec
0.75	0.075	15

From the table, 0.075 is not an easy volume to track over 15 seconds when giving a direct IV. Instead, you can round this number to 0.1 to track the volume your are giving better.

9. First, calculate the total volume of the injection.

$$x \text{ mL} = \frac{1 \text{ mL}}{50 \text{ mg}} \times 75 \text{ mg}$$

$$x \text{ mL} = \frac{1 \text{ mL}}{50 \cancel{\text{mg}}} \times 75 \cancel{\text{mg}}$$

$$x \text{ mL} = \frac{75 \text{ mL}}{50}$$

$$x \text{ mL} = 1.5 \text{ mL}$$

Enter the total amount, volume and period of time in the first row.
Next, choose an amount to divide each value by. In this answer, each value has been divided by 2.

Amount (units)	**Volume (mL)**	**Time Interval**
75	1.5	2 min
37.5	0.75	1 min
18.75	0.375	30 sec
9.375	0.1875	15 sec

From the table, 0.1875 is not an easy volume to track over 15 seconds when giving a direct IV. Instead, you can round this number to 0.2 to track the volume your are giving better.

10. First, calculate the dose in mg from the weight of the patient given.
$2 \text{ mcg} \times 20 \text{ kg} = 40 \text{ mcg/dose}$
Then, calculate the total volume of the injection.

$$x \text{ mL} = \frac{1 \text{ mL}}{100 \text{ mcg}} \times 40 \text{ mcg}$$

$$x \text{ mL} = \frac{1 \text{ mL}}{100 \cancel{\text{mcg}}} \times 40 \cancel{\text{mcg}}$$

$$x \text{ mL} = \frac{40 \text{ mL}}{100}$$

$$x \text{ mL} = 0.4 \text{ mL}$$

Enter the total amount, volume and period of time in the first row.
Next, choose an amount to divide each value by. In this answer, each value has been divided by 2.

Amount (mcg)	**Volume (mL)**	**Time Interval**
40	0.4	2 min
20	0.2	1 min
10	0.1	30 sec
5	0.05	15 sec

IV

Understanding Statistics

This section is designed for students who have not taken any courses in statistics. In the following three chapters, you will be introduced to the field of statistics and how it may be used in nursing. You will learn why a variety of statistical measures are used and how to define them. Developing a basic understanding of these measures early on in your nursing program will help you when reading literature and reports which include statistics.

18.

Introduction to Statistics

Lesson

Learning Outcomes

By the end of this chapter, learners will be able to:

- describe how statistics can inform nursing practice,
- differentiate between descriptive and inferential statistics,
- define population and sample, and
- appreciate factors which contribute to data quality.

Statistics In Nursing

There are vast amounts of information available about health and health care. How do we make sense of it? The field of statistics is one tool we can use to help us in collecting, displaying, analyzing and interpreting this information. The use of statistics can be applied to the work of nurses in a variety of ways, in work related to all fields of nursing, such as clinical practice, education, research and management. In all of these areas of nursing, effective use of statistics can support clinical decision making.

It's likely you have encountered statistics already in your life, but have you understood the meaning of the statistics you were presented with? Would you be able to identify if the way statistics were presented was misleading? The aim of this section of this workbook is to help you begin to understand what statistics represent when you encounter them in your studies. You will be introduced to some basic terms and you will be presented with examples to help you learn about them. As you progress through your nursing program, you may take a course in statistics to learn how to calculate statistics from data sets or learn about more complex statistical methods. Regardless of how you learn about statistics in your program, it is important to build an understand of what statistics represent, in order to use information available to you in an effective manner.

Branches of Statistics

There are two main branches of statistics, **descriptive statistics** and **inferential statistics**. Descriptive statistics helps us describe data and can be used to summarize it. This helps turn data sets into useful information which can then inform our nursing work. Inferential statistics helps us to interpret this data by analyzing for relationships between variables. It can help us test hypotheses, make conclusions and make decisions in uncertain situations. In Table 18.1: Ways to Use Descriptive and Inferential Statistics, an example is given to illustrate how these branches work in real life situations.

Table 18.1 Ways to Use Descriptive and Inferential Statistics

Branch of Statistics	Example of Use
Descriptive Statistics	To describe the number of primary care physicians and nurse practitioners in each town or city in British Columbia. This could be done by counting the number of primary care physicians and nurse practitioners in each town or city and displaying the numbers for each town or city in a graph.
Inferential Statistics	To predict if people without a primary care provider were more likely to be hospitalized after visiting the emergency room.

Sample Exercise 18.1

Identify if the following situation uses descriptive or inferential statistics:

A nurse manager shows a graph of the types of patient safety events at the monthly staff meeting.

Answer:
Descriptive. The activity involves summarizing data.

Importance of Data Quality

When data is used to make decisions and inform our practice, we need to have data that is accurate, complete, clearly defined and applicable in order to make the best decisions. Poor quality of data can lead to a host of problems, such as errors, inappropriate choices or unsafe nursing care. Learning about research methods and data collection can be helpful in understanding how to assess the quality of data and how to take measures to ensure the data we are collecting and using is of good quality. For the purpose of this section, we will look at one aspect of data applicability and how statistics can help us determine if data is applicable.

Researchers often seek to gather data related to a particular topic when engaged in a research study. When studies are conducted about the health of people, often a particular group of people are being studied, versus the all of the people in the world for whom the study would apply to. This is because it is not feasible to study all the members of a large population. All the people who meet the group criteria are referred to as the population and the small group of people is called a sample. When the participants who make up the sample are chosen, they must share a similar distribution of characteristics to the whole population, otherwise inferences about the study results may not apply to the population.

To give an example, you could consider a study about the effectiveness of a nursing intervention, such as nurse led mindfulness activities to reduce anxiety before insertion of an intrauterine device (IUD) in people with a uterus. The research team would need to identify all the characteristics of the population which might effect their experience of anxiety and how well a mindfulness activity might work. For instance, things which might impact the effectiveness of a mindfulness activity could include factors such as the level of anxiety the person is experiencing, if they have had a traumatic experience with a previous IUD insertion, and if they have previous experience practicing mindfulness activities. In the study sample, if the participants were only reporting an experience of mild anxiety the results of the study would not be applicable to the whole population, as we can assume some people will report an experience of moderate or severe anxiety before insertion. Researchers must be transparent about the process used to select the participants in the sample and if they are aware of any differences in characteristics between the sample and the population. At times, it may not be possible to create a sample which is representative of the general population and so researchers may define the population very specifically so users of the information are aware of which people the results might be applicable to. For example, a study might consider the effectiveness of nurse led mindfulness activities to reduce mild to moderate anxiety before insertion of an IUD in people 18 and over.

The use of statistics can help us choose a sample that is representative of the population and determine how applicable the results of the study will be to the population.

Critical Thinking Question

You are working with a person admitted to the medical floor with an exacerbation of chronic back pain. They report their pain is not managed well at home, and so you decide to review the types of interventions which can be used to reduce back pain. If you were reading a research report about the effectiveness of daily stretching to reduce chronic back pain, how would you know if you can apply the conclusions of this study to this person's situation?

Answer:
You would need to determine the following:

1. If the research methods of this study were appropriate and led the researchers to sound conclusions, which would require you to work through a critique of the study methods (noting here that you may not have learned about the process to critique a study at this point in your nursing program).
2. If the characteristics of the person you were working with were represented in the study participants. For instance, you would consider what the contributing factors to the experience of back pain were in this person. If they had a diagnosis of bone cancer with lesions in their spine, you would want to consider if this study included participants who also had a diagnosis of bone cancer. If no people with bone cancer were studied,

you would need to make an assumption about the applicability of the findings to your client.

Key Takeaways

- Statistics is a tool to help make meaning of information.
- The two branches of statistics are descriptive statistics and inferential statistics.
- Descriptive statistics is used to describe or summarize data.
- Inferential statistics is used to interpret and analyze data.

Practice Set 18.1: Differentiating Between Descriptive and Inferential Statistics

Practice Set 18.1: Differentiating between descriptive and inferential statistics

Identify if the following situation uses descriptive or inferential statistics:

1. Nursing researchers present the birth weights of full term infants, born from mothers who spent their first trimester in an area experiencing ongoing wildfires, in a graph.
2. A nurse manager uses historical hospital data to predict the number of people who will need hip surgery related to osteoporosis in the upcoming year.
3. A research article lists the number of people who developed testicular cancer, by age.
4. A pharmacist recommends a particular brand of antihypertensive medication to be purchased, for use in hospital, after reviewing a study on adverse effects of beta blockers used in Canada.
5. A student nurse decides on which nursing school to apply to after reviewing data from public student satisfaction surveys.

Answers:

1. Descriptive. Results are summarized.
2. Inferential. The nurse manager is comparing two variables, people who have hip surgery and have a diagnosis of osteoporosis, in order to make a prediction.

3. Descriptive. Results are summarized.
4. Inferential. The pharmacist is comparing variables, the type of beta blocker and the adverse effects experienced by users, in order to make a conclusion about which one to purchase.
5. Inferential. The student nurse is comparing variables, nursing schools and students satisfaction.

19.

Descriptive Statistics

Lesson

Learning Outcomes

By the end of this chapter, learners will be able to:

- differentiate between types of data,
- define mode, median and mean,
- describe range, standard deviation, and a 5 number summary, and
- explain how histograms, density curves, stemplots, and boxplots are used.

Introduction to Descriptive Statistics

As described in the previous chapter, Introduction to Statistics, descriptive statistics is the branch of statistics which helps to describe and summarize data. You might use descriptive statistics in situations such as presenting information from a patient satisfaction survey at a staff meeting or summarizing the reasons that people visit different health care providers in a town, such as a primary health care center, walk in clinic, traditional Chinese medicine clinic, and emergency room.

The first section of this chapter describes various types of data. Being able to differentiate between types of data is helpful when you are using statistics because different statistical methods are used to describe and analyze different types of data.

The second section of this chapter explains ways to describe the middle, or commonly occurring values in a data set. These are categorized as measurements of center and specific measurements explained include **mode**, **median**, and **mean**.

The third section of this chapter explains ways to describe the amount of variation between values in a data set. Examples of measurements of variation described in this text are **range**, **standard deviation**, and a **5 number summary**.

The last section of this chapter describes some common ways in which health care data is displayed with images. The types of images and graphs described are **histograms**, **density curves**, **stemplots**, and **boxplots**.

There are several terms which may be helpful for you to review before continuing in this chapter. Refer to Table 19.1: Examples of Basic Terms for Statistics to learn about the terms **individual**, **variable**, range, **outlier**, **parameter**, and **statistic**.

Table 19.1 Examples of Basic Terms for Statistics

Term	Description	Examples
Individual	The thing being studied, not necessarily a person	Community acquired pneumonia
Variable	A characteristic of the "individual"	Temperature
Range	The difference between the lowest and highest values	3.5 (if highest temp 40°C and lowest 36.5°C)
Outlier	A value which is widely outside of the range of values	34.2°C
Parameter	A number describing a particular characteristic of a population	The median age of all of the people living in Canada
Statistic	A number describing a particular characteristic of a sample of a population	The average call time of a random sample of people phoning the Talk Suicide Canada crisis line.

Types of Data

When data is measured and recorded, it can be described with numbers or words. The types of data are referred to as numerical (with numbers) or categorical (with words). You will likely come across alternate terms like variable (for data), quantitative (for numerical) and qualitative (for categorical) as you begin to use research data to inform your nursing practice. Refer to Chart 19.1: Data Types for a summary of types of data.

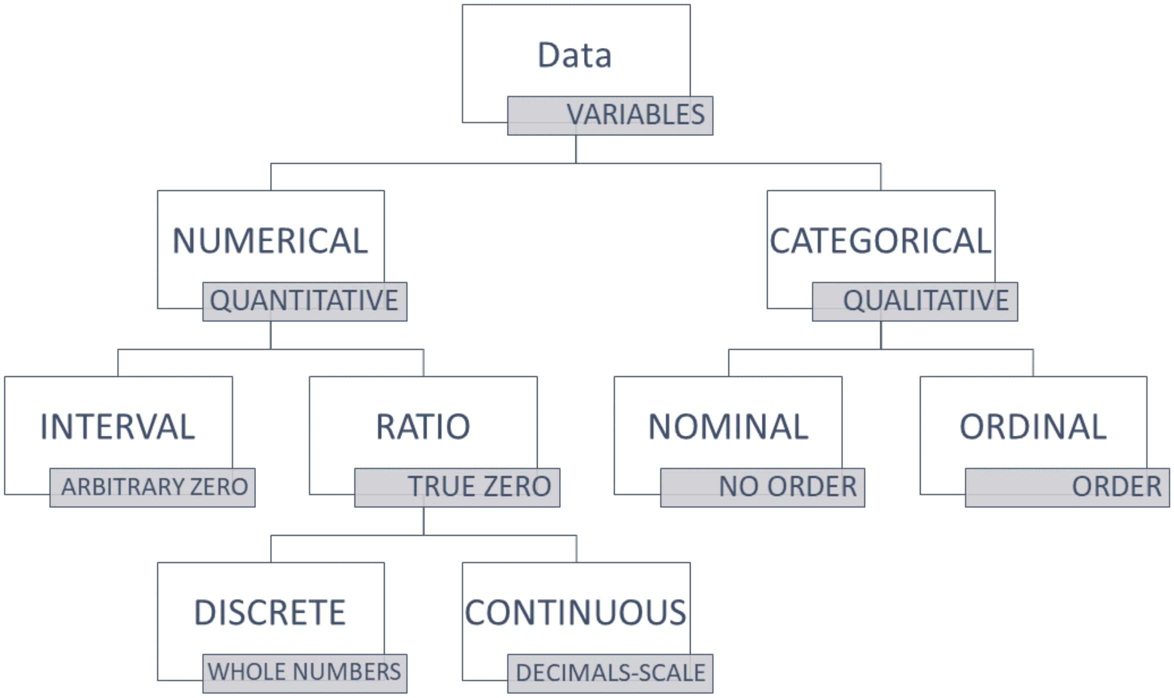


Chart 19.1 Data Types [Data Types chart image description]

Numerical Data

Numerical data, which is data that has a numerical value, is subdivided into two types, ratio and interval measurements.

a. **Ratio Measurements** are used for counting items, starting with the number 0. The number zero refers to an absence of the thing being measured in ratio measurements. There will never be any negative numbers because you cannot count negative items. For instance, it is possible for you can have 0, 1, or 2 alcohol swabs in your pocket, but you could not have -1. When ratio measurements are used, they are measured on a numerical scale where there is the same amount of difference between the levels on the scale. For instance, think of a ruler which measures centimeters. There is exactly one centimeter between each number marking on the ruler.
   There are two ways ratio measurements are recorded, and these are by **discrete** and **continuous** types of data. Discrete data counts numbers of things, and is represented by whole numbers. For instance, the number of people accessing a particular clinic for sexual and reproductive health. There are no portions of people entering the clinic! Continuous data relates to data with values on a scale measuring a numerical value, and can be represented by numbers with decimals. For instance, the birthweight of infants born in Saskatchewan or the length of various catheter sizes.

b. **Interval Measurements** are measured with scales created by people to compare amounts. The space between each unit on the scale is equal. This probably sounds a lot like ratio measurements, but with interval scales the number zero does not mean there is nothing to measure. Therefore, this is why we say interval scales do not have an absolute zero. The measurement of temperature is a very popular example to describe an interval scale because it is a scale that most people are familiar with. The scale is based on the temperature which water freezes at. A measurement of 0 degrees does not mean there is no temperature, it is the temperature water freezes at and it is cold. We can compare it to a negative temperature, which is a temperature below the freezing point of water, or a positive temperature, which is warmer. We can also calculate the difference between temperatures because the space between each degree on the scale is equal. For instance, if we are measuring the temperature of a child before and after we give them acetaminophen, we might note that their temperature dropped 2.5 degrees if their temperature was measured at 39.5 degrees prior to the acetaminophen and 37 degrees one hour after administration. Refer to Table 19.2: Examples of Categorical Data to compare these classifications of data.

Clear as mud? Another way to check if something is an interval measurement is to consider the way you would compare values you are measuring. If using a ratio doesn't make sense, but noting the difference (by using subtraction) does, then the measurements are from an interval scale. Refer to the example below.

What if I'm not sure if the zero is arbitrary?

If using a ratio to compare values does not make sense, but using the difference does, the measurements are from an interval scale. See the following example to learn how this works.

Nursing instructor B.D. graduated nursing school in 1994.
Nursing instructor C.R. graduated nursing school in 2002.

First, try to calculate a ratio from the values.

$$\frac{2002}{1994} = 1.004 \text{ or } \frac{1994}{2002} = 0.996$$

These numbers do not have any meaning when relating the values of years to each other.

Next, try to calculate the difference.

$$2002 - 1994 = 8$$

This gives a meaningful answer. CR and BD graduated 8 years apart. It describes something specific about the relationship between the values.

Therefore, the measurement of years is on an interval scale.

19.2 Examples of Numerical Data

Data Type	Examples
Ratio: Discrete	• Number of people accessing health clinic each day • The number of IVs started each day on a medical ward • The number of people who have received a vaccine for shingles
Ratio: Continuous	• Birthweights of infants in Saskatchewan • Length of a surgical incision • Milliliters of blood in one unit of blood for transfusion
Interval	• The time lunch is delivered on different wards of a hospital • The temperature of a medication fridge • The year each of your classmates were born

Categorical Data

Categorical data is subdivided into **nominal** and **ordinal** types of data. Nominal data refers to categories of data which are distinct from one another. Meaning, they do not have a particular order or sequence between them. An example of nominal data is the name of brands of stethoscopes used by nursing students. Nominal data might just have two categories, like yes/no, positive/negative, vaccinated/unvaccinated. Ordinal data refers to categories of data which do have a particular order or relationship between them. An example of ordinal data could be the types of nurses working in an acute care medical floor at a rural hospital, using the categories from Patricia Benner's From Novice to Expert Theory: novice, advanced beginner, competent, proficient, expert. These categories are ordinal as they have a particular ranking in relation to each other. Ordinal data also refers to categories that organize a state into levels, like stages of pressure ulcers (I, II, III, IV). Although you can read a number in the stage, it doesn't refer to a numerical value. It does help someone conceptualize that stages progress in levels of severity, so there is a ranking between the stages. Refer to Table 19.3: Examples of Categorical data to compare nominal and ordinal data types.

Table 19.3 Examples of Categorical Data

Data Type	Examples
Nominal	• Brands of stethoscopes used by nursing students • The city a person was born in • Exposure to chicken pox as a child
Ordinal	• Types of Nurses: novice, advanced beginner, competent, proficient, expert • Pressure Ulcer stages: I, II, III, IV • Lower class, middle class, upper class

Measurements of Center

Measurements of center tell us about the middle, or commonly occurring values, of a data set. It is sometimes helpful to understand measures of center when using information in your nursing work. In a very simple example, one could use knowledge of the average size of brief worn by adults in order to stock a personal care cart with the briefs which are used most often. Now, this does not mean that on any given day a nurse would actually use this size most often, but it would be helpful in creating a standard stock list for the cart with the expectation nurses would add to the cart if the situation on the ward on a given day required more briefs of a rarely used size.

There are several ways to describe the center of data, and they are each calculated in a specific way. The measures described in this text are mode, median, and mean. Which measure to use depends on the type of data being measured and what and how the data is used for.

These measures will be described in detail in the following three sections and are summarized in Table 19.4: Definitions of Mode, Median and Mean. An example using the same fictional data set is used to portray the differences between these measures in each of the sections.

Table 19.4 Definitions of Mode, Median and Mean

Statistic	**Measurement of Data Set**
Mode	Value occurring most often
Median	Value in the physical middle
Mean	Average of all values

Mode

The mode is the statistic which describes the value that occurs most often in a data set. In a small data set, one can simply count the value occurring most often. In a large data set, it can be helpful to use spreadsheets and graphs to sort and count values to find the mode.

Determining the Mode

To find the mode, count the number of times each specific value in a data set occurs. The one which occurs most often is the mode.

Sample Data Set: Ages of Nursing Students in a First Year Nursing Class
19, 20, 20, 21, 21, 22, 22, 23, 23, 23, **24, 24, 24, 24**, 25, 25, 26, 26, 27, 28, 28, 29, 29, 30, 32, 32, 34, 35, 36, 38, 40, 42

The mode is 24, it occurs most often in this data set. No other value occurs 4 or more times.

Sample Exercise 19.1

Determine the mode of the following data set.

Sample Data Set: Number of Siblings of Nursing Students in a Particular Cohort
0 0 0 0 0 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 2 2 3 3 3 3 3 4 5 8

Answer:
The mode is 2. The value 2 occurs more times than any other value in this data set.

Median

The median is the middle point in a data set, once the values have been listed in numerical order. If there are an odd number of values in the data set, the value of the median is exactly the same as the number in the physical middle of the data set. If there are an even number of values, the middle is considered to be the value that would fall between the two numbers in the middle. The examples following illustrate the difference in physical location of the median in data sets with odd and even numbers of values.

Odd Number of Values

$$\begin{array}{ccccc} & & \text{median} & & \\ & & \downarrow & & \\ 2 & 6 & 8 & 10 & 15 \end{array}$$

Even Number of Values

$$\begin{array}{ccccc} & & \text{median} & & \\ & & \downarrow & & \\ 2 & 6 & & 8 & 15 \\ & & =7 & & \end{array}$$

It is easy to identify where the middle is in the examples above because the middle point is visually easy to identify. In larger data sets, a formula can be used to identify the location of the middle.

$$\frac{n+1}{2} = \text{location of median}$$

For a data set with an odd number of values the formula gives the location of where the value would be in a numbered list of values. In the example above, the median is the third number in the list and so the formula for finding the median in this set gives the number 3. You can see that the location, 3, and the median, 8, are different numbers. This can be confusing for some people. The formula just gives the location, or place of the number, in the list of values. Once the formula gives the location, you need to figure out which value is at that particular place in the list. The process for using the formula is summarized in the box below.

Determining the Median of a Data Set with an Odd Number of Values

Sample Data Set: 2 6 8 10 15

First, find out the location of the middle of the data set.

$$\begin{aligned} \text{location of median} &= \frac{n+1}{2} \\ &= \frac{5+1}{2} \\ &= 3 \end{aligned}$$

Next, identify the third value in the list of values from the data set.

$$\begin{array}{ccccc} 1 & 2 & 3 & & \\ & & \downarrow & & \\ 2 & 6 & 8 & 10 & 15 \end{array}$$

8 is the median of this data set. It is the value in the physical center of the data set.

In a data set with an even number of values the formula will give a number with a decimal place of 0.5 because the location is always between two numbers. The actual value of the median is found by calculating the average of these two numbers. The formula below can be used to calculate the average of two values. The variable a and the variable b refer to the values of the numbers of either side of the middle point in the data set.

$$\frac{a+b}{2} = \text{value of median}$$

Determining the Median of a Data Set with an Even Number of Values

First, find out the location of the middle of the data set.

$$\begin{aligned} \text{location of median} &= \frac{n+1}{2} \\ &= \frac{32+1}{2} \\ &= 16.5 \end{aligned}$$

In this case, there is an even number of values in the data set so the median will fall between two values. The median value will between the 16th and 17th values of the ordered data set. Remember that the data must be in numerical order, otherwise the values will not relate to the middle values of the data set.

Next, count to find the 16th and 17th value. In this sample set, the 16th and 17th values are 25 and 26.

Sample Data Set: Ages of Nursing Students in a First Year Nursing Class
19, 20, 20, 21, 21, 22, 22, 23, 23, 23, 24, 24, 24, 24, 25, **25,**
26, 26, 27, 28, 28, 29, 29, 30, 32, 32, 34, 35, 36, 38, 40, 42

Now you can find the mean of these two values.

$$\text{value of median} = \frac{a+b}{2}$$

$$= \frac{25+26}{2}$$

$$= 25.5$$

25.5 is the median of this data set. It is the number that relates to the exact center of this data set.

Sample Exercise 19.2

Find the median of the sample data set.

Sample Data Set: Number of Siblings of Nursing Students in a Particular Cohort
0 0 0 0 0 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 2 2 3 3 3 3 4 5 8

Answer:
2 is the median of this data set. It is the value in the physical center of the data set.

$$\text{location of median} = \frac{n+1}{2}$$

$$= \frac{31+1}{2}$$

$$= 16$$

Now count to the sixteenth value in the list of values from the data set.

0 0 0 0 0 1 1 1 1 1 1 1 1 2 2 **2** 2 2 2 2 2 2 2 2 2 3 3 3 3 4 5 8

Mean

The mean is the average of all of the values in a data set. To calculate the average, add up all of the values in the data set and divide by the total number of values. For small data sets a calculator can easily be used. For large data sets it is easy to make mistakes with a calculator so it is common to record all of the values in a spreadsheet and use a function of the software to complete this task. The following formula is used to calculate the mean.

$$\text{mean} = \frac{\sum(x_1 + x_2 + \ldots + x_x)}{n}$$

Formula Symbol Legend

x refers to a number in the data set, and the use of different subscript numbers means that each variation of x is referring to an individual value in the data set.

… refers to the variables continuing in the same pattern shown by the variables to the left of the …

n refers to the total number of values in the data set.

$\sum$ is the symbol (the Greek uppercase letter sigma) that means to take a sum (or add) everything in a specified sequence. In this formula, it shows the sequence inside the brackets. The pattern of variables indicates to keep adding each different number, all the way to the last, identified as x_x.

Determining the Mean

Sample Data Set: Ages of Nursing Students in a First Year Nursing Class

19, 20, 20, 21, 21, 22, 22, 23, 23, 23, 24, 24, 24, 24, 25, 25, 26, 26, 27, 28, 28, 29, 29, 30, 32, 32, 34, 35, 36, 38, 40, 42

$$\text{mean} = \frac{\sum(x_1 + x_2 + \ldots + x_x)}{n}$$

First, add up all of the values in the data set. Then divide this value by the number of values in the data set.

$$\text{mean} = \frac{843}{32}$$

$$= 26.3$$

Sample Exercise 19.3

Find the mean of the sample data set.

Sample Data Set: Number of Siblings of Nursing Students in a Particular Cohort
0 0 0 0 0 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 2 2 3 3 3 3 4 5 8

Answer:

$$\text{mean} = \frac{\sum(x_1 + x_2 + \ldots + x_x)}{n}$$

$$= \frac{59}{31}$$

$$= 1.9$$

Critical Thinking Questions

1. How do you decide what measures of center to use to describe data?
2. Are there situations when one measure is better than another?

Data Variability

Another approach to describe values in a data set is to give information about how different the values are from each other. For instance, are all the values very close to the same, or are they all very different from each other? Picture a researcher conducting a study about the effectiveness of a new medication on blood glucose levels. One value being measured might be the blood glucose level of a person after taking the medication. It would be important to know if the response to the medication gave a change in values of blood glucose which were similar between different people in the study, or if the values were very different.

In the following subsections, three ways to describe variability in data will be explained: range, standard deviation and a 5 number summary.

Range

The range of a data set refers to the difference between the minimum and maximum values. This can also be referred to as the spread.

$$\text{range} = \text{maximum value} - \text{minimum value}$$

Thus, the range is found when you subtract the minimum value from the maximum value.

Determining the Range

Sample Data Set: Ages of Nursing Students in a First Year Nursing Class
19, 20, 20, 21, 21, 22, 22, 23, 23, 23, 24, 24, 24, 24, 25, 25,
26, 26, 27, 28, 28, 29, 29, 30, 32, 32, 34, 35, 36, 38, 40, 42

Identify the maximum and minimum values in the data set.

42 and 19

$$\begin{aligned}\text{range} &= \text{maximum value} - \text{minimum value}\\ &= 42 - 19\\ &= 23\end{aligned}$$

The range is 23 years. This means there are 23 years between the youngest and oldest students in this particular class.

Sample Exercise 19.4

Find the range of the sample data set.

Sample Data Set: Number of Siblings of Nursing Students in a Particular Cohort
0 0 0 0 0 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 2 3 3 3 3 4 5 8

Answer:

$$\begin{aligned}\text{range} &= \text{maximum value} - \text{minimum value}\\ &= 8 - 0\\ &= 8\end{aligned}$$

Standard Deviation

Defining Standard Deviation

The standard deviation provides a measure of the overall variation in a data set as it measures how far individual values are from their mean. In some data sets, the values are more widely spread out from the mean.

The standard deviation is always positive or zero. The standard deviation is small when the individual values are all concentrated close to the mean, exhibiting little variation or spread. The standard deviation is larger when individual values are more spread out from the mean, exhibiting more variation.

A value that is two standard deviations from the average is just on the borderline for what many statisticians would consider to be far from the average. Considering data to be far from the mean if it is more than two standard deviations away is more of an approximate “rule of thumb” than a rigid rule. In general, the shape of the distribution of the data affects how much of the data is further away than two standard deviations. (You will learn more about this in later sections).

Suppose that we are studying the amount of time patients wait in line for vaccinations at a public health clinic. The average wait time is calculated to be five minutes and the standard deviation for the wait time is two minutes. We can use the standard deviation to determine whether a particular value is close to or far from the mean.

Suppose that Daniella and Harjit both visit the public health clinic. Daniella waits to see the nurse for seven minutes and Harjit waits for one minute. We know the standard deviation was calculated to be two minutes and the average wait time is five minutes. What does this tell us about the wait times of Daniella and Harjit?

Daniella waits for seven minutes:

Daniella’s wait time of seven minutes is **two minutes longer than the average of five minutes.**
Two minutes is equal to one standard deviation.
Daniella’s wait time of seven minutes is **one standard deviation above the average** of five minutes.

Harjit waits for one minute:

Harjit’s wait time of one minute is **four minutes less than the average of five minutes**.
Four minutes is equal to two standard deviations.
Harjit’s wait time of one minute is **two standard deviations below the average** of five minutes.

Knowing that Harjit’s wait time is two standard deviations below the mean and Daniella’s in one standard deviation above tells us Harjit’s wait time was further from the average. Now, with this simple example, it is possible you would have been able to look at the numbers given and come to the same conclusion without knowing anything about standard deviation. Statistics like standard deviation become really useful when analyzing larger data sets when it is not easy to see how individual values differ from the average.

Standard deviations are also helpful in comparing data from similar studies. For instance, we could

repeat the study at a different public health clinic and determine the average wait time and standard deviation at this alternate clinic. If the average wait time at this clinic was also five minutes, but the standard deviation was 2.75, what does this tell you about the wait times at this clinic?
Answer:

The standard deviation at clinic A was 2 minutes. The standard deviation at clinic B was 2.75 minutes. This tells us there is more variation from the mean at clinic B, meaning wait times fluctuate more at clinic B. It's important to note this does not tell us anything about why there is variation. This measure just describes what the variation in data is like.

Sample Exercise 19.5

You are reading the results of a study comparing two non-pharmacological nursing interventions to reduce pain. In this study, pain has been measured using a pain scale of 0-10. You can assume that the characteristics of participants in each intervention group are similar.

Intervention	**Mean Reduction of Pain**	**Standard Deviation**
Intervention A	2.5	0.75
Intervention B	2.5	2.0

1. Explain what the mean reduction of pain is referring to.
2. Based on the information provided above, which intervention has the most consistent reduction in pain?

Answers:

1. The mean reduction of pain is referring to the average pain reduction measured in units of pain (from the pain scale). The mean reduction of pain is calculated separately with data from participants receiving intervention A and intervention B.
2. Intervention A has the most consistent reduction in pain because the standard deviation is smaller than the standard deviation of Intervention B. A smaller standard deviation means that the data values are more closely centered around the average (mean) value.

Calculating the Standard Deviation

It is important to note there are two different formulas for calculating the standard deviation (SD). The formulas are chosen based on if we are looking at data from a sample or the data of a population.

When we calculate measures from population data, it means we know all of the data points for an entire population and use this information to calculate different measures. These types of numbers describing the population can also be referred to as parameters. When we know all of the data related to a population, then we can be certain our findings represent the actual values related to the population.

A sample refers to data collected from a portion of the population. If we are using data from a sample it is unlikely we will find the actual values of the population, but we might get very close, depending on how we chose the sample and how big the sample is. Therefore, a sample estimates the values of the population. In most cases in health care, we are collecting data from a sample of a population because it is too difficult to collect data from an entire population. The numbers calculated from a sample can also be referred to as statistics.

Standard Deviation of a Population (μ)

$$\sigma = \sqrt{\frac{\sum |X - \bar{\mu}|^2}{N}}$$

Formula Breakdown

N refers to the number of values in the population.

$\sum$ is the symbol (the Greek uppercase letter sigma) that means to take a sum (or add) everything in a specified pattern, as noted with the bracketed part of the formula to the right.

X refers to each value found in the population.

$\bar{\mu}$ refers to the population mean, or the average.

Standard Deviation of a Sample (s)

$$s = \sqrt{\frac{\sum |X - \bar{x}|^2}{n - 1}}$$

Formula Breakdown Here

$\sum$ is the symbol (the Greek uppercase letter sigma) that means to take a sum (or add) everything in a specified pattern, as noted with the bracketed part of the formula to the right.

X refers to each value of the sample.

$\bar{x}$ refers to the sample mean, or the average.

Standard Deviation Calculator by Calculator Soup

Click here for further detail about this formula.

If x is a number, then the difference “x – mean” is called its deviation. In a data set, there are as many deviations as there are items in the data set. The deviations are used to calculate the standard deviation. You can think of the standard deviation as a special average of the deviations.

To calculate the standard deviation, we need to calculate the variance in deviations first. The variance is calculated by taking the average of the squares of the deviations related to each value in the data set.

If the numbers come from a census of the entire population and not a sample, when we calculate the average of the squared deviations to find the variance, we divide by N, the number of items in the population. If the data are from a sample rather than a population, when we calculate the average of the squared deviations, we divide by n – 1, one less than the number of items in the sample.

5 Number Summary

Distribution may be described in text as a summary of five statistics: the minimum value, first quartile (Q1), median value, third quartile (Q3), and maximum value. These numbers separate the values of a data set into quarters. This summary is often presented in a graphic called a **boxplot.**

You should already be familiar with the minimum, median and maximum values. Refer back to the glossary if you need a refresher on these terms. You can also think about the median as the point where 50% of the values are above and below the median.

The first quartile is the number whereby 25 % of values are below Q1, and 75 % are above. The formulas to find the locations of Q1 and Q3 are very similar to the formulas for determining the median. Sometimes, you might see the median labelled as Q2. Here is the formula to find the location of Q1:

$$\text{location of Q1} = \frac{1}{4} \times (n + 1)$$

If the number calculated is a decimal number, you will need to take the mean of the actual values to the right and the left of this number to determine the value of Q1.

The third quartile is the number whereby 25 % of the values are above Q3 and 75% are below. Here is the formula to find the location of Q3:

$$\text{location of Q3} = \frac{3}{4} \times (n + 1)$$

If the number calculated is a decimal number, you will need to take the mean of the actual values to the right and the left of this number to determine the value of Q3.

Can you see the pattern in the formulas for the 1st quartile, the median, and the third quartile?

Determining the 1st and 3rd Quartiles of the 5 Number Summary

Sample Data Set: Ages of Nursing Students in a First Year Nursing Class
19, 20, 20, 21, 21, 22, 22, 23, 23, 23, 24, 24, 24, 24, 25, 25, 26, 26, 27, 28, 28, 29, 29, 30, 32, 32, 34, 35, 36, 38, 40, 42

Minimum = 19
Median = 25.5 (as calculated in the example **here**)
Maximum= 42

Use the formula to find the location of Q1.

$$\text{location of Q1} = \frac{1}{4} \times (n+1)$$

$$= \frac{32+1}{4}$$

$$= 8.25$$

Now we have found the location, between the 8th and 9th value, we can determine the mean of these values. Since the 8th and 9th values are both 23, the mean will be the same as these values, 23.

The first quartile is 23.

Use the formula to find the location of Q3.

$$\text{location of Q3} = \frac{3}{4} \times (n+1)$$

$$= \frac{3}{4} \times (32+1)$$

$$= \frac{3}{4} \times 33$$

$$= \frac{99}{4}$$

$$= 24.75$$

Identify the values on either side of the location of this median and calculate the mean. In this example, the values are 30 and 32.

$$\text{value of median} = \frac{a+b}{2}$$

$$= \frac{30+32}{2}$$

$$= 31$$

The third quartile is 31.

Now you have determined all of the individual numbers in the 5 Number Summary, write them all in a list, separated with commas.

Five Number Summary: 19, 23, 25.5, 31, 42

Describing Data with Imagery

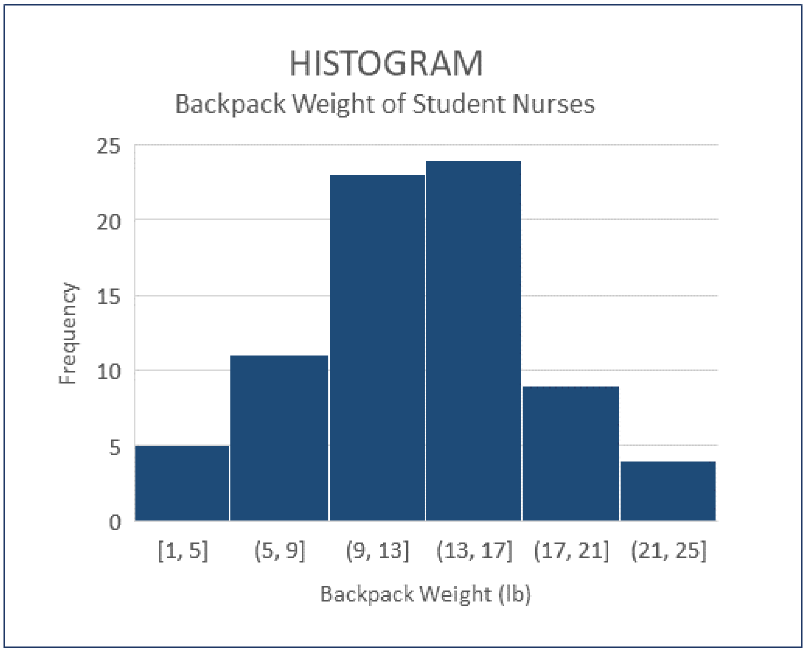
There are a variety of ways large data sets can be summarized in tables, graphs, and charts in order to make the data easy to understand quickly. How graphs and tables are presented can make a significant difference in how easy it is to understand what is being presented. A graph that is labelled well with an appropriate scale make it easier to understand what is being presented. Likewise, a table with too many rows and columns can make it hard to see relationships in the data. When using graphs and tables in your own work, consider what the purpose for displaying the information is and then check to see if the table or graph you created helps others appreciate the purpose of the image. Following are some examples of graphs you might be unfamiliar with.

Graphs for Describing Numerical Information

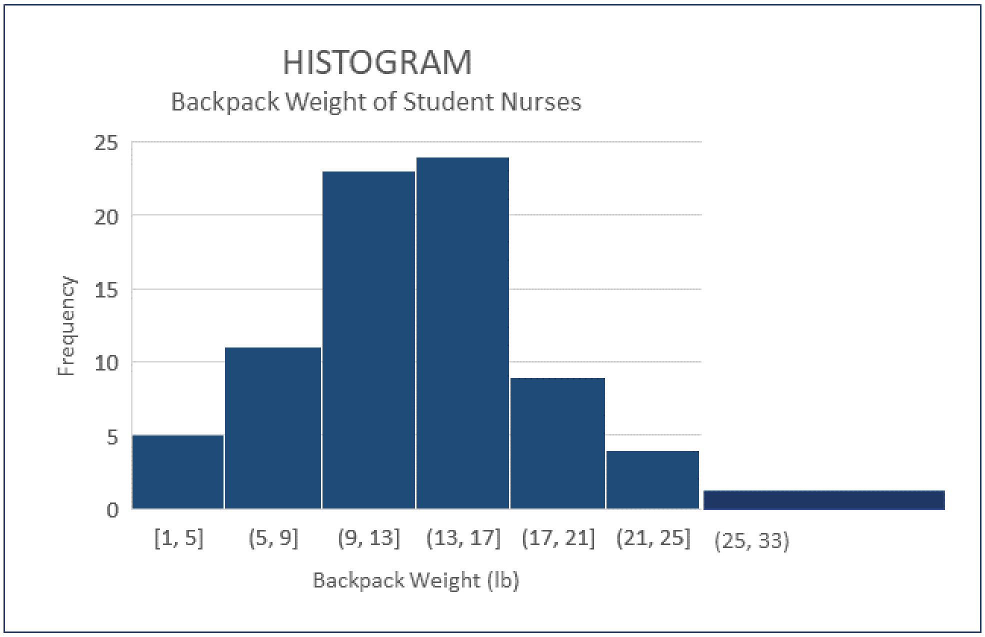
Histogram

A histogram is very similar to a column chart, but is used for presentation of continuous data. A histogram uses a numerical range for each column of the graph. The bars touch together, versus being separate, which indicates the numerical amount can include any numerical value up to, but not including, the beginning value of the column to the right. To plot the data on a histogram, the researcher needs to decide what the range will be for each column. Most of the time, you will want the range to be large enough so the number of columns is not too high and so it clearly gives a visual representation of the information being collected. If you are using software to create a histogram, the width of the column is referred to as bin size.

Look at the image of the sample histogram below. It summarizes the results of a fictitious survey which asked nursing students at a particular college how much their backpack weighed on the day of the survey. In this graph, the numbers on the x axis (horizontal) are associated with the weight of backpacks, in pounds. The y axis (vertical) represents the number of students nurses who had backpacks with a weight in a specific range. Therefore, in the first column the possible values of backpack weight include any backpacks weighing 1.0 lb up to, but not including, 5 lb and there were 5 students with backpacks weighing that much. Overall, this graph tells us about the frequency of particular findings. It is easily seen most of the backpacks weighed between 9-17 pounds.

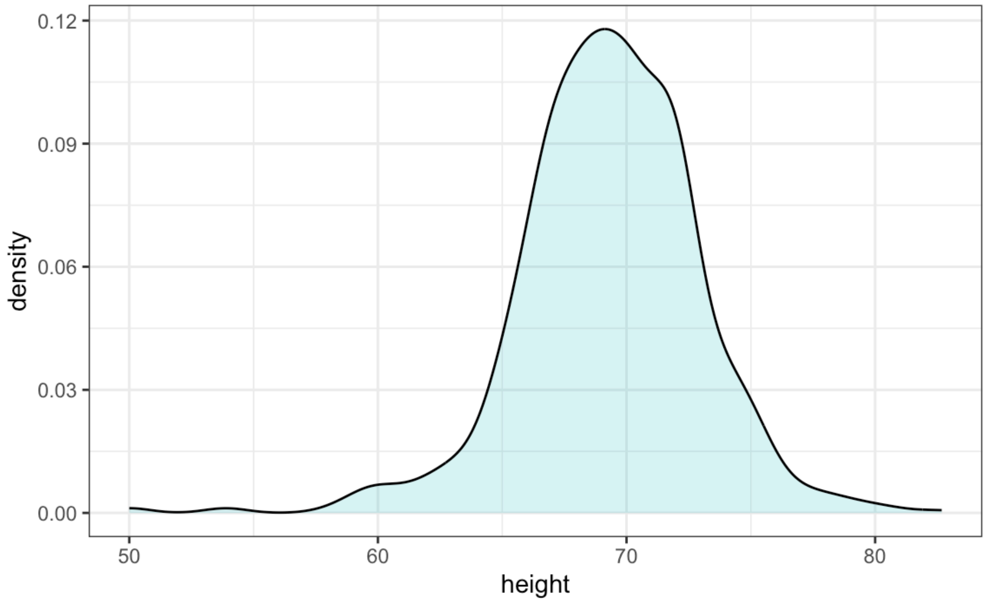


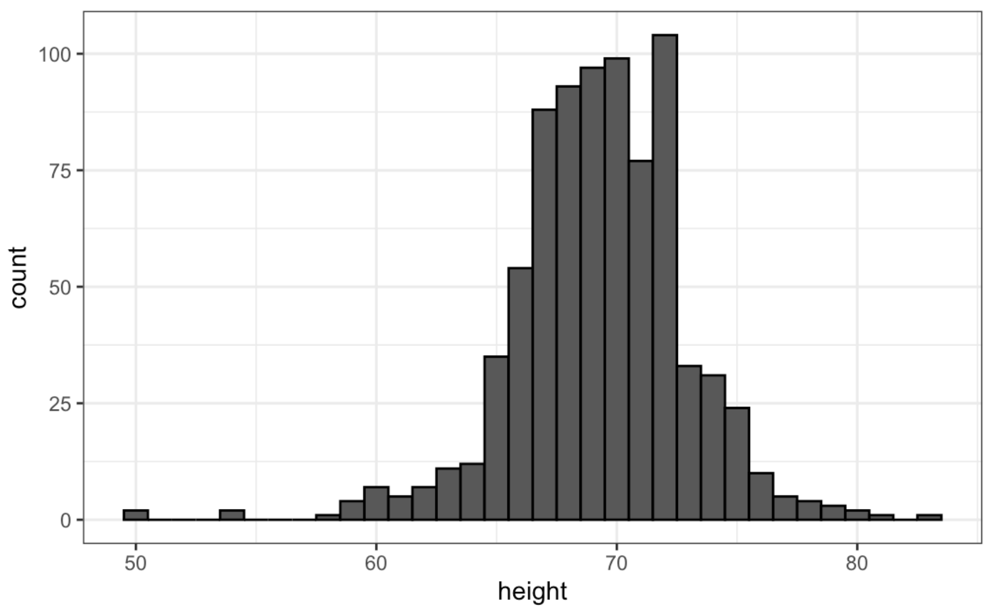
You may come across some slight variations in formatting of histograms. For instance, it is possible to create a histogram with unequal ranges on columns, which can be helpful when there are few occurrences over a large spread of values. The image below shows a wide column with a larger range. When you are interpreting the data in a histogram with unequal ranges, you need to be aware that the vertical height will not equal the actual frequency of the occurrences in unequal columns. The frequency is actually based on the area of the column, the column height times the width. When all of the columns are equal, you can infer the frequency directly from the graph, but not when they are unequal. Since it is a bit of a tricky concept to understand how to interpret the frequency in columns with varying widths you will not see graphs of this type very often.



Density Curves

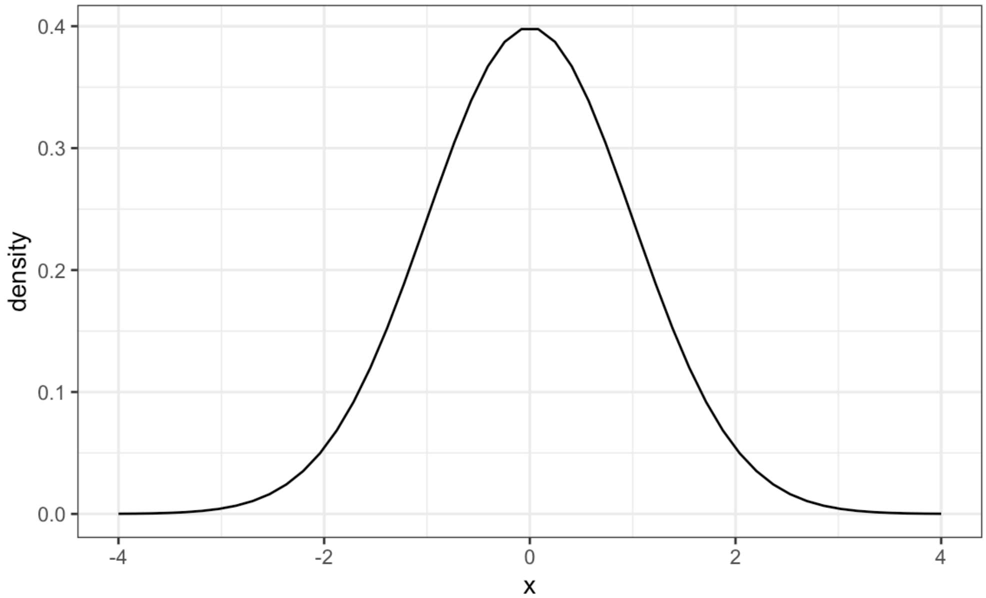
While a histogram plots the actual frequency of values occurring in a data set, a density curve plots the estimation of the distribution of values occurring in a larger sample. Sometimes they are referred to as smooth density curves, as it is like the individual column heights of a corresponding histogram have been smoothed out as the line of the graph follows the tops of the histogram columns. It is important to note the y axis is no longer representing an actual count of a particular value. It is now labelled as density. Below are two graphs created from the same sample data set related to height. You can see how the overall shapes are similar in each of the graphs. These graphs can vary in shape, depending on how the data values of a particular sample are distributed.



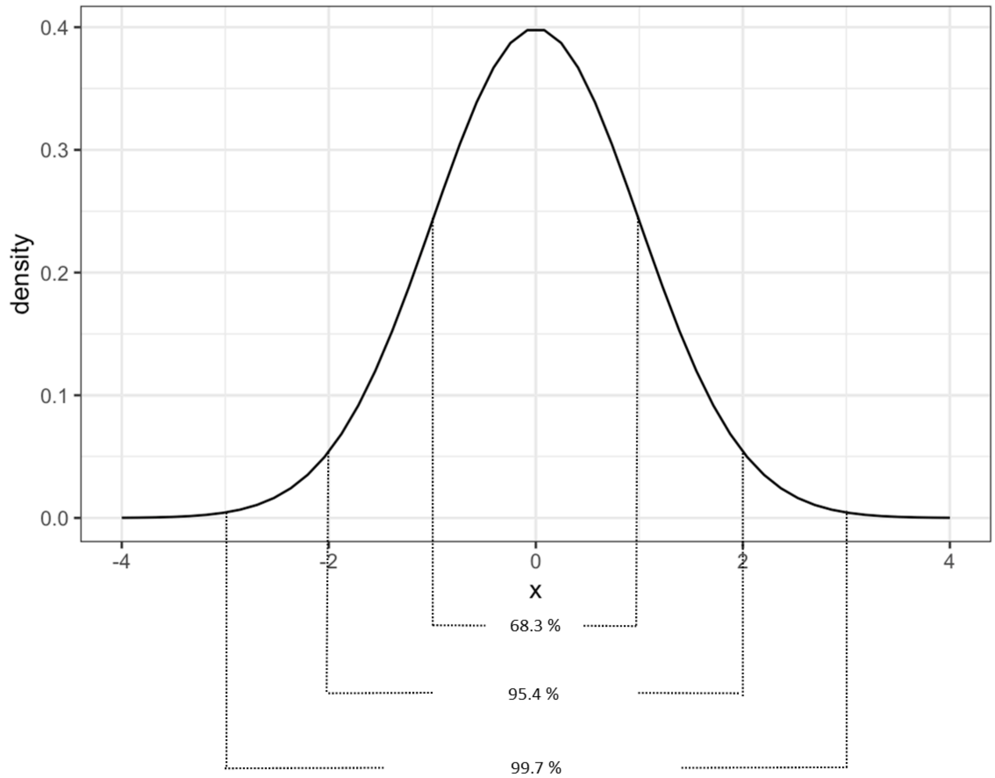


Normal Distribution

It is likely you have already been introduced to the normal distribution curve at some point in your academic studies. Perhaps you have heard the term bell curve? These terms are referring to the same thing, which refers to the distribution of data values being equally centered around the mean. You might see this represented graphically like the sample graph below. In the graph below, the mean occurs at 0. The area under the line represents where data values can be on either side of the mean. Each side of this curve is symmetrical. The x-axis in this graph is labelled to show standard deviations and the y-axis is labelled to show density.



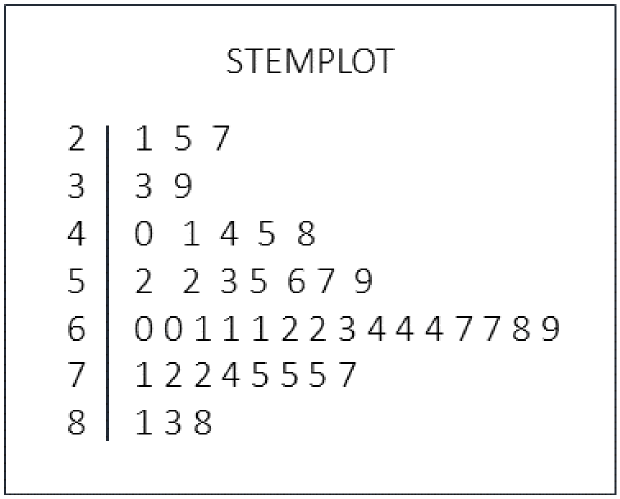
When data is analyzed which has a normal distribution, we can infer that most of the values will be within three standard deviations above or below the mean. When you are just beginning to learn about statistics, a basic understanding of what this graph represents is sufficient. Picture all of the area under the curve as equal to 100% of where the data values being measured are. If we break up the area under the curve into sections, we can convert that area into a percentage of the data. The graph below shows a summary of how much of the data falls within one, two, and three standard deviations away from the mean. 68.3 % of values fall within the area under the curve and one standard deviation above and below the mean. If this area is increased to two standard deviations away from the mean 95.4 % of values fall within this area. If the area is increased to three standard deviations away, 99.7 % of values are captured. This is why we can infer that most of data with a normal distribution will be within three standard deviations from the mean.

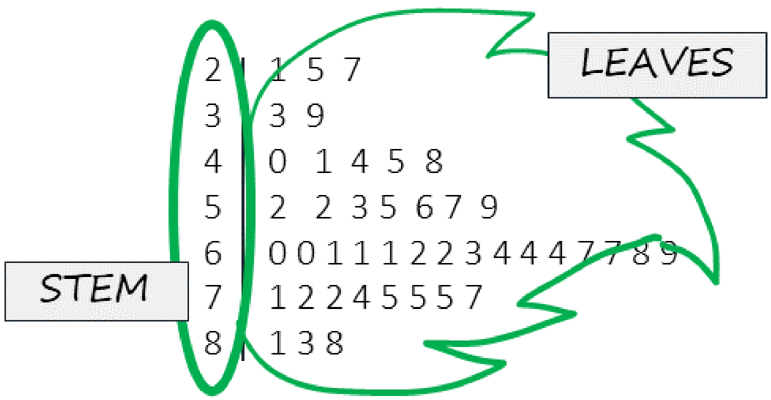


Stemplot

A stemplot is another type of graph you may come across in your studies. Rather than writing a long list of numbers from a data set into a report, the stemplot summarizes all the data values so the distribution is easier to interpret at a glance. The "stem" refers to all but the last number in each numerical value and is listed to the left of a vertical bar. The last number in each value is placed to the right of the vertical bar and are referred to as "leaves". When one leaf is joined with the stem you are able to determine individual values from the data set. If duplicate values are included in the data set, then there will be duplicate leaves in the stemplot. If you find a stem with no leaves, then no values were found with this stem in the dataset. Stemplots are used for relatively small data set, as a data set with thousands of values would be better expressed in an alternate type of graph. Following this paragraph is a fictitious data set. Refer to figure 19.1 below to see a sample stemplot of this data and figure x.x to see a visual representation of the stem and leaves overlaid on the sample stemplot. Can you see how the distribution of values is represented in the stemplot?

Data set for figure x.x: 21, 25, 27, 33, 39, 40, 41, 44, 45, 48, 52, 52, 53, 55, 56, 57, 59, 60, 60, 61, 61, 61, 62, 62, 63 64, 64, 64, 67, 67, 68, 69, 71, 72, 72, 74, 75, 75, 75, 77, 81, 83, 88





Decimal Numbers and Stemplots

Stemplots can be used with whole number or with decimal numbers. Stemplots may have a key noted beside them to show the reader how to interpret the stemplot values into numbers. If there is no key, you can assume the stemplot values convert to whole numbers. When stemplots use decimal numbers they should always include a key to show the stemplot is referring to decimal numbers.

Stemplot Key Examples

Whole Numbers

5|2 = 52

Decimal Numbers

2|9 = 2.9

Back to Back Stemplots

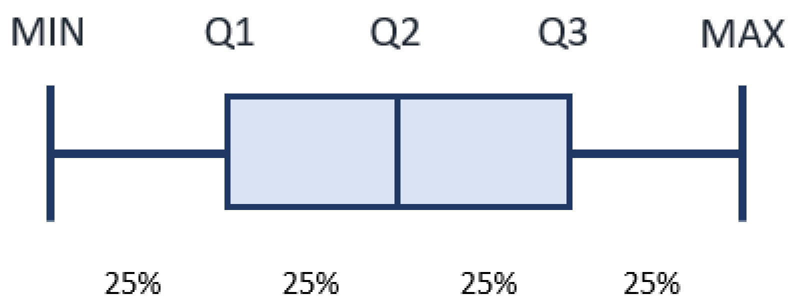
You might come across two stemplots which are created back to back, using the same stem. This is a helpful visual for comparing values related to two groups. Refer to table 19.4 for a sample back to back stemplot comparing ages of students in two college classes. What can you infer about the distribution of ages in these two courses from looking at this stemplot?

Stemplot Comparing Age of Students in Two College Classes		
Introductory Statistics		Life Drawing
0 0 0 0 0 0 0 1 1 1 1 2 2 2 3 4 5 6 7 7 7 8 9	2	2 2 3 4 5 5 6 7 8 9
0 0 1 1 2 2 2 3 5 7 7 8	3	0 1 1 2 3 3 4 4 5 6 6 6 7 9
2 6 7	4	0 1 1 2 4 7 8 8
2 4	5	0 1 4 5 7 9
	6	1 3 4 8

Boxplot

A 5 number summary can be displayed as a visual graphic which helps to show how data is centered around the mean. Looking at boxplots can quickly help you infer if data values occur evenly above and below the mean, and essentially how they are spread around the center. Boxplots are most often used when data is **skewed** as it helps to easily show where more of the values occur. This type of graphic is sometimes referred to as a box and whisker diagram, with the box in the center and the “whiskers” on either side.

The image below shows the location of each of the five values in the 5 number summary. The spaces in between each of these values encompass 25% of the values from the data set. The two center sections are usually depicted with a rectangle, and together these boxes represent where 50% of the values occur. The widths of each of these elements are related to the spread, or range, of the values depicted by them. Boxplots representing actual data will also include the actual values of the 5 number summary on the graphic.

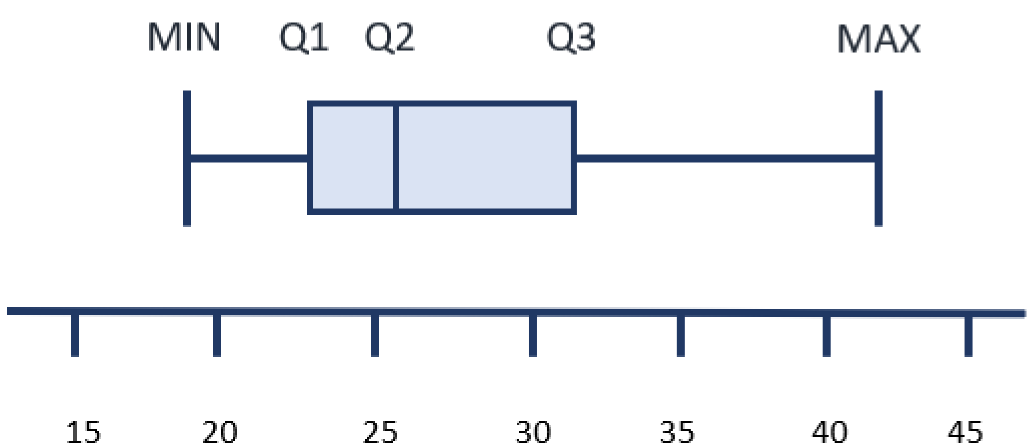


Components of Boxplot

A sample boxplot is included below which uses the values from the five number summary sample to create the elements of this graphic.

5 Number Summary of Ages of Nursing Students in a Fictitious Class

19, 23, 25.5, 31, 42



The shaded box between Q1 and Q2 represents the values occurring between the 1st quartile and the median. The shaded box between Q2 and Q3 represents the values occurring between the median and the 3rd quartile. Since the box on the left is narrow in comparison to the box on the right, this tells you the range of values between Q1 and Q2 is less than Q2 and Q3.

The line between the minimum value and Q1 and the line between Q3 and the maximum value also each relate to 25% of the values.

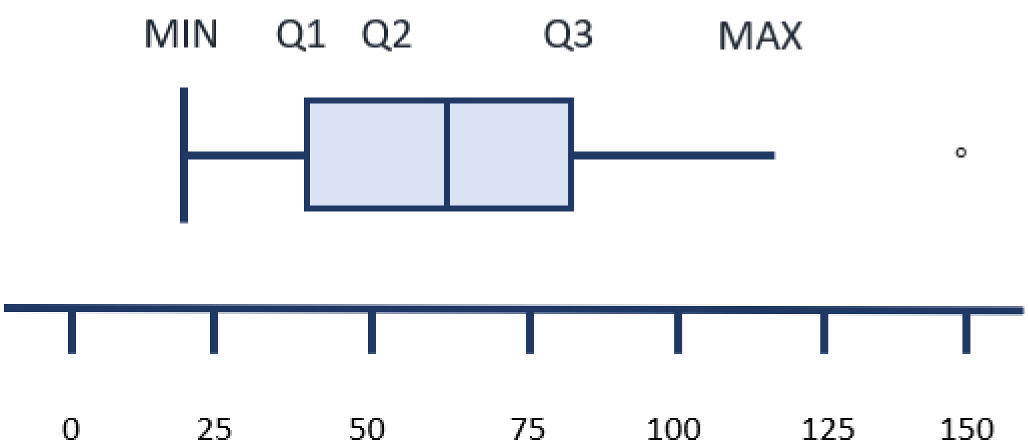
The position of the median, or Q2, also helps to identify if the data was closer to the minimum or maximum values. Look at the boxplot below and see if you can describe how the data was centered around the mean from looking at this graphic. What does it tell you about the ages of nursing students in this class?

Answer:

There is a wider range of ages in older students than the younger students in this class. This is because the size of the line and bow to the left of the median (Q2) is much smaller than the size of the box and line to the left of Q2. The section with the smallest width is the section between Q1 and Q2, so more students had ages in this section than any of the other sections.

Modified Boxplots

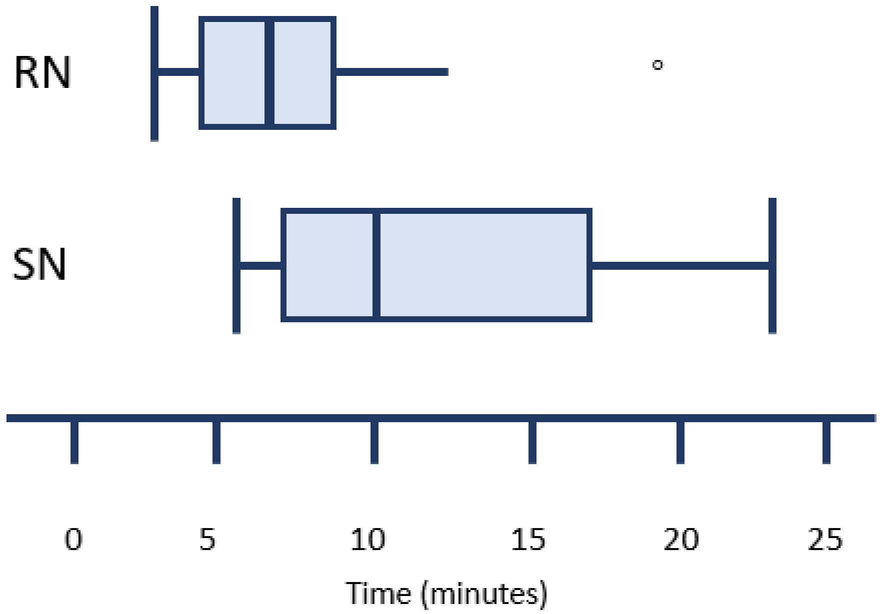
Sometimes, the horizontal lines at the right and left of the central boxes do not have a vertical line at the far edge. If the data includes a value which is considered to be an outlier, it is represented on the boxplot as a single dot. If there are more than one outliers, then a dot will be included for each possible outlier. The sample boxplot below depicts a graphic of a boxplot with one outlier.



Comparing Boxplots

Boxplots can be used within a report to compare the distribution of individual variables in a study. One measurement scale is placed beside two or more boxplots. Each boxplot is labelled with the variable it is related to.

Suppose a study was undertaken to compare the length of time, in minutes, that registered nurses versus second year nursing students took to prepare a particular IV medication. Assume that additional variables which could affect the outcome were similar between both groups. After data is collected, a boxplot could be made for each group to compare the distributions. The image below represents a comparison of this imaginary data. When you look at this image, you should be able to quickly tell which group was slower and which group had a more consistent length of preparation time.



Sample Exercise 19.6

Create a boxplot of the following sample data set:

Average minutes per week nursing instructors engage in moderate physical activity in a sample from a small rural college: 20, 35, 50, 60, 75, 75, 75, 80, 90, 110, 120, 120, 120, 120, 150, 175, 180, 300

Answer:
First, determine the 5 number summary. Min, Q1, Median (or Q2), Q3, Max.

Minimum = 20, Maximum = 300

To find Q1:

$$\text{location of Q1} = \frac{1}{4} \times (n+1) \qquad \text{value of Q1} = \frac{a+b}{2}$$

$$= \frac{18+1}{4} \qquad = \frac{60+75}{2}$$

$$= 4.75 \qquad = 67.5$$

To find the median:

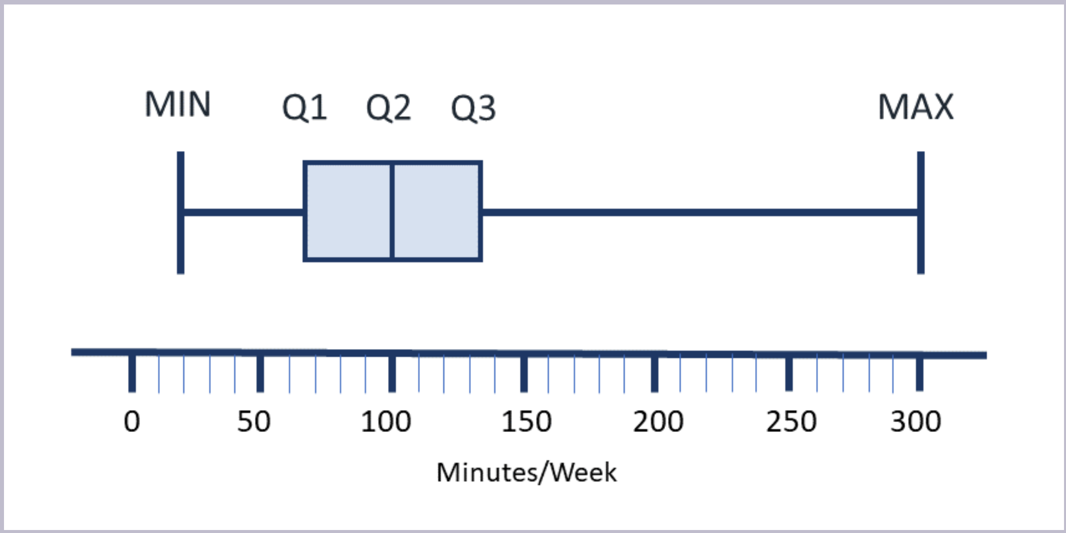
$$\text{location of median} = \frac{n+1}{2} = \frac{18+1}{2} = 9.5$$

$$\text{value of median} = \frac{a+b}{2} = \frac{90+110}{2} = 100$$

To find Q3:

$$\text{location of Q3} = \frac{3}{4} \times (n+1) = \frac{3}{4} \times (18+1) = \frac{3}{4} \times 19 = \frac{57}{4} = 14.25$$

$$\text{value of Q3} = \frac{a+b}{2} = \frac{120+150}{2} = 135$$



Key Takeaways

- Not all statistical measures are appropriate for all categories of data.
- The mode, median, and mean are examples of measurements related to the center of data sets.
- The range, standard deviation and 5 number summary are examples of ways to describe the variation in data within a set.
- There are a variety of was images and graphs can be used to display data.

Practice Set 19.1: Identifying Types of Data

Practice Set 19.1: Identifying types of data

Identify the following types of data as either discrete, continuous, nominal or ordinal:

1. The number of discharges per day from the surgical ward of a particular hospital.
2. The types of dressing products used for chronic would care in a particular home health center.
3. The average number of minutes it takes nursing students to walk up the stairs of an outpatient treatment center with 5 stories.
4. The letter grade received by nursing students in an introduction to statistics course.
5. The amount of waste sent to the incinerator each day from a particular hospital, measured in kilograms.
6. The number of devices with screen owned by nursing students.
7. The satisfaction of new graduates with hospital orientation, measured on a Likert scale using descriptors of very satisfied, satisfied, neither satisfied or dissatisfied, dissatisfied, very dissatisfied.
8. The colours of scrub tops owned by a nursing student.
9. The weight of laptops owned by nursing students in a first year class at a particular college, measured in kilograms.
10. The number of IV pumps available on the surgical ward of a particular hospital.

Answers:

1. Discrete. Discharges per day are counted in whole numbers.

2. Nominal. The types of dressings are described in words (hydrocolloid, semi-occlusive, etc.)
3. Continuous. The number of minutes can include a partial measure of a minute. (eg. 3.5 minutes)
4. Ordinal. Letter grades are a system of ranking.
5. Continuous. The number of kilograms can include a partial measure (eg. 127.9 kg)
6. Discrete. The number of devices are counted in whole numbers.
7. Ordinal. The Likert scale measurements area a system of ranking.
8. Nominal. The colours of scrub tops are described in words.
9. Continuous. The number of kilograms can include a partial measure (eg. 0.94 kg)
10. Discrete. Pumps are counted in whole numbers.

Practice Set 19.2: Identifying Types of Data

Practice Set 19.2: Identifying Types of Data

Identify the following types of data as either interval, discrete, continuous, nominal or ordinal:

1. Eye colour
2. Stages of cancer (Stage I, II, II, IV)
3. Height of 12 year old children in a particular town
4. Survey question with answer choices of: not at all, a little, neutral, some, a lot
5. Types of walking aids used by people in a long term care home
6. The level of education held by nursing instructors
7. The Faces pain scale
8. The number of textbooks owned by each nursing student in a class.
9. The price of various brands of glucose test strips at pharmacies in a particular city
10. the number of minutes college students wait on hold when making telephone inquiries about bursaries

Answers:

1. Nominal. Eye colour is described in words with distinct meanings from one another.
2. Ordinal. There is a ranking system but no specific numerical value between ranks.

3. Continuous. The measurement of height can include a decimal number.
4. Ordinal. There is a rank, but not a specific numerical value attached.
5. Nominal. Walking aids are described with words with distinct meanings from one another.
6. Ordinal. Types of degrees (bachelor's, master's, doctorate) belong to a ranking system.
7. Ordinal and interval-there are faces, words and a number with each pain rating.
8. Discrete. The number of textbooks is counted in whole numbers.
9. Continuous. Cost can be counted in portions of dollars.
10. Continuous. Zero has an absolute value and the number of minutes can have a partial value.

Practice Set 19.3: Calculating Mode

Practice Set 19.3: Calculating Mode

Calculate the mode for the following sample data sets, which have been conveniently sorted into numerical order:

1. 12, 16, 18, 18, 18, 20, 22, 25, 27, 27, 29, 30
2. 0, 0, 2, 5, 8, 9, 15, 17, 17, 32
3. 1, 1, 1, 1, 2, 2, 2, 3, 4, 4, 4, 5, 5, 5, 5, 5, 6, 6, 7, 7, 7
4. 4, 6, 8, 12, 13, 16, 17, 19, 20
5. 30, 32, 35, 37, 37, 40, 60, 77, 88, 99, 137, 150

Answers:

1. 18 (this value occurs 3 times, no other value occurs this many times).
2. 0 and 17 (both of these values occur twice).
3. 5 (this value is repeated the most).
4. There is no mode, no value is repeated.
5. 37 (this value occurs twice, no other value is repeated).

Practice Set 19.4: Calculating Median

Practice Set 19.4: Calculating Median

Calculate the median of the following data sets:

1. 12, 16, 18, 18, 18, 20, 22, 25, 27, 27, 29, 30
2. 0, 0, 2, 5, 8, 9, 15, 17, 17, 32
3. 1, 1, 1, 1, 2, 2, 2, 3, 4, 4, 4, 5, 5, 5, 5, 5, 6, 6, 7, 7, 7
4. 4, 6, 8, 12, 13, 16, 17, 19, 20
5. 30, 32, 35, 37, 37, 40, 60, 77, 88, 99, 137, 150

Answers:

1. 21
2. 8.5
3. 4
4. 13
5. 50

Recall the median is the value in the physical middle of the data set. The following formula can be used to calculate the location of the median. You might not have used a formula to find the location in these very small data sets.

$$\frac{n+1}{2} = \text{location of median}$$

In a data set with an odd number of values the median will equal the number at this location.
In a data set with an even number of values, the median is equivalent to the mean of the values to the right and left of this location.

Use the following formula to find the mean in a data set with an even number of values:

$$\text{value of median} = \frac{a+b}{2}$$

1.

$$\text{location of median} = \frac{12+1}{2} = \frac{13}{2} = 6.5 \qquad \text{value of median} = \frac{a+b}{2} = \frac{20+22}{2} = 21$$

2.

$$\text{location of median} = \frac{10+1}{2} = \frac{11}{2} = 6.5 \qquad \text{value of median} = \frac{a+b}{2} = \frac{8+9}{2} = 8.5$$

3.

$$\text{location of median} = \frac{21+1}{2} = \frac{22}{2} = 11$$

Count to the 11th value.

4.

$$\text{location of median} = \frac{9+1}{2} = \frac{10}{2} = 5$$

Count to the 5th value.

5.
$$\text{location of median} = \frac{12+1}{2} = \frac{13}{2} = 6.5 \qquad \text{value of median} = \frac{a+b}{2} = \frac{40+60}{2} = 50$$

Practice Set 19.5: Calculating Mean

Practice Set 19.5: Calculating Mean

Calculate the mean of the following data sets, up to two decimal places.

1. 12, 16, 18, 18, 18, 20, 22, 25, 27, 27, 29, 30
2. 0, 0, 2, 5, 8, 9, 15, 17, 17, 32
3. 1, 1, 1, 1, 2, 2, 2, 3, 4, 4, 4, 5, 5, 5, 5, 5, 6, 6, 7, 7, 7
4. 4, 6, 8, 12, 13, 16, 17, 19, 20
5. 30, 32, 35, 37, 37, 40, 60, 77, 88, 99, 137, 150

Answers:

Use the following formula to calculate the mean:

$$\text{mean} = \frac{\sum(x_1 + x_2 + \ldots + x_x)}{n}$$

1. 21.83
$$\text{mean} = \frac{12+16+18+18+18+20+22+25+27+27+29+30}{12}$$
$$\text{mean} = \frac{262}{12}$$
$$= 21.83$$
2. 10.5

$$\text{mean} = \frac{0+0+2+5+8+9+15+17+17+32}{10}$$

$$\text{mean} = \frac{105}{10}$$

$$= 10.5$$

3. 3.95

$$\text{mean} = \frac{1+1+1+1+2+2+2+3+4+4+4+5+5+5+5+5+6+6+7+7+7}{21}$$

$$\text{mean} = \frac{83}{21}$$

$$= 3.95$$

4. 12.78

$$\text{mean} = \frac{4+6+8+12+13+16+17+19+20}{9}$$

$$\text{mean} = \frac{115}{9}$$

$$= 12.78$$

5. 68.5

$$\text{mean} = \frac{30, 32, 35, 37, 37, 40, 60, 77, 88, 99, 137, 150}{12}$$

$$\text{mean} = \frac{822}{12}$$

$$= 68.5$$

Practice Set 19.6: Calculating Range

Practice Set 19.6: Calculating Range

Calculate the range for the following data sets.

1. 12, 16, 18, 18, 18, 20, 22, 25, 27, 27, 29, 30
2. 0, 0, 2, 5, 8, 9, 15, 17, 17, 32
3. 1, 1, 1, 1, 2, 2, 2, 3, 4, 4, 4, 5, 5, 5, 5, 5, 6, 6, 7, 7, 7
4. 4, 6, 8, 12, 13, 16, 17, 19, 20
5. 30, 32, 35, 37, 37, 40, 60, 77, 88, 99, 137, 150

Answers:

1. $$\text{range} = 30 - 12 \\ = 18$$
2. $$\text{range} = 32 - 0 \\ = 32$$
3. $$\text{range} = 7 - 1 \\ = 6$$
4. $$\text{range} = 20 - 4 \\ = 16$$
5. $$\text{range} = 150 - 30 \\ = 120$$

Practice Set 19.7: Interpreting Standard Deviation

Practice Set 19.7: Interpreting Standard Deviation

1. Suppose you were looking at the results of a study in which the intervention affects weight (in kilograms) of a person. If the standard deviation is very small, are the measured values of weight very similar or very different from each other in each people being studied?

2. You are reading the results of a study comparing how different ways of cooking white basmati rice affects the blood glucose level of people with diabetes one hour after eating one half cup of cooked white rice. You can assume that the characteristics of participants in each intervention group are similar. Refer to the table below for a summary of mean increase in blood sugar based on the method of cooking and the calculated standard deviation.
   a. Which of the following methods results in the most consistent rise in blood glucose?
   b. Which method results in the highest possible blood glucose reading at exactly one standard deviation away from the calculated mean?

Intervention	**Mean Increase in Blood Sugar**	**Standard Deviation**
Method A	6 mmol/L	1.07 mmol/L
Method B	5.2 mmol/L	0.8 mmol/L
Method C	4.9 mmol/L	1.21 mmol/L

Answers:

1. If the standard deviation is small, it means the numbers in the data set are closer together, so the weights will have a small amount of variation.

2. a. Method B has the most consistent rise in blood glucose, as the standard deviation is the smallest. The smallest standard deviation has the least amount of variability in values.
   b. Method A would have the highest blood glucose reading at exactly one standard deviation above the mean.

$$6 + 1.07 = 7.07$$
$$5.2 + 0.8 = 6.0$$
$$4.9 + 1.21 = 6.11$$

Practice Set 19.8: 5 Number Summary and Boxplots

Practice Set 19.8: 5 Number Summary and Boxplots

1. List the types of numbers included in a 5 number summary.
2. What type of graphic is used to present the numbers in a 5 number summary?
3. What are the "whiskers" of a boxplot?
4. How is an outlier noted on a boxplot?
5. Determine the 5 number summary for the following fictional data set. The average number of minutes spent by first year nursing students on social media per day.
   10, 10, 13, 14, 15, 15, 15, 18, 20, 20, 20, 22, 30, 31, 31, 35, 36 38, 44, 50, 60, 78
6. Create a boxplot to display the 5 number summary from question 5.
7. Determine the 5 number summary for the following fictional data set. The number of times a nursing student hand washes in one shift on an inpatient medical floor.
   27, 35, 48, 54, 58, 59, 62, 63, 63, 66, 67, 71, 72, 73, 76, 77, 78, 83, 87, 92, 102
8. Determine the 5 number summary for the following fictional data set.
   The number of migraines per month using a particular treatment for prevention.
   0, 0, 1, 1, 1, 1, 1, 1, 1, 2, 2, 2, 2, 2, 3, 4, 4, 8, 12
9. Determine the 5 number summary for the following fictional data set.
   The number of migraines per month using a placebo for prevention.
   1, 1, 1, 1, 2, 2, 2, 2, 2, 3, 3, 3, 4, 4, 5, 7, 9, 12, 13
10. Create two boxplots comparing the 5 number summaries from questions 8 and 9.

Answers:

1. The minimum, the first quartile, the median, the third quartile, and the maximum.
2. A boxplot.
3. The whiskers of a boxplot extend from Q3 to the maximum number and from Q1 to the minimum number.
4. Each outlier is noted as a single dot outside of the whiskers.
5. 10, 15, 21, 37, 78
   The minimum and maximum are the smallest and largest numbers in the data set.
   To find Q1:

$$\text{location of Q1} = \frac{1}{4} \times (n+1) \qquad \text{value of Q1} = \frac{a+b}{2}$$

$$= \frac{22+1}{4} \qquad\qquad = \frac{15+15}{2}$$

$$= 5.75 \qquad\qquad = 15$$

To find the median:

$$\text{location of median} = \frac{n+1}{2} \qquad \text{value of median} = \frac{a+b}{2}$$

$$= \frac{22+1}{2} \qquad\qquad = \frac{20+22}{2}$$

$$= 11.5 \qquad\qquad = 21$$

To find Q3:

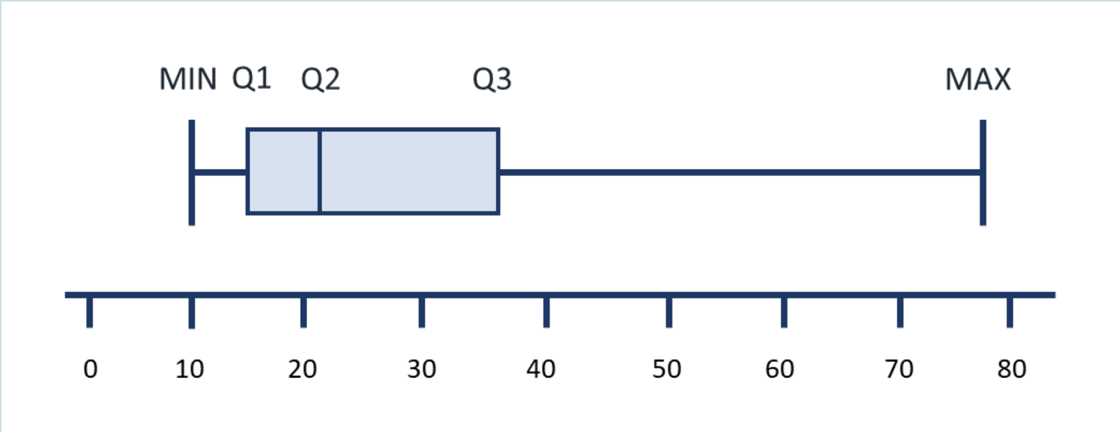
$$\text{location of Q3} = \frac{3}{4} \times (n+1)$$

$$= \frac{3}{4} \times (22+1) \qquad \text{value of Q3} = \frac{a+b}{2}$$

$$= \frac{3}{4} \times 23 \qquad\qquad = \frac{36+38}{2}$$

$$= \frac{69}{4} \qquad\qquad = 37$$

$$= 17.25$$

6. 

7. 27, 58.5, 67, 77.5, 102

The minimum and maximum are the smallest and largest numbers in the data set.

To find Q1:

$$\text{location of Q1} = \frac{1}{4} \times (n+1) \qquad \text{value of Q1} = \frac{a+b}{2}$$

$$= \frac{21+1}{4} \qquad = \frac{58+59}{2}$$

$$= 5.5 \qquad = 58.5$$

To find the median:

$$\text{location of median} = \frac{n+1}{2}$$

$$= \frac{21+1}{2}$$

$$= 11$$

To find Q3:

$$\text{location of Q3} = \frac{3}{4} \times (n+1)$$

$$= \frac{3}{4} \times (21+1) \quad \text{value of Q3} = \frac{a+b}{2}$$

$$= \frac{3}{4} \times 22 \quad\quad = \frac{77+78}{2}$$

$$= \frac{66}{4} \quad\quad = 77.5$$

$$= 16.5$$

8. 0, 1, 2, 3, 12
The minimum and maximum are the smallest and largest numbers in the data set.
To find Q1:

$$\text{location of Q1} = \frac{1}{4} \times (n+1)$$

$$= \frac{19+1}{4}$$

$$= 5$$

To find the median:

$$\text{location of median} = \frac{n+1}{2}$$

$$= \frac{19+1}{2}$$

$$= 10$$

To find Q3:

$$\text{location of Q3} = \frac{3}{4} \times (n+1)$$

$$= \frac{3}{4} \times (19+1)$$

$$= \frac{3}{4} \times 20$$

$$= \frac{60}{4}$$

$$= 15$$

9. 1, 2, 3, 5, 13
   The minimum and maximum are the smallest and largest numbers in the data set.
   To find Q1:

$$\text{location of Q1} = \frac{1}{4} \times (n+1)$$

$$= \frac{19+1}{4}$$

$$= 5$$

   To find the median:

$$\text{location of median} = \frac{n+1}{2}$$

$$= \frac{19+1}{2}$$

$$= 10$$

   To find Q3:

$$\text{location of Q3} = \frac{3}{4} \times (n+1)$$

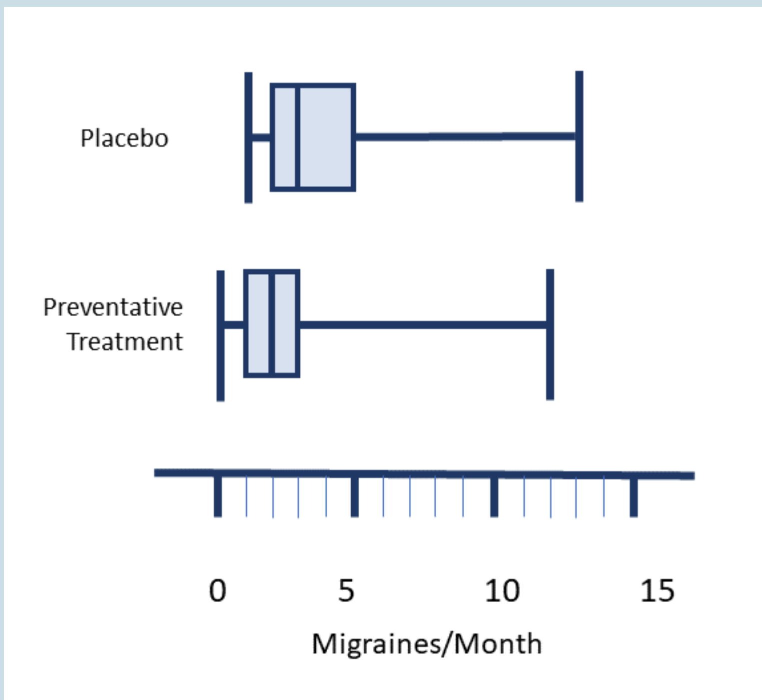
$$= \frac{3}{4} \times (19+1)$$

$$= \frac{3}{4} \times 20$$

$$= \frac{60}{4}$$

$$= 15$$

10.



Practice Set 19.9: Using Stemplots, Histograms and Density Curves

Practice Set 19.9: Using Stemplots, Histograms and Density Curves

1. Explain how an individual value in a data set can be split into a stem and a leaf.
2. What kind of data is displayed in a histogram?
3. Create a stemplot for the following data set which includes fictional values of the number of times per day the medication cabinet on the acute medical floor is accessed by a sample of nursing students.
   3, 5, 6, 6, 6, 7, 7, 8, 9, 9, 10, 11, 13, 14, 14, 15, 17, 18, 22, 27
4. Create a stemplot for the following data set which includes fictional values of visits per day to an emergency room.
   187, 190, 195, 196, 199, 204, 206, 208, 211, 215, 215, 218, 219, 222, 225, 227, 230, 233, 242, 260
5. What type of graph would you create to display the values of the following data set? This data set includes fictional values of the age in months in which the first tooth appeared for a sample of two year old children.
   5.2, 5.7, 5.9, 6.1, 6.1, 6.3, 6.4, 6.4, 6.5, 6.5, 6.5, 6.7, 6.8, 6.8, 6.8, 6.9, 6.9, 7.2, 7.3, 7.5, 7.7, 7.8, 8.0, 8.1, 8.4, 8.5, 9.2, 10.7, 10.8, 11.3, 13.5, 14.1
6. Convert the stem and leaves into actual values from the stemplot below.

   Key
   2 | 2 = 2.2

   1 | 0, 4, 5, 7, 8
   2 | 1, 2, 2, 4, 6, 7, 9
   3 | 2, 5, 6, 9
   4 | 4, 7

7. How does the shape of a density curve compare to a histogram using the same data set?

Answers:

1. The last digit in the value is always represented as a leaf. The stem includes the numbers to the left of the last digit. Stems can have more than one digit while a leaf is always a single digit. A vertical line can divide the stem from the leaves. The stem is written on the left of the vertical line and the leaf is written to the right.
2. Continuous data, or data with decimals.

3.

Frequency of Med Cabinet Access by Nursing Students

0	3, 5, 6, 6, 6, 7, 7, 8, 9, 9
1	0, 1, 3, 4, 4, 5, 7, 8
2	2, 7

4.

Visits Per Day

18	7
19	0
20	4, 6, 8
21	1, 5, 5, 8, 9
22	2, 5, 7
23	0, 3
24	2
25	
26	0

5. A histogram would be an appropriate type of graph as this data set includes data which is continuous.
6. 1.0, 1.4, 1.5, 1.7, 1.8, 2.1, 2.2, 2.2, 2.4, 2.6, 2.7, 2.9, 3.2, 3.5, 3.6, 3.9, 4.4, 4.7
7. The density curve will have a shape that looks like a line has been drawn through the tops of the columns of the histogram. If the histogram bin sizes (the width of columns on x axis) are very small, the density curve will follow the tops quite closely.

Image Descriptions

Data types branching flow chart:

- Numerical (Quantitative)
    - Interval (arbitrary zero)
    - Ratio (true zero)
        - Discrete (whole numbers)
        - Continuous (decimals scale)
- Categorical (Qualitative)
    - Nominal (no order)
    - Ordinal (order)

[Return to Chart 19.1 Data Types]

20.

Inferential Statistics

Lesson

Learning Outcomes

By the end of this chapter, learners will be able to:

- define inferential statistics,
- identify examples of statistics used to measure effects of dichotomous outcomes, and
- identify examples of statistics used to measure effects of continuous outcomes.

Introduction to Inferential Statistics

Inferential statistics can help you to analyze sample data to make estimates, predictions and conclusions about populations. There are numerous statistical tests you can learn about which fall into the category of inferential statistics, but they will not all be discussed in this chapter. Instead, a sample of statistical tests you will see more commonly in research articles will be reviewed.

There are many factors to consider when determining which statistical tests should be used to analyze the results of a particular study effectively. However, we also need to ask questions to determine if the study results should be trusted to make estimates, predictions and conclusions about the population. For example, it is important to consider whether the measurements taken in the study were accurate and it is essential to determine if the sample chosen accurately represented the population. If the sample is not similar to the population, then the study results cannot be used to make predictions about what might be true for the population. You can read more about study designs, measurement and analysis in open textbooks such as Introductory Statistics, Literature Reviews for Education and Nursing Graduate Students and Scientific Inquiry in Social Work or textbooks like Nursing Research In Canada by LoBiondo-Wood, G., Cameron, C., Singh, M., & Haber, J. (2017). Assuming the study used good research methodology and is a reliable representation of the population, inferential statistics can then be used to make estimates, predictions and conclusions about what might be true for the population, based on the data from the sample.

Measuring Effect Between Outcomes

When analyzing research data, statistical tests can be used to analyze the effects of variables. For instance, they can be used to analyze the sample measurements in a study comparing the effect of two different drugs designed for potential treatment of pancreatic cancer.

The type of tests used to answer different types of questions vary. In particular, questions that have yes or no answers, or questions which have values falling on a scale, will use different types of tests. These types of answers are generally referred to as **dichotomous** and **continuous outcomes**. Dichotomous outcomes are the yes/no answer types. They relate to questions with two options for answers. For instance, does a particular medication have a potential adverse reaction of anaphylaxis? Continuous outcomes are the answer type which falls on a scale, such as how does the amount of protein in enteral feeds affect the growth of preterm infants?

Dichotomous Outcomes

There are a variety of measures that can be used to compare the effects of a variable between groups. Refer to table 20.1 to see a comparison of some of these measures.

Table 20.1 Examples of Statistics Related to Dichotomous Outcomes

Statistical Test	**Description**
Risk	The chance of an outcome occurring.
Relative Risk (RR)	The comparison of the chance of an outcome occurring between two experimental groups.
Odds	The probability an event will occur divided by the probability of the event not occurring.
Odds Ratio (OR)	The probability of one event divided by the probability of another event.

These can be tricky topics to conceptualize and challenging to determine when a particular test should be used for a specific circumstance over another. The following textboxes contain some sample scenarios to help you begin to learn about the differences in these measurements. Please note, all of the data presented in these questions are fictional and they do not represent actual measurements from real samples or studies.

Risk

Risk is a measurement of how likely an outcome will occur in a particular group, often written as a percentage. Risk is calculated by dividing the number of times the outcome occurs by the total number of cases being studied.

Risk

Let's suppose you ask, what is the chance ingesting any amount of amanita muscaria mushrooms leads to death? If you review 100 cases of known ingestion of amanita muscaria mushrooms, you might find death occurred in 5 cases.

To determine risk, the amount of times the event occurred is divided by the total amount of cases studied.

$$\frac{5}{100} = 0.05$$

or 5%

Sample Exercise 20.1

Researchers are studying a new drug for potential treatment of ischemic stroke. The drug is administered to 100 mice with a known thrombus causing cerebral ischemia. Two mice suffer a fatal hemorrhage after receiving the treatment. What is the risk of fatal hemorrhage for this new fibrinolytic drug?

Answer:

$$\frac{2}{100} = 0.02$$

or 2 %

Risk is calculated by dividing the number of times the event happened, by the total number of cases being studied.

Relative Risk (RR)

Relative risk is the chance of an event occurring between two groups. Relative risk is calculated by dividing the risk of the group of interest by the risk of the other group.

Values of 0 to < 1 = there is less probability of the first group having the outcome

Value of 1 = there is no difference in probability between the two groups

Values of > 1 to infinity = there is more chance of the first group having the outcome

Relative Risk (RR)

For instance, a study could review how probable antibiotic X and antibiotic Z are in curing a particular type of infection. Researchers would calculate the probability of antibiotic X in curing the infection and calculate the probability of antibiotic Z in curing the infection. Let's say the calculated probability of antibiotic X was 98% and antibiotic Z was 85%.

$$\frac{98}{85} = 1.52$$

This means antibiotic X could be 1.52 times more likely to cure the infection. However, just calculating the relative risk is not enough to say antibiotic X is the best option for treatment. We need to consider whether the study findings are statistically significant and consider many other factors about study design and potential patient outcomes before determining if antibiotic X is a good drug to use.

Choosing the Numerator and Denominator

When you set up the equation, it might be confusing to determine which risk should be the numerator and which should be the denominator. In a study where the risk for a particular group is being compared to all other groups, the particular group is the numerator and the control or comparison group is the denominator. For instance, we could compare a particular risk of an experimental treatment compared to a placebo. The risk of the experimental group would be the numerator and the risk of the group receiving the placebo would be the denominator.

Sample Exercise 20.2

A study measures the outcomes related to two drugs being used for the treatment in chronic renal failure (CRF). Drug A is an experimental drug and Drug B is one currently used in treatment of CRF. Out of 990 subjects taking drug A, 17 developed hypokalemia. Out of 998 subjects taking drug B, 32 developed hypokalemia. What is the relative risk of developing hypokalemia during treatment? What impact might this have on future use of Drugs A and B?

Answer:
Calculate the risk of hypokalemia for each drug being studied.

$$\frac{17}{990} = 0.017$$

$$\frac{32}{998} = 0.032$$

Calculate the relative risk by dividing the risk of hypokalemia developing with Drug A by the risk of it developing with Drug B.

$$\frac{0.017}{0.032} = 0.53$$

But what does this mean? Since the value is between 0 – 1, there is less chance of hypokalemia developing with Drug A. If all other effects and characteristics of the drugs were similar, it could mean Drug A may be a better option for treatment as the risk of hypokalemia is less than Drug B.

Odds

Odds are a measure which compares the probability of something happening versus it not happening. Using odds can help people make decisions about what to do when the outcome of a particular event is uncertain. When odds are low, or close to zero, the chance of the outcome occurring are less than when the odds are high.

Odds

For instance, one might calculate the probability of nursing students graduating from a particular nursing school. In a study of 1000 BSN students, perhaps 87 students did not complete their nursing degree. That would mean that 913 students did complete their degree.

To calculate the odds, we divide the number of students who graduated by the number who did not.

$$\text{Odds} = \frac{913}{87}$$
$$\text{Odds} = 10.5$$

Therefore, the odds of graduating is 10.5

Sample Exercise 20.3

What are the odds of a disease being cured if in a group of 1000 people being studied, 676 people were deemed to be cured after treatment?

Answer:

$$\frac{\text{number cured}}{\text{number not cured}}$$

$$\frac{676}{324} = 2.09$$

Divide the number of people cured by the number of people not cured. The odds of being cured is 2.09.

Odds Ratio (OR)

The **odds ratio** is used to compare the difference in odds between groups. An odds ratio of 1 would mean there is no difference between the two groups.

Odds Ratio

For instance, we could compare the odds of early births in first pregnancies in women with and without gestational diabetes (GD). Let's suppose that 16/100 women with GD delivered prematurely and 5/100 women without GD delivered early.

We first need to calculate the odds of each group:
Odds premature delivery of first pregnancy in women with GD = 0.19
Odds premature delivery of first pregnancy without GD =0.052

$$\text{Odds Ratio} = \frac{0.19}{0.052}$$
$$\text{Odds Ratio} = 3.65$$

This number indicates it is 3.65 times more likely for a premature birth to occur early in a first pregnancy for someone with gestational diabetes.

Sample Exercise 20.4

Researchers compare the effects of taking two nutritional supplements while studying the rate of healing of pressure ulcers. They find supplement A improves average healing time by at least 7 days in 32/100 cases and supplement B improves average healing time by at least 7 days in 4/100 cases.

Answer:
Calculate the probability of average healing time improving by at least 7 days for each nutritional supplement.

$$\frac{32}{100} = 0.32 \text{ or } 32\ \%$$
$$\frac{4}{100} = 0.04 \text{ or } 4\ \%$$

Divide the probability of improvement with supplement A by the probability of improvement with supplement B.

$$\frac{32}{4} = 8$$

The odds ratio of 8 shows a value > 1, meaning there is more chance of improvement with supplement A.

Continuous Outcomes

Two common types of statistics which help us determine the validity of study findings are **p-values** and **confidence intervals**. P-values can help us to determine how often the effect found in a study is more or less likely to be due to random chance than being a true finding and confidence intervals can tell us about the replicability of results.

P-Values

Researchers look for associations between variables and effects in studies and will calculate statistics, like p-values, to help determine if an effect found is actually a true finding. Calculation of p-values help determine if study results are just a coincidence by estimating what chance there is of the effect found to be related to sampling error during the study process.

P-values exist on a scale. The higher the p-value, the less certain one can be regarding the true effect of the variable. The lower the p-value, the more likely the results are representative of an actual effect and less likely results are just a coincidental finding. It is important to note one study with a low p-value does not prove conclusively that the results are true for the population. The more studies which show a low p-value, the more likely the results can be applied to conclusions about the population.

P-values belong in a category of statistical tests called hypothesis tests. This category of tests helps researchers to determine if they accept or reject a hypothesis. When setting up a study, the researcher will write a **null hypothesis** (H_0) and an **alternate hypothesis** (H_A). The null hypothesis describes a circumstance in which the variable does not have an effect on the outcome being studied. The alternate hypothesis describes a circumstance in which the variable has an effect.

Sample Hypothesis Statements

H_0: Drinking caffeine increases in systolic blood pressure by less than 5 mmHg.

H_A: Drinking caffeine increases blood pressure by at least 5 mmHg.

These statements can be abbreviated like this:

H_0: < 5

H_A: ≥ to 5

The p-value statistic always assume the null hypothesis is true. If p-values are higher, the study results are consistent with a true null hypothesis, meaning the study did not find any evidence of the variable having an actual effect. In this case, the researcher would state they accept the null hypothesis. If the p-values are small, the study results are not consistent with the null hypothesis. If this is the case, it means the thing being studied either has an effect or there may have been sampling error influencing the study results and the effect found is actually just a coincidence. The researcher would state the null hypothesis is rejected.

In order to make a decision to accept or reject the null hypothesis, the researchers must determine the level of certainty they will accept in order to consider the findings statistically significant and apply the study findings to inferences about the population. They determine this level, and call it the alpha (α) value. An alpha value can be anywhere between 0 – 1, with lower numbers having a higher degree of certainty. In many studies, the alpha value is often 0.05. Other studies might set the alpha value to 0.01. If the calculated p-value is less than alpha, then the null hypothesis is rejected. Recall that the lower the p-value, the more certain one can be an effect is a true finding and not a finding produced by a random sampling error. It is still possible a p-value lower than alpha could indicate the results were produced due to a sampling error, hence why the researcher say the reject the null hypothesis versus they accept the alternate hypothesis. Consequently, the more studies able to replicate the results, the more certain we are about the validity of the findings.

Accepting or Rejecting a Null Hypothesis

A study is undertaken to measure the effect of a new treatment for muscle rigidity in Parkinson’s disease. Measurements of muscle rigidity are taken with clinical instruments to obtain an objective measurement. Alpha is set to 0.01. The calculated p-value is 0.0082.

H_0: there is no difference in muscle rigidity measurements at rest

H_A: there is at least a 5% decrease in muscle rigidity measurements at rest

Based on the calculated p-value, does the researcher accept or reject the null hypothesis?

Since the p-value is lower than alpha, the researcher rejects the null hypothesis.

P-values are measured with different types of statistical tests depending on the number and type of variables being studied. Table 20.2 depicts the types of statistical tests to calculate p-values for various types of data. Future courses in statistics will help you learn how to calculate these measures to aid in analyzing study results.

Table 20.2 Examples of Statistical Tests Calculating P-Values for Data of Various Types

Type of Data	Statistical Test
1 Category	1 Sample Proportion Test
2 Categories	Chi Squared Test
1 Numeric	T-test
1 Numeric and 1 Category	T-test, 1 way ANOVA
1 Numeric and 2 Categories	2 way ANOVA
2 Numeric	Correlation Test

Sample Exercise 20.5

A study is undertaken to measure the effect of a potential new drug for hypercholesterolemia.. Alpha is set to 0.01. The calculated p-value is 0.18.

H_0: there is no change in serum LDL levels

H_A: there is a decrease in serum LDL levels by ≥ 20 mg/dL

Based on the calculated p-value, does the researcher accept or reject the null hypothesis?

Answer:
Since the p-value is higher than alpha, the researcher accepts the null hypothesis.

Confidence Intervals

Confidence intervals help to give an idea of how well the sample statistic represents a population parameter. They describe the range in which the true population parameter is likely to be in and give the probability of how often it would be found in the range. Examples of sample statistics with confidence intervals could be data like the mean, odds ratio, or relative risk.

In a study, is it highly unlikely the reported sample statistic will match the true population parameter because not all of the measurements from the population are included in the calculation. Inherently, there is some degree of measurement error which will occur from using a sample. The more the characteristics of the sample correlate with the characteristics of the population, the smaller the amount of error. Taking larger samples may also reduce error and lead to more precise estimates of the actual population parameter. Confidence intervals can have a very small or very large range of minimum and maximum interval values, depending on how precise the estimate is. The more precise the estimate, the smaller the range of the confidence interval will be.

The two numbers in the interval represent values which are a certain number of standard deviations above and below the sample statistic. The number of standard deviations chosen is related to the percentage of confidence noted. Recall, in a normal distribution, 95% of the values will be within two standard deviations of the point estimate. If three standard deviations above and below are considered, this equates to 99.7% of the values. Most often, you will see confidence intervals which note the 95% level of confidence.

Interpreting Confidence Intervals

In a study measuring the average time for epinephrine to reduce hives associated with anaphylaxis, a statement in the research article might say:

"There is a 95% confidence interval that IV administration of epinephrine will reduce hives within five to seven minutes of administration."

It may be abbreviated like this: 95% CI 6 (5, 7)

This means if the same experiment was repeated many times, 95% of the time the population mean will fall within the range of five to seven minutes.

Sample Exercise 20.6

A study is completed measuring the prevalence of pre-test exam related anxiety at a particular university. Prevalence is reported as a percentage of students. Study data is analyzed and a researcher reports the following:

95% CI 29.6% (24.4, 34.8)

Explain the above statistic in your own words. What do each of the numbers represent?

Answer:
Based on the data collected from study participants, 29.6% of students reported pre-test exam related anxiety. 29.6% is not likely to be the exact percentage of the true prevalence of anxiety in all students at the university due to error from using a sample of the population. The researcher is giving a range of values in which they are 95% certain the actual population prevalence of pre-test anxiety falls within. The range is 24.4-34.8 %.

Meta-analysis

In recent years, more health care providers are seeking to use the results of multiple studies investigating the effect of a particular variable on a specific outcome when making decisions regarding best practice. Egger and Smith (1997) describe metanalysis as "the statistical integration of separate studies." A basic process for metanalysis would include the following steps:

1. The researcher considers what research question they are trying to answer. They must be able to articulate the specific qualities of the intervention and the characteristics of the population being studied. Defining the variables and outcomes being studied explicitly help the researcher in the next step of the process.
2. A thorough literature review is conducted to find reports of studies which help to answer the research question. Studies which look at a particular intervention but are studying different populations cannot be analyzed together. Think about this step as ensuring you are comparing apples to apples. Some studies may not be comparable to each other and therefore would not be included in the actual metanalysis. It can be very challenging to find studies which have populations with characteristics similar enough to be able to be analyzed together, so there may be times when a literature review does not proceed to the next steps of meta-analysis.
3. The researcher uses statistical analysis to compare the results of studies deemed to be homogeneous.
4. A report is written to present the summary of findings and methods of statistical analysis.

Egger, M. & Smith, G. D. (1997). Meta-analysis: Potentials and promise. *BMJ, 315*(1371). https://doi.org/10.1136/bmj.315.7119.1371

Forest Plots

Forest plots are used to graphically summarize the comparison of results of multiple studies used in a meta-analysis. The forest plot has data relating to each individual study included in the analysis and a representation of the combined study results. It helps to predict if the combined results of studies lean towards the subject having a true effect or not.

There are several standard features of forest plots:

Square: A square shape is used to depict the results from one study. The size of the square is related to the sample size of the study. Squares of each study on the forest plot will differ in size, depending on the sample size used in each study. For instance, bigger squares quickly indicate that the sample sizes of those studies were larger.

Diamond: A diamond shape is used to indicate the combined estimated effect of the study results. On a graph, the center of the diamond equates to the value of the calculated statistic. The point at the furthest left and furthest right equate to the values of the confidence interval for the calculated statistic. The longer the width of the diamond, the more range there is in potential true value. Therefore, a diamond with a shorter width has a potential true value in a smaller range.

Line of No effect: On the forest plot there will be a vertical line depicting the value at which the variables have no effect on the outcome. The value depends on the statistic that is being compared. For instance, if odds ratio is being measured, there is no difference in effect when the odds ratio equals one, so the line of no effect is placed at one on the x axis. Study results which have a confidence interval crossing the line of no effect are considered to not be statistically significant, as there is a chance the variable has no effect on the outcome.

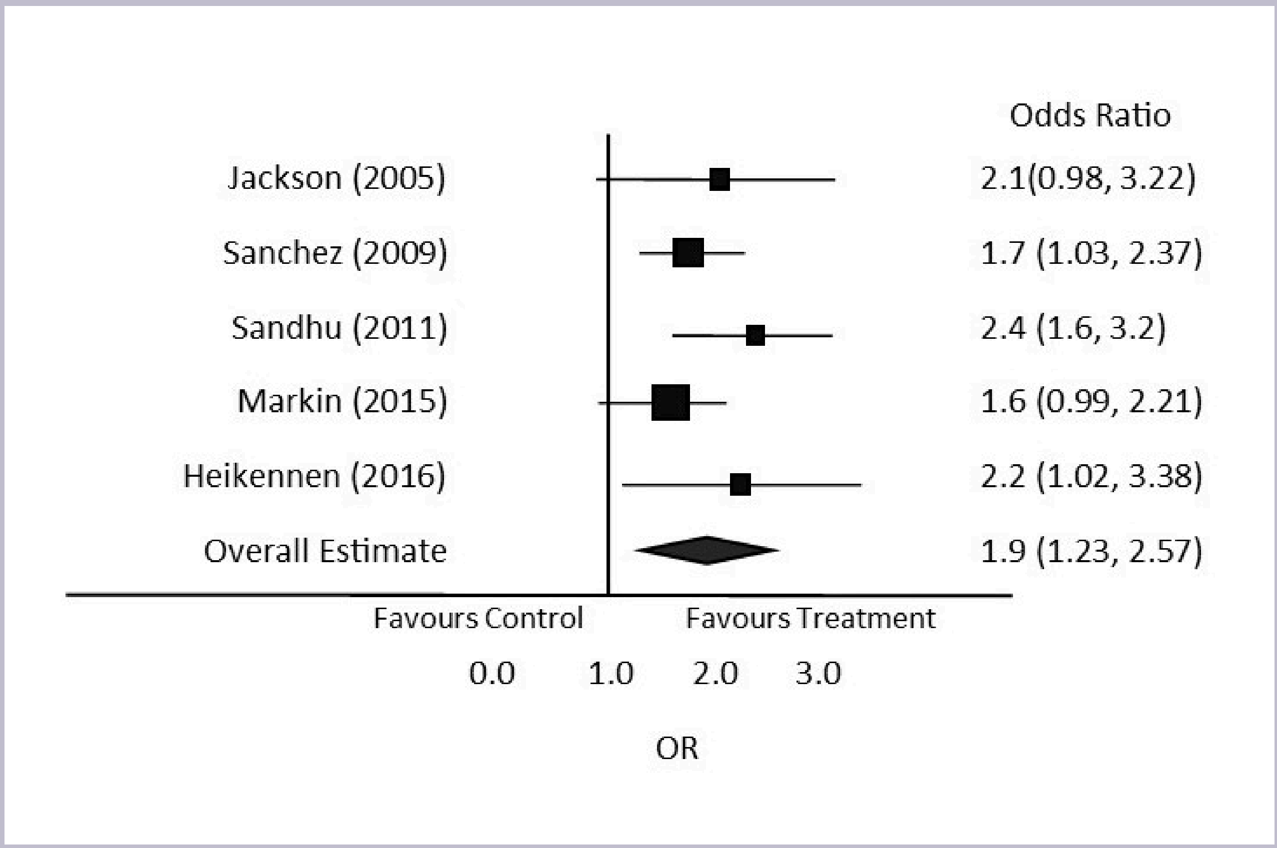
Horizontal lines: Indicate the confidence interval calculated for each study.

See image below to review some standard features of a forest plot:

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://opentextbc.ca/nursingnumeracy/?p=139#h5p-46

Sample Exercise 20.7

Refer to the image of the sample forest plot to answer the following questions:



1. Which individual study has the smallest sample size?
2. What is the calculated odds ratio of the overall estimate?

3. Which individual studies are statistically significant?
4. If the odds ratio of > 1 favours the treatment over the control, does this summary of study data suggest the treatment has an effect on the outcome being studied?

Answers:

1. Sandhu (2011). The sample size correlates to the size of the square. It is the smallest square on the forest plot, therefore it has the smallest sample size.
2. 1.9
3. The studies by Sanchez, Sandhu and Heikennen. They are considered statistically significant because the confidence interval does not cross the line of no effect.
4. Yes. The diamond is to the right of the line of no effect, and the graph is labelled as favouring treatment on the right side of the line of effect.

Critical Thinking Questions

1. If a finding is considered statistically significant, should we then conclude this is something which should now be adopted as part of our practice?
2. In a particular study, if alpha = 0.01, are the researchers seeking more or less certainty in their findings than if alpha = 0.05?

Answers:

1. Not necessarily, there are more factors to consider that just statistical significance of an effect. Additional analysis should be undertaken to determine if a particular approach should be used, and the type of analysis will depend on the subject of the study. For instance, if you were considering whether or not to use a new drug, you would also need to analyze for potential serious adverse reactions and determine if it is a cost-effective treatment.
2. The researchers are looking for more certainty when determining whether or not to reject the null hypothesis. If p = 0.01, this would mean there is a 1% chance of the null hypothesis being true.

Key Takeaways

- Inferential statistics is used to analyze sample data when making estimates, predictions and conclusions about populations.

- Risk is a measurement of how likely an outcome will occur in a particular group, often written as a percentage.
- Relative risk is the chance of an event occurring between two experimental groups.
- Odds are a measure which compares the probability of something happening versus it not happening.
- The odds ratio is used to compare the difference in odds between groups.
- P-values are calculated to help identify if a null hypothesis should be accepted or rejected. They help determine if study results are just a coincidence by estimating what chance there is of the effect found to be related to sampling error.
- Confidence intervals of a sample statistic describe the range in which the true population parameter is likely to be in and give the probability of how often it would be found in the range.
- Meta-analysis is a process used to for statistical analysis of data pooled from comparable studies.
- Forest plots are used to graphically summarize the comparison of results of multiple studies used in a meta-analysis.

Practice Set 20.1: Calculating Risk

Practice Set 20.1: Calculating Risk

Calculate the risk in the following scenarios.

1. 1,000 people are exposed to a particular protozoa while swimming in a tropical lake. 54 people become infected and exhibit symptoms of disease. What is the risk of developing the disease?

2. A study is completed to review the risk of a particular disease developing during childhood. 100,000 cases were reviewed and it was found that 3,411 children developed the disease. What is the risk of developing the disease?

3. 150,000 people in a small town use a particular reservoir for all of their drinking water. A toxic spill occurs in the reservoir and 2, 347 people suffer with symptoms of poisoning. What is the risk of being poisoned by this substance?

4. Researchers review 10,000 cases of people who were diagnosed with a particular

cancer. 8,984 people survived 5 years after treatment was complete. What is the risk of death within 5 years of completion of treatment?

5. A new drug is being tested for treatment of hypertension. Researchers determine the drug is effective at reducing blood pressure, but are concerned with the possibility of severe adverse reactions. Of the 100 people who receive the drug, researchers determine 7 people have severe adverse reactions. What is the risk of developing a severe adverse reaction?

Answers:

1. $\frac{54}{1000} = 0.05$ or 5%
2. $\frac{3411}{100000} = 0.03$ or 3%
3. $\frac{2347}{150000} = 0.02$ or 2%
4. $\frac{1016}{10000} = 0.1$ or 10%
5. $\frac{7}{100} = 0.07$ or 7%

Practice Set 20.2: Calculating Relative Risk

Practice Set 20.2: Calculating Relative Risk

Calculate relative risk for the following questions and write a statement in your own words describing the relative risk.

1. Two treatments for stage 3 ovarian cancer are being compared. A new treatment, treatment A, has a probability of 10 year survival of 88 %. The current treatment, treatment B, is 67 %.
2. Cure of a fungal nail infection is determined to be 0.62 with drug A and 0.45 with drug

B.

3. Two drugs for the treatment of pulmonary embolism are being studied. The probability of resolution of the embolism is 0.7 for drug A and 0.87 for drug B.
4. The risk of nephropathy after using a particular contrast dye, “dye x” for CT preparation in people with diabetes is 32 %. The calculated risk of the control group is 21%.
5. The risk of a serious birth defect occurring for treatment of a maternal infection during the first trimester with drug X is 0.003 and is 0.011 for drug Y.

Answers:

1. $\frac{88}{67} = 1.31$
   The 10 year survival rate using treatment A compared to treatment B is increased by 1.3 fold.
2. $\frac{0.62}{0.45} = 1.38$
   drug A is 1.38 times more likely to cure the fungal nail infection than drug B.
3. $\frac{0.7}{0.87} = 0.82$
   The likelihood of resolution of a pulmonary embolism using drug A is 0.8 times less likely than using drug B.
4. $\frac{32}{21} = 1.52$
   The risk of nephropathy after using contrast dye “X” in people with diabetes is 1.52 times more likely than those without diabetes.
5. $\frac{0.003}{0.011} = 0.27$
   The risk of developing a serious birth defect during the first trimester, while treating a maternal infection, is 0.27 times less likely with drug X.

Practice Set 20.3: Calculating Odds

Practice Set 20.3: Calculating Odds

Calculate the odds in the following scenarios.

1. Self reported patient anxiety is reduced by at least 3 points on a scale of 1 – 10 after the nurse guides the patient through a deep breathing exercise in 945 out of 1000 cases.
2. Heart disease develops after daily use of a new sugar substitute over a one year period in 7/100 cases studied.
3. In a study measuring the occurrence of febrile seizures in children 5 years and younger, researchers determined out of 1000 children with a particular illness resulting in fever, 49 experienced a febrile seizure.
4. A year long research study was being conducted on a potential new treatment for myalgic encephalomyelitis. The treatment resulted in improvement of daily fatigue ratings during the study period in 211 out of 500 cases.
5. A study of a new dietary treatment plan for drug-resistant epilepsy found 77 of 1000 people attained six months being seizure free.

Answers:

1. $\frac{945}{55} = 17.2$
2. $\frac{7}{93} = 0.08$
3. $\frac{49}{951} = 0.05$
4. $\frac{211}{289} = 0.73$
5. $\frac{77}{923} = 0.08$

Practice Set 20.4: Calculating Odds Ratio

Practice Set 20.4: Calculating Odds Ratio

Calculate the odds ratio for the following scenarios.

1. Self reported patient anxiety is reduced by at least 3 points on a scale of 1 – 10 after the nurse guides the patient through a deep breathing exercise in 945 out of 1000 cases. An alternate deep breathing exercise reduced anxiety by at least 3 points on a scale of 1 – 10 in 722 out of 987 cases.
2. Heart disease develops after daily use of a new sugar substitute over a one year period in 7/100 cases studied. A commonly used sugar substitute was also studied, and researchers found heart disease developed in 1/100 cases.
3. Researchers measure the effect of two potential new drugs for the treatment of neuropathic pain. Drug A achieved a reduction of moderate pain to mild pain in 32/100 cases. Drub B achieved a reduction of moderate pain to mild pain in 15/100 cases.
4. The effects of two exercise programs on increasing range of motion (ROM) during the rehabilitation phase of a grade 3 ankle sprain are studied. Researchers find that participants using exercise program A achieved an acceptable ROM in 82/98 cases. Participants using exercise program B achieved an acceptable ROM in 84/100 cases.
5. A study is measuring the severity of nausea in two chemotherapy drugs with similar effectiveness in treating a particular cancer. Researchers find study participants receiving chemotherapy drug A have a nausea rating of at least 4 on a scale of 0-10 in 645/978 cases. Participants receiving chemotherapy drug B have a nausea rating of at least 4 in 552/967 cases.

Answers:

1. Calculate the odds for each study group. Divide the odds of the first group by the odds of the second group. The odds ratio is 6.4
   $$\frac{945}{55} = 17.2 \frac{722}{265} = 2.7 \frac{17.2}{2.7} = 6.4$$
2. The odds ratio is 8
   $$\frac{7}{93} = 0.08 \frac{1}{99} = 0.01 \frac{0.08}{0.01} = 8$$
3. The odds ratio is 2.6

$$\frac{32}{68} = 0.47 \frac{15}{85} = 0.18 \frac{0.47}{0.18} = 2.6$$

4. The odds ratio is 0.98
$$\frac{82}{16} = 5.13 \frac{84}{16} = 5.25 \frac{5.13}{5.25} = 0.98$$

5. The odds ratio is 1.46
$$\frac{645}{333} = 1.94 \frac{552}{415} = 1.33 \frac{1.94}{1.33} = 1.46$$

Practice Set 20.5: P-Values Fill in the Blanks

Practice Set 20.5: P-Values Fill in the Blanks

An interactive H5P element has been excluded from this version of the text. You can view it online here:
https://opentextbc.ca/nursingnumeracy/?p=139#h5p-47

Practice Set 20.6: Interpreting P-Values

Practice Set 20.6: Interpreting P-Values

For the following questions, state if the p-value is considered to be statistically significant. Is the null hypothesis accepted or rejected?

1. A study is undertaken to compare the effect of a particular variable on the development of atrial fibrillation compared to a control group. Alpha is 0.01. The P-value is 0.27.

2. A researcher presents the results of a study. Alpha is 0.01. The P-value is 0.012.
3. A study is undertaken to compare the effect of a particular variable on the development of ulcerative colitis compared to a control group. Alpha is 0.01. The P-value is 0.003.
4. A researcher presents the results of a study. Alpha is 0.05. The P-value is 0.077.
5. A study is undertaken to compare the effect of a particular variable on the development of multiple sclerosis compared to a control group. Alpha is 0.05. The P-value is 0.038.
6. A researcher presents the results of a study. Alpha is 0.01. The P-value is 0.0026.
7. A study is undertaken to compare the effect of a particular variable on the development of Parkinson's disease compared to a control group. Alpha is 0.01. The P-value is 0.87.
8. A researcher presents the results of a study. Alpha is 0.01. The P-value is 0.25.
9. A study is undertaken to compare the effect of a particular variable on the incidence of asthma compared to a control group. Alpha is 0.05. The P-value is 0.016.
10. A researcher presents the results of a study. Alpha is 0.05. The P-value is 0.096.

Answers:

1. The P-value is not statistically significant and the null hypotheses is accepted.
2. The P-value is not statistically significant and the null hypotheses is accepted.
3. The P-value is statistically significant and the null hypotheses is rejected.
4. The P-value is not statistically significant and the null hypotheses is accepted.
5. The P-value is statistically significant and the null hypotheses is rejected.
6. The P-value is statistically significant and the null hypotheses is rejected.
7. The P-value is not statistically significant and the null hypotheses is accepted.
8. The P-value is not statistically significant and the null hypotheses is accepted.
9. The P-value is statistically significant and the null hypotheses is rejected.
10. The P-value is not statistically significant and the null hypotheses is accepted.

Practice Set 20.7: Confidence Intervals

Practice Set 20.7: Confidence Intervals

1. If the sample size of a study was increased, what is likely to happen to the size of the confidence interval? Why?
2. Data is collected to estimate how many hours of sleep fourth year nursing students receive per night. Researchers report a 95% CI of a population mean between 6.8 – 8.7. Is it possible that the average amount of sleep per night is less than 6.8?
3. For a confidence interval reporting 99.7% confidence, how many standard deviations away from a sample mean are used to determine the interval numbers?
4. Study data is analyzed comparing a placebo to a treatment for the reduction of pregnancy related nausea, with numbers lower than 1 favouring the placebo. The following statistics are reported:

   Odds ratio 1.57 (1.27, 1.87) with 95% CI

   Explain the above statistic in your own words. What do each of the numbers represent?
5. A study is completed to explore the effects of a variety of birth control methods on menstrual pain. One effect researchers were curious about was the highest level of pain reported in each menstrual cycle over a period of one year. Pain is measured on a scale of 0-10 and the following results are reported:

   Control Group 95% CI 3.8 (3.1, 4.5)

   Option A 95% CI 5.6 (5.2, 6.0)

   Option B 95% CI 3.9 (2.9, 4.9)

   Option C 95% CI 2.1 (1.5, 3.6)

   a. What is the average highest pain rating for the control group?

   b. Is there a group whereby the sample mean indicates a lower rating of pain than the control? If so, which group?

   c. Is there a group whereby the population mean is likely to be higher than the control group? If so, which group?

   d. If the researchers wanted to report a 99.7% confidence interval, what would happen to the size of the intervals for each group?

Answers:

1. The confidence interval would likely decrease because as the sample size is increased,

the amount of standard error is reduced. (Assuming the sample taken remains a random sample of the population).

2. Yes, it is possible the true population mean is outside of the reported range. It can be higher or lower than the reported interval, therefore it could be less than 6.8.

3. To report with 99.7% confidence, a statistician would use the numbers three standard deviations above and below the sample mean to determine the confidence interval.

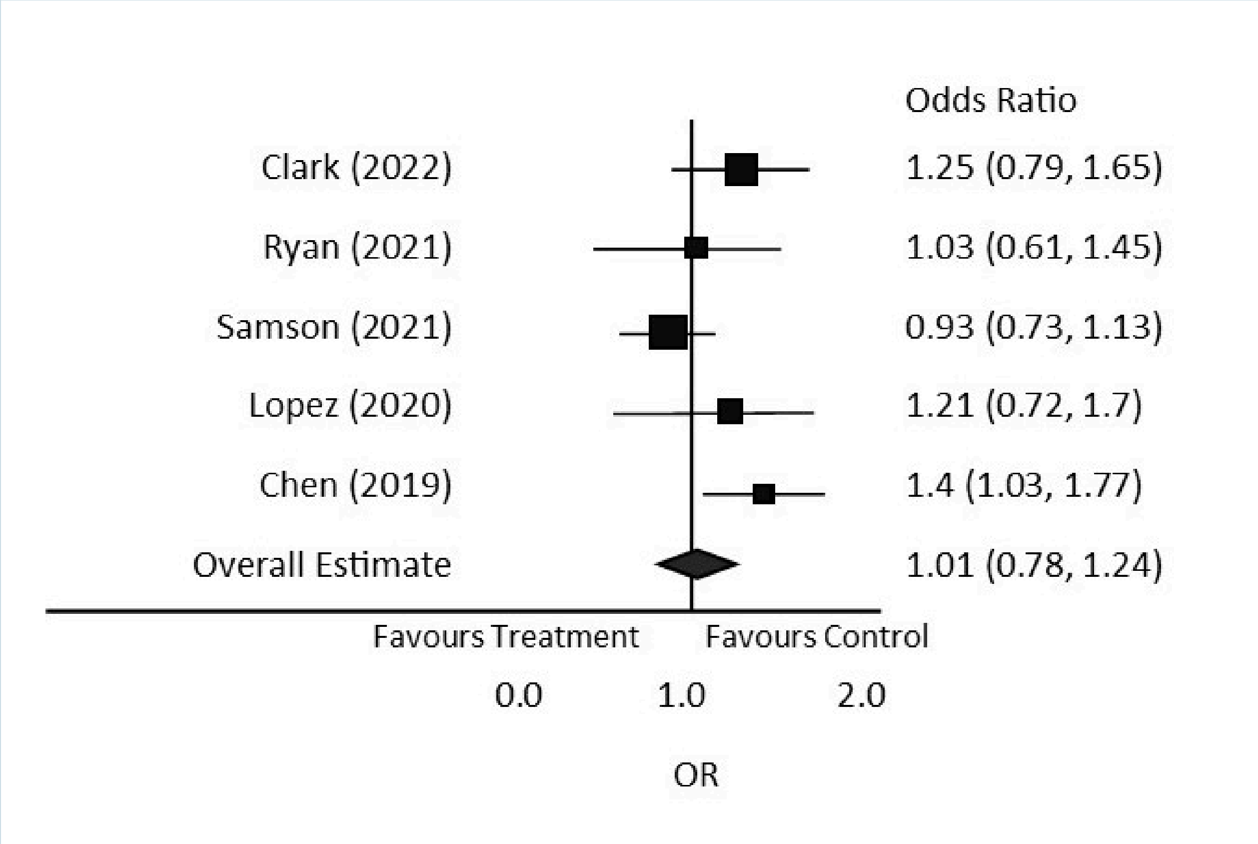
4. The treatment is estimated to be 1.57 times more likely to reduce nausea than the placebo. In 95% of well chosen samples, the true odds ratio will fall in the range of 1.27 to 1.87.

5. a. 3.8/10
b. Option C
c. Option A
d. The size of the intervals would increase, as the intervals reported would need to be 3, instead of 2, standard deviations away from the sample mean.

Practice Set 20.8-20.9: Interpreting Forest Plots

Practice Set 20.8: Interpreting Forest Plots

The image below depicts a forest plot comparing the results of multiple studies. Refer to the image of the sample forest plot to answer the following questions:



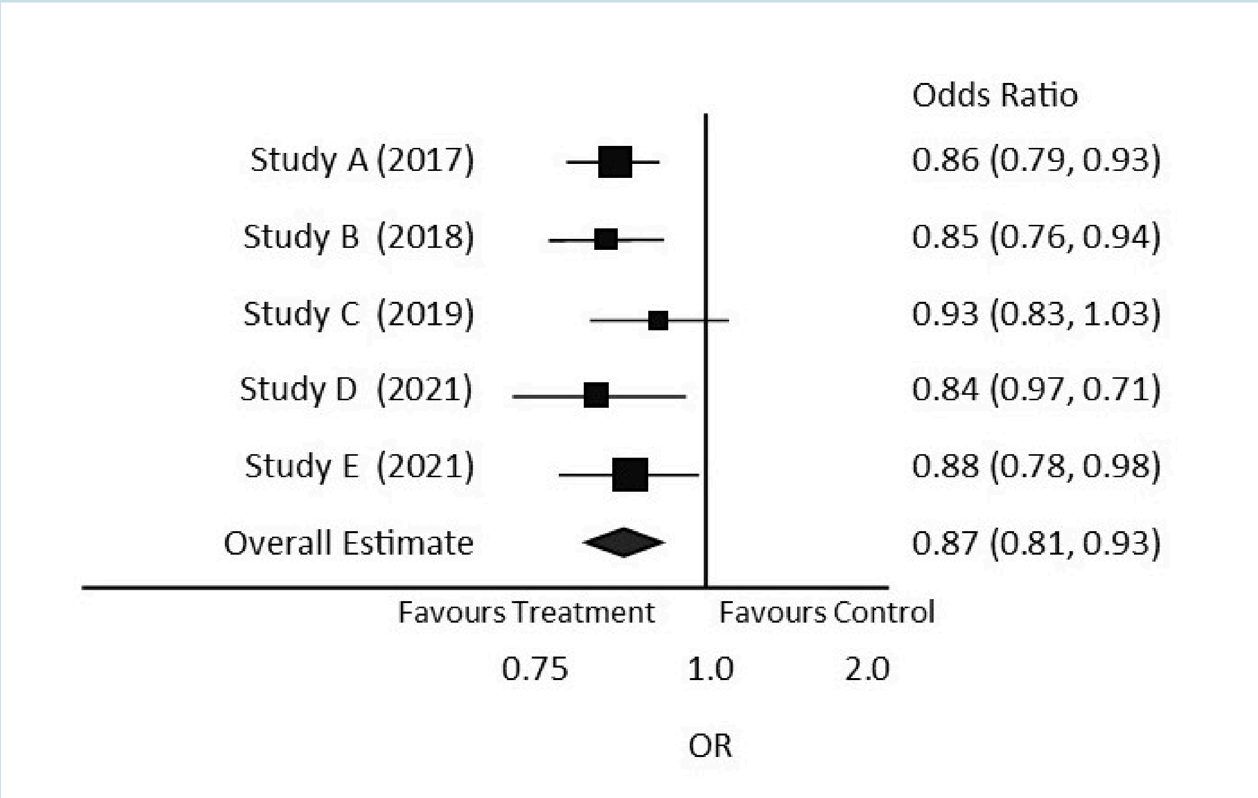
1. What does the vertical line represent?
2. Are the findings of this meta-analysis considered to be statistically significant?
3. Which study has the largest effect on the overall summary?
4. Which study or studies have significant results?

Answers:

1. The line of no effect.
2. No, the diamond shape crosses the vertical line of no effect, so the results are not considered to be statistically significant.
3. Samson (2021)
4. Chen (2019) is the only study with statistically significant results because it does not cross the line of no effect.

Practice Set 20.9: Interpreting Forest Plots

The image below depicts a forest plot comparing the results of multiple studies. Refer to the image of the sample forest plot to answer the following questions:



1. What study has the smallest sample size?
2. Is the overall summary considered to be statistically significant?
3. Which individual studies are considered to be statistically significant?
4. Which study has the largest confidence interval?

Answers:

1. Study C
2. Yes, it does not cross the line of no effect.
3. Study A, B, D and E are statistically significant as they do not cross the line of no effect.

4. Study D

V

Interpreting Lab Values

In this section you will be introduced to ways to measure, report, and analyze laboratory values. Topics such as units of measurement, reference ranges, and critical values are discussed as they relate to interpretation of laboratory values in individuals.

21.

Introduction to Interpretation of Lab Values

Lesson

Learning Outcomes

By the end of this chapter, learners will be able to:

- explain types of units used in laboratory testing (Conventional and Standard International Units),
- explain the use of reference ranges and critical values, and
- describe factors which affect the interpretation of numerical lab results.

Units in Laboratory Testing

At times, individuals will have various laboratory (lab) tests taken to aid in monitoring their health. Generally, you will come across lab results measured in Standard International (SI) units. Conventional Units (CU) are used in some settings, particularly in the United States, and so you may come across lab values using conventional units in American learning activities or when reviewing results in a client's chart if they were transferred from the United States. If you find yourself needing to convert between CU and SI units, there are a variety of conversion charts outlining conversion factors (CF) online. In some lab tests, the type of units used in conventional and SI systems are the same. Included in the table below are examples of differences in types of units used for some common lab tests. Do you recall what the unit abbreviations stand for? Refer back to the conversion table as needed.

Table 21.1 Examples of Laboratory Tests

Lab Test	Example for Conventional Units	Example for Standard International Units	Conversion Factor
hemoglobin	13.4 g/dL	134 g/L	10
potassium, serum	3.9 mEq/L	3. 9 mmol/L	1
thyroxine, free	1.1032 ng/dL	14.2 pmol/L	12.871

To convert between units without a conversion calculator, use the following formulas:
CU x CF = SI Units
SI Units/CF = CU

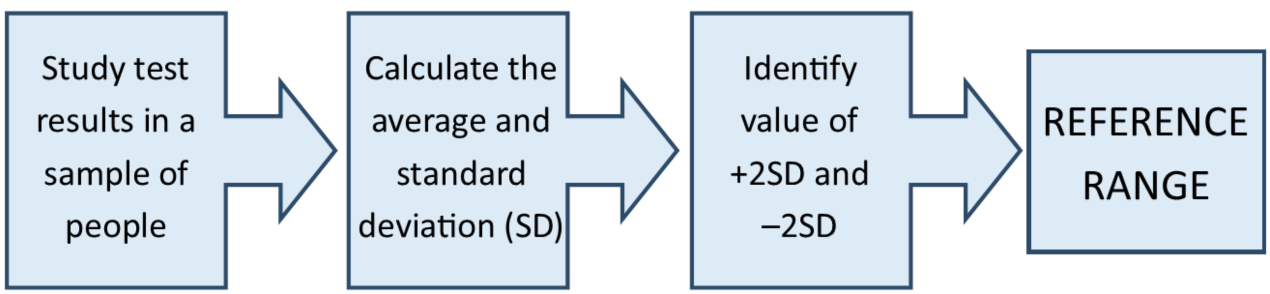
Reference Ranges

When a lab test is measuring an amount of a particular substance in the body, it is typical that normal results will vary slightly between individuals. A reference range shows a spread of possible values you would expect to find for a particular test and is usually reported alongside the results of the lab test.

Serum Potassium Reference Range = 3.5 to 5.0 mmol/L

This means any value below 3.5 is considered low, and any value above 5.0 is considered high.
Therefore, most people have a normal value between 3.5 to 5.0 mmol/L.

These ranges are based on the results of studies which measure the results of a particular lab test in a large number of people. Researchers identify the average result and show the distribution of possible values in a graph. They determine what the **standard deviation** is for a particular laboratory test and identify values for up to 3 standard deviations away from the average result. Reference ranges usually correlate to the values of 2 standard deviations below and above the average value calculated from the study. This means that some people will have a normal value slightly outside of the reference range.



It's worth noting a study must follow best practice guidelines in order to ensure that the results are valid. For instance, the population sample used in a study should be diverse, so results are not skewed. If a researcher was trying to determine a reference range for hemoglobin and the majority of the study participants had a diagnosis of anemia, the resulting average value of hemoglobin would likely be much lower than if the study participants had a diverse distribution of characteristics which could affect the value being studied. This would not give a good representation of average hemoglobin levels.

Sometimes, there are multiple reference ranges for a particular test because characteristics like age and sex affect the amount of some substances in our bodies. Other factors which can affect laboratory results are time of day or a specific phase of a person's menstrual cycle. The following tables show some examples where multiple reference ranges are used for a particular test.

Table 21.2 Reference Ranges for Potassium Based on Age

Age	Reference Ranges
Newborn	4.5 to 7.2 mEq/L
2 days to 3 months	4.0 to 6.2 mEq/L
3 months to 1 year	3.7 to 5.6 mEq/L
1 year to 16 years	3.5 to 5.0 mEq/L
Adult	3.5 to 5.0 mEq/L

Table 21.3 Reference Ranges for Testosterone

Sex	Reference Ranges
Female	≤ 2.6 nmol/L
Male	6.1 to 27.1 nmol/L

Table 21.4 Reference Ranges for Follicle-Stimulating Hormone (FSH) in Females

Phase	Reference Ranges
Midfollicular Phase	3.9 to 8.8 IU/L
Midcycle Peak	4.5 to 22.5 IU/L
Midluteal Phase	1.8 to 5.1 IU/L
Postmenopausal	16.7 to 113.6 IU/L

You may notice that reference ranges at particular laboratories may be reported differently from those in a diagnostic manual, as there are some factors which can affect the results of particular tests. For example, arterial blood gas (ABG) results are affected by altitude. Therefore, a laboratory in Banff, Alberta (the city with the highest altitude in Canada) may list their ABG results with a slightly different reference range that Vancouver, British Columbia (at sea level). In other cases, the way that a specific test is processed at an individual laboratory varies, and may result in slightly different test results.

Table 21.5 Comparison of Reference Ranges For Hemoglobin

Source	Adult Female	Adult Male
Medical Council of Canada	115 to 155 g/L	125 to 170 g/L
Health Link BC	120 to 160 g/L	140 to 174 g/L

Health Link BC. (2021, December). *Complete blood count.* https://www.healthlinkbc.ca/tests-treatments-medications/medical-tests/complete-blood-count-cbc

Medical Council of Canada. (2023). *Clinical laboratory tests: Adult normal values.* https://mcc.ca/objectives/normal-values/

PediaMCU: Cairo University Specialized Pediatric Hospital. (2022). *Reference values for children*. https://pediamcu.com/172/

Critical Thinking Question

How do you access reference ranges for the clinical practice site you are working in?

Critical Values

In some cases, lab test results may be reported with a warning of a critical value to help alert health care staff of serious results. Critical values always fall outside of the reference range. Results with a critical value may pose an immediate threat to a person's wellbeing and require urgent intervention to protect health. Depending on the test, there may only be a critical high or a critical low, or a test might have both a critical high and low. It is also possible that a particular test may not have a critical value associated with it, this often happens in cases where results are reported as positive or negative. For instance, a pregnancy test detecting human chorionic gonadotropin (hCG) do not have a critical result. Each health care site and laboratory you work in will have a particular list of critical values they use and a policy and process for responding to critical values.

Serum Potassium Reference Range = 3.3 to 5.0 mmol/L

Critical Low < 3.0 mmol/L

Critical High > 6.1 mmol/L

Critical Values List ARUP Laboratories National Reference Laboratory

Interpreting Lab Values

Reference ranges and critical values are important to understand when interpreting lab results, but they are not the only factors to be considered when determining what the result means for an individual. Interpretation of results often requires knowledge of additional information about the individual's health history and their care plan. In addition, conversations between members of the interdisciplinary team may be necessary in complex situations. It is also important to be mindful of considering whether or not the test results are accurate. Here are some questions you can ask yourself to guide your critical thinking process when interpreting lab results. Please note that these questions are focused on the interpretation of numerical values of the lab results and do not encompass all of the nursing care and assessments required for patients who have abnormal lab results! Practice exercises in this chapter are focused on individual lab tests, however in actual nursing practice you will often be interpreting results of multiple lab tests in conjunction with each other.

- How does the actual result compare to the result I expected for this person?
    - Did I expect the result to be positive or negative, high, low or within the reference range?
    - Has the person received a recent intervention which would cause a change in this test result?
    - What was the previous result of this test (if it has been done before)?
- What do I know about their current condition and their history that would tell me about why this result was obtained?
    - Does this person have a health issue that would impact the result of this test?
    - Does the person have assessment findings that correlate with the result of the test?
    - How quickly are test results changing?
- How accurate are the test results?
    - Was there anything that interfered with any part of the procedure which could impact accuracy?
    - Are there any conditions which could cause a false positive or false negative for this person?
- Does this person require follow up care based on the test result?
    - What is the person's goal of care?
    - What is the person's code status?
    - Does the person want or need education about the result?
    - What kind of monitoring is required?
    - What symptoms would I expect to see based on the result of the test?
    - Has the person received new orders from the primary care provider?
- What else do I need to know to effectively care for this person?
    - Do I need to connect with other members of the interprofessional team?
    - What reference materials can I access to increase my understanding related to this topic?

You are caring for a client on the second day after having a total hip arthroplasty. You are following up on the client's daily hemoglobin test on post op day 2. Here is a sample of how you might use the following prompting questions to interpret the client's hemoglobin result. We will use the following information to work through this example:

Client MB, male, age 71, full code. No history of bleeding disorders.
Hemoglobin results: Pre op 162 g/L, Post op day 1 125 g/L, Post op day 2 79 g/L, Reference range 125 to 170 g/L.
Pain level 4/10, moderate shadowing to hip dressing. Appears somewhat pale and reports feeling tired today.

- How does the actual result compare to the result I expected for this person?
    - Did I expect the result to be positive or negative, high, low or within the reference range? *Considering if there was visible bleeding, how saturated the dressing was (the client had moderate shadowing to the dressing) and typical prognosis after a total hip surgery, I expected the client to have a lower value for hemoglobin today. The reference range given by the lab is 125 to 170 g/L. (If you do not see a reference range in a case study question, refer to a diagnostic and lab test manual).*
    - Has the person received a recent intervention which would cause a change in this test result? *I would consider if they had a recent blood transfusion, what typical blood loss is like during a total hip arthroplasty.*
    - What was the previous result of this test (if it has been done before)? *I would refer back to the previous results on the chart-I see the previous results were 162 and then 125.*
- What do I know about their current condition and their history that would tell me about why this result was obtained?
    - Does this person have a health issue that would impact the result of this test? *Yes, they just had a major surgery.*
    - Does the person have assessment findings that correlate with the result of the test? *I would look to see if VS had changed today (particularly drop in blood pressure or increase in heart rate). I'll observe for skin condition (CWMS) , saturation or shadowing on the dressing and the client's reported feeling of pain, energy levels and anxiety.*
    - How quickly are test results changing? *Relatively quickly, there was a significant drop both days.*
- How accurate are the test results?
    - Was there anything that interfered with any part of the procedure

which could impact accuracy? *no*
    - Are there any conditions which could cause a false positive or false negative for this person? *no*
- Does this person require follow up care based on the test result?
    - What is the person's goal of care? *To regain mobility post op and be discharged home. I would also need to know if they accept blood products as part of their treatment plan.*
    - What is the person's code status? *Full code, this indicates I anticipate treatment for low hemoglobin to be given, as warranted by specific test results.*
    - Does the person want or need education about the result? *I would need to ask if the client understood the results given by the primary care provider and/or if they wanted further information.*
    - What kind of monitoring is required? *VS, surgical site and dressing, client's subjective symptoms, repeat lab work.*
    - What symptoms would I expect to see based on the result of the test? P*otential change in skin colour, becoming paler, fatigue or weakness, possible shortness of breath or other symptoms related to reduced oxygenation to tissues.*
    - Has the person received new orders from the primary care provider? *I would need to check the chart for further orders, anticipating a potential blood transfusion or support with intravenous fluids*
- What else do I need to know to effectively care for this person?
    - Do I need to connect with others members of the interprofessional team? *I need to ensure the primary care physician is aware of the results, I would inform the physio or rehab assistant if they were coming in soon to assist with mobilizing the client.*
    - What reference materials can I access to increase my understanding related to this topic? *Diagnostic test manual, articles related to blood loss and hip arthroplasty.*

Sample Exercise 21.1

You are working with a person admitted with dehydration to an acute care medical unit, after experiencing several days of vomiting and diarrhea associated with gastroenteritis. They have a history of chronic renal failure, requiring hemodialysis three times a week on Monday, Wednesday and Saturday. On Friday morning, you receive results from their daily lab work and see their serum potassium result is 5.6 mmol/L. Your nursing instructor asks if you are concerned about this finding. How do you respond? (Use the suggested questions in the section on interpreting lab results to help guide your answer).

For additional information on hyperkalemia refer to the following source: Simon, L. V., Hashmi, M. F., & Farrell, M. W. (2022). Hyperkalemia. In *StatPearls*. StatPearls Publishing. https://www.ncbi.nlm.nih.gov/books/NBK470284/

Answers:
Suggested exemplary response of a senior nursing student, based on the available information (your answer will vary depending on how much you have learned about fluid and electrolyte imbalance, renal failure and dialysis, and the amount of experience you have had in the clinical practice setting):

A serum potassium of 5.6 mmol/L is higher than normal, but I know potassium excretion is impaired in people with chronic renal failure. I also think you can lose potassium when someone has a lot of vomiting and diarrhea with gastroenteritis, so I don't think the potassium is raised related to their admission diagnosis. I know that dialysis will help to reduce the potassium level, and they are scheduled for dialysis tomorrow. I want to know if this is a typical result for this person because I'm not sure how much their potassium usually increases between dialysis runs. I can check the electronic record to compare to their previous lab results. I wonder if they changed their dialysis treatment on Wednesday because they were worried about them losing too much potassium when they were experiencing a lot of vomiting and diarrhea with their gastroenteritis? I haven't noticed any symptoms associated with hyperkalemia, but I'll continue to monitor for muscle pain, weakness or numbness and heart palpitations throughout my shift and report my findings to the primary nurse. Pseudohyperkalemia can occur if the sample wasn't taken correctly, but if the result is similar to their previous potassium levels on Fridays then I don't think this is likely (Simon, S. L. et al., 2022). I will see if the physician has seen them this morning yet, and if not discuss the result and treatment plan with them when they arrive. I'm not sure if they would order any medications to reduce the potassium today or check their potassium again before their dialysis run tomorrow. I'm a bit concerned because hyperkalemia can have serious side effects when it starts to get higher, but right now I think I need to check on their previous results to see if this is typical and to see how much it has increased since yesterday. I'm also not sure if the client is on any medications which would increase potassium. Is there anything else I should be considering?

Critical Thinking Questions

1. What would you do if a critical result was reported to you while caring for a patient in the hospital?
2. Do you think a client with a critical low result will always receive intervention from the healthcare team?

3. A male client has a hemoglobin of 124 g/L. How concerned are you? What additional information do you need to consider when interpreting this lab result?
4. How do you approach the use of reference ranges for gender diverse clients?

Answers:

1. Several things should be considered in related to this question:
    a. What is your scope, what is your school's policy, and what is the agency policy?
    b. Who do you need to communicate this result to and how fast should you be reporting the result? How do you document your communication and actions?
    c. What should be done in relation the particular result that was critical and the context of the individual?
2. Discussion should focus on what is appropriate for the particular individual, and what intervention means.
    a. Is this the first time the result has been reported, or a repeat result?
    b. Have interventions been initiated already (prior to the lab test) that we expect will shift the individual's future results?
    c. What does intervention look like from various members of the healthcare team? (education, new orders, increased monitoring or assessments, symptom management, etc.)
    d. What is the goal of care for this person?
3. Several factors can influence the significance of this result.
    a. What is the reference range given by the lab which reported the result?
    b. What have past hemoglobin levels been for this person?
    c. What factors do you know of in the person's history and current condition that might influence the current result?
    d. Is the person actively bleeding, and if so, by how much?
4. At this time, there are no reference ranges specific to diverse gender expressions. As reference ranges are reported as male or female for some tests, a decision must be made to determine if a particular reference range is most appropriate to use for a particular test. The decision might be made by a laboratory staff member, or in partnership with the person's primary health care provider or specialist, such as an endocrinologist. At other times, the primary care provider might refer to both male and female reference ranges of a particular test. For transgender people, reference ranges will be selected based on the affirmed gender if a person is using gender-affirming hormone therapy (Cheung, 2020). In some cases, gender-affirming hormone therapy will affect the results obtained. For example, erythropoiesis has been found to be affected by treatment with full-dose gender affirming hormone therapy, and tests such as hemoglobin will

shift after treatment is started (Cheung, 2020). Tests dependent on organ size may continue to use reference ranges for the person's assigned sex at birth, such as prostate specific antigen and cardiac troponin (Cheung, 2020). As a student nurse, you should be considerate of the language you are using when providing education and information to people about their lab results to ensure you avoid misgendering people and are sensitive to situations which may be triggering for the person. The article by Irwig (2021) provides an in depth commentary on this topic, and includes ideas for ways to improve health care systems to support better care for transgender and gender diverse patients in relation to effective lab testing.

References:

Cheung, A. S., Lim, H. Y., Cook, T., Zwickl, S., Ginger, A., Chiang, C., & Zajac, J. D. (2020). Approach to interpreting common laboratory pathology tests in transgender individuals. *The Journal of Clinical Endocrinology & Metabolism, (106)*3, 893-901. https://doi.org/10.1210/clinem/dgaa546

Irwig, S. M. (2021). Which reference range should we use for transgender and gender diverse patients? *The Journal of Clinical Endocrinology & Metabolism, 106*(3), 1479–1480. https://doi.org/10.1210/clinem/dgaa671

Key Takeaways

- Laboratory results can be reported in Conventional or Standard International Units.
- Conversion factors can be used to convert between the types of units.
- Reference ranges identify the spread of lab values when values fall in a range.
- Reference ranges for a particular test may vary between individual laboratories or for individuals with particular characteristics (eg. age, sex)
- Critical values refer to lab values which fall out of the normal reference range and are considered to be an immediate threat to health.
- Interpreting lab values requires consideration of multiple factors related to the context of the individual.

Practice Set 21.1

Practice Set 21.1: Interpreting blood glucose

You are caring for a client admitted to the acute care medical floor with cellulitis. They have a history of hypertension and type I diabetes.

Admission orders include:

hydrocholothiazide 12.5 mg
insulin aspart SC – see sliding scale QID
glargine 15 units SC OD
ramipril 5mg PO OD
cephalexin 500 mg PO QID

It is the beginning of day shift, 0730, and you have just taken a blood glucose test using the glucometer on the ward to check the client's blood glucose this morning. The result was 23.2. Use the following suggested questions to discuss the result. Make note of additional information you might need to gather when answering these questions.

1. How does the actual result compare to the result I expected for this person?
    a. Did I expect the result to be positive or negative, high, low or within the reference range?
    b. Has the person received a recent intervention which would cause a change in this test result?
    c. What was the previous result of this test (if it has been done before)?
2. What do I know about their current condition and their history that would tell me about why this result was obtained?
    a. Does this person have a health issue that would impact the result of this test?
    b. Does the person have assessment findings that correlate with the result of the test?
    c. How quickly are test results changing?
3. How accurate are the test results?
    a. Was there anything that interfered with any part of the procedure which could impact accuracy?
    b. Are there any conditions which could cause a false positive or false negative for this person?
4. Does this person require follow up care based on the test result?

   a. What is the person's goal of care?
   b. What is the person's code status?
   c. Does the person want or need education about the result?
   d. What kind of monitoring is required?
   e. What symptoms would I expect to see based on the result of the test?
   f. Has the person received new orders from the primary care provider?

5. What else do I need to know to effectively care for this person?
   a. Do I need to connect with others members of the interprofessional team?
   b. What reference materials can I access to increase my understanding related to this topic?

Answers:

1. You will need to consider if you anticipate the client's results to be within or outside the reference range. Depending on the client's use of insulin, food intake, and metabolic needs, you might be able to make a prediction about if there blood sugar should be within, above, or below, the reference range. You should also be comparing the value to the previous blood glucose readings and identify if they have had recent changes in their insulin dose.
2. The client has a history of type I diabetes and has a current infection, which can contribute to an increase in blood glucose due to the stress response of the body. You would need to assess for signs and symptoms of high blood glucose to see if the glucose reading correlates to the patient presentation. Has there been a sudden increase in the blood glucose reading? If so, is there anything else you could find from your assessment that would correlate to a sudden increase in blood glucose? For instance, what has your client's intake been? Did they receive their last dose of insulin?
3. Was the test done correctly? Has the blood glucose machine been calibrated? Is the reading at a level that would require a repeat test to confirm accuracy?
4. How will the client's blood glucose be managed? In this case, it needs to be reduced and will require a phone call to the primary care provider to adjust their insulin dose. When will you recheck their blood glucose level? Will you monitor for any additional signs and symptoms? Make sure to check the facility policy on treatment of hyperglycemia. Find out what the client understands about blood glucose during infection. This may be a good opportunity for client teaching.
5. In this case, it may not be necessary for intervention from team members other than the primary care provider at this time. You could consider if there is there a need for this client to meet with the diabetic educator, if there is a knowledge deficit requiring further education prior to discharge. Reference materials could include reference to your nursing textbooks, journal articles and hospital policy documents.

Practice Set 21.2

Practice Set 21.2: Interpreting urine drugs of abuse screen

A client is brought to the emergency department with decreased level of consciousness. On arrival the Glasgow coma scale was 12/15. As part of the investigations, a urine for drugs of abuse screen was taken and is positive for opiates. The client's spouse is adamant the client does not use opiates. No other clear reason for decreased level of consciousness is apparent at this time.

Read the following questions and determine the most important factors to consider for each question.

1. How does the actual result compare to the result I expected for this person?
2. What do I know about their current condition and their history that would tell me about why this result was obtained?
3. How accurate are the test results?

Answers:

1. Were there any medications given in the ER which would impact this test result?
2. A thorough history, including current prescriptions, must be taken if not already complete. If naloxone was given after the test results were received, did it have any effect on the client's condition?
3. Is it possible to have a false positive for opiates from this test? Yes, there are a variety of over the counter and prescription medications which can cause false positives.

Practice Set 21.3

Practice Set 21.3: Interpreting Arterial Blood Gases

A client is admitted to the hospital with hyperemesis gravidarum during the first trimester of pregnancy. They have vomited multiple times today despite taking antiemetics. Additional symptoms include persistent nausea, fatigue, muscle cramps, and mild disorientation. The client is started on IV fluid to rehydrate and undergoes a variety of diagnostic testing, including examination of arterial blood gases.

pH = 7.46
$PaCO_2$ = 50 mmHg

PaO_2 = 97 mmHg
HCO^{3-} = 35 mEq/L

Use the following suggested questions to discuss the result. Make note of additional information you might need to gather when answering these questions.

1. Do these results indicate a specific acid-base imbalance?
2. How does the actual result compare to the result I expected for this person?
    a. Did I expect the result to be positive or negative, high, low or within the reference range?
    b. Has the person received a recent intervention which would cause a change in this test result?
    c. What was the previous result of this test (if it has been done before)?
3. What do I know about their current condition and their history that would tell me about why this result was obtained?
    a. Does this person have a health issue that would impact the result of this test?
    b. Does the person have assessment findings that correlate with the result of the test?
    c. How quickly are test results changing?
4. How accurate are the test results?
    a. Was there anything that interfered with any part of the procedure which could impact accuracy?
    b. Are there any conditions which could cause a false positive or false negative for this person?
5. Does this person require follow up care based on the test result?
    a. What is the person's goal of care?
    b. What is the person's code status?
    c. Does the person want or need education about the result?
    d. What kind of monitoring is required?
    e. What symptoms would I expect to see based on the result of the test?
    f. Has the person received new orders from the primary care provider?
6. What else do I need to know to effectively care for this person?
    a. Do I need to connect with others members of the interprofessional team?
    b. What reference materials can I access to increase my understanding related to this topic?

Answers:

1. These results indicate the client is in a state of partially compensated metabolic alkalosis. The pH is high, therefore the client is in a state of alkalosis. Increases in carbon dioxide would shift the pH downwards and increases in bicarbonate would shift the pH upwards. This means the client is in metabolic alkalosis, since the resulting direction of change in pH of an increased bicarbonate level matches the current state of the pH. It is partially compensated as there are changes in carbon dioxide levels without the pH shifting back to a normal level.
2. Excessive vomiting can lead to metabolic alkalosis in some severe cases. From the information provided, there are no interventions noted which would cause metabolic alkalosis (eg. excessive gastric suctioning). It is unknown if this patient had previous ABGs taken, and there is no past medical history noted which would affect pH balance.
3. The information provided in this case indicates they had persistent, severe vomiting which is a symptom which can lead to alkalosis. Assessment findings which can be associated with metabolic alkalosis include fatigue, muscle cramps and confusion. Therefore, the patient condition correlates with the lab results.
4. You may wonder if the sample result is accurate. Results may not be accurate if the test was not collected, stored or handled properly. You might wonder if it was possible that a venous blood sample was taken and not arterial. Aside from double checking with the person who drew the labs and checking to ensure the order was entered correctly you might consider how a venous sample might differ from an arterial sample. Knowing that a venous blood gas would commonly give a lower pH, slightly higher CO2 and bicarb level, it is unlikely to be a venous sample because the pH is higher that normal.
5. After reviewing the abnormal ABG results, you should determine how often the client needs reassessment. This can be informed by the frequency of vomiting, the client’s current vitals signs, hospital protocols and types of treatment being provided. At minimum, the client will need to be assessed hourly while receiving intravenous fluid replacement. Check the orders to see if there is a repeat ABG ordered for a particular time or other associated lab test results, such as electrolyte levels. Treatments you should expect are fluid replacement and management of nausea and vomiting. In addition, you could be anticipating what other signs and symptoms and complications you should assess for, such as other electrolyte imbalances or signs of worsening condition, such as further changes in orientation, level of consciousness and signs of seizure activity.
6. Review information about collection and interpretation of ABG’s in the hospital lab manual, your nursing textbooks, the hospital library and/or online reference materials.

Glossary

5 number summary

A summary of five statistics describing the distribution of values in a data set (minimum value, first quartile, median value, third quartile and maximum value).

alternate hypothesis

A statement about a population that is contradictory to the null hypothesis, in which a variable has an effect on an outcome being studied.

ante meridiem

Before noon.

boxplot

A graph using the details of a 5 number summary to show how data is centered around the mean. An alternate name is a box and whisker diagram.

centimetre

One hundredth of a metre.

confidence interval

A statistic which describes the range in which the true population parameter is likely to be in and gives the probability of how often it would be found in the range.

continuous data

Data which are represented by values on a scale and may use numbers with decimals.

continuous outcomes

Outcomes which have numerous possible outcomes, measured on a scale.

conversion factor

A conversion factor is a specific number used to change a number with a specific unit to another unit by either multiplying or dividing. The specific number is based on the relationship between the old unit and the new unit.

denominator

The number on the bottom of a fraction.

density curve

A graph which visually represents the estimation of distribution of values in a sample.

descriptive statistics

A category of statistics used to summarize or describe characteristics about a data set.

dichotomous outcomes

Outcomes which have only two possible options.

discrete data

Data which are represented by whole numbers.

drop factor

The number identifying the number of drops in 1 mL of fluid for particular IV tubing sets.

drop rate

The number of drops infusing per minute of an intravenous infusion.

forest plot

A graph summarizing the comparison of results of multiple studies used in a meta-analysis. The forest plot has data relating to each individual study included in the analysis and a representation of the combined study results.

gram

One thousandth of a kilogram.

histogram

A bar graph used to visually display continuous data.

Improper fraction

A fraction with a numerator larger than the denominator.

individual

In statistics, individual refers to the subject being studied.

inferential statistics

A category of statistics which are used to make conclusions about populations through analysis of data collected from randomly selected samples.

international unit

A quantity of a substance that produces a particular effect, as agreed on though the international standard.

interval measurements

Interval measurements refer to data which is measured on scales without an absolute zero.

kilogram

The standard international unit for mass.

largest common factor

The largest factor shared by a group of numbers.

litre

A metric measurement of volume equivalent to one thousand cubic centimetres.

mean

The statistic describing the average of all values in a data set.

median

A statistic describing the middle of a data set.

metre

The standard international unit for length.

microgram

One millionth of a gram.

milliequivalent

One thousandth of an equivalent, which is an amount of substance that reacts with a particular amount of hydrogen ions.

milligram

One thousandth of a gram.

millilitre

One thousandth of a litre.

millimole

One thousandth of a mole.

mixed fraction

A fraction representing more than one whole, using a whole number to the left of the numerator and denominator.

mode

A statistic describing the value occurring most often in a data set.

nominal data

Nominal data refers to categories of data which are distinct from one another, described using words.

normal saline

A 0.9% mixture of sodium chloride in water.

null hypothesis

A statement describing a circumstance where there is no difference between the variables being studied.

numerator

The number on top of a fraction.

odds

The probability an event will occur divided by the probability of the event not occurring.

odds ratio

The probability of one event divided by the probability of another event.

order of operations

The order of operations are the rules of which calculation comes first in an expression (when doing expressions with more than one operation).
1. the brackets or parentheses (innermost first)
2. exponent (power)
3. multiplication and division (from left-to-right)
4. addition and subtraction (from left-to-right)
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ordinal data

Ordinal data refers to categories of data which are related to one another, described using words.

outlier

A value widely outside of the range of values in a data set.

P-values

A calculated statistic to help determine if study results are just a coincidence by estimating what chance there is of the effect found to be related to sampling error during the study process.

parameter

A measured quantity describing a particular characteristic of a population.

parenterally

Referring to parenteral administration of medications, which is by any route outside of the GI tract.

post meridiem

After noon.

prime numbers

Prime numbers only have two factors, the number one and the number itself.

range

A statistic describing the difference between the maximum and minimum values of a data set.

ratio

A ratio is a numerical expression which shows the connection between two or more related numbers.

ratio measurements

Ratio measurements refer to data measurements which are counted on a scale with a true zero.

reciprocal of a fraction

The reciprocal of a fraction is a fraction made by switching the places of the numerator and denominator.

relative risk

The comparison of the chance of an outcome occurring between two experimental groups.

risk

The chance of an outcome occurring.

standard deviation

A statistic which provides a measure of the overall variation in a data set relative to the mean.

statistic

A calculated number describing a particular characteristic of a sample of a population.

stemplot

A visual summary of the distribution of numbers in a data set.

variable

A particular characteristic of the subject being studied.

Versioning History

This page provides a record of edits and changes made to this book since its initial publication. Whenever edits or updates are made in the text, we provide a record and description of those changes here. If the change is minor, the version number increases by 0.01. If the edits involve substantial updates, the version number increases to the next full number.

The files posted by this book always reflect the most recent version. If you find an error in this book, please fill out the Report an Error form.

Version	Date	Change	Details
1.00	June 28, 2023	Book published.	