CURRENT HEALTHCARE INITIATIVES focus on quality and safety in patient care, and a primary component of safe nursing care is medication administration. Despite advances in medication safety technologies, dosage calculations continue to be challenging for many nurses. The dimensional analysis (DA) method offers one logical format that can be used for all types of calculations.

This article introduces the DA method of performing dosage calculations to practicing nurses. Easy to understand, this standardized format can be used for any type of dosage calculation to enhance conceptual understanding, improve accuracy, and help prevent medication errors.1,2 DA is also called the factor-label method.

Perils of medication errors
The Joint Commission notes that of all medical errors, medication errors are not only the most common but also the riskiest in terms of potential for adverse patient outcomes.3 The risk of harm is greater in weight-based dosage calculations, which are more commonly used for pediatric patients.3 In the United States, at least one death per day and 1.3 million injuries per year result from medication errors.4 Errors can occur anywhere along the medication administration process and involve any or all healthcare professionals involved in the process.4

Research reveals that many nursing students and practicing nurses have weak mathematic skills and poor conceptual understanding of dosage calculations that affect their computation abilities.1,2,5-7 Retaining how to correctly set up dosage calculations is also a problem for both students and nurses.2,8 (See A framework of quality and safety.)

The implementation of safety technology, such as bar coding medication packages and patient wristbands and using smart infusion pumps, are
designed to reduce medication errors, but nurses can’t rely on them blindly to prevent mistakes. Safety technology can be beneficial, but scant evidence shows that they prevent life-threatening medication errors.⑨ To reduce risks when using infusion pumps, the FDA recommends nurses continue to use the familiar “seven rights” of medication administration—right patient, drug, dose, route, time, reason, and documentation—and cocheckhigh-risk medication calculations.⑩

Comparing DA to the formula method
Many practicing nurses were taught the traditional formula method for calculating dosages. This method requires memorizing various formulas but doesn’t promote understanding or future retention.①②⑩⑪ Wright notes that when using a formula without labeling the numerals with a unit of measure such as mg or mL, a dosage calculation becomes just an arithmetic problem that’s removed from its clinical context.⑪ A numeric answer that’s not labeled has no meaning. Labels such as milligram (mg) or milliliter (mL) shouldn’t be separated from the numerals because they explain the mass or volume of a medication. These points illustrate why the formula method is difficult to understand and remember.⑪

In my experience as a nursing instructor, I found DA easier for students to understand and recall than the formula technique. Formulas vary depending on the type of dosage calculation needed, making which one to use difficult to remember. If students don’t label the numerals, they may obtain the correct numeric answer, but then aren’t sure what unit of measure it represents and are left wondering if the correct answer is, for example, 5 mg or 5 mL. If numerals are inverted when placed into the formula, the result of the calculation will be a dose that’s wrong. Another concern is that when complex calculations aren’t performed routinely, formulas are difficult to remember.

The DA method consists of arranging conversion and dosage numerals into an equation, using the same logical format for all calculations. When using DA, all numerals must be labeled to correctly set up a calculation. This results in a correctly labeled answer, serving as a double check for accuracy. Because the DA method can be used for all dosage calculations, it’s used frequently, which helps nurses to retain it. As a practicing obstetric nurse, I find DA especially useful when solving I.V. infusion calculations, such as for magnesium sulfate, and weight-based neonatal dosages, such as for antibiotics.

Several researchers found that most calculation errors were conceptual and caused by incorrectly setting up an equation.①②⑦⑧ Long-term retention of specific calculations may depend on a conceptual understanding of dosage problems.②⑧ For a review of the research comparing DA to the formula method, see Supporting literature.

Dosage calculation review
All dosage calculations have two main components:
• a medication dosage prescribed by the healthcare provider.
• a medication concentration supplied by a pharmacy.

The supplied form of a medication is a concentration, not a fraction. The numerator (top) and denominator (bottom) factors can be flipped when setting up an equation because they’re equivalent.

Example: 325 mg = 1 tablet
1 tablet = 325 mg

In all calculations, the units of measure in the numerator will cancel out the same units of measure in the denominator, and vice versa.

Example: 1 tablet  x 650 mg
325 mg

A framework of quality and safety
The nursing profession has always been dedicated to safe, quality patient care. However, with an over-burdened U.S. healthcare system, major concerns regarding quality and safety have been documented.⑫ Quality and Safety Education for Nurses (QSEN) is an innovative framework for describing competencies applicable to the nursing profession.⑫ QSEN is being introduced in prelicensure nursing programs to better relate nursing education to nursing practice. The QSEN framework includes descriptions of the knowledge, skills, and attitudes necessary to carry out these six competencies: patient-centered care, teamwork and collaboration, evidence-based practice, quality improvement, informatics, and safety.⑫ Novel teaching strategies are needed to equip not only students but also nurses in practice with the knowledge, skills, and attitudes needed to achieve quality and safety standards.

As part of its goal, the competency of safety speaks of decreasing the risk of harm to patients.⑫ The knowledge needed to promote patient safety includes being aware of the limitations of certain technologies, such as I.V. pumps and their dosage alerts. The skills required to ensure patient safety include using technologies such as I.V. pumps correctly, and applying strategies that lessen reliance on memory. Safe patient care includes appreciating the safety benefits of standardized practices and recognizing the cognitive limits of human actions.⑫

The QSEN competency of safety is most relevant to medication administration. The DA method relates to the knowledge, skills, and attitudes of safety because the same standardized method can be used for all dosage calculations, without relying on memorization of specific formulas. Factors must be labeled to use the DA method, resulting in a correctly labeled answer for administration. This labeled dose also helps to ensure correct programming of I.V. infusion pumps as opposed to an unlabeled numeric answer.
Conversions within the metric system are in increments of 1,000. Move the decimal point three places to the left or the right when converting from one unit of measure to another:

1 kilogram (kg) = 1,000 gram (g)

0.25 milligram (mg) = 250 microgram (mcg)

1 g = 1,000 mg

0.5 g = 500 mg

1 mg = 1,000 mcg

3.5 kg = 3,500 g

1 liter (L) = 1,000 milliliter (mL)

0.5 L = 500 mL

The metric conversions can also be illustrated as:

kilogram ↔ gram ↔ milligram ↔ microgram

Other conversions to memorize include these:

2.2 pounds (lb) = 1 kg

1 grain = 60 mg

1 ounce (oz) = 30 mL

The goal is to set up the equation to cancel out all units of measure (labels) not needed in the answer (the dose to be administered). In DA, no formula needs to be memorized and the calculation results in a clearly labeled dose to be administered. The following steps to DA can be used to solve all dosage calculations. I’ll use some simple examples that can be performed without a calculator to introduce the DA method.

DA in four steps

Prescribed: acetaminophen 650 mg P.O. every 4 hours p.r.n.

Supplied: acetaminophen 325-mg tablets.

• Step 1: Determine what unit of measure (label) is needed to administer the medication as prescribed. Set up the left side of the equation so that the label needed for administration is in the correct numerator (and denominator, if applicable) position.

In this case, the medication to be administered is in tablet form.

? tablets

• Step 2: On the right side of the equation, place the information given with the same label as the answer in the numerator position to maintain the label needed for administration. In this case, place the concentration of the supplied medication in tablet/mg.

? tablets = 1 tablet

325 mg

• Step 3: Sequentially place information with the same label as the preceding denominator into the equation in the numerator position to cancel out the unwanted labels. Continue to place information until all unwanted labels are cancelled out. You’ll delete all labels except those needed for administration.

In this case, the prescription for 650 mg is placed in the numerator to be cancelled.

? tablets = 1 tablet

× 650 mg

325 mg

• Step 4: Multiply all the numbers across the numerator, and then all the numbers across the denominator, before dividing the top number by the bottom number for the final numerical answer that’s correctly labeled.

? tablets = 1 tablet

× 650 mg

325 mg

= 650

325

= 2 tablets

When you focus on understanding the reasoning behind the DA method, you won’t need to memorize the four steps. To summarize:

• Remember the phrase, “Start with the labels needed in the answer” to know what unit of measure is needed to begin setting up calculations using DA.

• From that point, build the calculation until all units of measure not needed in the answer are cancelled out.

• Perform the arithmetic in the calculation to determine the correctly labeled numeric answer. Don’t round any numbers in an equation until you obtain the final answer.

Practice makes perfect

Nurses are performing fewer dosage calculations due to medication safety technology. But practicing to solve dosage calculations is essential to maintain proficiency, regardless of the chosen method. Now let’s apply what you just learned to solve the practice problems on the following pages.
Oral medications; example 1:
Prescribed: potassium chloride 30 mEq P.O.
Supplied: potassium chloride 40 mEq/15 mL

<table>
<thead>
<tr>
<th>Step 1: Label needed?</th>
<th>? mL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 2: Same numerator.</td>
<td>? mL = 15 mL 30 mEq 40 mEq</td>
</tr>
<tr>
<td>Step 3: Place and cancel.</td>
<td>? mL = 15 mL 30 mEq 40 mEq</td>
</tr>
<tr>
<td>Step 4: Do the math.</td>
<td>( ? \text{ mL} = \frac{15 \text{ mL} \times 30 \text{ mEq}}{40 \text{ mEq}} = \frac{450}{40} = 11.25 \text{ mL} )</td>
</tr>
</tbody>
</table>

Oral medications; example 2:
Prescribed: digoxin 0.125 mg P.O.
Supplied: digoxin 0.25 mg/tablet (tab).

<table>
<thead>
<tr>
<th>Step 1: Label needed?</th>
<th>? tab</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 2: Same numerator.</td>
<td>? tab = tab 0.25 mg</td>
</tr>
<tr>
<td>Step 3: Place and cancel.</td>
<td>? tab = tab 0.125 mg 0.25 mg</td>
</tr>
<tr>
<td>Step 4: Do the math.</td>
<td>( ? \text{ tab} = \frac{\text{tab} \times 0.125 \text{ mg}}{0.25 \text{ mg}} = 0.5 \text{ tab} )</td>
</tr>
</tbody>
</table>

Injectable medications; example 1:
Prescribed: nalbuphine 15 mg subcutaneous now.
Supplied: nalbuphine 20 mg/mL

<table>
<thead>
<tr>
<th>Step 1: Label needed?</th>
<th>? mL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 2: Same numerator.</td>
<td>? mL = 1 mL 20 mg</td>
</tr>
<tr>
<td>Step 3: Place and cancel.</td>
<td>? mL = 1 mL 15 mg 20 mg</td>
</tr>
<tr>
<td>Step 4: Do the math.</td>
<td>( ? \text{ mL} = \frac{1 \text{ mL} \times 15 \text{ mg}}{20 \text{ mg}} = \frac{15}{20} \text{ mL} )</td>
</tr>
</tbody>
</table>

Injectable medications; example 2:
Prescribed: cefazolin sodium 250 mg I.M. now.
Supplied: cefazolin sodium 1 g/3 mL

<table>
<thead>
<tr>
<th>Step 1: Label needed?</th>
<th>? mL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 2: Same numerator.</td>
<td>? mL = 3 mL 1 g</td>
</tr>
<tr>
<td>Step 3: Place and cancel.</td>
<td>? mL = ( \frac{3 \text{ mL}}{1 \text{ g}} \times \frac{1 \text{ g}}{1,000 \text{ mg}} \times \frac{250 \text{ mg}}{1 \text{ mL}} = \frac{750}{1,000} \text{ mL} = 0.75 \text{ mL} )</td>
</tr>
</tbody>
</table>

Basic I.V. calculations; example 1:
Prescribed: cephalixin 1 g I.V. piggyback every 8 hours.
Supplied: cephalixin 1 g in 50 mL D10W to infuse over 30 minutes.
Reminder: I.V. pumps administer infusions in mL/hour.

<table>
<thead>
<tr>
<th>Step 1: Label needed?</th>
<th>? mL/( \text{hour} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 2: Same numerator.</td>
<td>( ? \text{ mL/( \text{hour} )} = \frac{50 \text{ mL}}{30 \text{ minutes}} \times \frac{60 \text{ minutes}}{1 \text{ hour}} = \frac{3,000}{100} \text{ mL/( \text{hour} )} )</td>
</tr>
<tr>
<td>Step 3: Place to cancel.</td>
<td>( ? \text{ mL/( \text{hour} )} = \frac{50 \text{ mL}}{30 \text{ minutes}} \times \frac{60 \text{ minutes}}{1 \text{ hour}} = \frac{3,000}{100} \text{ mL/( \text{hour} )} )</td>
</tr>
<tr>
<td>Step 4: Do the math.</td>
<td>( ? \text{ mL/( \text{hour} )} = \frac{50 \text{ mL}}{30 \text{ minutes}} \times \frac{60 \text{ minutes}}{1 \text{ hour}} = \frac{3,000}{100} \text{ mL/( \text{hour} )} )</td>
</tr>
</tbody>
</table>
Basic I.V. calculations; example 2:
**Prescribed:** regular insulin at 7 units/hour I.V.
**Supplied:** regular insulin 100 units in 100 mL 0.9% sodium chloride solution.

<table>
<thead>
<tr>
<th>Step 1: Label needed?</th>
<th>? mL hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 2: Same numerator.</td>
<td>? mL = ( \frac{100 \text{ mL}}{100 \text{ units}} )</td>
</tr>
<tr>
<td>Step 3: Place to cancel.</td>
<td>? mL = ( \frac{100 \text{ mL} \times 7 \text{ units}}{100 \text{ units} \times 1 \text{ hour}} )</td>
</tr>
<tr>
<td>Step 4: Do the math.</td>
<td>? mL = ( \frac{100 \text{ mL} \times 7 \text{ units}}{100 \text{ units} \times 1 \text{ hour}} \times \frac{100 \text{ mL}}{1 \text{ hour}} = 700 \times \frac{7 \text{ mL}}{100} )</td>
</tr>
</tbody>
</table>

Basic I.V. calculations; example 3:
**Prescribed:** nitroglycerin 5 mcg/minute I.V.
**Supplied:** nitroglycerin 50 mg in 500 mL 0.9% sodium chloride solution.

<table>
<thead>
<tr>
<th>Step 1: Label needed?</th>
<th>? mL hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 2: Same numerator.</td>
<td>? mL = ( \frac{500 \text{ mL}}{800 \text{ mg}} )</td>
</tr>
<tr>
<td>Step 3: Place to cancel.</td>
<td>? mL = ( \frac{500 \text{ mL} \times 1 \text{ mg} \times 5 \text{ mcg} \times 60 \text{ minutes}}{50 \text{ mg} \times 1,000 \text{ mcg} \times 1 \text{ hour}} )</td>
</tr>
<tr>
<td>Step 4: Do the math.</td>
<td>? mL = ( \frac{500 \text{ mL} \times 1 \text{ mg} \times 5 \text{ mcg} \times 60 \text{ minutes}}{50 \text{ mg} \times 1,000 \text{ mcg} \times 1 \text{ hour}} = \frac{150,000 \times 3 \text{ mL}}{50,000} \times \frac{60 \text{ minutes}}{1 \text{ hour}} )</td>
</tr>
</tbody>
</table>

Note: In this calculation, \( \frac{1 \text{ mg}}{1,000 \text{ mcg}} \) was needed to convert between mg and mcg. This step could be eliminated by converting the metric units before placing them into the equation. For example, 5 mcg could be converted to 0.005 mg by moving the decimal point three places to the left because mg is a larger unit of measure than mcg. Then it would be placed into the equation as \( \frac{0.005 \text{ mg}}{1 \text{ minute}} \) and the mg would cancel out.

Complex weight-based I.V. calculations; example 1:
**Prescribed:** heparin 15 units/kg/hour I.V.
**Supplied:** heparin 25,000 units/250 mL D,W = 100 units/1 mL
**Patient weight:** 195 lb.

<table>
<thead>
<tr>
<th>Step 1: Label needed?</th>
<th>? mL hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 2: Same numerator.</td>
<td>? mL = ( \frac{1 \text{ mL}}{100 \text{ units} \times 1 \text{ kg} \times 195 \text{ lb}} )</td>
</tr>
<tr>
<td>Step 3: Place to cancel.</td>
<td>? mL = ( \frac{1 \text{ mL} \times 15 \text{ units} \times 1 \text{ kg} \times 195 \text{ lb}}{100 \text{ units} \times 1 \text{ kg} \times 2.2 \text{ lb}} )</td>
</tr>
<tr>
<td>Step 4: Do the math.</td>
<td>? mL = ( \frac{1 \text{ mL} \times 15 \text{ units} \times 1 \text{ kg} \times 195 \text{ lb}}{100 \text{ units} \times 1 \text{ kg} \times 2.2 \text{ lb} \times \frac{60 \text{ minutes}}{1 \text{ hour}} = 2,925 \times \frac{13 \text{ mL}}{220} )</td>
</tr>
</tbody>
</table>

Note: In this calculation, lb needs to be converted to kg. This step could be completed before placing it into the equation by dividing the patient’s weight in lb by 2.2 because 1 kg = 2.2 lb.

Complex weight-based I.V. calculations; example 2:
**Prescribed:** dopamine 3 mcg/kg/minute I.V.
**Supplied:** dopamine 800 mg in 250 mL 0.9% sodium chloride solution
**Patient weight:** 167.5 lb (76 kg).

<table>
<thead>
<tr>
<th>Step 1: Label needed?</th>
<th>? mL hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 2: Same numerator.</td>
<td>? mL = ( \frac{250 \text{ mL}}{800 \text{ mg}} )</td>
</tr>
<tr>
<td>Step 3: Place to cancel.</td>
<td>? mL = ( \frac{250 \text{ mL} \times 1 \text{ mg} \times 3 \text{ mcg} \times 76 \text{ kg}}{800 \text{ mg} \times 1,000 \text{ mcg} \times 1 \text{ kg} \times 1 \text{ hour} \times \frac{60 \text{ minutes}}{1 \text{ hour}} = 3,420,000 \times \frac{4 \text{ mL}}{800,000} )</td>
</tr>
</tbody>
</table>

Note: In this calculation, \( \frac{1 \text{ mg}}{1,000 \text{ mcg}} \) was needed to convert between mg and mcg. This step could be eliminated by converting the metric units before placing them into the equation. For example, 3 mcg could be converted to...
0.003 mg by moving the decimal point three places to the left because mg is a larger unit of measure than mcg. Then it would be placed into the equation as \[ \frac{0.003 \text{ mg}}{\text{kg/minute}} \] and the mg would cancel out.

**Complex weight-based I.V. calculations; example 3:**

**Prescribed:** propofol 20 mcg/kg/minute I.V.

**Supplied:** propofol 15 mg/mL.

**Patient weight:** 217 lb.

<table>
<thead>
<tr>
<th>Step 1: Label needed?</th>
<th>? mL/hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 2: Same numerator.</td>
<td>? mL/hr = 1 mL/hr 15 mg</td>
</tr>
<tr>
<td>Step 3: Place to cancel.</td>
<td>? mL/hr = 1 mL/hr 15 mg x 1 mg/1,000 mcg x 20 mcg/kg x 1 kg/2.2 lb x 217 lb/60 minutes x 1 hour</td>
</tr>
<tr>
<td>Step 4: Do the math.</td>
<td>? mL/hr = 260,400 mL/33,000 hour x 8 mL/1 hour</td>
</tr>
</tbody>
</table>

**Note:** In this calculation, \[ \frac{1 \text{ mg}}{1,000 \text{ mcg}} \] was needed to convert from mg to mcg. This step could be eliminated by converting the metric units before placing them into the equation. For example, 20 mcg could be converted to 0.02 mg by moving the decimal point three places to the left because mg is a larger unit of measure than mcg. Then it would be placed into the equation as \[ \frac{0.02 \text{ mg}}{\text{kg/minute}} \] and the mg would cancel out.

**Summing up:** Following these guidelines and using the DA method can help improve the efficiency and accuracy of medication dosage calculations. This simple method may lead to a reduction in dosage calculation errors in clinical practice and add up to improved patient safety. ■

**REFERENCES**


Kristine L. Cookson is an RN at the Family Birthing Center of Promedica St. Luke’s Hospital in Maumee, Ohio, and an adjunct nursing instructor at Owens Community College in Toledo, Ohio.

The author has disclosed that she has no financial relationships related to this article.

DOI-10.1097/01.NURSE.0000428696.87216.e1