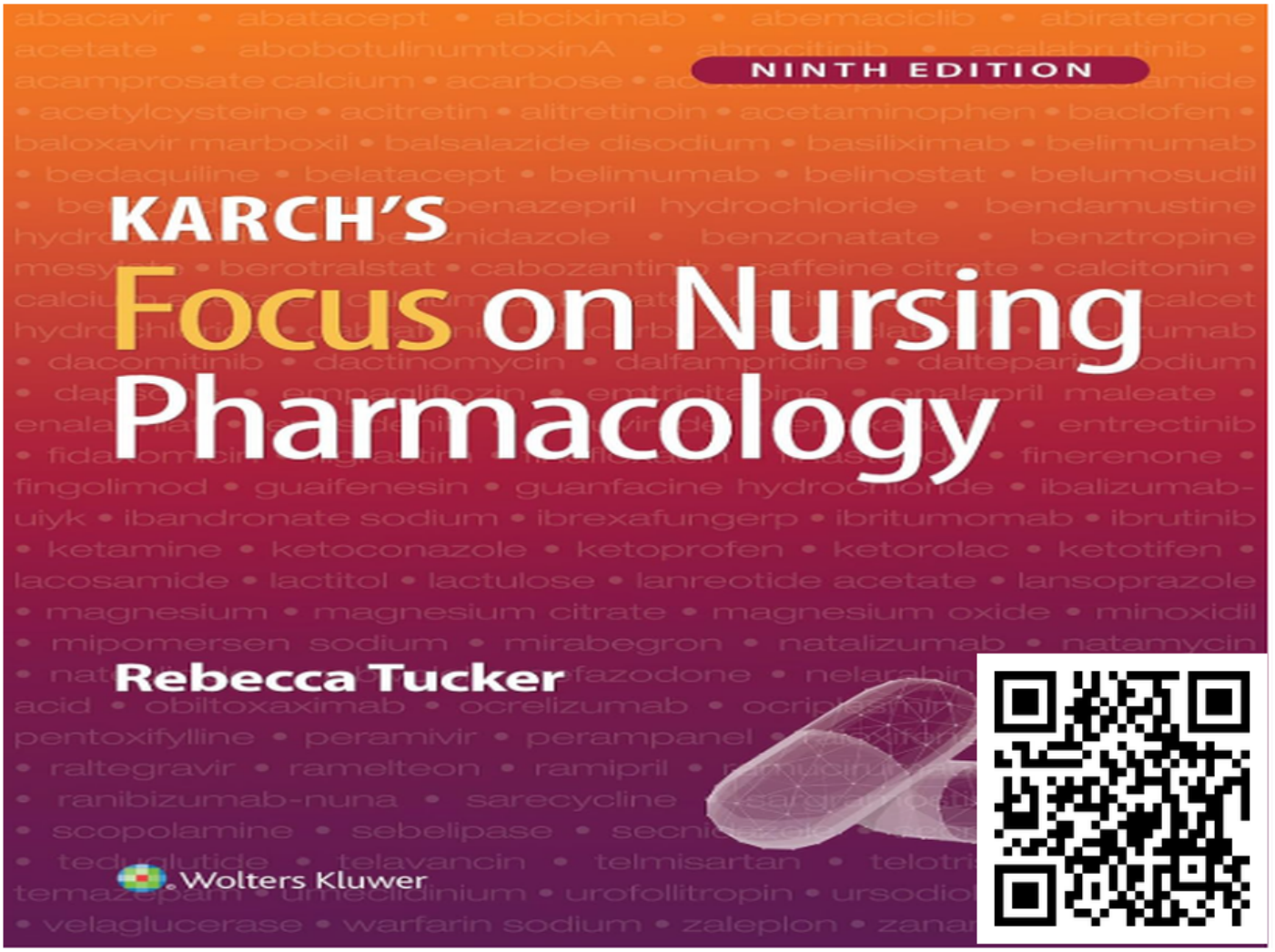

NINTH EDITION

KARCH'S Focus on Nursing Pharmacology

Rebecca Tucker

Wolters Kluwer

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of sources. When prescribing medication, healthcare professionals are advised to consult the product information sheet (the manufacturer's package insert) accompanying each drug to verify, among other things, conditions of use, warnings and side effects and identify any changes in dosage schedule or contraindications, particularly if the medication to be administered is new, infrequently used or has a narrow therapeutic range. To the maximum extent permitted under applicable law, no responsibility is assumed by the publisher for any injury and/or damage to persons or property, as a matter of products liability, negligence law or otherwise, or from any reference to or use by any person of this work.

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In memory of Amy M. Karch

Amy was a prolific and brilliant author who was dedicated to her dream of facilitating the learning of nurses who wanted to be the best for their patients/families. We (the faculty at the University of Rochester) were blessed to work with her generous and humorous soul. I was additionally fortunate to have her as a mentor and friend. Amy worked on eight editions, and I am extremely honored to be able to continue her work by authoring the ninth edition. This edition is dedicated to Amy Karch. She is missed dearly.

Rebecca G. Tucker
Assistant Professor, Clinical Nursing
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I met Amy Karch for the first time when I assumed the role of Publisher for Nursing Education at Wolters Kluwer several years ago. She immediately impressed me with her enthusiasm for nursing education and her clear devotion to her students. Amy also was passionate about online education, designing her own courses and ensuring she developed a relationship with her students no matter the type of class or learning modality, while also ensuring they were prepared and knowledgeable about nursing pharmacology. Amy was a consummate professional during her work on publications with us and an advocate for her profession. All of us at Wolters Kluwer will greatly miss Amy and are grateful we had the opportunity to work with and learn from her. We are proud that this eighth edition of Focus on Nursing Pharmacology *is part of the great legacy she leaves behind.*

Julie K. Stegman
Vice President and Publisher, Nursing Education
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PREFACE

Pharmacology is a difficult course to teach in a standard nursing curriculum, whether it be a diploma, associate, baccalaureate, or graduate program. Instructors have the challenge to facilitate learning of material that is often in flux. New medications are approved, and others are discontinued. New side effects or prescribing warnings can be added as we learn more about how the substances effect people. Nurses and nurse practitioners need a foundational knowledge of medication classifications, yet also need the mental flexibility to build upon that foundation. Furthermore, it is imperative that all clinicians have the skills to evaluate research regarding pharmacology to be able to be knowledgeable in this evolving field.

Pharmacology should not be such a formidable obstacle in the nursing curriculum. The study of drug therapy incorporates physiology, pathophysiology, chemistry, and nursing fundamentals—subjects that are already taught in most schools. A textbook that approaches pharmacology as an understandable, teachable, and learnable subject would greatly facilitate the incorporation of this subject into nursing curricula. Yet many nursing pharmacology texts are large and burdensome, mainly because they need to cover not only the basic pharmacology but also the particulars included in each area considered.

The ninth edition of *Karch's Focus on Nursing Pharmacology* is based on the premise that students first need to have a solid and clearly focused concept of the principles of drug therapy before they can easily grasp the myriad details associated with individual drugs.

Armed with a fundamental knowledge of pharmacology, the student can appreciate and use the specific details that are so readily available in the many annually updated and published nursing drug guides, such as the *Lippincott Nursing Drug Guide*.

With this goal in mind, *Karch's Focus on Nursing Pharmacology* provides a concise, user-friendly, and uncluttered text for the modern

student. This difficult subject is presented in a streamlined, understandable, teachable, and learnable manner. Because this book is designed to be used in conjunction with a handbook of current drug information, it remains streamlined. This ninth edition of *Karch's Focus on Nursing Pharmacology* continues to emphasize "need-to-know" concepts and information that is tested on the National Council Licensure Examination (NCLEX) for nurses.

The text reviews and integrates previously learned knowledge of physiology, chemistry, and nursing fundamentals into chapters focused on helping students conceptualize what is important to know about each group of drugs. Illustrations, boxes, and tables sum up concepts to enhance learning. Special features further focus student learning on clinical application, critical thinking, patient safety, lifespan issues related to drug therapy, evidence-based practice, patient teaching, and case study–based critical thinking exercises that incorporate nursing process principles. The text incorporates study materials that conclude each chapter. Check Your Understanding sections provide both new- and old-format NCLEX-style review questions, as well as study guide review questions to help the student master the material and prepare for the national licensing exam.

Focus on Teaching/Learning Activities

thePoint® (available at http://thepoint.lww.com/), a trademark of Wolters Kluwer Health, is a web-based course and content management system that provides every resource instructors and students need in one easy-to-use site, where teaching, learning, and technology click!

Student Resources

Students can visit thePoint® to access supplemental multimedia resources to enhance their learning experience, download content, and upload assignments. thePoint® offers a variety of free student resources, including Watch and Learn video clips, a Spanish–English Audio Glossary, and free recently published journal articles related to topics discussed in the book. Also included are videos on preventing medication errors and three-dimensional animated depictions of pharmacology concepts.

This edition includes vSim for Nursing | Pharmacology, a new virtual simulation platform, available via thePoint®. Codeveloped by Laerdal

Medical, vSim for Nursing | Pharmacology helps students develop clinical competence and decision-making skills as they interact with virtual patients in a safe, realistic environment. vSim for Nursing records and assesses student decisions throughout the simulation, then provides a personalized feedback log highlighting areas needing improvement. Also available via thePoint, Lippincott DocuCare combines web-based electronic health record simulation software with clinical case scenarios that link directly to many of the skills presented in *Karch's Focus on Nursing Pharmacology*. Lippincott DocuCare's nonlinear solution works well in the classroom, simulation lab, and clinical practice.

Instructor Resources

Advanced technology and superior content combine at thePoint to allow instructors to design and deliver online and offline courses, maintain grades and class rosters, and communicate with students. thePoint also provides additional resources, including Pre-Lecture Quizzes, PowerPoints with Guided Lecture Notes, Discussion Topics, Assignments, and over 1,700 Test Generator questions!

Lippincott® CoursePoint+

The same trusted solution, innovation, and unmatched support that you have come to expect from *Lippincott CoursePoint+* is now enhanced with more engaging learning tools and deeper analytics to help prepare students for practice. This powerfully integrated, digital learning solution combines learning tools, case studies, virtual simulation, real-time data, and the most trusted nursing education content on the market to make curriculum-wide learning more efficient and to meet students where they're at in their learning. And now, it's easier than ever for instructors and students to use, giving them everything they need for course and curriculum success!

Lippincott CoursePoint+ includes the following:

- Engaging course content provides a variety of learning tools to engage students of all learning styles.
- A more personalized learning approach, including adaptive learning powered by PrepU, gives students the content and tools they need at

the moment they need it, giving them data for more focused remediation and helping to boost their confidence.
- Varying levels of case studies, virtual simulation, and access to Lippincott Advisor help students learn the critical thinking and clinical judgment skills to help them become practice-ready nurses.
- Unparalleled reporting provides in-depth dashboards with several data points to track student progress and help identify strengths and weaknesses.
- Unmatched support includes training coaches, product trainers, and nursing education consultants to help educators and students implement CoursePoint with ease.

Organization

Karch's Focus on Nursing Pharmacology is organized following a "simple-to-complex" approach, much like the syllabus for a basic nursing pharmacology course. Because students learn best "from the bottom up," the text is divided into distinct parts.

Part I begins with an overview of basic nursing pharmacology, including challenges as bioterrorism, street drugs, herbal therapies, the importance of preventing medication errors, and the information overload; each of the other parts begins with a review of the physiology of the system affected by the specific drugs being discussed. This review refreshes the information for the student and provides a quick and easy reference when he or she is reading about drug actions.

Part II of the text introduces the drug classes, starting with the chemotherapeutic agents—both antimicrobial and antineoplastic drugs. Because the effectiveness of these drugs depends on their interference with the most basic element of body physiology—the cell—students can easily understand the pharmacology of this class. Mastering the pharmacotherapeutic effects of this drug class helps the student establish a firm grasp of the basic principles taught in Part I. Once the easiest pharmacological concepts are understood, the student is prepared to move on to the more challenging physiological and pharmacological concepts.

Part III focuses on drugs affecting the immune system because recent knowledge about the immune system has made it the cornerstone of modern

therapy. All of the immune system drugs act in ways in which the immune system would act if it were able. Recent immunological research has contributed to a much greater understanding of this system, making it important to position information about drugs affecting this system close to the beginning of the text instead of at the end as has been the custom.

Parts IV and **V** of the text address drugs that affect the nervous system, the basic functioning system of the body. Following the discussion of the nervous system, and closely linked with it in **Part VI**, is the endocrine system. The sequence of these parts introduces students to the concept of control, teaches them about the interrelatedness of these two systems, and prepares them for understanding many aspects of shared physiological function and the inevitable linking of the two systems into one: the neuroendocrine system.

Parts VII, **VIII**, and **IX** discuss drugs affecting the reproductive, cardiovascular, and renal systems, respectively. The sequencing of cardiovascular and renal drugs is logical because most of the augmenting cardiovascular drugs (such as diuretics) affect the renal system.

Part X covers drugs that act on the respiratory system, which provides the link between the left and right ventricles of the heart.

Part XI addresses drugs acting on the gastrointestinal system. A new chapter has been added to this section titled "Vitamin, Minerals, Complementary/Alternative Medications."

Text Features

The features in this text are skillfully designed to support the text discussion, encouraging the student to look at the whole patient and to focus on the essential information that is important to learn about each drug class. Important features in the ninth edition focus on incorporating basic nursing skills, patient safety, critical thinking, and application of the material learned to the clinical scenario, helping the student to understand the pharmacology material.

Special Elements and Learning Aids

Each chapter opens with a list of learning objectives for that chapter, helping the student understand what the key learning points will be. A list of featured drugs and a glossary of key terms are also found on the opening chapter page. Key points appear periodically throughout each chapter to summarize important concepts. The text of each chapter ends with a summary of important concepts. This is followed by a series of review exercises, Check Your Understanding, which includes NCLEX-style questions to focus student learning on the seminal information presented in the chapter.

- In the *Drug List* at the beginning of each chapter, a special icon appears next to the drug that is considered the prototype drug of each class. In each chapter, *prototype summary* boxes spotlight need-to-know information for each prototype drug.
- *Drugs in Focus* tables clearly summarize and identify the drugs within a class, highlighting them by generic and trade names, usual dosage, and indications.
- *Focus on Safe Medication Administration* boxes present important safety information to help keep the patient safe, prevent medication errors, and increase the therapeutic effectiveness of the drugs.
- *Focus on the Evidence* boxes compile information based on research to identify the best nursing practices associated with specific drug therapy.
- *Focus on Herbal and Alternative Therapies* boxes highlight known interactions with specific herbs or alternative therapies that could affect the actions of the drugs being discussed.
- *Focus on Calculations* reviews are designed to help the student hone calculation and measurement skills while learning about the drugs for which doses might need to be calculated.
- *Focus on Drug Therapy Across the Lifespan* boxes concisely summarize points to consider when using the drugs of each class with children, adults, and the older adults.
- *Focus on Sex Differences* and *Focus on Cultural Considerations* boxes encourage the student to think about the patient as a unique individual with a special set of characteristics that not only influences variations in drug effectiveness but also could influence a patient's perspective on drug therapy.

- *Critical Thinking Scenarios* tie each chapter's content together by presenting clinical scenarios about a patient using a particular drug from the class being discussed. Included in the case study are hints to guide critical thinking about the case and a discussion of drug- and non–drug-related nursing considerations for that particular patient and situation. Most important, the case study provides a plan of nursing care specifically developed for that patient and specifically based on the nursing process. The care plan is followed by a checklist of patient teaching points designed for the patient presented in the case study. This approach helps the student to see how assessment and the collected data are applied in the clinical situation.
- *Check Your Understanding* sections present NCLEX-style questions, including alternate format questions, to help the student prepare for that exam. Other questions and activities in this section are designed to help students test their knowledge of the information that has been learned in the chapter.
- *Unfolding Patient Stories*, written by the National League for Nursing, are an engaging way to begin meaningful conversations in the classroom. These vignettes, which unfold in two parts each and are interspersed throughout the text, feature patients from Wolters Kluwer's vSim for Nursing for Nursing | *Pharmacology* (codeveloped by Laerdal Medical) and DocuCare products; however, each Unfolding Patient Story in the book stands alone, not requiring purchase of these products.
- *Concept Mastery Alerts* highlight and clarify the most common misconceptions in nursing pharmacology, as identified by Lippincott's online adaptive learning platform. Our team reviewed data from thousands of nursing pharmacology students across North America to identify the points of confusion for most students to help you learn more effectively.

To the Student Using This Text

As you begin your study of pharmacology, don't be overwhelmed or confused by all of the details. The study of drugs fits perfectly into your study of the human body—anatomy, physiology, chemistry, nutrition, psychology, and sociology. Approach the study of pharmacology from two

main perspectives. First, review the names of the medication classifications, how they work, what the common and dangerous side effects are, and pertinent teaching points for clients. Once you understand the classification, pick a few of the common medications in each classification as prototypes to know more details about. The second way to review pharmacology is starting from the "indication" or disease. It is imperative to know what medications are commonly used for each clinical problem. For example, what typical medications would be prescribed for a client with hypertension? Keep in mind that pharmacology is evolving as new research is performed and new substances are created. Therefore, the study of pharmacology is lifelong. Enjoy!

Rebecca G. Tucker, PhD, ACNPC, MEd, RN

Acknowledgments

I would like to acknowledge that all previous editions were primarily authored by Amy M. Karch who dedicated her career to nursing education. I have been extremely blessed by her mentorship and miss her.

I would like to thank my coinstructors, Deans, and staff at the University of Rochester School of Nursing who are dedicated to facilitating learning in the context of supporting each other and students as family. Dean Kathy Rideout, Associate Dean Lydia Rotondo, Dr. Patrick Hopkins, Dr. Elizabeth Palermo, Dr. Craig Sellers, MariaLainea Chennell, and Joseph Gomulak-Cavicchio—these are only a few that I value and am so grateful for. I would like to acknowledge Dr. Anne Schweighardt who provided pharmaceutical expertise that is invaluable.

Thank you to the people at Wolters Kluwer who are so willing to facilitate a positive writing environment. I am especially appreciative of Staci Wolfson (Supervisory Development Editor) who was my "go to" if I had any questions/concerns throughout this process and to Julie Kostelnik and Varshaanaa Muralidharan who were responsible for the first round of content editing. Thank you to Jonathan Joyce and Susan Hartman who were the official leaders of this project.

I am very fortunate to be motivated by my patients and students. They drive me to continually learn and evolve to provide the best care and education possible. Furthermore, I am blessed to be loved by family and

friends who support me through the best and worst of times. Without their support, this work would not be possible.

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Rebecca G. Tucker, PhD, ACNPC, MEd, RN

CONTENTS

PART **1**

Introduction to Nursing Pharmacology

CHAPTER 1

Introduction to Drugs

Learning Objectives

Upon completion of this chapter, you will be able to:

1. Define the word pharmacology.
2. Outline the steps involved in developing and approving a new drug in the United States.
3. Describe the federal controls on drugs that have abuse potential.
4. Differentiate between generic and brand name drugs and over-the-counter and prescription drugs.
5. Explain the benefits and risks associated with the use of over-the-counter drugs.

Key Terms

adverse effects: drug effects, sometimes called side effects, that are not the desired therapeutic effects; may be unpleasant or even dangerous

brand name: name given to a drug by the pharmaceutical company that developed it; also called a trade name or proprietary name

chemical name: name that reflects the chemical structure of a drug

drugs: chemicals that are introduced into the body to bring about change

Food and Drug Administration (FDA): federal agency responsible for the regulation and enforcement of drug evaluation and distribution policies in the United States

generic drugs: drugs sold by their generic name; not brand name or trade name product

generic name: the original designation that a drug is given when the drug company that developed it applies for the approval process

genetic engineering: process of altering DNA, usually of bacteria, to produce a chemical to be used as a drug

off-label uses: uses of a drug that are not part of the stated therapeutic indications for which the drug was approved by the FDA; off-label uses may lead to new indications for a drug

orphan drugs: drugs that have been discovered but would not be profitable for a drug company to develop without outside financial incentives; usually drugs that would treat only a small number of people

over-the-counter (OTC) drugs: drugs that are available without a prescription for self-treatment of a variety of complaints; deemed to be safe when used as directed; often formerly only available by prescription

pharmacology: the study of the biological effects of chemicals

pharmacotherapeutics: clinical pharmacology—the branch of pharmacology that deals with drugs; chemicals that are used in medicine for the treatment, prevention, and diagnosis of disease in humans

phase I study: a pilot study of a potential drug using a small number of selected, usually healthy human volunteers

phase II study: a clinical study of a proposed drug by selected physicians using actual patients who have the disorder the drug is designed to treat

phase III study: use of a proposed drug on a larger sample of the population of patients who have the disease the drug is thought to treat

phase IV study: continuous evaluation of a drug after it has been released for marketing

preclinical trials: initial trials of a chemical thought to have therapeutic potential either with in vitro or in vivo techniques; not human subjects

teratogenic: having adverse effects on all phases of the development inside the womb (zygote, embryo, or fetus)

The human body works through a complicated series of chemical reactions and processes. **Pharmacology** is the study of the biological effects of chemicals. **Drugs** are chemicals that are introduced into the body to cause some sort of change. When drugs are administered, the body begins a sequence of processes designed to handle the new chemicals. These processes, which involve breaking down and eliminating the drugs, affect the body's complex series of chemical reactions. In clinical practice, health care providers focus on how chemicals act on people.

Nurses deal with **pharmacotherapeutics**, or clinical pharmacology, the branch of pharmacology that uses drugs to treat, prevent, and diagnose disease. Clinical pharmacology addresses two key concerns: the drug's effects on the body and the body's response to the drug.

For many reasons, understanding how drugs act on the body to cause changes and applying that knowledge in the clinical setting are important aspects of nursing practice. For instance, patients today often follow complicated drug regimens and receive potentially toxic drugs and/or drug combinations. Also, many patients need to manage their care at home. A drug can have many effects, and the nurse must know which ones may occur when a particular drug is administered. Some drug effects are therapeutic, or helpful, but others are undesirable or potentially dangerous. These negative effects are called **adverse effects**, or side effects, of the drug. (See Chapter 3 for a detailed discussion of adverse effects.)

The nurse is in a unique position regarding drug therapy because nursing responsibilities include the following:

- Administering drugs
- Assessing drug effects
- Intervening to make the drug regimen more tolerable
- Providing patient teaching about drugs and drug regimens

- Monitoring the overall patient care plan to prevent medication errors

Knowing how drugs work makes these tasks easier to handle, thus enhancing the effectiveness of drug therapy.

This text is designed to provide the pharmacological basis for understanding drug therapy. The physiology of a body system and the related actions of many drugs on that system are presented in a way that allows clear understanding of how drugs work and what to anticipate when giving a particular type of drug.

Thousands of drugs are available, and it is impossible to memorize all of the individual differences among drugs in a class. This text addresses *general* drug information. The nurse can refer to the most recent editions of the *Nursing Drug Handbook*, the *Lippincott Pocket Drug Guide for Nurses*, or to another drug guide to obtain the *specific* details required for safe and effective drug administration. Drug details are changing constantly. The practicing nurse must be knowledgeable about these changes and rely on an up-to-date and comprehensive drug guide in the clinical setting.

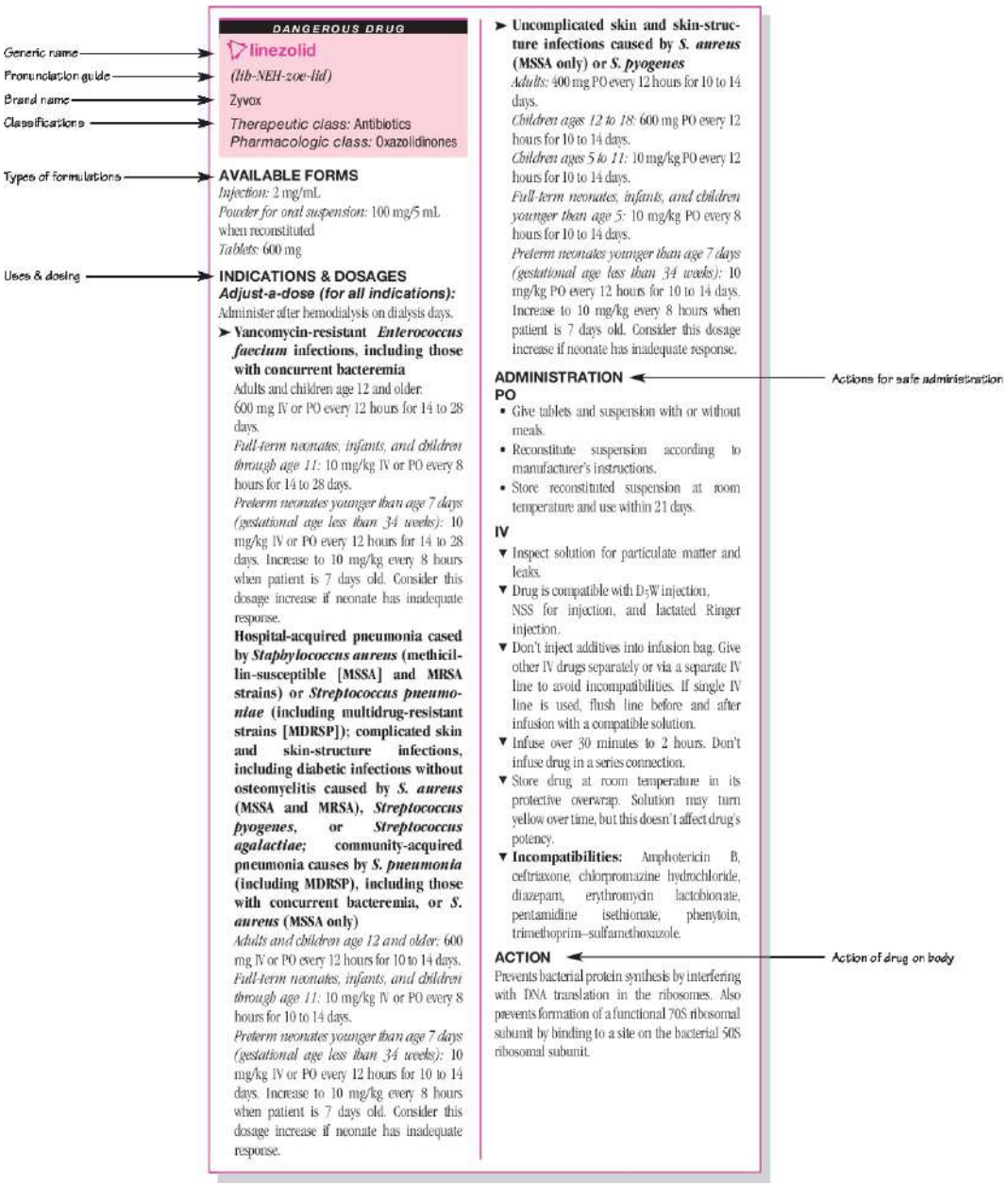
A section related to nursing considerations for patients receiving particular drugs will be found in each chapter of this book. This includes assessment points, nursing diagnoses to consider, planning for patient-centered care, implementation of particular interventions that should be considered, and evaluation points that will provide a guide for using the nursing process to effectively incorporate drug therapy into patient care. This information can be used to develop an individual nursing care plan for your patient (Table 1.1). The monographs in the *Nursing Drug Handbook* (**Fig. 1.1**) or any other nursing drug guide can be used to provide the specific information that you need to plan care for each particular drug you might be giving. The various sections of each drug monograph can provide information to help in the development of patient teaching guides and drug cards for reference in the clinical setting. The Patient Drug Sheet: Oral Linezolid (**Fig. 1.2**) is an example of how this information can be used to develop a patient teaching guide.

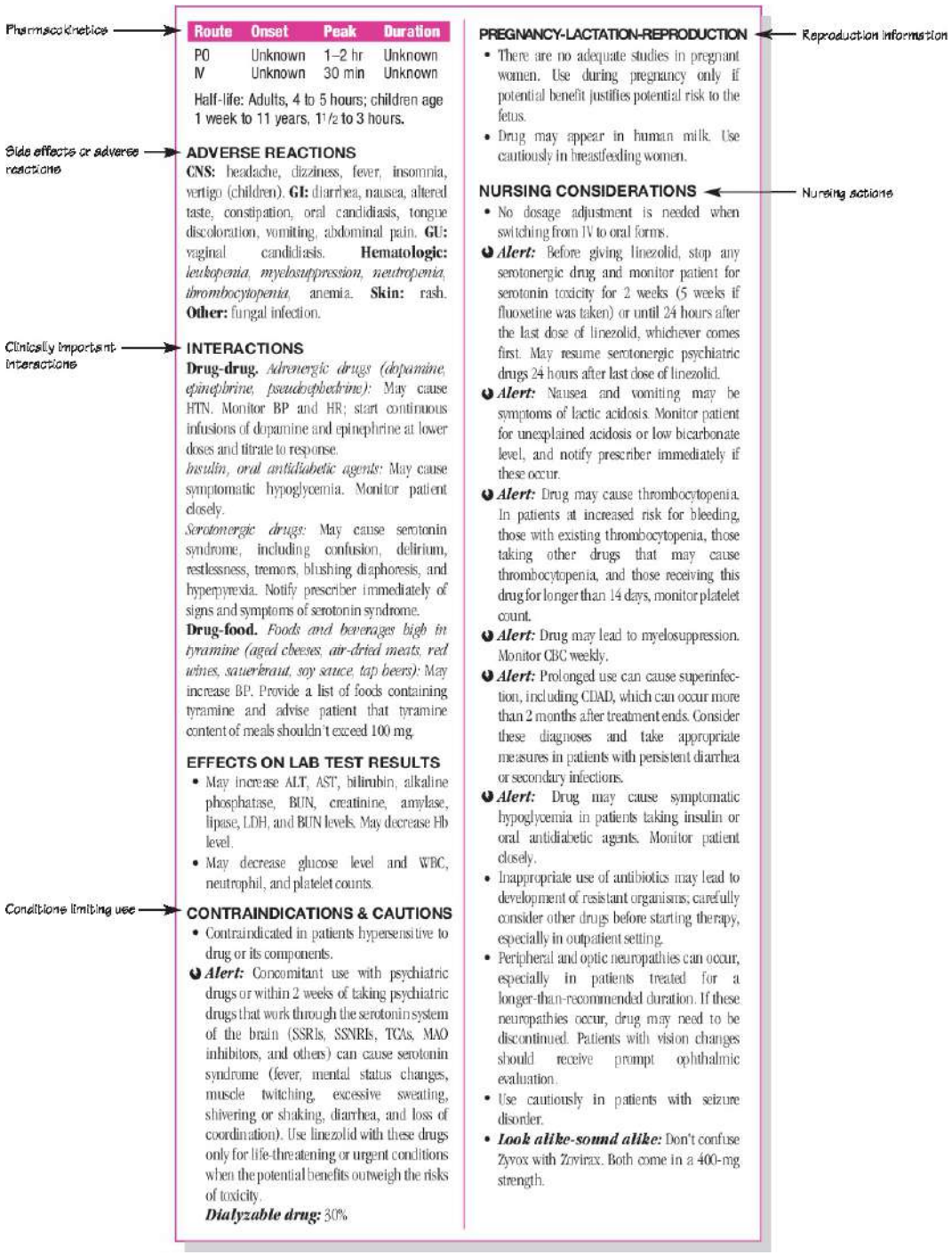
Table 1.1 Sample Nursing Care Plan From *Nursing Drug Handbook* for a Patient Receiving

Oral Linezolid

Assessment	Nursing Diagnosis	Implementation	Evaluation
History (contraindications/cautions) Hypertension Hyperthyroidism Blood dyscrasias Hepatic dysfunction Pheochromocytoma Phenylketonuria Carcinoid syndrome Pregnancy Lactation Known allergy to: linezolid **Medication History** (possible drug–drug interactions) Pseudoephedrine Selective serotonin reuptake inhibitors MAOIs Antiplatelet drugs **Diet History** (possible drug–food interactions) Foods high in tyramine **Physical Assessment** (screen for contraindications and to establish a baseline for evaluating effects and adverse effects) Local: culture site of infection CNS: affect, reflexes, orientation CV: P, BP, peripheral perfusion GI: bowel sounds, liver evaluation Skin: color, lesions Hematologic: CBC with differential, liver function tests	Malnutrition risk, less than body requirements, related to GI effects Acute pain related to GI effects, headache Altered tissue perfusion related to bone marrow effects Knowledge deficiency related to drug therapy	Safe and appropriate administration of drug: culture infection site to ensure appropriate use of drug Provision of safety and comfort measures: • Monitor BP periodically • Monitor platelet counts before and periodically during therapy • Alleviation of GI upset • Ready access to bathroom facilities • Nutritional consult • Safety provisions if dizziness and CNS effects occur • Avoidance of tyramine-rich foods Patient teaching regarding: Drug Side effects to anticipate Warnings Reactions to report Support and encouragement to cope with disease, high cost of therapy, and side effects Provision of emergency and life support measures in cases of acute hypersensitivity	Monitor for therapeutic effects of drug: resolution of infection If resolution does not occur, reculture site Monitor for adverse effects of drug: • GI upset—nausea, vomiting, diarrhea • Liver function changes • Pseudomembranous colitis • Blood dyscrasias—changes in platelet counts • Fever • Rash • Sweating • Photosensitivity • Acute hypersensitivity reactions Evaluate effectiveness of patient teaching program: patient can name drug, dose of drug, use of drug, adverse effects to expect, and reactions to report Evaluate effectiveness of comfort and safety measures Monitor for drug–drug and drug–food interactions as appropriate Evaluate effectiveness of life support measures if needed

MAOI, monoamine oxidase inhibitor; CNS, central nervous system; CV, cardiovascular; P, pulse; BP, blood pressure; GI, gastrointestinal; CBC, complete blood count.


Generic name
Pronunciation guide
Brand name
Classifications
Types of formulations
Uses & dosing
DANGEROUS DRUG
linezolid
(lih-NEH-zoe-lid)
Zyvox
Therapeutic class: Antibiotics
Pharmacologic class: Oxazolidinones
AVAILABLE FORMS
Injection: 2 mg/mL
Powder for oral suspension: 100 mg/5 mL when reconstituted
Tablets: 600 mg
INDICATIONS & DOSAGES
Adjust-a-dose (for all indications):
Administer after hemodialysis on dialysis days.
➤ Vancomycin-resistant Enterococcus faecium infections, including those with concurrent bacteremia
Adults and children age 12 and older: 600 mg IV or PO every 12 hours for 14 to 28 days.
Full-term neonates, infants, and children through age 11: 10 mg/kg IV or PO every 8 hours for 14 to 28 days.
Preterm neonates younger than age 7 days (gestational age less than 34 weeks): 10 mg/kg IV or PO every 12 hours for 14 to 28 days. Increase to 10 mg/kg every 8 hours when patient is 7 days old. Consider this dosage increase if neonate has inadequate response.
Hospital-acquired pneumonia cased by Staphylococcus aureus (methicillin-susceptible [MSSA] and MRSA strains) or Streptococcus pneumoniae (including multidrug-resistant strains [MDRSP]); complicated skin and skin-structure infections, including diabetic infections without osteomyelitis caused by S. aureus (MSSA and MRSA), Streptococcus pyogenes, or Streptococcus agalactiae; community-acquired pneumonia causes by S. pneumonia (including MDRSP), including those with concurrent bacteremia, or S. aureus (MSSA only)
Adults and children age 12 and older: 600 mg IV or PO every 12 hours for 10 to 14 days.
Full-term neonates, infants, and children through age 11: 10 mg/kg IV or PO every 8 hours for 10 to 14 days.
Preterm neonates younger than age 7 days (gestational age less than 34 weeks): 10 mg/kg IV or PO every 12 hours for 10 to 14 days. Increase to 10 mg/kg every 8 hours when patient is 7 days old. Consider this dosage increase if neonate has inadequate response.
➤ Uncomplicated skin and skin-structure infections caused by S. aureus (MSSA only) or S. pyogenes
Adults: 400 mg PO every 12 hours for 10 to 14 days.
Children ages 12 to 18: 600 mg PO every 12 hours for 10 to 14 days.
Children ages 5 to 11: 10 mg/kg PO every 12 hours for 10 to 14 days.
Full-term neonates, infants, and children younger than age 5: 10 mg/kg PO every 8 hours for 10 to 14 days.
Preterm neonates younger than age 7 days (gestational age less than 34 weeks): 10 mg/kg PO every 12 hours for 10 to 14 days. Increase to 10 mg/kg every 8 hours when patient is 7 days old. Consider this dosage increase if neonate has inadequate response.
ADMINISTRATION
Actions for safe administration
PO
• Give tablets and suspension with or without meals.
• Reconstitute suspension according to manufacturer's instructions.
• Store reconstituted suspension at room temperature and use within 21 days.
IV
▼ Inspect solution for particulate matter and leaks.
▼ Drug is compatible with D5W injection, NSS for injection, and lactated Ringer injection.
▼ Don't inject additives into infusion bag. Give other IV drugs separately or via a separate IV line to avoid incompatibilities. If single IV line is used, flush line before and after infusion with a compatible solution.
▼ Infuse over 30 minutes to 2 hours. Don't infuse drug in a series connection.
▼ Store drug at room temperature in its protective overwrap. Solution may turn yellow over time, but this doesn't affect drug's potency.
▼ Incompatibilities: Amphotericin B, ceftriaxone, chlorpromazine hydrochloride, diazepam, erythromycin lactobionate, pentamidine isethionate, phenytoin, trimethoprim–sulfamethoxazole.
ACTION
Action of drug on body
Prevents bacterial protein synthesis by interfering with DNA translation in the ribosomes. Also prevents formation of a functional 70S ribosomal subunit by binding to a site on the bacterial 50S ribosomal subunit.



Route	Onset	Peak	Duration
PO	Unknown	1–2 hr	Unknown
IV	Unknown	30 min	Unknown

Half-life: Adults, 4 to 5 hours; children age 1 week to 11 years, 1½ to 3 hours.

ADVERSE REACTIONS

CNS: headache, dizziness, fever, insomnia, vertigo (children). **GI:** diarrhea, nausea, altered taste, constipation, oral candidiasis, tongue discoloration, vomiting, abdominal pain. **GU:** vaginal candidiasis. **Hematologic:** *leukopenia, myelosuppression, neutropenia, thrombocytopenia,* anemia. **Skin:** rash. **Other:** fungal infection.

INTERACTIONS

Drug-drug. *Adrenergic drugs (dopamine, epinephrine, pseudoephedrine):* May cause HTN. Monitor BP and HR; start continuous infusions of dopamine and epinephrine at lower doses and titrate to response.

Insulin, oral antidiabetic agents: May cause symptomatic hypoglycemia. Monitor patient closely.

Serotonergic drugs: May cause serotonin syndrome, including confusion, delirium, restlessness, tremors, blushing, diaphoresis, and hyperpyrexia. Notify prescriber immediately of signs and symptoms of serotonin syndrome.

Drug-food. *Foods and beverages high in tyramine (aged cheeses, air-dried meats, red wines, sauerkraut, soy sauce, tap beers):* May increase BP. Provide a list of foods containing tyramine and advise patient that tyramine content of meals shouldn't exceed 100 mg.

EFFECTS ON LAB TEST RESULTS

- May increase ALT, AST, bilirubin, alkaline phosphatase, BUN, creatinine, amylase, lipase, LDH, and BUN levels. May decrease Hb level.
- May decrease glucose level and WBC, neutrophil, and platelet counts.

CONTRAINDICATIONS & CAUTIONS

- Contraindicated in patients hypersensitive to drug or its components.
- ***Alert:*** Concomitant use with psychiatric drugs or within 2 weeks of taking psychiatric drugs that work through the serotonin system of the brain (SSRIs, SSNRIs, TCAs, MAO inhibitors, and others) can cause serotonin syndrome (fever, mental status changes, muscle twitching, excessive sweating, shivering or shaking, diarrhea, and loss of coordination). Use linezolid with these drugs only for life-threatening or urgent conditions when the potential benefits outweigh the risks of toxicity.

Dialyzable drug: 30%

PREGNANCY-LACTATION-REPRODUCTION

- There are no adequate studies in pregnant women. Use during pregnancy only if potential benefit justifies potential risk to the fetus.
- Drug may appear in human milk. Use cautiously in breastfeeding women.

NURSING CONSIDERATIONS

- No dosage adjustment is needed when switching from IV to oral forms.
- ***Alert:*** Before giving linezolid, stop any serotonergic drug and monitor patient for serotonin toxicity for 2 weeks (5 weeks if fluoxetine was taken) or until 24 hours after the last dose of linezolid, whichever comes first. May resume serotonergic psychiatric drugs 24 hours after last dose of linezolid.
- ***Alert:*** Nausea and vomiting may be symptoms of lactic acidosis. Monitor patient for unexplained acidosis or low bicarbonate level, and notify prescriber immediately if these occur.
- ***Alert:*** Drug may cause thrombocytopenia. In patients at increased risk for bleeding, those with existing thrombocytopenia, those taking other drugs that may cause thrombocytopenia, and those receiving this drug for longer than 14 days, monitor platelet count.
- ***Alert:*** Drug may lead to myelosuppression. Monitor CBC weekly.
- ***Alert:*** Prolonged use can cause superinfection, including CDAD, which can occur more than 2 months after treatment ends. Consider these diagnoses and take appropriate measures in patients with persistent diarrhea or secondary infections.
- ***Alert:*** Drug may cause symptomatic hypoglycemia in patients taking insulin or oral antidiabetic agents. Monitor patient closely.
- Inappropriate use of antibiotics may lead to development of resistant organisms; carefully consider other drugs before starting therapy, especially in outpatient setting.
- Peripheral and optic neuropathies can occur, especially in patients treated for a longer-than-recommended duration. If these neuropathies occur, drug may need to be discontinued. Patients with vision changes should receive prompt ophthalmic evaluation.
- Use cautiously in patients with seizure disorder.
- ***Look alike-sound alike:*** Don't confuse Zyvox with Zovirax. Both come in a 400-mg strength.

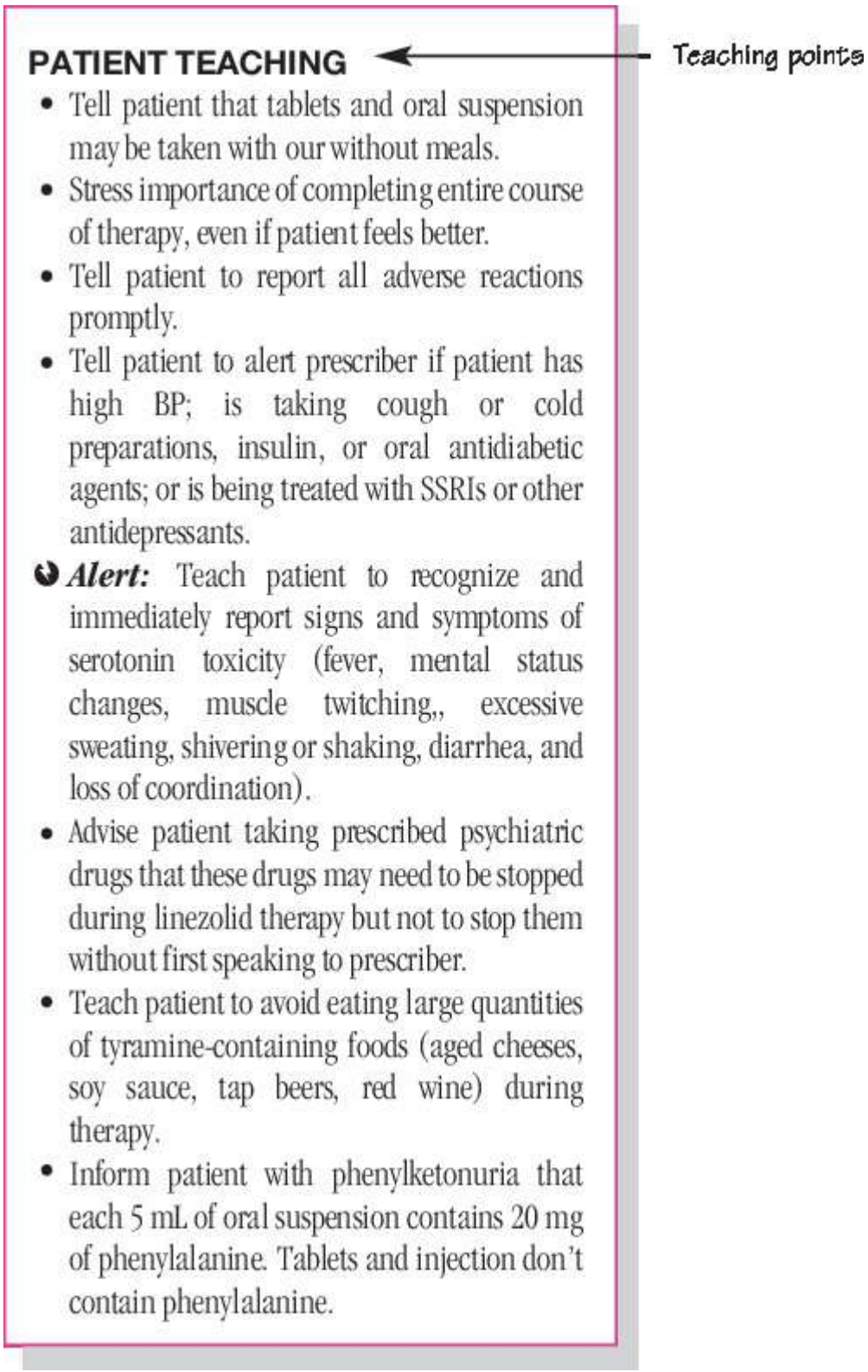


Figure 1.1 Example of a drug monograph. (Created using an excerpt from (2020) *Nursing2021 drug handbook* (41st

ed.). Wolters Kluwer.)

Patient Drug Sheet: Oral Linezolid

Patient's Name: Mr. Kors
Prescriber's Name: J. Smith, ANP
Phone Number: 555-555-5555

Instructions:

1. The name of your drug is *linezolid*; the brand name is *Zyvox*. This drug is an antibiotic that is being used to treat your *pneumonia*. This drug is very specific in its action and is only indicated for your particular infection. Take the full course of your drug. Do not share this drug with other people or save tablets for future use.
2. The dose of the drug that has been prescribed for you is: *600 mg* (*1 tablet*).
3. The drug should be taken *once every 12 hours*. The best time for you to take this drug will be *8:00 in the morning and 8:00 in the evening*. Do not skip any doses. Do not take two doses at once if you forget a dose. If you miss a dose, take the dose as soon as you remember and then again in 12 hours.
4. The drug can be taken with food if GI upset is a problem. Avoid foods that are rich in tyramine (list is below) while you are taking this drug.
5. The following side effects may occur:
   Nausea, vomiting, abdominal pain (taking the drug with food and eating frequent small meals may help).
   Diarrhea (ensure ready access to bathroom facilities). Notify your healthcare provider if this becomes severe.
6. Do not take this drug with over-the-counter drugs or herbal remedies without first checking with your healthcare provider. Many of these agents can cause problems with your drug.
7. Tell any nurse, physician, or dentist who is taking care of you that you are on this drug.
8. Keep this and all medications out of the reach of children.

Notify your health care provider if any of the following occur:
Rash, severe GI problems, bloody or excessive diarrhea, weakness, tremors, increased bleeding or bruising, anxiety.

Foods high in tyramine to avoid: Aged cheeses, avocados, bananas, beer, bologna (polony), caffeinated beverages, chocolate, liver, over-ripe fruit, pepperoni, pickled fish, red wine, salami, smoked fish, yeast, yogurt.

Figure 1.2 Example of a patient teaching sheet. (Created using data from (2020) *Nursing2021 drug handbook* (41st ed.). Wolters Kluwer.)

The nurse can use this text as a resource for basic concepts of pharmacology and a nursing drug guide as an easy-to-use reference in the clinical setting.

Sources of Drugs

Drugs are available from varied sources, both natural and synthetic. Natural sources include plants, animals, and inorganic compounds.

Natural Sources

Chemicals that might prove useful as drugs can come from many natural sources, such as plants, animals, or inorganic compounds. To become a drug, a chemical must have a demonstrated therapeutic value or efficacy without severe toxicity or damaging properties.

Plants

Plants and plant parts have been used as medicines since prehistoric times. Even today, plants are an important source of chemicals that are developed into drugs. For example, digitalis used to treat cardiac disorders and various opiates used for sedation were originally derived from plants. Table 1.2 provides examples of drugs derived from plant sources.

Table 1.2 Drugs Derived From Plants

Plant	Product
Ricinus communis	Seed Oil Castor oil
Digitalis purpurea (foxglove)	Leaves Dried leaves Digitalis leaf
Papaver somniferum (poppy)	Unripe capsule Juice Opium (*Paregoric*) Morphine (*MS Contin*) Codeine Papaverine

Drugs also may be processed using a synthetic version of the active chemical found in a plant. An example of this type of drug is dronabinol (*Marinol*), which contains the active ingredient delta-9-tetrahydrocannabinol found in marijuana. This drug helps to prevent nausea and vomiting in cancer patients and treats weight loss in clients with acquired immunodeficiency syndrome (AIDS) but does not have all the adverse effects that occur when the marijuana leaf is smoked. Marijuana leaf is a controlled substance with high abuse potential and is legal for medical use in some states but not approved for recreational use in many states. The synthetic version of the active ingredient allows for an accepted form to achieve the desired therapeutic effects.

Ingestion of a plant-derived food can sometimes lead to a drug effect. For instance, the ingredient in natural licorice (glycyrrhizine) inhibits the inactivation of cortisol. This increases the active cortisol and allows increased stimulation of renal mineralocorticoid receptors. This has a pseudoaldosterone effect. Aldosterone is a hormone found in the body that acts in the kidneys to increase fluid retention and decrease potassium levels. Therefore, when people ingest large amounts of licorice, they can retain

fluid to cause high blood pressures and develop hypokalemia (low serum potassium levels). However, people seldom think of licorice as a drug. Black licorice candy does include the ingredient glycyrrhizine, but red licorice candy does not.

Finally, plants and plant by-products have become the main component of the growing herbal and alternative therapy movement. Chapters 6 and 60 discuss the alternative therapy movement and its impact on today's drug regimens.

Animal Products

Animal products are used to replace human chemicals that fail to be produced because of disease or genetic problems. Insulin for treating diabetes used to be obtained exclusively from the pancreas of cows and pigs. Now **genetic engineering**—the process of altering DNA—permits scientists to produce human insulin by altering *Escherichia coli* bacteria, making insulin a better product without some of the impurities that come with animal products.

Thyroid drugs and growth hormone preparations also may be obtained from animal thyroid and hypothalamic tissues. Many of these preparations are now created synthetically, however, and the synthetic preparations are considered purer and safer than preparations derived from animals.

Inorganic Compounds

Salts of various chemical elements can have therapeutic effects in the human body. Aluminum, fluoride, iron, and even gold are used to treat various conditions. The effects of these elements usually were discovered accidentally when a cause–effect relationship was observed. Table 1.3 shows examples of some elements used for their therapeutic benefit.

Table 1.3 Elements Used for Their Therapeutic Effects

Element	Therapeutic Use
Aluminum	Antacid to decrease gastric acidity Management of hyperphosphatemia Prevention of the formation of phosphate urinary stones
Fluorine (as fluoride)	Prevention of dental cavities Prevention of osteoporosis
Gold	Treatment of rheumatoid arthritis
Iron	Treatment of iron deficiency anemia

Synthetic Sources

Today, many drugs are developed synthetically after chemicals in plants, animals, or the environment have been tested and found to have therapeutic activity. Scientists use genetic engineering to alter bacteria to produce chemicals that are therapeutic and effective. Other technical advances allow scientists to alter a chemical with proven therapeutic effectiveness to make it better. Sometimes, a small change in a chemical's structure can make that chemical more useful as a drug—more potent, more stable, and less toxic. These technological advances have led to the development of groups of similar drugs, all of which are derived from an original prototype, but each of which has slightly different properties, making a particular drug more desirable in a specific situation.

Throughout this book, the icon  will be used to designate those drugs of a class that are considered the prototype of the class, the original drug in the class, or the drug that has emerged as the most effective. For example, the cephalosporins are a large group of antibiotics derived from the same chemical structure. Alterations in the chemical rings or attachments to that structure make it possible for some of these drugs to be absorbed orally, whereas others must be given parenterally. Some of these drugs cause severe toxic effects (e.g., renal toxicity), but others do not.

Key Points

- Clinical pharmacology is the study of drugs used to treat, diagnose, or prevent a disease.
- Drugs are chemicals that are introduced into the body and affect the body's chemical processes.
- Drugs can come from natural sources including plants, foods, animals, salts of inorganic compounds, or synthetic sources.

Drug Evaluation

After a chemical that might have therapeutic value is identified, it must undergo a series of scientific tests to evaluate its actual therapeutic and toxic effects. This process is tightly controlled by the U.S. **Food and Drug Administration (FDA)**, an agency of the U.S. Department of Health and Human Services that regulates the development and sale of drugs. FDA-regulated tests are designed to ensure the safety and reliability of any drug approved in this country. There are many more chemicals tested compared with the number of medications that are approved. Before receiving final FDA approval to be marketed to the public, drugs must pass through several stages of development to determine if the benefits outweigh the known and potential risks of the medication. These include preclinical trials and phase I, II, and III studies. The drugs listed in this book have been through rigorous testing and are approved for sale to the public, either with or without a prescription from a health care provider.

Preclinical Trials

In **preclinical trials**, chemicals that may have therapeutic value are tested either in vitro (outside of a living organism) or in vivo (inside or on a living organism) for two main purposes: (a) to determine whether they have the presumed effects in living tissue and (b) to evaluate any adverse effects. The trials do not include humans as participants. Preclinical trials with living organisms are important because unique biological differences can cause very different reactions to the chemical. These differences can be

found only in living organisms, so computer-generated models alone are often inadequate.

At the end of the preclinical trials, some chemicals are discarded for the following reasons:

- The chemical lacks therapeutic activity when used with living organisms.
- The chemical is too toxic be worth the risk of developing into a drug.
- The chemical is highly **teratogenic** (causing adverse effects to a fetus).
- The safety margins are so small that the chemical would not be useful in the clinical setting.

Some chemicals, however, are found to have therapeutic effects and reasonable safety margins. This means that the chemicals are therapeutic at doses that are reasonably different from doses that cause toxic effects. Such chemicals will pass the preclinical trials and advance to phase I studies.

Phase I Studies

A **phase I study** uses human volunteers to test the drugs for safety and dosage information. These studies are more tightly controlled than preclinical trials and are performed by specially trained clinical investigators. The volunteers are fully informed of possible risks and may be paid for their participation. Usually, the studies would include 20 to 100 healthy volunteers or participants with the disease or condition that the medication is designed to help with. Volunteers who elect to participate in phase I studies have to be informed of the potential risks and must sign a consent form outlining the possible effects.

Some chemicals are therapeutic in other animals but have no effects in humans. Investigators in phase I studies scrutinize the drugs being tested for effects in humans. They also look for adverse effects and toxicity. At the end of phase I studies, about 70% of the drugs being tested move on to the next phase of testing. Many chemicals are dropped from the process for the following reasons:

- They cause unacceptable adverse effects.
- They are highly teratogenic.

- They are too toxic.
- They lack evidence of potential therapeutic effect in humans.

Some chemicals move to the next stage of testing despite undesirable effects. For example, the antihypertensive drug minoxidil was found to effectively treat hypertensive crisis, but it caused unusual hair growth on the palms and other body areas. However, because it was so much more effective for treating malignant hypertension at the time of its development than any other antihypertensive drug and because the undesired effects were not dangerous, it proceeded to phase II studies. (Now, its hair-growing effect has been channeled for therapeutic use into various topical hair-growth preparations such as *Rogaine*.)

Phase II Studies

A **phase II study** allows clinical investigators to evaluate the drug in more patients who have the disease that the drug is designed to treat. Patients are told about the possible benefits of the drug and are invited to participate in the study. Those who consent to participate are fully informed about possible risks and are monitored very closely, to evaluate the drug's effects. Usually, phase II studies are performed at various sites across the country—in hospitals, clinics, and doctors' offices—and are monitored by representatives of the pharmaceutical company studying the drug. At the end of phase II studies, a drug may be removed from further investigation for the following reasons:

- It is less effective than anticipated.
- It is too toxic when used with patients.
- It produces unacceptable adverse effects.
- It has a low benefit-to-risk ratio, meaning that the therapeutic benefit it provides does not outweigh the risk of potential adverse effects that it causes.
- It is no more effective than other drugs already on the market, making the cost of continued research and production less attractive to the drug company.

A drug that continues to show promise as a therapeutic agent receives additional scrutiny in phase III studies. About 33% of chemicals from phase

II studies are able to move to phase III.

Phase III Studies

A **phase III study** involves use of the drug in a larger sample of the population. The purpose is to determine the treatment benefit and to monitor side effects that may not have been apparent in the earlier studies. Participants are informed of all the known reactions to the drug and precautions required for its safe use. Researchers observe patients very closely, monitoring them for any adverse effects. Often, participants are asked to keep journals and record any symptoms they experience. Researchers then evaluate the reported effects to determine whether they are caused by the disease or by the drug. Approximately 25% to 30% of the medications from phase III studies are able to move to the next phase. The medications that produce unacceptable side effects or unexpected responses will not be approved.

Food and Drug Administration Approval

Drugs that finish phase III studies are evaluated by the FDA, which relies on committees of experts familiar with the specialty area in which the drugs will be used. Only those drugs that receive FDA committee approval may be marketed. **Figure 1.3** recaps the various phases of drug development discussed.

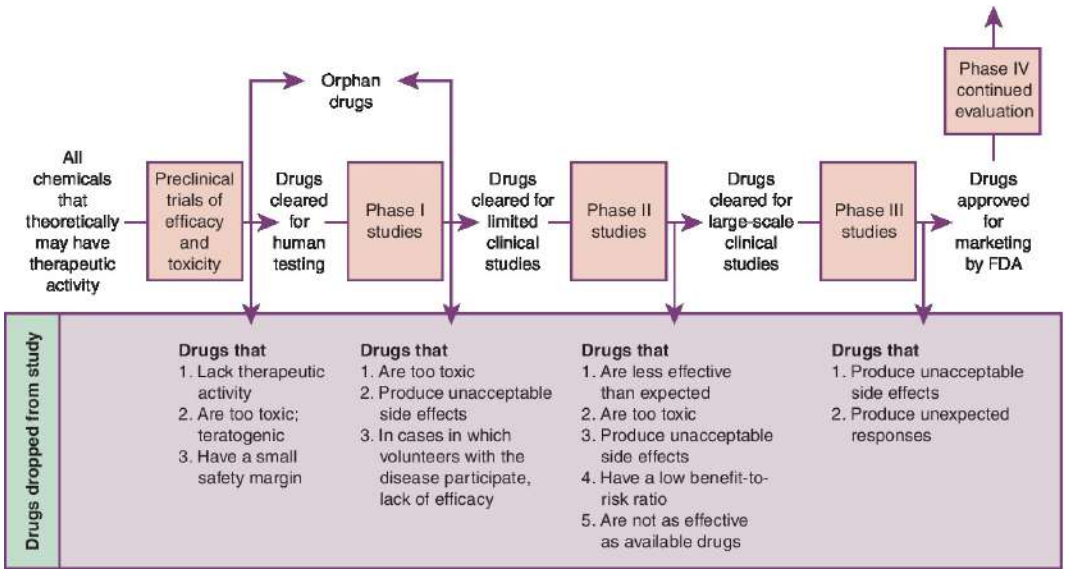


Figure 1.3 Phases of drug development.

An approved drug is given a **brand name** (trade name) by the pharmaceutical company that developed it. The **generic name** of a drug is the original designation that the drug was given when the drug company applied for the approval process. **Chemical names** are names that reflect the chemical structure of a drug. Some drugs are known by all three names. It can be confusing to study drugs when so many different names are used for the same compound. In this text, the generic and chemical names always appear in straight print, and the brand name is always capitalized and italicized (e.g., minoxidil [*Rogaine*]). Since there are times when multiple companies manufacture the medications, there can be multiple brand names for the same generic drug. Table 1.4 compares examples of drug names.

Table 1.4 Comparison of Chemical, Generic, and Brand Names of Drugs

L-Thyroxine, T_4	←	Chemical name	→	Delta-9-tetrahydrocannabinol
Levothyroxine sodium	←	Generic name	→	Dronabinol
Levoxyl, Synthroid	←	Brand names	→	*Marinol*

The entire drug development and approval process can take 5 to 6 years, resulting in a so-called drug lag in the United States. In some instances, a drug that is available in another country may not become available here for years. The FDA regards public safety as primary in drug approval, so the process remains strict; however, it can be accelerated in certain instances involving the treatment of deadly diseases. A drug can be "fast tracked" if it shows great promise and no other drug is available that gives those effects. For example, some drugs (e.g., delavirdine [*Rescriptor*] and efavirenz [*Sustiva*]) that were thought to offer a benefit to patients with AIDS, a potentially fatal immune disorder, were approved more quickly because of the progressive nature of AIDS and the lack of a cure. Several vaccines and medications studied for the prevention or treatment of SARS-COV-2 (the virus that causes COVID-19 infection) were authorized for emergency use prior to completion of all of the phase III trials. They continued to be studied. Some of them were eventually fully approved and others had the emergency authorization revoked. A drug can also be granted "breakthrough" status if in preliminary clinical evidence it shows the ability to treat serious diseases when no other therapy is available or it demonstrates substantial improvement over available therapy. Many of the most recent cancer therapies and enzyme therapies fall into this group. All literature associated with these drugs indicates that long-term effects and other information about the drug may not yet be known.

In addition to the drug lag issue, there also are concerns about the high cost of drug approval. A 2020 study published in the *Journal of American Medical Association (JAMA)* reported that the mean investment to bring a new medication to market was approximately $1.3 billion. Antineoplastic

and immunomodulating agents generally cost even more to develop and market. Because of this kind of financial investment, pharmaceutical companies are unwilling to risk approval of a drug that might cause serious problems and prompt lawsuits.

Phase IV Studies

After a drug is approved for marketing, it enters a phase of continual evaluation, or **phase IV study**. Prescribers and all health care professionals are obligated to report to the FDA any untoward or unexpected adverse effects associated with drugs they are using, and the FDA continually evaluates this information. Some drugs cause unexpected effects that are not seen until wide distribution occurs. Sometimes, those effects are therapeutic. For example, patients taking the antiparkinsonism drug amantadine (*Symmetrel*) were found to have fewer cases of influenza than other patients, leading to the discovery that amantadine is an effective antiviral agent.

In other instances, the unexpected effects are dangerous. In 1997, the diet drug dexfenfluramine (*Redux*) was removed from the market only months after its release because patients taking it developed serious heart problems. In 2004, the drug company Merck withdrew its cyclooxygenase-2 (Cox-2)-specific nonsteroidal anti-inflammatory drug rofecoxib (*Vioxx*) from the market when postmarketing studies seemed to show a significant increase in cardiovascular mortality in patients who were taking the drug. These problems were not seen in any of the premarketing studies of the drug. The effects were only seen with a much wider use of the drug after it had been marketed.

FDA Labels and "Off-Label" Uses

When a medication undergoes Phase IV studies, the prescribing information is refined and the medication is "labeled". The FDA label will list the approved uses and the risks and benefits of the medication based on the clinical trials. The label will also have information about the absorption, distribution, metabolism, and excretion of the medication from the body.

"Off-label" use refers to uses of a drug that are not part of the stated therapeutic indications for which the drug was approved by the FDA. Once

a drug becomes available for use, it may be found to be effective in a situation not on the approved list. Using it for this indication may eventually lead to an approval of the drug for that new indication. Off-label use is commonly done for groups of patients for which there is little premarketing testing, particularly pediatric and geriatric groups.

"Off-label" use of drugs is widespread and often leads to discovery of a new use for a drug. However, the nurse needs to be cognizant of off-label uses and know when to question the use of a drug before administering it. Liability issues surrounding many of these uses are unclear, and the nurse should be aware of the intended use, why the drug is being tried, and its potential for problems.

Key Points

- The FDA carefully regulates the testing and approval of all drugs in this country.
- To be approved for marketing by the FDA, a drug must pass through both preclinical and clinical trials.
- Off-label uses of drugs occur when a drug is used for an indication that is not on the FDA label.

Legal Regulation of Drugs

The FDA regulates the development and sale of drugs. Local laws further regulate the distribution and administration of drugs. In most cases, the strictest law is the one that prevails. Nurses should become familiar with the rules and regulations in the area in which they practice. These regulations can vary from state to state and even within a state.

Over the years, the FDA has become more powerful, usually in response to a drug disaster affecting many people. In the 1930s, the drug "elixir of sulfanilamide" was distributed in a vehicle of ethylene glycol that had never been tested in humans. It turned out that ethylene glycol is toxic to humans, and hundreds of people died and many others became very ill. This led to the Federal Food, Drug and Cosmetic Act of 1938, which gave

the FDA power to enforce standards for testing drug toxicity and monitoring labeling.

In the 1960s, the drug thalidomide (*Thalomid*) was used as a sleeping aid during pregnancy, resulting in the birth of many babies with limb deformities. The public outcry resulted in the Kefauver-Harris Act of 1962, which gave the FDA regulatory control over the testing and evaluating of drugs and set standards for efficacy and safety.

Other laws have given the FDA control over monitoring of potentially addictive drugs, dietary supplements, and responsibility for monitoring the sale of drugs that are available without prescription. Table 1.5 provides a summary of some of these laws.

Table 1.5 Federal Legislation Affecting the Clinical Use of Drugs

Year Enacted	Law	Impact
1906	Pure Food and Drug Act	Prevented the marketing of adulterated drugs; required labeling to eliminate false or misleading claims
1938	Federal Food, Drug, and Cosmetic Act	Mandated tests for drug toxicity and provided means for recall of drugs; established procedures for introducing new drugs; gave FDA the power of enforcement
1951	Durham-Humphrey Amendment	Tightened control of certain drugs; specified drugs to be labeled "may not be distributed without a prescription"
1962	Kefauver-Harris Act	Tightened control over the quality of drugs; gave FDA regulatory power over the procedure of drug investigations; stated that efficacy as well as safety of drugs had to be established
1970	Comprehensive Drug Abuse Prevention and Control Act	Defined drug abuse and classified drugs as to their potential for abuse; provided strict controls over the distribution, storage, and use of these drugs
1983	Orphan Drug Act	Provided incentives for the development of orphan drugs for treatment of rare diseases
1988	Food and Drug Administration Act and Prescription Drug Marketing Act	FDA established at official agency of Department of Health and Human Services. Prescription drugs must go through legitimate commercial channels
1994	Dietary Supplement Health and Education Act	Established specific labeling requirements for dietary supplements and classified them as "foods"