Abstract
This is the second of two articles which aim to provide children’s nurses with an opportunity to develop their knowledge and skills of medicines management when caring for children and young people. The first article considered the processes associated with effective medicines management, including the concept of human error. This article addresses essential numeracy and calculation skills that have been identified as an important risk factor associated with medication errors in children. The range of activities throughout the article will help you develop and practise numeracy skills, with the answers for each activity at the end of the article.

Keywords
calculations, child health, medicines management, numeracy, paediatrics

Aims and intended learning outcomes
This article aims to refresh your knowledge of essential numeracy and calculation skills. By reading the article and completing the time out activities you will be able to:

» Describe the International System of Units used in the clinical environment.
» Convert units of measure by manipulating decimal points.
» Apply the common medicine calculation formula to complete a range of medicines calculations.

Nursing interventions often involve the application of essential numeracy skills. Medicines management is a fundamental role of the nurse that requires them to have the ability to understand and calculate drug doses. Nurses are directly accountable for ensuring medicines are prescribed, dispensed and administered safely and within their limits of training and competence (Nursing and Midwifery Council (NMC) 2010, NMC 2015). Prescribing and administering medicines to children and young people is challenging because children vary in weight, body surface area, and their ability to metabolise and excrete medications changes as body systems develop, which requires everyone involved to be competent in essential numeracy skills (Blair and Standing 2011).

Medication doses must be calculated specifically for each child, which results in greater potential for errors compared to adult patients (Manias et al 2014). Also, advances in technology and treatments have resulted in care and interventions being more complex with greater accuracy in prescribed doses required (Wilson 2003, Blair and Standing 2011).

To undertake calculations accurately nurses must be able to add, subtract, divide, multiply, convert units of measure and work with fractions (Hutton 1998). Age and the decade of the nurse’s education can have an influence on how numeracy skills were taught (Pentin and Smith 2006). Nurses may therefore apply different methods when undertaking a calculation, which needs to be recognised when nurses are being supported to develop their calculation skills and maintain their confidence.

TIME OUT 1
Reflect on your own practice.

» What are your strengths and weaknesses when undertaking calculations?
» List the types of calculations you find the most challenging. You may wish to discuss with your colleagues which calculations they find challenging.

International System of Units (SI) of measure made simple
The most common measurements used in calculations are weight (essential when...
Calculating drug dosage, length (required to calculate body mass) and volume (required when calculating volume and rates of infusions). The International System of Units (SI), sometimes referred to as the metric system, is the most widely adopted system for units of measure and was standardised in the UK in 1975. Failure to use SI units can lead to potentially life-threatening errors. Before the introduction of SI units, imperial measurements were used and parents sometimes use pounds and ounces when referring to their child’s weight.

However, as medicines and fluids administered to children require calculations based on weight, weight must always be recorded in SI units. In rare situations where a child is unable to be weighed, parents may be able to provide an up-to-date weight, if this is in pounds and ounces the weight must be converted to SI units (Hutton and Gardner 2005). The SI system is a metric system based on powers of ten, which enables numbers to be manipulated to make them more manageable, for example, 1/1000th of a gram could be written as 0.001g or 1mg (Box 1).

Converting units of measure by manipulating decimal points

When converting measures of weight between grams, milligrams, micrograms and nanograms, divisions or multiplications between each unit of measure occur in thousands. To convert from a larger unit to a smaller unit, for example, grams to milligrams, multiply by 1000. One way to do this is to move the decimal point three places to the right. It can be useful to ensure there are three numbers after the decimal point which is achieved by adding ‘0’ to the end of the number.

To convert a smaller unit to a larger unit, for example, milligrams to grams, divide by 1000. Again, one way to do this is to move the decimal point three places to the right. The same principles apply when converting liquid measures between litres and millilitres. Think logically: multiplying makes numbers bigger, whereas dividing makes numbers smaller. Box 2 provides examples of moving decimal points.

Poorly written numbers can be misinterpreted and are a common cause of medication error (Pryce-Miller and Emanuel 2010). When working with decimal points errors are easy to make. Prescriptions should not be written using fractional numbers (numbers less than a whole) (Health Education Yorkshire and Humber 2015). For example, 0.6g should be written as 600mg and 0.7mg should be written as 700 micrograms. Where possible,
In time out 2 it is important that the decimal point was moved the required number of places and that the unit of measure was recorded correctly. There is a potential for error when using decimal points; misplacing a decimal point can result in a significant change in the amount of drug prescribed and administered. For example, if 7.5mg of intravenous diclofenac sodium was prescribed but because of a misplaced decimal point this became 75mg, the infant would receive ten times the recommended dose. It is important to consider what would be a reasonable dose of a medication for the age of child – use your intuition and experience. Ensure your knowledge about medications is current and use the resources available to you. Never make assumptions.

Medication calculations

Every year medication errors occur, many of which are attributable to incorrect medication doses with unit conversion errors being the most common (Department for Education and Skills/Department of Health 2004, National Patient Safety Agency 2007). All children’s nurses must be able to calculate medication doses accurately. The most common formula to calculate medications is:

\[
\text{What you want} \times \frac{\text{what volume the drug is in}}{\text{What you've got}}
\]

Other formulae are available, however, and the safest method to use is the one you understand (Health Education Yorkshire and Humber 2015). Whichever formula is used, understanding the mathematical principles of fractions is essential for many nursing calculations. Box 3 explains fractions and Box 4 presents examples of medication calculations.

The registered nurse is responsible for ensuring the correct dose of medication is administered (NMC 2010). Before undertaking the drug calculation ensure the correct dose has been prescribed; do not presume the prescriber has prescribed correctly. You will become familiar with the doses of drugs you use regularly, however, if you are uncertain of the dose you must check the dose with a recognised resource such as the British National Formulary for Children (Paediatric Formulary Committee 2015). If you are still unsure that the dose is correct refer back to the prescriber. You may wish to revisit part one of this article, published in July, which highlights your responsibility when administering medicines.

TIME OUT 2
Converting units of measure

a) How many grams are in 700mg?
b) How many micrograms are in 0.6mg?
c) How many milligrams are in 1.56g?
d) How many grams are in 2.87kg?
e) How many litres are in 1670mL?
f) How many nanograms are in 124 micrograms?

In simple terms fractions state the number of parts of a whole, for example, a half is two parts of a whole. Fractions can be written as two numbers separated by a forward slash, for example, half would be written as 1/2 but when undertaking calculations with fractions it can be useful to write the numbers above each other:

The top number (1) is referred to as the numerator
The bottom number (2) is referred to as the denominator

Fractions are easier to work with when they are in their simplest form, so 2/4 is the same as 1/2. These fractions are equivalent because they can be converted from one to the other by multiplying (or dividing) the numerator and the denominator by the same number, in this case two. Dividing numerators and denominators is often referred to as ‘cancelling fractions’ making them easier to manipulate particularly when we multiply and divide them.

To multiply two fractions, multiply the numerators (and denominators) of the fractions:

\[
\frac{1}{2} \times \frac{1}{2} = \frac{1 \times 1}{2 \times 2} = \frac{1}{4}
\]

think of this as half of a half which, intuitively, is smaller
Once you are sure the correct dose has been prescribed use your experience to estimate what is the likely amount you will be administering. This is a useful internal safety check in identifying potential errors and ensuring patient safety (Ramjan et al 2014). For example, if you require 2.7mg and the drug is dispensed as 2.5mg/5mL, your estimate would suggest you need slightly more than 5mL.

Next, calculate the volume required using the formula you are familiar with and check it against your estimation and with the second checker, depending on local NHS trust guidelines, who should calculate the volume required independently. In this example, 5.4mL is the correct amount.

TIME OUT 3
Medication calculations
a) Rebecca requires 40mg of prednisolone, which is available in 5mg tablets. How many tablets does Rebecca require?
b) Sophie requires 730mg of vancomycin, which is prepared as a solution of 500mg/100mL. How many mL of the solution does Sophie require?
c) Harry requires 450 micrograms/day of digoxin administered in two divided doses. How many micrograms should be prescribed per dose?
d) Zoe requires 120mg of ranitidine, which is available as a solution of 75mg/5mL. How many mL of the solution does Zoe require?

You will note in time out 3 that all of the drugs prescribed are in the same unit of measure to the dispensed unit. Therefore, the formula presented in Box 4 can easily be applied to calculate how much of the drug needs to be administered. However, care must be taken if a drug is prescribed in a different unit of measure to the dispensed unit. For example, if 400 micrograms of a drug is prescribed and is only available in ampoules containing 4mg/mL, calculating the amount to be administered requires both the dose and drug strength to be converted to the same unit of measure, here 1mL solution contains 4000 micrograms. In this example first you need to convert mg to micrograms (4mg = 4000 micrograms), the calculation is now 400/4000 x 1 = 0.1mL; 0.1mL of the drug would be administered.

TIME OUT 4
Medication calculations requiring measure conversions
a) Joshua requires 2.1g of benzylpenicillin sodium, which is available as a solution of 600mg/10mL. How many mL of the solution does Joshua require?
b) Sam requires 600 micrograms of morphine, which has been prepared as a solution of 10mg/5mL. How many mL of the solution does Sam require?
c) Grace requires 1.2g of cefuroxime, which is available as a solution of 750mg/20mL. How many mL of the solution does Grace require?
d) Lauren requires 1200 nanograms/hour of alprostadil, which is available as a solution of 600 micrograms/50mL. How many mL/hour of the solution does Lauren require?

The first three questions in time out 4 can be calculated by taking the same steps as in the worked example, ensuring that you used the same unit of measure for the prescribed and dispensed units. The last question is a calculation related to an infusion. This should not cause any additional difficulty as it is calculated in the same way, because the

BOX 5. Factors to consider when deciding fluid requirements
» Weight
» Age
» Fluid type
» Any fluid restrictions/fluid replacement requirements
» The child’s condition/underlying disease
» Results of blood tests, in particular urea and electrolytes

BOX 6. Calculating fluid requirements

<table>
<thead>
<tr>
<th>Body weight</th>
<th>24-hour replacement</th>
</tr>
</thead>
<tbody>
<tr>
<td>First 10kg</td>
<td>100mL/kg</td>
</tr>
<tr>
<td>Second 10kg</td>
<td>50mL/kg</td>
</tr>
<tr>
<td>Subsequent kg</td>
<td>20mL/kg</td>
</tr>
</tbody>
</table>

Anya is 32kg and is unable to take oral fluid and therefore requires standard intravenous fluids

<table>
<thead>
<tr>
<th>Body weight</th>
<th>24-hour replacement</th>
</tr>
</thead>
<tbody>
<tr>
<td>First 10kg</td>
<td>10 x 100mL = 1,000mL</td>
</tr>
<tr>
<td>Second 10kg</td>
<td>10 x 50mL = 500mL</td>
</tr>
<tr>
<td>Subsequent kg</td>
<td>12 x 20 = 240mL</td>
</tr>
</tbody>
</table>

Total 24-hour requirement = 1740mL

Hourly fluid requirement = 1740/24 = 72.5mL/hour
amount of drug Lauren is prescribed and the dispensed units are both mL/hour. Fluid calculations are explored in more detail in the next section.

**Fluid and infusion calculations**

The ability to calculate fluid requirements for children and young people correctly is an important nursing skill (Blair and Standing 2011). As well as the calculation skills already outlined, other factors that should be considered when calculating fluid requirements or administering infusions in children are presented in Box 5.

Although a range of guidelines exist for calculating fluid requirements in children in the UK, the British Medical Association guidance is widely used (Paediatric Formulary Committee 2015) (Box 6).

When calculating fluid infusions there is a final step to the calculation process as fluid infusions are given over a prescribed time – often this is a 24-hour period. Consequently, the total volume of fluid required needs to be divided by 24 before the hourly infusion rate on the infusion pump can be set, as outlined for Anya in Box 6. However, some intravenous fluids and drugs may require administering over a shorter period of time, for example, an intravenous antibiotic may be prescribed to be administered over 30 minutes. Calculating short infusion times are presented in Box 7.

Infusion pumps are programmed to deliver mL/hour – when calculating rates ensure time is converted to the same units.

**Fluid restrictions**

Some children’s underlying conditions may necessitate fluid intake being restricted. If restricted, fluids are likely to be prescribed as a percentage of the standard fluid regimen. For example, Sophie is four years old and weighs 18kg, she is admitted to hospital with renal failure. Sophie’s fluids are restricted as a percentage of the standard fluid regimen.

If restricted, fluids are likely to be prescribed as a percentage of the standard fluid regimen. For example, Sophie is four years old and weighs 18kg, she is admitted to hospital with renal failure. Sophie’s fluids are restricted as a percentage of the standard fluid regimen.

Calculate the usual fluid requirement for a child of Sophie’s age and weight:

\[
10\text{kg} \times 100 = 1,000\text{mL} \\
8\text{kg} \times 50 = 400\text{mL}
\]

Total daily fluid = 1,400mL

Calculate 75% of 1400mL to meet Sophie’s specific requirements:

\[
\frac{75}{100} = 0.75 \\
0.75 \times 1400 = 1050\text{mL in 24 hours}
\]

Hourly fluid requirement = \(1050 \div 24\) = 43.8mL/hour

Where a child has a restricted daily fluid requirement but has oral fluids, IV infusions and medications, all these fluids must be included and recorded.

Benjamin weighs 5kg and is restricted to 65% of standard fluids. Benjamin can have milk as part of his fluid intake and usually has six feeds a day, his full fluid requirement can be calculated in the following way:

\[
5\text{kg} \times 100\text{mL/kg} = 500\text{mL}
\]

Calculate 76.5% of 500mL:

\[
\frac{76.5}{100} = 0.65
\]

Hourly fluid requirement = \(0.65 \times 500\) = 325mL in 24 hours

Benjamin also has an IV infusion running at 2mL/hour and is receiving medication that totals 6mL every 12 hours, both need to be included in his daily total.

Infusion:

\[
2\text{mL/hour} \times 24 = 48\text{mL}
\]

Medication:

\[
6\text{mL} \times 12 \text{ hourly} = 12\text{mL}
\]

24 hour total:

\[
48\text{mL} + 12\text{mL} = 60\text{mL}
\]

Deduct this from the daily total:

\[
325\text{mL} - 60\text{mL} = 265\text{mL}
\]

Divide this by number of feeds in 24 hours:

\[
\frac{265}{6} = 44\text{mL per feed.}
\]

**BOX 7. Calculating short infusion times**

<table>
<thead>
<tr>
<th>Name</th>
<th>Calculation Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sarah</td>
<td>Requires 17mL of a drug to be administered over 30 minutes (pump programmed in mL/hour) The drug needs to be administered over 30 minutes: 60 divided by 30 = 2. Therefore, the volume to be infused needs to be multiplied by 2. Pump infusion rate: 17mL x 2 = 34mL/hour</td>
</tr>
<tr>
<td>Asyah</td>
<td>Requires 372mL of packed cells to be administered over four hours Divide the volume to be infused (372) by the number of hours the packed cells are to be infused over (4). Pump infusion rate: 372 ÷ 4 = 93mL/hour</td>
</tr>
<tr>
<td>George</td>
<td>Requires 27mL of a drug to be administered over 15 minutes (pump programmed in mL/hour) The drug needs to be administered over 15 minutes: 60 minutes divided by 15 = 4. Therefore, the volume to be infused needs to be multiplied by 4. Pump infusion rate: 27mL x 4 = 108mL/hour</td>
</tr>
</tbody>
</table>

**USEFUL RESOURCES**

- Royal College of Nursing: Safety in Numbers Numeracy Refresher. www2.rcn.org.uk/development/learning/learningzone
- Maths is fun www.mathsisfun.com
- Quick and dirty tips www.quickanddirtytips.com
- Cool maths 4 kids, a website for children www.coolmath4kids.com
- Basic Mathematics Skills www.basic-mathematics.com
- math.com www.math.com
- Paediatric Drug Calculations for Health Professionals www.uhs.nhs.uk/Media/suhtideal/TopNavigationArticles/SkillsForPractice/ClinicalSkills/Paediatricdrugcalculationsforthirdearlymedicalstudents.pdf
- Good Practice for Drug Calculations www.baxterhealthcare.co.uk/downloads/healthcare_professionals/therapies/pharmacy_services/ps_calc_guide.pdf

nursingchildrenandyoungpeople.co.uk
TIME OUT 5
Fluid restriction calculations
a) Lizzie weighs 13kg and is restricted to 70% of standard fluid requirement and she requires an intravenous infusion. Calculate the pump infusion rate in mL/hour.
b) George weighs 7kg and is restricted to 75% of standard fluid requirement. He is receiving five feeds per day. Calculate how much milk he should receive for each feed.
c) Charlotte weighs 15kg and is restricted to 80% of standard fluid requirement. She is receiving a drug infusion of 240mL/day. How much fluid is she able to drink in a 24-hour period?
d) Faisal weighs 36kg and is restricted to 80% of his standard fluid requirement. His medication fluids are 224mL in 24 hours, he also requires intravenous fluids. Calculate the pump infusion rate in mL/hour.

The questions in time out 5 require more complex calculation skills, however, if you follow the steps in the worked examples and undertake each stage systematically you should be able to calculate how much oral or intravenous fluid each child requires.

Percentage concentrations
Solutions used in practice may be expressed as percentages, for example, 0.9% sodium chloride, a frequently used intravenous fluid. Per cent means ‘per 100’, for example 0.9% means that every 100mL of water contains 0.9g of sodium chloride and 5% dextrose means there are 5g of dextrose in every 100mL of water. Therefore, a 500mL bag of 5% dextrose contains 25g of dextrose, 5g of dextrose in 100mL multiplied by 5 = 25g dextrose in 500mL.

Conclusion
Essential numeracy and calculation skills underpin safe and effective medicines and fluid management in children. This article and associated activities will have assisted you to develop your ability to undertake a range of calculations by outlining the underpinning processes. Calculations in children’s nursing are complex, requiring practice and ongoing development to remain a competent practitioner.

TIME OUT 6
Reflective account
Now that you have completed the article you may want to complete the questionnaire on page 45 and write a reflective account as part of your revalidation. Go to journals.rcni.com/r/ncyp-reflective-account to find out more.

Time out answers
» Time out 2
  - a. 0.7g, b. 600 micrograms, c. 1560mg, d. 2870g, e. 1.67 litres, f. 1240 nanograms
» Time out 3
  - a. Eight tablets, b. 146mL, c. 225 micrograms, d. 8mL
» Time out 4
  - a. 35mL, b. 0.3mL, c. 32mL, d. 0.1mL/hour
» Time out 5
  - a. 33.5mL/hour, b. 105mL, c. 760mL, d. 51.3mL/hour

These time out answers have been corrected from the printed version.

References
(Part accessed: April 29 2016.)
Medicines administration part 2: essential numeracy
TEST YOUR KNOWLEDGE BY COMPLETING THIS SELF-ASSESSMENT QUESTIONNAIRE 22

1. How are fractions multiplied?
   a) Add the numerators and denominators
   b) Multiply the denominators
   c) Multiply the numerators and multiply the denominators
   d) Divide the numerator by the denominator

2. How would ¾ be written in its simplest form?
   a) 1/3
   b) 2/8
   c) 1/2
   d) 1/4

3. To change a unit of measure, which number do you need to multiply or divide by?
   a) 10
   b) 100
   c) 1000
   d) 10,000

4. What is the most common reason an incorrect medication dose is administered?
   a) Unit conversion error
   b) Incorrect use of a drug calculation formula
   c) Administering the wrong drug
   d) Giving the incorrect number of doses in a 24-hour period

5. Ellie requires 3.5g of a drug every 24 hours. The drug is prescribed six hourly. How much of the drug should Ellie receive for each dose?
   a) 1750mg
   b) 117g
   c) 583mg
   d) 875mg

6. Liam requires 320nanograms of a drug, which is available as a solution of 2micrograms/mL. How many mL of the solution does Liam require?
   a) 0.006mL
   b) 1.6mL
   c) 16mL
   d) 0.16mL

7. Ikram requires 275mL of an antibiotic to be administered by infusion over 20 minutes. How many mL/hour should the infusion pump be set at?
   a) 275mL/hour
   b) 1000mL/hour
   c) 825mL/hour
   d) 550mL/hour

8. Georgia requires 282mL of packed cells to be administered over six hours. Calculate the pump infusion rate in mL/hour:
   a) 47mL/hour
   b) 70.5mL/hour
   c) 32.3mL/hour
   d) 50mL/hour

9. Holly weighs 23kg and is restricted to 75% of the standard fluid requirement. How much fluid can she have in a 24-hour period?
   a) 1248mL
   b) 1560mL
   c) 1770mL
   d) 1872mL

10. A 500mL bag of 0.45% sodium chloride contains how much sodium chloride?
    a) 0.45g
    b) 2.25g
    c) 225g
    d) 45g

Question 6 has been changed from the printed version.

How to complete this assessment
This self-assessment questionnaire will help you to test your knowledge. It comprises ten multiple choice questions that are broadly linked to the previous article. There is one correct answer to each question.

You can test your subject knowledge by attempting the questions before reading the article, and then go back over them to see if you would answer any differently.

You might like to read the article before trying the questions. The answers will be published in the next issue.

When you have completed the questionnaire, cut out this page and add it to your professional portfolio. You can record the amount of time it has taken you to complete it.

You may want to write a reflective account. Visit journals.rcni.com/page/ns/cpd/write-a-reflective-account

Go online to do this self-assessment questionnaire and you can save it to your RCNi portfolio to help meet your revalidation requirements. Go to rcni.com/revalidation

This self-assessment questionnaire was compiled by Jayne Pentin, Michelle Green and Joanna Smith

The answers to the SAQ in the July issue are:
   1d, 2b, 3b, 4c, 5a, 6a, 7d, 8d, 9a, 10c

This activity has taken me minutes/hours to complete. Now that I have read this article and completed this assessment, I think my knowledge is:

Excellent
Good
Satisfactory
Unsatisfactory
Poor

As a result of this I intend to:

________________________________________________________________________________________
________________________________________________________________________________________
________________________________________________________________________________________
________________________________________________________________________________________