SECOND EDITION

Calculating Drug Dosages

A Patient-Safe Approach to Nursing and Math

Castillo • Werner-McCullough

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A Patient-Safe Approach to Nursing and Math

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To God for the many blessings, and my parents for their vision.
— Sandra

To Gabriel, may the path you choose bring you peace and true happiness.
— Maryanne

PREFACE

Dear Students:

We are excited to present the second edition of *Calculating Drug Dosages: A Patient-Safe Approach to Nursing and Math.* Prevention of medication errors and promoting patient safety continues to be the focus of this book. In addition to demonstrating how to solve a drug dosage problem, we have included medication administration situations encountered in clinical practice. Each chapter is unique and designed to build your confidence in drug dosage calculation.

In the chapters you will find:

- A choice of four methods of calculation.
- Math tips that are related to medication administration in clinical practice.
- Updated clinical situations that demonstrate issues regarding medication administration.
- Updated simulated medication orders and electronic medication administration records.
- Updated excerpts from drug references that apply to the calculation of dosages.
- Practice problems that will help you to develop math competency.
- Situations that promote clinical judgment and decision making.

Developing competency in drug dosage calculations takes practice. We encourage you to practice solving drug dosage problems every day and to always follow recommended guidelines when administering medications. Taking the time to practice drug dosage calculations demonstrates a commitment to patient safety.

To the Instructor:

Thank you for using *Calculating Drug Dosages: A Patient-Safe Approach to Nursing and Math* to teach students how to calculate drug dosages accurately and with confidence. In the second edition we continue to emphasize the importance of safety in the total process of medication

administration, from reading the medication order to the calculation of the dose and documentation of the medication.

Key features of the book include:

- Drug dosage problems solved in four methods: Linear Ratio and Proportion, Fractional Ratio and Proportion, Dimensional Analysis, and the Formula Method.
- Drug dosage problems that require the use of critical thinking and clinical judgment.
- Emphasis on the implementation of evidence-based safe practices appropriate to the situation.
- Updated simulated medication orders and electronic medication administration records.
- Updated drug labels and excerpts from drug references that apply to the calculation of dosages.
- *Apply Learned Knowledge* activities that reinforce the mathematical and clinical concepts presented.
- *Developing Competency* drug dosage problems at the end of each chapter.
- Additional drug dosage problems available online that reinforce the content of each unit.
- NEW! Added content, including U-500 insulin administration, weight-based dosing protocols for IV heparin, and formulas for calculating pediatric maintenance IV fluid rates.
- Advocacy for applying a "Vigilant Process" in medication administration for special populations such as the older adult.

We hope that this book is a valuable resource for you and your students.

Sandra and Maryanne

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Body Surface Area Nomogram

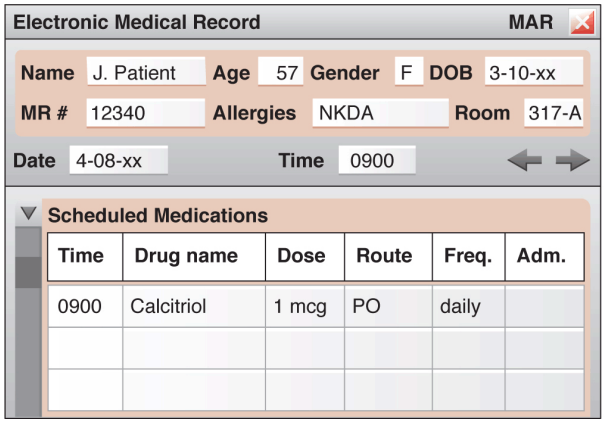
UNIT 1

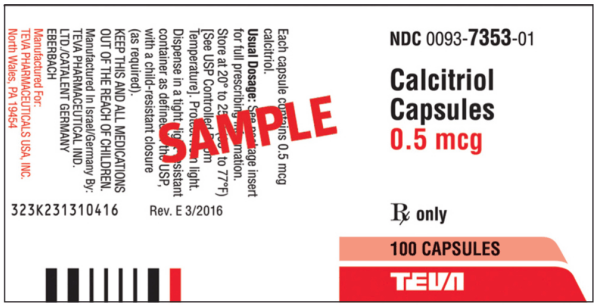
Safety in Medication Administration

Safe medication administration requires the collaborative effort of all healthcare providers to initiate, evaluate, and contribute to practices that promote patient safety. This unit provides you with information that emphasizes safe medication administration practice, from the initial reading of a medication order and drug label to the application of the Six Rights of Medication Administration.

APPLICATION TO NURSING PRACTICE

The nurse uses the patient's medication administration record and the drug label to ensure that the correct drug and dose is administered to the patient.





In applying safe medication administration practice, the nurse must understand the information on the drug label to answer questions such as:

- *Is this the right drug?*
- *What is the dosage strength of the drug?*
- *What is the recommended route of administration?*
- *Is this a controlled substance?*

CHAPTER 1

Safety in Medication Administration

LEARNING OUTCOMES

Discuss safe practices that help to prevent medication administration errors.

Identify safe medication practices that assist patients and families in taking greater responsibility for the management of their medication therapy.

Discuss how the Six Rights of Medication Administration promote safe practice.

Safety in medication administration involves the collaborative effort of healthcare professionals, drug manufacturers, healthcare organizations, ongoing scholarly research, and informed patients and families. Safety in medication administration is everyone's responsibility, from the establishment of national standards for the manufacturing and monitoring of drugs, to standard guidelines for prescribing and administering medications, to assisting patients in assuming greater responsibility for the management of their medication.

The prominent report *To Err Is Human: Building a Safer Health System* (1999), published by the Institute of Medicine, brought attention to the number of annual deaths in hospitals that were attributed to preventable medical errors. Medical errors that cause harm to the patient, including medication errors, are costly and have devastating effects for patients, families, and society.

To consistently work toward minimizing errors, healthcare organizations are encouraged to establish a ***"culture of safety."*** Organizations that embrace a culture of safety promote activities that create a continuous awareness for patient safety and encourage collaboration among healthcare staff from all levels to seek solutions to problems. An integral component of the culture of safety is the concept of ***"just culture."*** First introduced in 2001 by attorney David Marx, the concept focuses on identifying and analyzing factors and the sequence of actions that lead to a patient error. This careful analysis of the error recognizes that situations or processes within the healthcare system may lead the individual to make an unintentional error. This nonpunitive approach allows healthcare professionals to discuss the error or situations that may cause possible errors without fear of punishment. The culture of safety also recognizes that healthcare professionals need to be held accountable for errors that occur due to at-risk behaviors (i.e., not using two patient identifiers prior to giving medications, not double-checking medications per institutional policy) or reckless behaviors (i.e., taking shortcuts such as not following the Six Rights of Medication Administration). The primary focus of this analysis is to learn how best to prevent similar errors in the future.

There are many government and nongovernment agencies that address healthcare and patient safety issues, for example: the U.S. Food and Drug Administration (FDA), the U.S. Department of Health and Human Services, the American Society of Health-System Pharmacists, and the National Coordinating Council for Medication Error Reporting and Prevention. Because of the research with medication safety and the implications of the findings and recommendations to nursing practice, the Health and Medicine Division of the National Academies and the Institute of Medicine and the Institute of Safe Medication Practices will be discussed.

The Health and Medicine Division of the National Academies

The Health and Medicine Division (HMD) is a division of the National Academies of Sciences, Engineering, and Medicine. The National Academies is a private nonprofit organization that serves to provide independent analysis and advice to the nation related to science, technology, and medicine. The HMD was previously known as the Institute of Medicine

(IOM). The IOM conducted prominent research studies that addressed national healthcare issues. Through national research studies, the IOM provided reliable information and made recommendations for best practices. In the July 2006 IOM report *Preventing Medication Error: Quality Chasm Series*, the IOM indicated that medication errors can occur at every phase of the medication process, from prescribing and dispensing to administering and monitoring for the effects of the drug. However, based on the report, medication errors occurred most frequently at the prescribing and administering phases. The prevention of harm to a patient is of priority. To this end, the IOM strongly advocated that the first and foremost intervention for safety in the use of medications is the establishment of a partnership between the patient and the healthcare provider. The goal of this partnership was to facilitate the process for the patient to take more responsibility in the management and in the monitoring of his or her medications.

Table 1-1 lists the recommendation identified in the IOM report. The 2007 IOM publication and other patient safety recommendations can be found in the National Academy of Sciences website: nationalacademies.org.

The implications for nursing practice, by the IOM, in Table 1-1 serve as a reminder of the importance of teaching patients and families so that they can take a more active role in monitoring their medications.

Table 1-1. Institute of Medicine Recommendations for Reducing Medication Errors

IOM RECOMMENDATIONS	IMPLICATIONS FOR NURSING PRACTICE
Patients/families need to take greater responsibility for monitoring their medications and reporting changes.	Communicate and provide ongoing patient teaching regarding drug therapy, with a focus on the individual needs of the patient, his or her culture, and lifestyle.
	Encourage the use of reliable resources for obtaining drug information. Ensure the patient knows whom to contact for questions regarding his or her drug therapy.
Patients/families need to maintain accurate records of all medications.	Review list of all medications, educate, consult, and listen to patient's concerns and questions.
Openness regarding errors and problems.	Communicate openly with the patient and family when errors occur, explain consequences and interventions to correct the problem.

The Institute of Safe Medication Practices

The Institute of Safe Medication Practices (ISMP) is a nonprofit agency established in 1975 with the primary purpose of identifying the causes of medication errors and of recommending evidence-based strategies for the prevention of these errors. An invaluable resource, ISMP keeps healthcare professionals, healthcare facilities, the pharmaceutical industry, and other government agencies informed of medication safety issues (http://www.ismp.org). The research, resources, and services provided by the ISMP have had a strong influence in changing medication practices

across all healthcare settings. In 2003, the ISMP published a list of abbreviations, symbols, and dose designations (the way medication doses are written) that were prone to cause medication errors if misread or misinterpreted. Table 1-2 highlights some of the ISMP recommended changes in the use of abbreviations, symbols, and dose designations with examples for correct use. The recommendations made by the ISMP were supported by national patient safety organizations and have become standard practice. The complete list of Error-Prone Abbreviations, Symbols and Dose Designations published by ISMP is found in the Safe Dosage Resources on FADavis.com

HIGH ALERT MEDICATION LIST

The ISMP also provides a listing of high-alert medications; these are medications that have an increased risk of causing significant patient harm (see Safe Dosage Resources on FADavis.com). All drugs have the potential for side effects and adverse effects; however, drugs identified as "high alert" indicate that the drug has an increased potential for patient harm, and signifies the need for healthcare professionals to be vigilant in the preparation of the ordered dose, the administration of the drug to the patient, and the monitoring of the patient for the drug's effects. Drug references prominently identify high alert drugs (Fig. 1-1).

Table 1-2. ISMP's List of Error-Prone Abbreviations, Symbols, and Dose Designations

ERROR-PRONE ABBREVIATIONS, SYMBOLS, AND DOSE DESIGNATIONS	EXAMPLE
Do not use trailing zeros for doses expressed as whole numbers.	Write 5 mg, never 5.0 mg
Use a zero before a decimal point when the dose is less than one whole unit.	Write 0.3 mg, never .3 mg
Place adequate space between the drug name, dose, and unit of measure.	Write calcitriol 0.5 mcg, never calcitriol 0.5 mcg
Spell out the word "unit." Never use "U," which easily can be mistaken as a zero, causing a 10-fold overdose.	Write 30 units, never 30 u
Do not use a period after abbreviations such as "mg." or "mL." (Write "mg" or "mL" without the period.)	Write mL, mg, mcg, g, etc. Never mL•, mg•, mcg•, or g•
Use the abbreviation "mcg" for microgram. Do not use the Greek letter μ to represent "micro" in healthcare.	Write 4 mcg or 4 micrograms, never 4 μg, because "μg" could be misread as mg
For the abbreviation of milliliter, use mL (lower/uppercase). Do not use "cc," which has been misread as "U" or the number 4.	Write 10 mL, never 10 cc
Include properly spaced commas for dose numbers expressed in thousands (e.g., 5,000 units).	Write heparin 5,000 units, never heparin 5000 units

Use the word “thousand” for larger doses in the hundreds of thousands (e.g., 150 thousand rather than 150,000).	
Use the word “million” for doses expressed in millions (e.g., 1 million units) to avoid possible misplacement of commas and misreading the dose if the commas are not seen correctly with such large numbers.	Write penicillin 1 .5 million units, never penicillin 1,500,000 units

Modified from the complete listing available at https://ismp.org/recommendations/error-prone-abbreviations-list

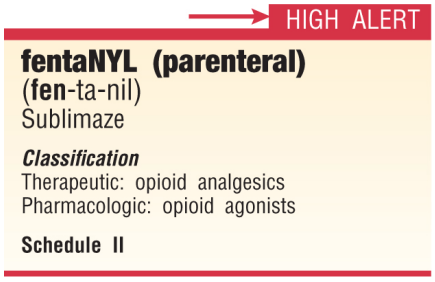


Figure 1-1. Identification of a high alert drug in a drug reference guide.

CONFUSED DRUG NAMES LIST

There are several drug names that, when spoken or written, look alike and sound alike. These drug names have the potential to be confused with each other and may lead to a medication error. Figure 1-2 provides an example of drug name pairs that look alike and sound alike. The ISMP publishes a listing of drugs names that ***look alike*** or ***sound alike*** (Confused Drug Names). This listing is found at the Web site www.ismp.org/tools/confuseddrugnames.pdf, and is included in the Safe Dosage Resources on FADavis.com. To minimize errors, it is recommended that the nurse become familiar with look-alike and sound-alike drug names, double-check the drug name against the doctor’s order and the patient medication record, and know why the patient is

receiving the drug. More information regarding look-alike and sound-alike drugs can be found in Chapter 2, The Drug Label.

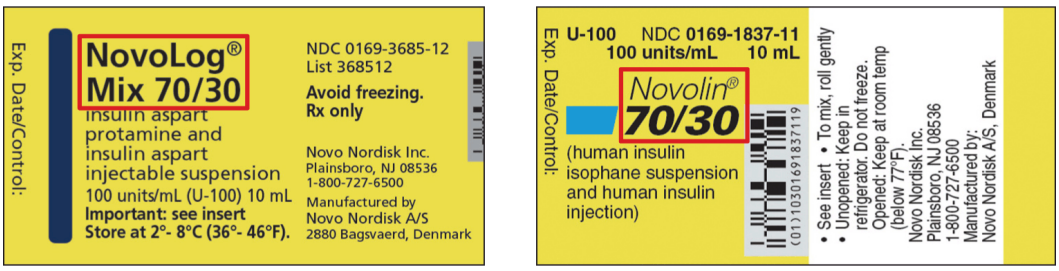


Figure 1-2. Examples of confused drug name pairs from the ISMP listing.

THE JOINT COMMISSION

The Joint Commission, the national healthcare accrediting organization, developed a "Do Not Use" list of abbreviations as a national safety patient goal, emphasizing the importance of eliminating the use of several abbreviations. The list from The Joint Commission includes some abbreviations found in the ISMP's list of Error-Prone Abbreviations, Symbols, and Dose Designation. The Joint Commission's official list can be found in the Safe Dosage Resources on FADavis.com and at https://www.jointcommission.org/-/media/tjc/documents/resources/patient-safety-topics/do_not_use_list_6_28_19.pdf.

More Safety Practices

TALL MAN LETTERING

In its continuous effort to promote safety in medication administration and to reduce the risk of errors, the Office of Generic Drugs of the U.S. Food and Drug Administration (FDA) recommends that drug manufacturers use tall man lettering in writing the names of specific drugs. ***Tall man lettering*** is the use of mixed-case letters (lower- and uppercase) in a drug name with the specific purpose of highlighting a section of the drug name in bold uppercase letters, therefore making the name more noticeable on the packaging and on the drug label. This helps distinguish the drug from another drug with a similar name (Fig. 1-3).

RISK EVALUATION AND MITIGATION STRATEGY

In 2007, the FDA was granted the authority to implement the ***Risk Evaluation and Mitigation Strategy (REMS)*** program to watch over the use of certain drugs, such as opioids, prescribed primarily in the management of moderate to severe pain. The REMS is a drug safety program that helps to ensure that the benefits of a specific drug or drug class outweigh the risks. When a drug or drug class is under the REMS program, drug manufacturers are mandated to comply with specific requirements, such as the development of a plan for monitoring the drug for as long as the drug is on the market, safety strategies that address training for healthcare providers, and development of patient information that identifies the drug's risks and benefits. As part of the safety strategies, manufacturers need to provide a medication guide or package insert to be issued by the pharmacist each time the drug is dispensed.

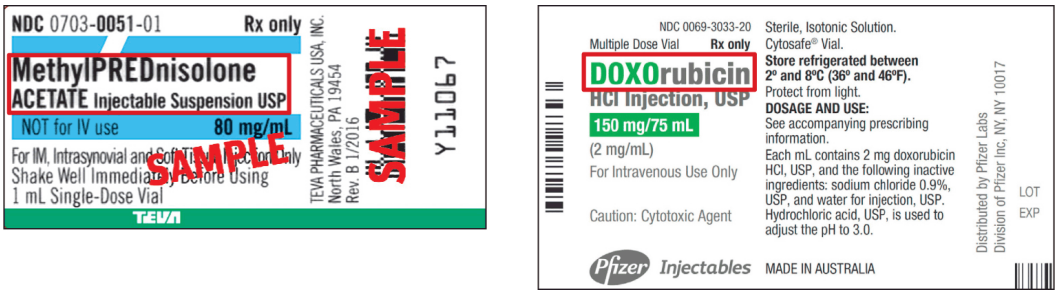


Figure 1-3. Examples of drug names with tall man lettering.

The medication guide includes FDA-approved information to help reduce the occurrence and severity of certain serious risks by informing the consumer and supporting the safe use of the drug. The desired outcome of the REMS program is improved patient safety. Box 1-1 contains an example of a medication guide. Information regarding medication guides can be found at: https://www.fda.gov/drugs/drug-safety-and-availability/medication-guides

Box 1-1. Example of a REMS Medication Guide Approved by the FDA

Medication Guide

MS CONTIN® (MS-KON-tin)
(morphine sulfate controlled-release) Tablets, CII
MS CONTIN is:

- A strong prescription pain medicine that contains an opioid (narcotic) that is used to treat moderate to severe around-the-clock pain.

Important information about MS CONTIN:

- Get emergency help right away if you take too much MS CONTIN (overdose). MS CONTIN overdose can cause life-threatening breathing problems that can lead to death.
- Never give anyone else your MS CONTIN. They could die from taking it. Store MS CONTIN away from children and in a safe place to prevent stealing or abuse. Selling or giving away MS CONTIN is against the law.

Do not take MS CONTIN if you have:

- severe asthma, trouble breathing, or other lung problems.
- a bowel blockage or narrowing of the stomach or intestines.

Before taking MS CONTIN, tell your healthcare provider if you have a history of:

- head injury, seizures
- liver, kidney, thyroid problems
- problems urinating
- pancreas or gallbladder problems
- abuse of street or prescription drugs, alcohol addiction, or mental health problems

Tell your healthcare provider if you are:

- pregnant or planning to become pregnant. MS CONTIN may harm your unborn baby.
- breastfeeding. MS CONTIN passes into breast milk and may harm your baby.
- taking prescription or over-the-counter medicines, vitamins, or herbal supplements.

When taking MS CONTIN:

- do not change your dose. Take MS CONTIN exactly as prescribed by your healthcare provider.
- take each dose at the same time every day. If you miss a dose, take MS CONTIN as soon as possible and then take your next dose 8 or 12 hours later as directed by your healthcare provider. If it is almost time for your next dose, skip the missed dose and go back to your regular dosing schedule. Do not take more than 1 dose in 8 hours.
- swallow MS CONTIN whole. Do not cut, break, chew, crush, dissolve, or inject MS CONTIN.
- Call your healthcare provider if the dose you are taking does not control your pain.
- Do not stop taking MS CONTIN without talking to your healthcare provider.

While taking MS CONTIN Do Not:

- drive or operate heavy machinery, until you know how MS CONTIN affects you. MS CONTIN can make you sleepy, dizzy, or light-headed.
- drink alcohol or use prescription or over-the-counter medicines that contain alcohol.

The possible side effects of MS CONTIN are:

- constipation, nausea, sleepiness, vomiting, tiredness, headache, dizziness, abdominal pain. Call your healthcare provider if you have any of these symptoms and they are severe.

Get emergency medical help if you:

- have trouble breathing; shortness of breath; fast heart beat; chest pain; swelling of your face, tongue, or throat; extreme drowsiness; or if you are feeling faint

These are not all the possible side effects of MS CONTIN. Call your doctor for medical advice about side effects. You may report side effects to the FDA at 1-800-FDA-1088. For more information, go to http://dailymed.nlm.nih.gov.

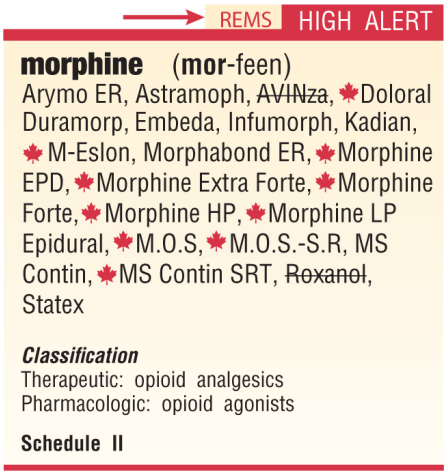
Manufactured by: Purdue Pharma L.P., Stamford, CT 06901-3431, www.purduepharma.com or call 1-888-726-7535.
This Medication Guide has been approved by the U.S. Food and Drug Administration. Issue: July 2012 Modified from https://www.fda.gov/media/83936/download

Drug references identify medications under the REMS program by adding the REMS acronym to the drug information (Fig. 1-4). The nurse can use the medication guide to help teach the patient and family about the drug.

BOXED WARNINGS

Boxed warnings, often referred to as "black box warnings," have been included on the label of specific prescription medications to advise the healthcare professional and the patient about serious potential risks and side effects related to the use of the drug. Figure 1-5 on page 8 provides an example of the boxed warning from the package insert for the drug metoclopramide. Notice the accompanying directions on the drug label.

Healthcare professionals need to make a concerted effort to read drug labels carefully, consult the pharmacist, and seek reliable drug references and Web sites for current information and FDA recommendations. More information regarding boxed warnings on drug labels can be found in Chapter 2.

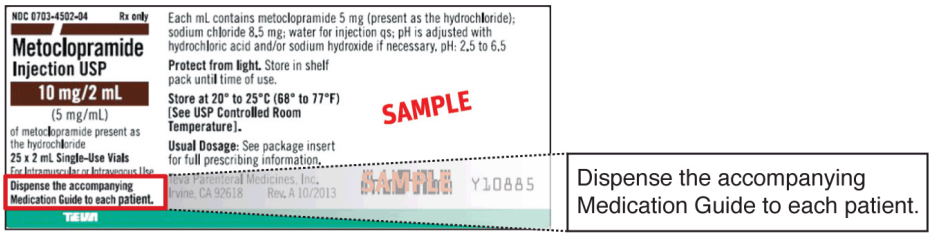

REMS HIGH ALERT

morphine (**mor**-feen)
Arymo ER, Astramoph, ~~AVINza~~, Doloral Duramorp, Embeda, Infumorph, Kadian, M-Eslon, Morphabond ER, Morphine EPD, Morphine Extra Forte, Morphine Forte, Morphine HP, Morphine LP Epidural, M.O.S, M.O.S.-S.R, MS Contin, MS Contin SRT, ~~Roxanol~~, Statex

Classification
Therapeutic: opioid analgesics
Pharmacologic: opioid agonists

Schedule II

Figure 1-4. Morphine identified as part of the REMS program



Metoclopramide Injection USP
Package Insert
4502
Rx only

WARNING: TARDIVE DYSKINESIA

Treatment with metoclopramide can cause tardive dyskinesia, a serious movement disorder that is often irreversible. The risk of developing tardive dyskinesia increases with duration of treatment and total cumulative dose.

Metoclopramide therapy should be discontinued in patients who develop signs or symptoms of tardive dyskinesia. There is no known treatment for tardive dyskinesia. In some patients, symptoms may lessen or resolve after metoclopramide treatment is stopped.

Treatment with metoclopramide for longer than 12 weeks should be avoided in all but rare cases where therapeutic benefit is thought to outweigh the risk of developing tardive dyskinesia. See WARNINGS.

Figure 1-5. Boxed warning for metodopramide.

The Medication Administration Process

The medication process involves several steps:

1. The medication is ordered.
2. The medication order is interpreted (validating the accuracy and completion of the order) and transcribed as written.
3. The components of the Six Rights of Medication Administration are used to
   - prepare the ordered medication and
   - administer the medication to the patient.

THE MEDICATION ORDER

The administration of medications begins with the medication order. Technology has facilitated the process for prescribing medications and making the medication order more legible. It is important to remember that in the administration of medications, the medication order, whether it is electronically generated or handwritten, must contain the following basic

components: patient identification information, drug name, ordered dose, route of administration, and frequency of administration (Fig. 1-6).

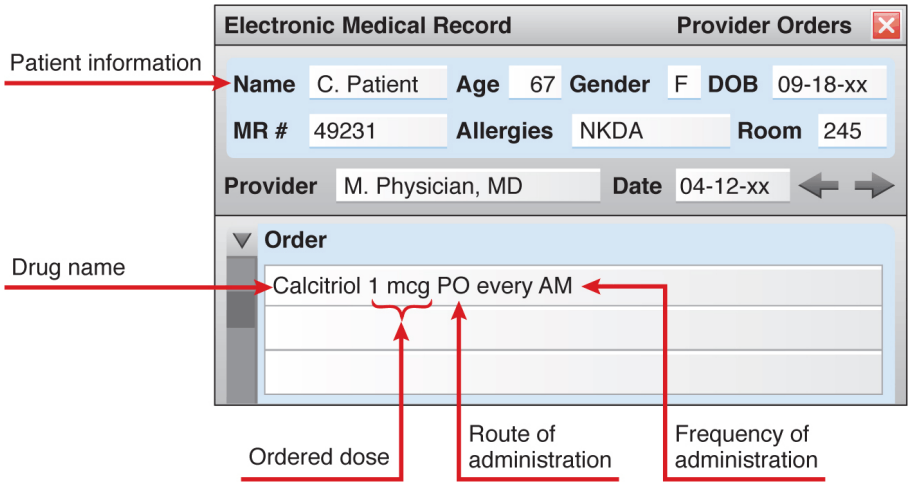


Figure 1-6. Medication order with medication administration components.

Safety considerations in reading the medication order begin by knowing the basic components that constitute the medication order and seeking clarification if any of the components are missing or are unclear.

INTERPRETATION AND TRANSCRIPTION OF THE MEDICATION ORDER

Once the medication order is written, the order needs to be interpreted and transcribed. The medication administration record (MAR) may be electronically generated by the pharmacist (Fig. 1-7), or the medication order may be interpreted and transcribed by the nurse into a MAR in paper format (Fig. 1-8). Regardless of the format, the MAR must correctly identify the patient as well as identify all of the basic components of the ordered drug name, ordered dose, route, and frequency of administration ordered by the physician. Additional instructions for the safe administration of the drug may be ordered by the physician. The instructions guide the nurse in determining the safe administration of the drug based on the patient's clinical condition.

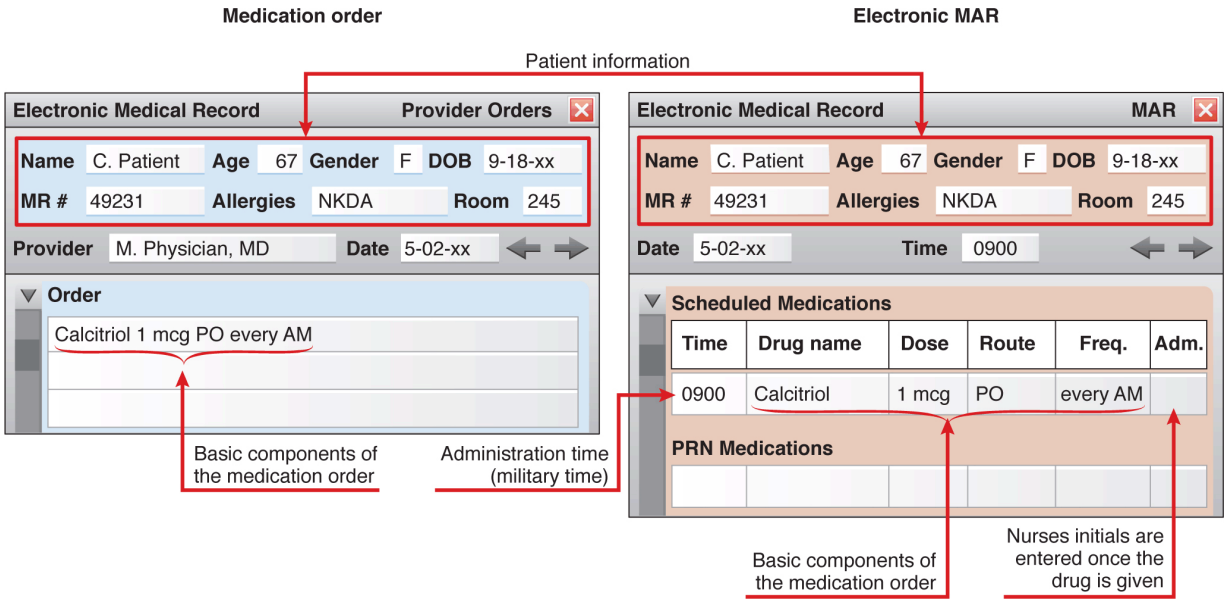


Figure 1-7. Example of medication order transcribed into the electronic MAR.

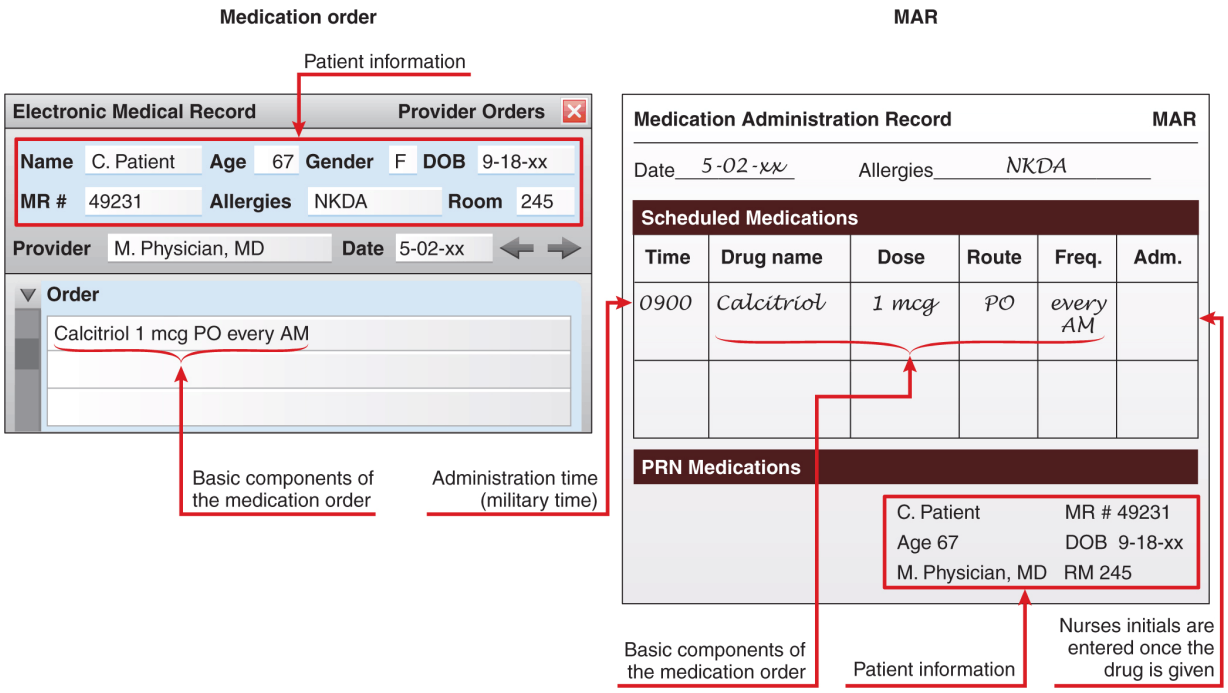


Figure 1-8. Example of medication order transcribed onto the MAR (paper format).

The actual time for the administration of the medication is based on the frequency ordered by the physician and the facility's standard times for the

administration of medications. Notice how the basic components of the medication order appear on the electronic medication record and paper format of the MAR. After the drug has been given to the patient, the initials of the nurse are entered and recorded.

Military time is commonly used in clinical facilities. The benefits of using military time and instructions on reading and writing military time are discussed in Chapter 15, Calculating Infusion and Completion Time.

THE SIX RIGHTS OF MEDICATION ADMINISTRATION

The ***Six Rights of Medication Administration*** (Fig. 1-9) provide the guidelines for implementing safe medication administration practices. Each "right" provides the nurse the opportunity to question and clarify any misinterpretations in the administration of the drug that may lead to a medication error before administering the drug to the patient.

Patient safety is always an integral part of each "right" during the entire medication administration process. This includes the correlation of the medication with the patient's needs and the follow-up care of the patient after the administration of the drug. This requires the nurse to

- know the drug's action
- have an understanding of why the drug is ordered for the patient
- carefully monitor the patient for the drug's therapeutic and side effects

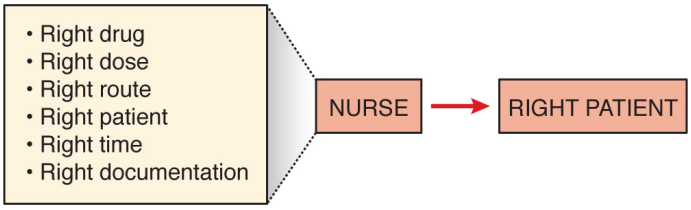


Figure 1-9. The Six Rights of Medication Administration.

Safe practices in the medication administration process involve more than learning the skill of preparing and administering medications. Rather, safety in medication administration involves a deliberate collaborative approach to preventing medication errors.

The Preparation of the Medication