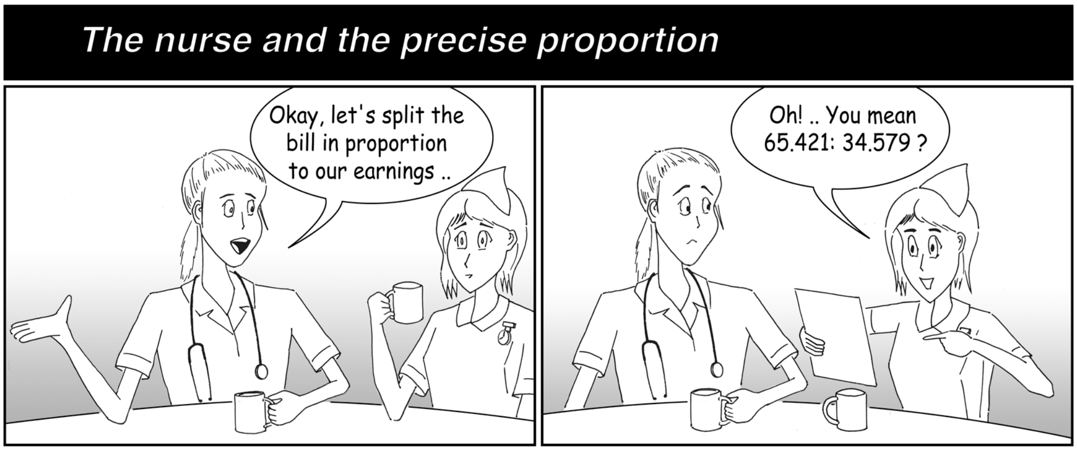
Module 9 – Proportions and Ratios

Introduction



Scenario: Suppose you need to distribute paracetamol tablets but must give instructions on the dosage to individual people. You know 500mg of the active ingredient is present in each tablet.

For all medicines, this ultimately depends on how much absorbing tissue the patient has. A really big person will need lots and a baby will need very little. But as a nurse you need to be more exact than that. Doctors may prescribe the dose, but it is up to the nurse to ensure the correct dose is given using appropriate mathematics.

In fact you have already been practicing this mathematics in previous modules, but in a different form – percentages and fractions can really be seen as concentrations or proportions.

In this module we will be taking a closer look at proportions and concentrations specifically in relation to taking medications. We will also look at how this relates to formulas that you may encounter in your career.

http://localhost:8000/packages/courseware/mat/1008/2007/s1/media/video/player_flv.swf?embed&media=Proportions_Ratios.flv&width=400&height=216

Objectives

On successful completion of this module you should be able to:

- Read a percentile chart;
- Manipulate equivalent fractions and ratios; and
- Use fractions and ratios in various drug calculations.

9.1 Pill Concentrations

A regular part of a nurse's role is to give drugs to patients usually prescribed by the doctor. These drugs can be in the form of tablets, capsules or syrup or they can be injected. Drugs are usually specified in milligrams (for tablets or capsules) or milliliters (for liquids) and the nurse must work out how many tablets etc. to give to the patient.

The following instructions came with the paracetamol tablets:

> *The recommended dosage of paracetamol in adults is two 500mg tablets (i.e. 1gm paracetamol) every four to six hours, not exceeding eight tablets (4gms) in any 24 hour period..*
>
> *Children's dosages vary with the age of the child and the type of product, therefore the instructions on the pack should always be followed.*
>
> *In general, children's dosages are based on a single dose of 10mg paracetamol per kilogram bodyweight, which can be repeated 4-6 hourly, not exceeding four doses per 24 hours.*
>
> *These dosages have been found to be effective, well tolerated and safe in OTC[1] usage and there are no circumstances in which they should be exceeded. If this dosage is not proving effective, then a pharmacist or doctor should be consulted for further advice.*

The following dosage instructions are suggested:

Children (3 – 6): ¼ to ½ tablet

Children (7 – 12): ½ to 1 tablet

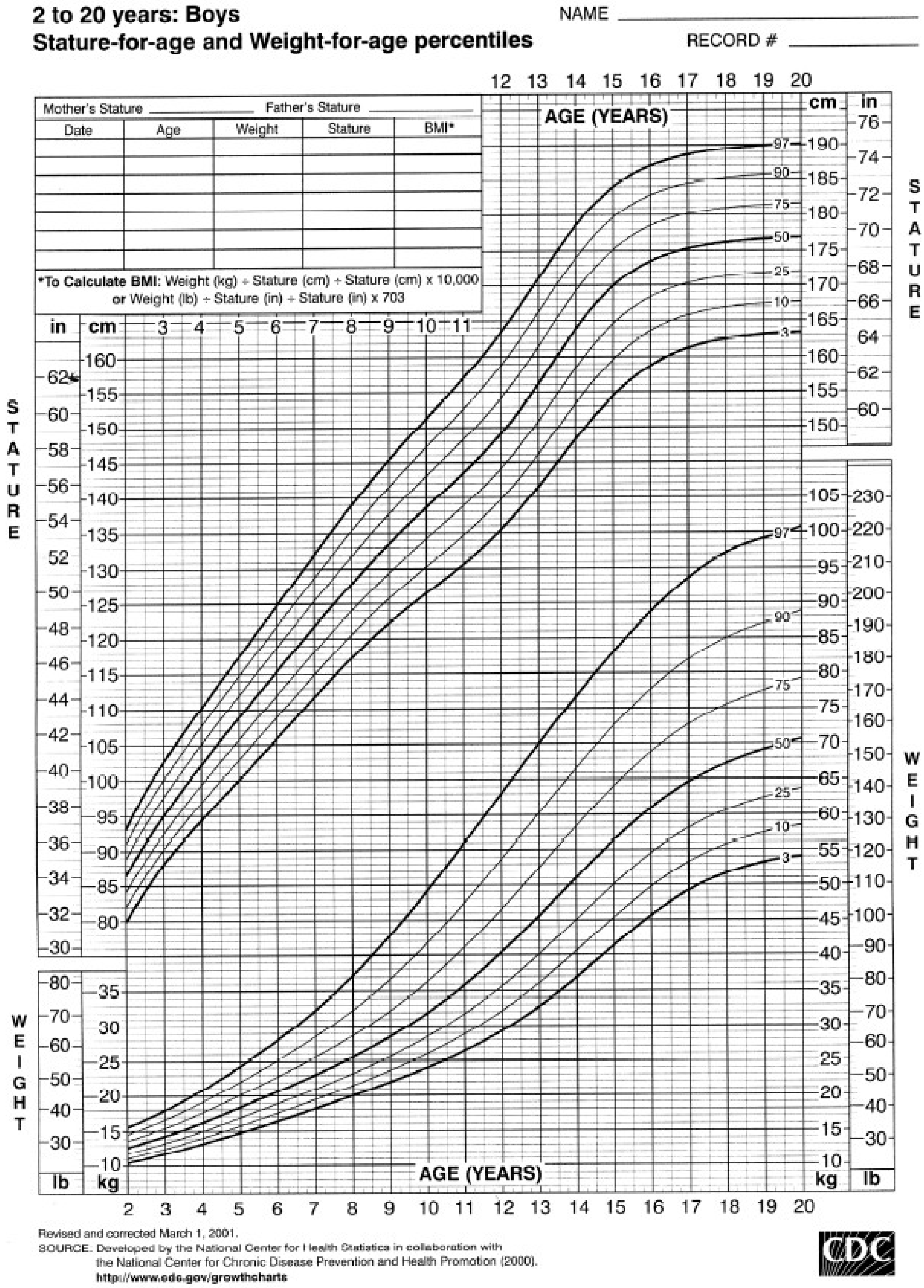
Adult & children over 12: 1 to 2 tablets

Source: http://www.pharmweb.net/pwmirror/pwy/paracetamol/pharmwebpicdosage.html

Discussion

Using the age-weight chart on the following page, do you agree with the dosage?

[1] OTC = Over the counter


2 to 20 years: Boys
Stature-for-age and Weight-for-age percentiles
NAME
RECORD #
Mother's Stature
Father's Stature
Date
Age
Weight
Stature
BMI*
*To Calculate BMI: Weight (kg) ÷ Stature (cm) ÷ Stature (cm) x 10,000
or Weight (lb) ÷ Stature (in) ÷ Stature (in) x 703
AGE (YEARS)
STATURE
WEIGHT
cm
in
kg
lb
Revised and corrected March 1, 2001.
SOURCE: Developed by the National Center for Health Statistics in collaboration with
the National Center for Chronic Disease Prevention and Health Promotion (2000).
http://www.cdc.gov/growthcharts

9.2 Ratios, Proportions and Drug calculations

Setting up drug calculations requires knowledge of fractions, ratios, proportions even algebra and solving equations. In the box below are a number of variations in methods in solving the drug calculation problem: *A patient required 8.5 mg nitrofurantoin. On hand are ampoules of 10mL/mL. What will you inject?*

$$\frac{\text{Dr's order}}{\text{Doese on Hand}} = \frac{x}{\text{quantity}}$$

$$\frac{8.5}{10} = \frac{x}{1\text{ cc}}$$

$$DimensionalAnalysis: 8.5\text{mg} \times \frac{1\text{ mL}}{10\text{ mg}} \times \frac{15\text{ m}}{1\text{ mL}}$$

$$8.5\text{ mg} : x\text{ cc} \equiv 10\text{ mg} : 1\text{ cc}$$

$$\frac{8.5}{x} :: \frac{10}{1}$$

$$\frac{10\text{mg}}{1\text{mL}} = \frac{8.5\text{mg}}{x\text{mL}}$$

$$10 : 1\text{mL} = 8.5 : x$$

$$\frac{D \times \text{vehicle}}{A} \frac{8.5}{10} = \frac{x}{1}$$

$$\frac{8.5\text{mg}}{10\text{mg}} \times 1\text{mL}$$

$$\frac{\text{D}}{\text{H}} \times Q$$

Known::Unknown

Have::Desired

$$8.5\text{mg} : x\text{ mL} \equiv 10\text{mg} : 1\text{mL}$$

How can all these mean the same thing? It all has to do with ratios and proportions. What is the difference? Well a ratio is a comparison of two or more related amounts. So let's compare the ratio of men to women in a room, for example. If there were 5 men and 15 women the ratio of men to women would be 5:15. Notice the ":" symbol meaning "is to". But we could also say the ratio of men to women is 1:3. That is for every 1 man there are 3 women. Sometimes you may see the relationship as:

$$1:3 \equiv 5:15$$

Meaning these are **equivalent** ratios.

A proportion is a statement of equality between two fractions as in $\frac{1}{2} = \frac{3}{6}$. The 1 is in the same proportion of 2 that the 3 is of 6. But you can also read from left to right, instead of from top to bottom, in which we can say that 1 is in the same proportion to 3 as 2 is to 6. Look at this in a picture. The picture on the left has the dimensions of 3 cm by 4 cm. The one on the right has the dimensions of 6 cm by 8 cm. We say the picture has the same proportions

– ie the ratio of the width to the length is the same: $3:4 \equiv 6:8$. This is another way of saying $\frac{3}{4} = \frac{6}{8}$

So you can see that fractions, ratios and proportions are very related concepts.

9.3 Equivalent fractions

Another important feature of fractions is equivalence.

$$\frac{2}{5} = \frac{4}{10}$$

If you said two fifths of the people are over 65 years old that would be the same as saying four tenths of the people or 40% of the people (since 40% is 40 over 100).

In this equation, what if we didn't know one of the numbers, say the 2. We would have:

$$\frac{x}{5} = \frac{4}{10}$$

Your knowledge of numbers may tell you the value of x is 2. However, we can also think of the equation as a balance. If you can't recall how to do this, go back to module 4.

On the left hand side we have one fifth of x. So if we multiply both sides by 5, we will still have a balanced equation:

$$\frac{x}{5} \times 5 = \frac{4}{10} \times 5$$
$$x = 2$$

Let's have a look at this in a nursing situation.

Example

During defibrillation procedure it is important that you don't touch the patient or the bed and there is no liquid in the floor surrounding the immediate area of the patient. There are three variables to think about here – voltage, current and resistance. Voltage is measured in volts and is equal to the current (in Amperes) times the resistance (in Ohms). So the formula is:

$V = I \times R$ or $V = IR$ (note in the last statement the $\times$ is not shown)

So how much you could get "zapped" depends on the resistance and the voltage put through the system in the first place. If you have wet skin you have less resistance (i.e. you are a better conductor).

Take different values of *R* for a 240 volt power:

a. If R = 1 000 000 Ohms (dry skin)

b. If R = 500 000 Ohms (Wet Skin)

c. If R = 350 000 Ohms (with elecro gel).

It would be useful to rearrange this formula to make *I* the subject.

$V = I \times R$

$\frac{\mathrm{V}}{\mathrm{R}} = \frac{I \times R}{R}$

$\frac{\mathrm{V}}{\mathrm{R}} = I$ You can read this from right to left if you like or write it like this:

$I = \frac{\mathrm{V}}{\mathrm{R}}$

Exercise

Now describe what happens for different values of R in the scenario above

9.4 Medications and ratios

Say you had to give a patient 1000mg of paracetamol. You looked at the tablets and saw that one tablet contained 500 mg. How many tablets would you give?

If you gave them 1 tablet they would get 500 mg. If you gave them 2 tablets, they would get double that or 1000 mg. So you'd give them 2 tablets. However, this is not a very efficient way of doing it! If you divided the 500 into 1000 you would get 2 as well. Looking at this another way:

$$\frac{1000\ mg}{500\ mg} = \frac{2\ \text{tablet}}{1\ \text{tablet}}$$

It doesn't matter how strong the tablets are or how much was to be given, the method is still the same.

Say you had to give Enduron tablets and the order was for 15 mg. The tablets come in strength of 3mg, how many tablets would you give?

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

So you would give the patient 5 tablets. (It may not be at the same time – that would be on orders from the doctor as well)

Example

How many Lanoxin tablets containing 62.5 mcg* (micrograms) of digoxin will be required for a dose of 0.125 mg digoxin?

First notice the units are not the same so either convert the micrograms to milligrams, or the milligrams to micrograms.

$$62.5\mu g = 0.0625mg$$

Now do the division as before:

$$\frac{0.125}{0.0625}$$

Does this look a bit harder? You can multiply top and bottom by 1000 to get an equivalent fraction:

$$\frac{0.125}{0.0625} = \frac{1250}{625} = 2$$

So you will need two tablets.

Did you find this a bit harder? Which number do you put on the top? There is are formulae often used in nursing:

$$\frac{\text{Dose required}}{\text{Dose in stock}} \text{ or } \frac{\text{Prescribed dose}}{\text{Tablet Strength}} \text{ or } \frac{\text{Required Strength}}{\text{Stock Strength}}$$

Can you see they are saying the same thing and are related to the work you have just done in ratios and fractions?

*Note

In Nursing, sometimes Mcg is used instead of the more conventional µg (Greek letter "mu").

Example

1. A patient requires Digoxin. Each tablet contains 0.125 mg of Digoxin. How many tablets are given to a patient who requires:
   (a) 0.25 mg of Digoxin
   (b) 2.0 mg of Digoxin
   (c) 250 μg of Digoxin.

2. A patient swallows 2½ Digoxin tablets. How many mg of Digoxin has been taken?

Look carefully at the method you used to solve those. There are about 5 steps to follow:

1. Read the question.
   Read question 1(a)
2. Extract what the question is wanting you to find.
   Question 1(a) asks for **number** of tablets.
3. Extract what is given
   • dose required is 0.25 mg
   • dose in stock is 0.125 mg
4. Perform the calculation

$$\text{No. tablets} = \frac{0.25}{0.125} = \frac{250}{125} = 2$$

5. Check and Think
   The patient requires more than one tablet - yes 2 tablets sounds right.

9.4.1 Volume concentrations

With tablet concentrations you are restricted by your ability to divide the tablets in to $\frac{1}{2}$ or $\frac{1}{4}$'s. Having the drug in liquid form allows you to administer the drug in more exact doses. Erythromycin is an antibiotic that comes in syrup form. It is taken orally. The Erythromycin syrup available contains 700mg of Erythromycin for each 10 mL of syrup.

Here the concentration is 700 mg in 10 mL. So when we are giving a person the drug we are giving them a VOLUME (in millilitres) not a weight (in grams). For example, if we want to give a patient 350 mg of Erythromycin, what volume of syrup is needed?

Notice we want half the dose so we need half of the volume or 5 mL. But let's look at this more closely:

$\frac{1}{2}$ of 10 mL

Where did the half come from?

Well it's $\frac{350}{700}$. Can you recognise this as $\frac{\text{dose required}}{\text{dose in stock}}$?

Once we have this fraction we then multiply it by the volume of syrup we have. The

formula then looks like this:

$$= \frac{1}{2} \times 10 \text{ mL} = 5 \text{ mL}$$

Instead of 350 mg of Erythromycin, the patient may need 420 mg. How much liquid is needed now?

$$\frac{\text{dose required}}{\text{dose at hand}} \times \text{volume} = \frac{420 \text{ mg}}{700 \text{ mg}} \times 10 \text{ mL}$$

$$= \frac{420 \cancel{\text{mg}}}{700 \cancel{\text{mg}}} \times 10 \text{ mL}$$

$$= \frac{42}{7} \text{ mL}$$

$$= 6 \text{ mL}$$

Notice in these calculations the units have been part of the fraction. In the above example you can see that the common units cancel leaving volume as the unit for the answer, which is indeed what we want. This is a useful check on whether you have done the calculation correctly too.

Exercise

Now try the following exercises.

1. What volume of syrup is to be given to a patient who needs:
   (a) 420 mg of Erythromycin?
   (b) 100 mg of Erythromycin?
   (c) 200 mg of Erythromycin?

2. A patient is given 15 mL of syrup, how many mg of Erythromycin does it contain?

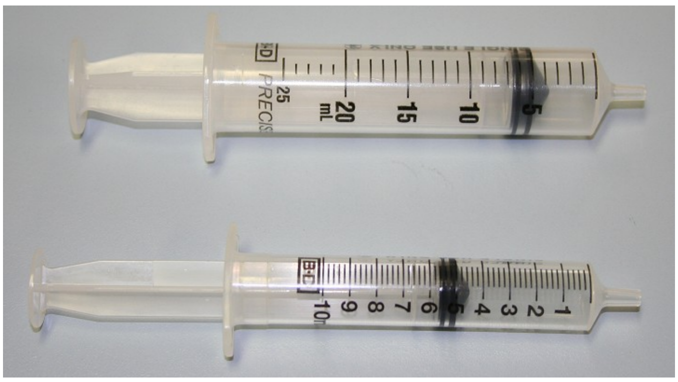
3. The strength of drugs is written on the container. Atropine shown here in ampoules* is 0.4 mg/mL. That means there is 0.4mg of Atropine in each mL of liquid or **per** mL of liquid.

   A patient is prescribed 15 mg of Morphine and 0.3 mg of Atropine. How many mL of each drug should be injected?

   Morphine ______________

   Atropine ______________

4. A patient needs 800 mcg of Atropine. Available are 1.2 mg/2mL ampoules of Atropine. In the picture there are two sized syringes. Shade in the volumes to be drawn up in both cases.



Conclusion

You will do more of these tablet and volume concentrations in your degree program. You should now you have more of an understanding of the relationship between the formulas used and the mathematics underneath these formulas. There are more exercises for you to complete:

Level A (+ solutions)

Level B (+ solutions)

Level C (+ solutions)

These can be found at Ratios and Proportions.