

Contextualized Curriculum

for Adult Learners in Math and Literacy

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It All Adds Up

Print:   

The importance of careful measurement in filling pharmaceutical orders

Industry Sector: [Healthcare](#)

Content Area: [Mathematics](#)

Core Topic: [Measurement and estimation](#)

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Common Core State Standards

Standards for Mathematical Practice:

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
6. Attend to precision.

High School—Number & Quantity: Quantities

- N-Q.1.** Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
- N-Q.3.** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

Adult Basic Education Standards

Geometry and Measurement

Standard G-4. Understand measurable attributes of objects and the units, systems, and processes of measurement and apply appropriate techniques, tools and formulas to determine measurements.

- 4.3** Estimate, measure, and compare lengths, weights, capacity using standard and non-standard units.
- 4.3.2** Making visual estimates of lengths.
- 4.5** Use the language (prefixes) of metric units to describe environment.

Industry Overview

Healthcare in America

From neonatal nurses to radiology technologists, medical coders to medical office assistants, health educators to home care aides, the healthcare industry provides a vast and diverse array of services to individuals at every stage of life. Providing [nearly 17 million jobs](#) and accounting for an estimated [\\$18 billion of the U.S. GDP in 2009](#), healthcare is the nation's largest industry. In Massachusetts, in particular, healthcare accounts for more than 15% of employment (compared with 12% nationally), accounting for approximately [one in six jobs](#). With an aging baby boomer population that is living longer, there is greater demand for more and higher quality preventative and long-term healthcare across the United States. [With eight of the 30 fastest growing occupations](#), healthcare is predicted to be one of the [fastest growing industries](#) both nationwide and in Massachusetts between now and 2020.

Careers in Healthcare

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

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

Mathematics and Communication Skills Needed in Healthcare

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

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

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

healthcare team perform specific function, and how well they communicate and collaborate with one another.

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

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

Career Opportunities in Healthcare with Education from Community Colleges

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

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

Recent Career Opportunities in Massachusetts

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

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

Employment Outlook for Healthcare

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

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

Emerging careers in Health/Information Technology (HIT): Estimates based on data from the Bureau of Labor Statistics (BLS), Department of Education, and independent studies indicate a shortfall of approximately 51,000 qualified Health IT (HIT) workers who will be required over the next five years to meet the needs of hospitals and [physicians](#) as they move to adopting an electronic healthcare system, facilitated by the Health Information Technology for Economic and Clinical Health (HITECH) Act of 2009. The HITECH Act is a key component of healthcare reform. The Act encompasses interoperable electronic health records (EHRs) including computerized systems to order tests and medications, and support systems to aid clinical decision making and the development of a national health information network to permit the secure exchange of electronic health information among providers. The Congressional Budget Office estimates that the incentive mechanisms in the HITECH Act will increase HIT adoption rates from 45 percent to about 70 percent for hospitals and from 65 percent to approximately 90 percent for [physicians](#). To support job growth in this emerging career field and ensure the adoption of EHRs, new types of workers are needed to facilitate information exchange across healthcare providers and public health authorities, and assist in redesigning workflows within healthcare settings to maximize the quality and efficiency [benefits](#) of EHRs, while maintaining privacy and security of health information and records. To that end, the Department of Health and Human Services has embarked on an initiative to build the HIT workforce with community colleges as the primary training ground for these new workers: (1) Practice workflow and information management redesign specialists; (2) Clinician/practitioner consultants; (3) Implementation support specialists; (4) Implementation managers; (5) Technical/software support staff; and (6) Trainers. The average hourly earnings for community college program graduates are expected to be in the target range of between \$12.46/hour to \$20.25/hour.

Resources:

Healthcare Employment Outlook:

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

Healthcare Career Information:

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

Massachusetts Healthcare Job Listings:

- [Massachusetts Healthcare Jobs, Jobs.net](#)
- [Healthcare Jobsite, Beyond.com](#)

Workplace Scenario (8th Grade Level)

This scenario is based on the work of a [pharmacy technician](#). For more information, view [this video](#).

You are a [pharmacy technician](#). You work at a large long-term care facility in Boston. You work with support from the facility's pharmacists. You prepare and give out [prescription medications](#) for patients. This may involve mixing two or more medications.

Technicians also prepare nutritional solutions for patients. Another responsibility is to prepare IV mixes. These are given directly in a patient's vein. A doctor sends you his or her orders. Your first task is to verify the medication. You also check the [dosage information](#). You then begin to prepare the order. This requires measuring different medications. You may need to find the [volume](#), [weight](#) or

[mass](#) of a substance. Then you will dispense the medication into containers. You carefully keep track of the number of pills. You are careful to put the correct number in each container.

You have worked for years at the pharmacy. You know the medications that are often used. You know their names, actions, uses and typical doses.

Precision in this field is essential. The wrong [dose](#) of a medication can cause a lot of harm. A patient could even die if given the wrong amount of medicine. Attention to detail is very important. This has enabled you to avoid potential problems. For example, sometimes a doctor makes mistakes. She or he might accidentally prescribe too large a [dose](#). You can ask the doctor to double check the order.

Different pharmacists work at your facility. You work closely with whichever pharmacist is on site. The pharmacist inspects each order. This makes sure that every medication and [dose](#) is correct. Then the medication is delivered to the nurse. The nurse dispenses the medication to the patient.

Workplace Scenario (High School Level)

This scenario is based on the work of a [pharmacy technician](#). For more information, view [this video](#).

You are a [pharmacy technician](#) at a large long-term care facility in Boston. You are one of a number of technicians who work under the supervision of the facility's pharmacists. You and the other technicians prepare and dispense [prescription medications](#) for patients. Preparing medications may involve mixing two or more medications to fill a doctor's prescription.

Technicians also prepare nutritional solutions and [intravenous mixes](#) for patients. After receiving a doctor's orders, you verify the prescribed medication and [dosage information](#). You then begin to prepare the order by measuring different medications. Measuring may involve finding the [volume](#), [weight](#) or [mass](#) of a substance. Once the medications are measured, you dispense them into containers. You are careful to keep track of the number of pills or tablets that go into each container.

You have worked for years at the pharmacy. As a result, you are familiar with the medications that are frequently used in the facility. You know the names, actions, uses and typical doses of these medications.

Precision in this field is essential. Too much or too little of a medication can cause serious harm, or even death, to a patient. Your attention to detail has enabled you to avoid potential problems. Several times, you have realized that a doctor mistakenly prescribed a [dose](#) that was far too large or small, and has corrected the amount before completing the order.

At any given time, one of several pharmacists will be at your facility. You work closely with whichever pharmacist is on site. The pharmacist inspects each order after you finish preparing it, to ensure that every medication and [dose](#) is correct. When the medication is released from the pharmacy, it is delivered to the nurse, who dispenses the medication to the patient.

Core instructional context

Measurement and estimation are critical life and workplace skills that are used frequently by students throughout their daily personal and working lives. Measurement is both a necessary skill for geometry and a tool that people rely on to help make sense of their world and understand physical objects and experiences, such as the temperature. Estimation, likewise, is important for informal measurements such as having a sense of what size something should be, how much something should cost, or how long a task should take.

Most students use measurement many times in their daily lives for activities such as cooking, home repairs and scheduling. In hobbies such as woodworking, precise measurement is crucial. Given students' experience and dependence on measurement, it is likely that they will have a high level of interest in tackling problems using measurement, and they will have many relevant experiences to share. It's also likely an area in which they will have a high degree of confidence in their abilities.

In healthcare, precise measurement is absolutely crucial—lives depend on healthcare workers paying careful attention to dosages and accurately measuring medications. Metric measurements are used more often than measurements in the U.S. standard units and can involve both converting within the metric system and converting between metric and non-metric units. In addition, some medical treatments, such as radiation therapy for cancer, require treating the disease with a substance that can harm the body. In these cases, measurements not only need to be extremely precise, but also can involve extremely small numbers, with little to no room for error. From doctors and nurses to pharmacists and down to the entry-level pharmacy technicians who fill orders for medications, these skills are absolutely essential. While pharmacy technicians might be hired with only a high school diploma in Massachusetts, they do then go through training with their employer. Employers and certificate programs require strong mathematics skills in candidates.

Worked Examples

Conversion Examples

The scenario in this module highlights the metric system and its importance in the medical field. To familiarize students more with the metric system, consider beginning with a basic activity that converts a number from one metric unit to another, involving just moving one decimal place to the left or right. Then, provide students with some more complex metric conversions. Some examples are:

- 1 cm to mm:
 - move the decimal one place to the right

Answer: 1 cm = 10 mm

- 0.1 g to mg
 - move the decimal three places to the right

Answer: 0.1 g = 100 mg

- 375 ml to l
 - move the decimal three places to the left

Answer: 375 ml = 0.375 l

Contextualized Example

You are a pharmacist checking on a doctor's order for 200 mg of medication to be taken by a 15.4 lb infant every 8 hours. The medication label shows that 75-150 mg/kg per day is the appropriate dosage range. Is this doctor's order within the desired range?

Present this formula to the class.

weight in kg * dosage per kg = Y (required dosage)

First, have students identify the known quantities and unknown quantities. Ask students what they think they need to find.

Then, give students the steps in bold, and let them figure out how to calculate the steps in groups, using the available resources to research the necessary conversion formulas.

Step 1: Convert pounds to kilograms.

Convert 15.4 lb to kg:

- lb → kg (divide [weight](#) in lb by 2.2)
- 15.4 lb ÷ 2.2 = 7 kg

Step 2: Find minimum and maximum desired dosage per day—in other words, the desired range per day.

7 kg * 75 mg/kg = 525 mg (Minimum Desired Dosage)

7 kg * 150 mg/kg = 1,050 mg (Maximum Desired Dosage)

Step 3: Figure out how much the infant would actually be getting in 24 hours.

24 hours in one day and the medication is ordered every 8 hours.

- 24 hrs / 8 hrs = 3 times per day doctor ordered medication
- 200 * 3 = 600 mg ordered per day
- 600 mg is within the desired range of 525-1,050 mg

Answer: Yes, the doctor has ordered a dosage within the desired range.

Contextualized learning activities

Pre-Reading

Ask students to think back about a time they ordered a prescription. It could be anything—allergy medication, antibiotics, or otherwise. Ask students what information they needed from the doctor and what information the pharmacist must have needed. Then, ask students to list what tasks they think go on “behind the scenes” when ordering [prescriptions](#).

Reading the Scenario

Have students read the scenario in this module—either as a whole group, in pairs, or to themselves. Ask students to circle or highlight mathematics-related concepts and terminology.

Many of the key responsibilities of a [pharmacy technician](#) involve measurement and dosage calculations. Ask students to [brainstorm](#) ways that mathematics is used to help with such daily activities. In particular, ask students if they can identify any ways that the fundamental operations (addition, subtraction, division and multiplication) are used. Ask students what accuracy and precision mean. After distinguishing between the two, discuss how these concepts are important in this profession. Discuss the possible consequences of inaccurate or imprecise measurements in this profession.

Optional Extension: Have students individually write down what they expect from a doctor and a pharmacist when they get a prescription. Have students share their description with a partner and then work together to list ways that they used mathematics in general during that time block. Have students be as explicit as possible and write down a particular number of examples if possible.

Medication Analysis

Provide an example of a medication label from a bottle. Discuss the information that is included on the label, including units of [volume](#), [mass](#), and time. Ask students to point out examples of where mathematics might be needed to interpret the meaning of the label. Choose an amount given on the label, and ask students work in pairs to write or draw or otherwise present as many different ways of expressing that amount as they can. (For example: 0.5 ml, showing a 0.2 ml syringe that is $\frac{1}{4}$ full.) If necessary, spend time with the class exploring why these amounts are equivalent and how they can find other equivalent amounts.

Role-Play Scenarios

Mr. Robert Hanover is a transplant patient and was prescribed 300 mg of Tacrolimus (a transplant medication) per month. On March 1, Robert ran out of medication and called the pharmacy to refill his

prescription. Because there were no refills available, the [pharmacy technician](#) called his physician. The physician verbally gave the order to dispense 5 mg capsules and the instructions were to take 5 capsules twice daily.

Have students answer these questions in pairs prior to role-playing:

1. If 300 mg are to be taken in a 30-day month, how many mg should be taken per day?
2. If the medicine is taken twice daily, and each capsule is 5 mg, how many capsules should the patient be taking each time?
3. Was the doctor's prescription the appropriate [dose](#) or not? If not, how much was it off by? How do you know?

After students have had a chance to answer these questions, review this information with the class:

If 30 days are used for a typical month, and the required dosage is 300 mg per month, you should expect 10 mg per day, or 2 x 5 mg a day. The doctor's dosage was 50 mg per day, or five times the appropriate [dose](#).

Now, have each pair will role-play the following scenario at their desks:

After the call with the doctor, the technician needs to report to the pharmacist that the doctor has made an error in calculating a [dose](#), resulting in more than the appropriate dosage for a month.

After role-playing within their pairs, one or more pairs will act out their role-playing in front of the class. Although the dialogue can be improvised to some extent, students should be aware of where the situation is going and should use the numbers from their calculations. Students will be evaluated on how well they integrate their knowledge of mathematical calculations into their role-play performance.

Lab Practical Stations

Have students rotate through different stations in the room. At each station, place containers with one or more substances, measuring tools, and instructions for the measurement exercise at that station.

Equipment Needed: scale, measuring cups, different types of spoons

Vocabulary: solution, solute, solvent, [volume](#), [mass](#), concentration

Example 1: At one station, have a measuring cup filled with 20 ml of water (as a proxy for a [dose](#) of children's medication). Have students at that station record the [dose](#) in milliliters using different pieces of measuring equipment.

Require students to record the precision of different measurement devices (for example, kitchen teaspoon versus medical teaspoon).

Example 2: Have students at another station measure out the [mass](#) of a solid to be dissolved in water. Have students then measure out the [volume](#) of water that the solid should be dissolved in. Then, have students determine the concentration of the solution.

After rotating through all the stations, students present their work and their findings. The instructor and the class provide feedback on their level of accuracy.

Contextualized Problems

1. An 85 lb child is prescribed 5 mg/kg of medication every 24 hours. Calculate how many mg she should take in a day.

Answer: 193 mg

2. A patient is prescribed 300 ml/hour of a medication for 4 hours. Calculate the total [volume](#) of medication he has been prescribed in liters (l).

Answer: 1.2 l

3. A [client](#) has ordered 15 mg of a medication. You have 2 ml of solution on hand, which contains 25 mg of the drug. What [volume](#) of solution would you give?

Answer: 1.2 ml

4. Student-Designed Problems: Have students write additional problems and share these problems with their classmates. For each problem, students should write an answer key depicting one effective problem solving process. Problems can involve patients of different ages, ranging from infant to elderly.

Contextualized test items

1. A patient is prescribed 0.1 mg of a medication daily. However, the medication is only available as 50 mcg tablets. How many tablets does the patient need to take daily?

- A. $\frac{1}{2}$ tablet
- B. 1 tablet
- C. **2 tablets**
- D. 10 tablets

2. A patient is prescribed 2 g of a medication daily. However, the tablets in stock are measured in mg. How many mg of medication should the patient be given?

- A. 0.002 mg
- B. 0.5 mg
- C. 500 mg
- D. **2000 mg**

3. How many days will a patient take a medication if the doctor orders a 240 ml bottle of the medication, and the patient takes the prescribed [dose](#) of 2 tsp every 8 hours?

- A. 2 days
- B. **8 days**
- C. 15 days
- D. 24 days

4. A physician prescribes a new medication for a child who weighs 110 lbs. The medication dosage should be 5 mg/kg daily. What is the correct daily [dose](#) for this child?

- A. **250 mg**
- B. 550 mg
- C. 1100 mg
- D. 1250 mg

5. A doctor gives her patient a prescription for a cough medicine and tells the patient to take 2 mg four times a day. There are 2 mg of the medicine in each 5 ml of the suspension. How many teaspoons does the patient need to take in each [dose](#)?

- A. 1 tsp
- B. 2 tsp
- C. $2\frac{1}{2}$ tsp
- D. **4 tsp**

Contextualized project

Students may interview a pharmacist about how mathematics is used in their field. A transcript and report could then be submitted for a grade, and a presentation on the interview could be made. The

instructor may want to create a “Voices from the Field” wiki or an online “Sharing Showcase” discussion forum where students post articles they have written about their interviews.

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

Converting between metric or non-metric units involves multiplying or dividing by conversion factors. The following are some online conversion tables that students might find helpful in their problem solving:

- [Metric to Non-metric Conversions](#), HotFlo!
- [Pharmacy Measurement Conversions](#), Pharmacy Tech Studies
- [Measurement Conversion Tables](#), TostePharmD

Videos and Practice Problems:

- [Dosage Calculations](#), Pharmacy Tech Study

Khan Academy Videos

Each of the videos below depicts how to solve one or more problems related to this topic. Consider working through these problems with students and having students watch the related video before or after they work the contextualized problems in this module.

- [Conversion Between Metric Units](#), Khan Academy
- [Solving Application Problems Involving Units of Volume](#), Khan Academy
- [Unit Conversion Example: Drug Dosage](#), Khan Academy

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