

PRINCIPLES OF CLINICAL RESEARCH

THE SCIENTIFIC APPROACH TO RESEARCH AND PRACTICE

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CHAPTER OBJECTIVES

- ▶ Define basic, applied, clinical, and translational research
- ▶ Understand the principles of scientific inquiry
- ▶ Describe the steps in scientific research and evidence-based practice
- ▶ Discuss the scientific basis of professional education

KEY TERMINOLOGY

Abstract	Evidence-based medicine	Practice-based research network
Analytical research	Hypothesis	Primary methods
Applied research	Introduction section	Quality
Basic research	Journal article	Research
Biomedical research	Method section	Research and development
Clinical research	Objectivity	Research design
Comparative effectiveness research	Patient-centered outcomes research	Research methodology
Descriptive research	Pharmaceutical practice and policy research	Research report
Development	Positivism	Results section
Discussion section	Posters	Secondary methods
Empiricism		Theory
Ethics		Translational research

INTRODUCTION

Pharmacists are a vital component of healthcare delivery and biomedical systems. Medications and clinical services are integral to the myriad roles pharmacists play in the healthcare system. Pharmaceutical research and development is instrumental in the discovery of new medications and pharmaceutical formulations. There are more than 10,000 prescription products and more than 300,000 over-the-counter products in the marketplace.¹ This is mainly attributed to research and development in basic sciences such as biology, chemistry, biochemistry, and microbiology, and applied sciences such as pharmacology, pharmaceuticals, and pharmacotherapy. During the past few decades, there has been significant growth of clinical pharmacy services to meet the complexities of delivering pharmaceutical care in diverse healthcare settings. Pharmacists provide a broad range of outpatient services, such as medication therapy management, immunizations, and health screenings, and inpatient services ranging from nutrition to therapeutic drug monitoring in institutional settings. High-quality research is vital to developing new medications and clinical services; it also provides the knowledge base to effectively use these products and services.

Pharmacists have an important role to play in creating and applying scientific evidence. Although pharmacists are mostly consumers of research information, they contribute immensely to the growing scientific knowledge base relevant to the pharmacy profession. Pharmacists involved in research make a vital difference by providing evidence that others can use. This knowledge is also important in academia to train the next generation of pharmacists. In recent years, practice-based innovations have created new models in delivering pharmaceutical care. With the increasing role of evidence-based paradigms, there is greater need to critically apply and evaluate research for pharmaceutical practice and policy. Both creating and applying research evidence require an understanding of the principles of research design. This chapter defines biomedical research and evolving clinical research paradigms relevant to the pharmacy practice. It discusses the principles of research design and steps involved in scientific research inquiry. Finally, the concept of evidence-based medicine is introduced to effectively translate scientific evidence to patient care.

BIOMEDICAL RESEARCH

Pharmaceuticals and pharmacists are vital for healthcare delivery. Research drives the increasing role of pharmaceuticals and pharmaceutical services in disease state management. The National Science Foundation (NSF) has defined **research** as “systematic study directed toward fuller scientific knowledge or understanding of the subject studied.”² **Biomedical research** is a broad area that deals with research in biological and medical sciences to understand and improve the health of patients and populations. Biomedical research can be further classified as *basic* or *applied* based on the goals of the research. **Basic research** is defined as “systematic study directed toward fuller knowledge or understanding of the fundamental aspects of phenomena and of observable facts without specific applications toward processes or products in mind.”² It is usually conducted in laboratories to provide knowledge and understanding of natural phenomena. Some areas of inquiry in basic biomedical research are biology, physiology, biochemistry, and genetics. Although scientists involved in basic research are only focused on generalized knowledge, this knowledge is critical for applied research that is product or application oriented.

Applied research is defined as “systematic study to gain [the] knowledge or understanding necessary to determine the means by which a recognized and specific need may be met.”² It focuses on applying basic knowledge for the purpose of developing a product or an application such as a new medication, drug regimen, or service. It has practical orientation rather than the explanation focus that is inherent in basic research. It is conducted in animals and other living systems to solve a practical problem or to create a product. Some areas of inquiry in applied biomedical research are pharmacology, medicinal chemistry, and pharmaceuticals. Research and development in applied biomedical research is the engine for the pharmaceutical industry.

Drug development is specifically focused on developing new drug products. **Development** is defined as “systematic application of knowledge or understanding, directed toward the production of useful materials, devices, and systems or methods.”² **Research and development (R&D)** refers to “creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications.”² In the pharmaceutical industry, R&D is an expensive and time-consuming process. It takes an average of 15 years for a new product to enter the market at an average cost of \$1.2 billion because of complex development, testing, legal, and regulatory considerations.³

Clinical research plays a vital role in the drug development process because approval of a drug by the Food and Drug Administration (FDA) requires clinical trials to demonstrate the safety and efficacy of pharmaceutical products. The National Institutes of Health (NIH) has defined **clinical research** as “research that either directly involves a particular person or group of people or uses materials from humans, such as their behavior or samples of their tissue.”⁴ Specifically, it is “any investigation in human subjects intended to discover or verify the clinical, pharmacological, and/or other pharmacodynamic effects of an investigational product(s), and/or to identify any adverse reactions to an investigational product(s), and/or to study absorption, distribution, metabolism, and excretion of an investigational product(s) with the object of ascertaining its safety and/or efficacy.”⁵ Clinical research helps in understanding and applying knowledge for products or processes in prevention, diagnosis, prognosis, treatment, and cure of diseases in humans. It is conducted in laboratories, healthcare settings, and other specialized locations according to regulatory guidelines.

Clinical research includes patient-oriented research, epidemiological and behavioral research, and health services research.⁴ Patient-oriented research examines the mechanisms of human diseases, effects of drug therapies and other interventions, and use of technologies and devices in humans. Epidemiological and behavioral research evaluates the distribution of and factors associated with diseases, health behavior, and health in general. Health services research evaluates the effectiveness and efficiency of treatment, interventions, and services in real-world practice. All facets of clinical research are important to improve the health of patients. Clinical research involving pharmaceuticals and pharmacy services is vital to improving the quality of pharmaceutical care.

Pharmaceutical practice and policy research is a component of health services research that deals with issues related to pharmaceuticals, pharmacist services, and pharmacy systems. It is defined as a “multidisciplinary field of scientific investigation that examines cost, access, and quality of pharmaceutical care from clinical, sociobehavioral, economic, organizational, and technological perspectives.”⁶ The goal of pharmaceutical practice and policy research is to increase knowledge and understanding of pharmaceuticals, pharmacist services, and pharmacy systems for individuals and populations. New areas such as pharmacoepidemiology, pharmacoconomics, pharmaceutical outcome research, and pharmacy practice-based research are evolving and expanding the research

frontiers of pharmaceutical practice and policy research. This evidence base is critical to expanding the scope and role of pharmacists and pharmacy systems.

EVOLVING RESEARCH PARADIGMS

Translational research is the new clinical research paradigm for transferring knowledge across the research and practice continuum. According to the NIH, **translational research** includes “two areas of translation: The first area is the process of applying discoveries generated during research in the laboratory, and in pre-clinical studies, to the development of trials and studies in humans. The second area of translation concerns research aimed at enhancing the adoption of best practices in the community.”⁷ The first area of translation is designed to improve the trajectory of research from laboratory to patient care. This is critical for diseases such as cancer and acquired immunodeficiency syndrome (AIDS) that are in need of products to cure or treat their devastating effects. The second area of translation is gaining the support of scientists, clinicians, educators, and funding agencies to rapidly adopt evidence-based patient care practices. According to the Institute of Medicine (IOM), there is a significant gap between what patients are receiving and what they should receive, leading to a quality chasm in health care.⁸ Translational research and evidence-based medicine can be instrumental in bridging this quality gap.

In recent years, there is significant interest in comparative effectiveness research due to limited data comparing two therapies, interventions, or devices. The demand for comparative effectiveness data is apparent as most clinicians want such data for clinical decisions. The efficacy data derived from placebo-controlled clinical trials are designed for the drug approval process. Comparative effectiveness research is based on the concepts of evaluation of alternatives so that the research can be used to select appropriate agents from among the alternatives to optimize patient outcomes. **Comparative effectiveness research** is the “generation and synthesis of evidence that compares the benefits and harms of alternative methods to prevent, diagnose, treat, and monitor a clinical condition or to improve delivery of care.”⁹ The goal of comparative research is to provide information to decision makers at both the individual and population levels.

With increasing focus on patient-centered care, a new type of clinical research called **patient-centered outcomes research** (PCOR) has evolved. PCOR is designed to incorporate patients’ input in the research process and to provide relevant information to providers and patients for deciding on healthcare choices. PCOR “helps people and their caregivers communicate and make informed healthcare decisions, allowing their voices to be heard in assessing the value of healthcare options.”¹⁰ For pharmaceutical products and services, the goal of PCOR is to “assess the benefits and harms of preventive, diagnostic, therapeutic, or health delivery system interventions to inform decision making, highlighting comparisons and outcomes that matter to people.”¹¹ The incorporation of patient-relevant outcomes is a new phenomenon as traditional clinical research, until now, emphasized outcomes from the clinician’s perspective. In an effort to generate evidence for patient-oriented outcomes, the federal government has created the Patient-Centered Outcomes Research Institute (PCORI), which will fund research on (1) assessment of prevention, diagnosis, and treatment options, (2) improving access and care in healthcare systems, (3) communication and dissemination research for shared decision making, (4) addressing disparities in prevention, diagnosis, or treatment effectiveness, and (5) accelerating patient-centered outcomes research and methodological research.¹¹

DETERMINANTS OF SCIENTIFIC METHODOLOGY

All scientific research is bound by principles of scientific inquiry. These include empiricism, objectivity, theory, and ethical standards.⁶ **Empiricism** refers to a collection of information based on human experience. It is based on the philosophy of **positivism** that states that all information derived from sensory experience is empirical evidence of science. All aspects of science should be observed and measured to be considered scientific evidence. All clinical outcomes in research are explicitly defined and measured to be considered evidence to evaluate the safety and effectiveness of medications. Measurement and quantification are vital for scientific research. **Objectivity** means there is no subjectivity or bias in any aspect of research including definition, measurement, design, and analysis. In clinical research, the measures to define effectiveness, such as blood pressure and blood glucose, are objective, and the measurement process is often blinded to minimize any kind of subjectivity. All biases in research are minimized to increase the strength of scientific evidence.

Theory provides an understanding or explanation of natural phenomena. Theories evolve over years or decades to explain natural phenomena. In pharmaceutical research, theories are often based on the pathophysiology of a disease and the pharmacology of a medication to investigate its effects. Sociobehavioral theories are often used to understand patient and provider behavior in pharmaceutical practice and policy research. Theories are also useful in developing a research hypothesis. They provide the rationale and logic for a research question and hypothesis. Research findings are used to strengthen or dispute a theory. **Ethics** provide moral societal standards for responsible research conduct. These standards are based on respect for, fairness to, and the well-being of research participants.¹² The standards are often governed by institutional review board (IRB), state, and federal regulations. To reflect all these principles in research, Kerlinger has defined scientific research as a “systematic, controlled, empirical, and critical investigation guided by theory and hypothesis about presumed relationships among such phenomena.”¹³

PROCESS OF SCIENTIFIC INQUIRY

The scientific research process involves the following steps: (1) pose a research question and hypothesis, (2) develop and implement a research plan, (3) perform data collection and analysis, and (4) prepare a research report.⁶ Each of these steps is critical for scientific inquiry. The research question or hypothesis dictates the research plans and data collection. Often, practical and scientific considerations necessitate overlap of these steps of the research process. The following description uses a clinical and translational research framework to explain the research steps (**Figure 1-1**).

The first step in the scientific research process is to pose a research question and hypothesis. It is important to develop a research question that needs empirical investigation. The commonly used sources for a research question are clinical practice, policy, current issue, literature, or theory. The desirable characteristics of a research question are that it is feasible, interesting, novel, ethical, and relevant (FINER).¹⁴ Practical considerations, such as funding, expertise, environment, and access to patient care data, are also important to address the feasibility of the research. The novelty aspect of the research question can be evaluated by conducting a literature review. The goal of the research is

to add something new to the existing evidence base. The ethical principles of research are governed by local IRBs and federal regulations. This requires appropriate regulatory approvals to conduct clinical research. Research relevant to the pharmacy profession should have strong implications for pharmaceutical practice and policy. Research that is not relevant will have limited value to stakeholders such as patients, providers, payers, and policy makers. These considerations will not only help develop a good research question but also ensure value for the research (**Box 1-1**).

The population, intervention, comparator, outcomes, timeline, and setting (PICOTS) framework is often used to develop a good clinical question. This framework is ideal for comparing interventions such as medications, devices, clinical services, policies, and programs. It also provides the components of a research question.^{15,16} The PICOTS framework requires the research question to identify the population to be studied, the intervention to be applied, the comparator to be used, the outcomes to be evaluated, the timeline to evaluate the outcomes, and the healthcare setting of interest (**Figure 1-2**).

The population of interest can be grouped based on age, disease, or location. The intervention is usually a pharmaceutical product or service. The comparator can be an

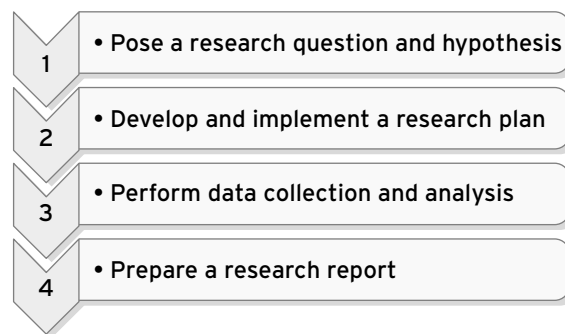


FIGURE 1-1 Steps in the scientific research process.

BOX 1-1

Research Question and Hypothesis

Question: In patients with diabetes, do clinical services by pharmacists improve short-term clinical outcomes compared with traditional care in an outpatient setting?

Hypothesis: Clinical services by pharmacists will improve short-term clinical outcomes in outpatients with diabetes compared to traditional care.

Data from Irons BK, Lenz RJ, Anderson SL, et al. *Pharmacotherapy*. 2002;22:1294–1300; and Choe HM, Mitrovich S, Dubay D, et al. *Am J Manag Care*. 2005;11:253–260.

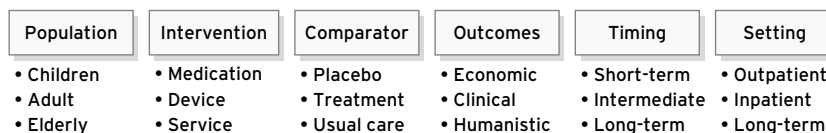


FIGURE 1-2 Component of a scientific research question with examples.

active medication/service or a placebo based on the goals of the research. The economic, clinical, and humanistic outcomes (ECHOs) are usually evaluated in pharmaceutical practice and policy research.¹⁷ Costs of direct and indirect medical care are often included as economic outcomes. Clinical outcomes include morbidity and mortality measures that represent the safety and effectiveness of treatment. Humanistic outcomes include patient-reported outcomes such as health-related quality of life and functional status. The timeline for research can be short-term or long-term based on the expected effects of pharmaceutical products or services.

In addition, research can be classified as descriptive or analytical. **Descriptive research** describes or explores characteristics of a population such as prevalence of disease. **Analytical research** evaluates the relationship between two or more variables. A **hypothesis** specifies an expected relationship that is being evaluated between intervention/exposure and outcome, or two or more variables. The hypothesis is often based on existing theories. The pathophysiology of disease and pharmacology of medication provide the rationale for expected effects of pharmaceutical products. The expected relationship between clinical intervention and outcomes is usually postulated based on sociobehavioral theories. Research hypothesis is not usually specified in descriptive or exploratory research.

Developing and implementing a research plan requires a strong understanding of the principles of clinical research. Research plans include specific details of research design and methodology. Grant proposals have other requirements, such as timeline and funding details, in addition to research plans. These plans are implemented after the necessary approvals by the local IRB. **Research design** refers to the overall plan that allows researchers to gather answers to study questions and test study hypotheses.¹⁸ The research designs can be broadly categorized into two types—experimental and observational. Experimental designs such as randomized controlled trials are the strongest study designs to test research hypotheses. The randomized designs are considered the gold standard in clinical research and are used to evaluate drug safety and efficacy. Observational research such as cohort or cross-sectional studies provides evidence of associations or relationships. The evidence from observational research is generally weaker than that from randomized controlled trials due to scientific considerations such as confounding and biases. Study design provides a structural framework for experimental or observational research.⁶ Various other study designs are available to address the research question; the goal is to select the best design that can address the research question.

Research methodology provides details of data collection and measurement techniques.⁶ The definitions and the measurement process of intervention and outcomes are specified in the methods. Research methods are broadly grouped as primary or secondary methods. **Primary methods** collect data specifically for research questions using techniques such as self-reported observations and biological assessments; examples include surveys and laboratory tests. These are often collected prospectively—that is, data collection begins after the study onset. **Secondary methods** involve the use of data that were collected for other purposes such as patient care or reimbursement; examples include medical charts and medical claims. These are retrospective in nature—that is, data are based on past events or existing data. Prospective methods are generally considered superior to retrospective methods because the researcher controls the data collection methods. The goal of research methods is to collect research data that are reliable (consistent) and valid (accurate). Researchers have a choice of research methods; the goal is to select the most appropriate method to collect research data (**Box 1-2**).

The research design and methodology define the data management and analysis plans. Data collected from all sources should be recorded at the patient level or other

BOX 1-2**Research Plan****Design:**

- Choe HM et al. used randomized controlled trials to evaluate the effect of clinical services by pharmacists on glycemic control and other process measures in diabetes patients.
- Irons BK et al. used a retrospective cohort design to evaluate the clinical effectiveness of clinical services by a pharmacist in primary care for patients with diabetes.

Methods:

- Choe HM et al. prospectively collected data on glycosylated hemoglobin using a high-performance liquid chromatography machine and other secondary data were collected using chart review.
- Irons BK et al. used secondary sources like medical charts to collect data related glycosylated hemoglobin and other secondary outcomes for the study population.

BOX 1-3**Data Collection and Analysis**

- Choe HM et al. analyzed data collected using Wilcoxon rank sum test and linear regression analysis. A level of $p < .05$ was set to define statistical significance.
- Irons BK et al. analyzed data collected using *t*-test, chi-square, analysis of variance, and Cox regression models. Two-sided tests were performed with an a priori alpha level of 0.05.

units of analysis to conduct appropriate statistical analyses. Data collected from surveys and laboratory tests should be gathered and coded accordingly. Similarly, data from secondary sources should be extracted and coded. Although data collection seems easy, it is often tedious and time consuming because any error can undermine the data integrity and subsequent steps in the research including statistical analyses. Statistical analysis provides the quantitative answers to the research question. It is a tool to organize, summarize, and analyze research data. Several descriptive and inferential statistics are used to analyze the data. The descriptive measures such as means, medians, and modes are often used to summarize study sample characteristics. Inferential statistics such as the *t*-test and analysis of variance are used to make inferences or draw conclusions based on the data collected. The appropriate statistical test is selected based on the research question, research hypothesis, research design, and methods (**Box 1-3**).

Research reports or journal articles are vital to communicate research findings to stakeholders such as patients, providers, payers, and policy makers. The **research report** or **journal article** is a detailed report that often includes the following sections: introduction, methods, results, and discussion (IMRaD).¹⁹ It is generally peer reviewed to ensure scientific discourse and scrutiny. The **posters** are often used for a graphic/visual presentation of research in scientific conferences usually employing the IMRaD format (**Figure 1-3**).

The **abstract** is a structured summary of research to provide quick and easy-to-use information to readers. The **introduction section** of a research report or journal article includes relevant background information and covers existing literature on

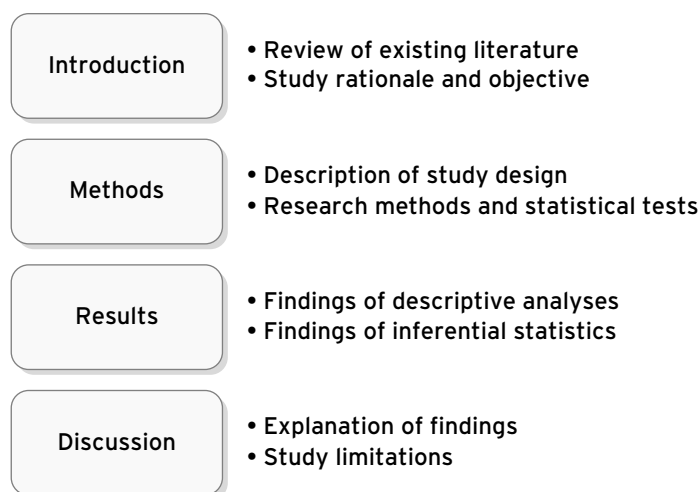


FIGURE 1-3 Components of a research report.

BOX 1-4

Key Findings and Research Report

- Choe HM et al. found a significant decrease (−2.1%) in glycosylated hemoglobin levels in the intervention group when compared to the decrease in the control group (−0.9%). Significant improvements were also seen in other process of care measures. The other results can be found in the research report.
- Irons BK et al. found no difference in glycosylated hemoglobin between the two groups. However, there was higher risk (5.19, 95% CI 2.62–10.26) of achieving the clinical goal ($A1C \leq 7\%$) in the study group compared to the control group. The other results can be found in the research report.

the subject. It provides a rationale for conducting the research. It specifies the research objective or question and research hypothesis. The **method section** includes descriptions of research design, data collection methods, and statistical tests. The **results section** describes the research findings based on the statistical analyses. The study sample is often summarized using descriptive statistics and graphs. Inferential statistics usually include confidence intervals and probability or p values. The results section provides quantitative answers to the research question. This is the most objective and unbiased section of the research report. The **discussion section** provides the interpretation and explanation of the research findings using previous research or theory. It also addresses possible limitations and future directions of the research (**Box 1-4**).

EVIDENCE-BASED MEDICINE

The goal of clinical research is to provide scientific evidence to improve the health and functioning of people. Healthcare providers, payers, and policy makers are all interested in ensuring delivery of the highest-quality patient care. **Quality** in health care refers to “the degree to which health services for individuals and populations increase the likelihood of desired health outcomes and are consistent with current professional knowledge.”²⁰ According to the IOM, all stakeholders in health care should pursue the

following six aims in the delivery of quality health care.⁸ Quality health care should be (1) safe: avoid harm to patients from the healthcare delivery; (2) effective: deliver care that benefits patients; (3) patient-centered: individualize care based on patient preferences and values; (4) timely: ensure timely, needed care and avoid delays; (5) efficient: maximize the use of healthcare resources; and (6) equitable: provide care that does not vary due to personal characteristics—race or ethnicity—and minimize healthcare disparities at the individual and population levels. To achieve these aims, patients and populations should receive health care that is based on the best scientific evidence (**Figure 1-4**).

The core of **evidence-based medicine** (EBM) is to translate scientific evidence to patient care. There are several definitions of EBM. Some initially emphasize the translational aspect of evidence to practice because a “process of systematically finding, appraising, and using contemporaneous research findings as the basis for clinical decisions.”²¹ Others define EBM holistically as “integration of best research evidence with clinical expertise and patient values.”²² The holistic definition is the one that is most widely accepted and practiced because it not only emphasizes scientific evidence but also incorporates expertise of clinicians and patient preferences. Clinical expertise includes the knowledge, skills, and experience of practitioners to integrate evidence with patient preferences. Any care that is not patient-centered will have limited value because treatment success is dependent on individualization. This holistic approach lends equal importance to evidence (scientific), expertise (provider), and values (patient) to achieve the desired patient outcomes.

Because scientific evidence is the core of EBM, the following steps of EBM are evidence centered: (1) asking an appropriate and answerable question, (2) finding evidence, (3) appraising evidence, and (4) applying evidence to practice.²² A simplified example is presented in **Figure 1-5**.

Each step is important to ensure that relevant evidence is obtained and combined with clinical expertise and patient values to deliver EBM. An understanding of the scientific research process and value of research evidence is critical in

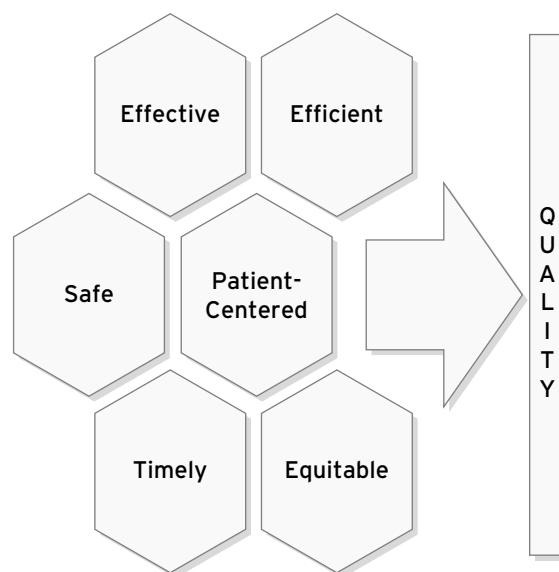


FIGURE 1-4 Six aims of quality improvements.

Data from Committee on Quality of Health Care in America. Institute of Medicine of the National Academies. *Crossing the Quality Chasm: A New Health System for the 21st Century*. Washington, DC: National Academies Press; 2001.

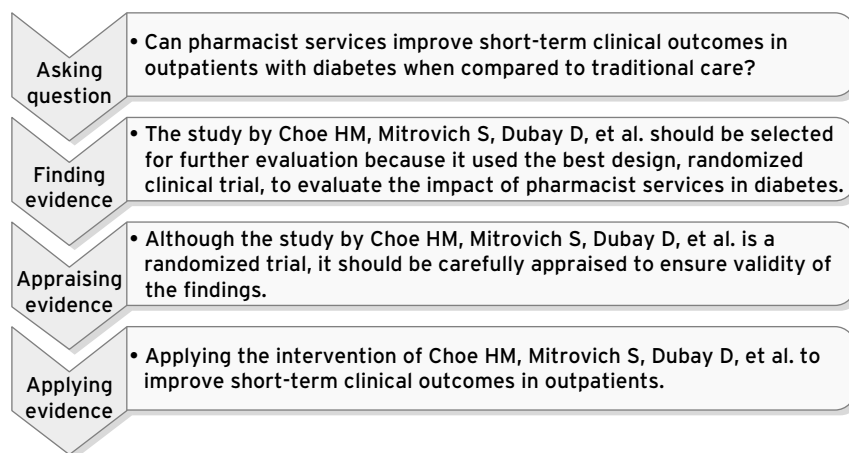


FIGURE 1-5 Example of evidence-based medicine.

Data from Choe HM, Mitrovich S, Dubay D, et al. Proactive case management of high-risk patients with type 2 diabetes mellitus by a clinical pharmacist: a randomized controlled trial. *Am J Manag Care.* 2005 Apr;11(4):253-60.

implementing EBM. If the goal of pharmaceutical practice and policy research is to develop an evidence base for pharmaceuticals, pharmacist services, and pharmacy systems, then the goal of EBM is to use the relevant scientific evidence to provide highest-quality patient care.

The research problem or question is the starting point for research. Similarly, asking the appropriate question is the starting point for providing EBM. The components of the question should include patient, intervention, comparator, and outcome (PICO). The relevant evidence is obtained after scouting for the evidence from various sources. The most relevant research is then critically appraised to ensure the validity and applicability of the evidence to patient care. This is often a time-consuming and critical process in EBM. Just because research is published in a peer-reviewed journal does not mean it is relevant or applicable to patient care.

The understanding of scientific principles is important to ensure that relevant evidence is valid and applicable. Critical appraisal of the selected research will ensure that research findings are correct (internal validity) and are applicable to the clinician's patient population (external validity). The best available and valid evidence is applied to provide patient-centered care. Medical decision making is a complex process with critical consequences; therefore, it requires "conscientious use, explicit, and judicious use of current best evidence in making decisions about the care of individual patients."²³

SCIENTIFIC BASIS OF PROFESSIONAL EDUCATION

Scientific contributions are critical for pharmacy education and the profession. The evidence base and scientific innovations immensely contribute to the knowledge base for pharmacist training and advancement of the pharmacy profession in the healthcare system. Pharmaceutical researchers, practitioners, and educators have an important role to play to generate and translate the evidence to patient care. Pharmacist involvement is needed across the research and practice continuum, from basic research to clinical and translation research to evidence-based practice (**Figure 1-6**).

Basic and clinical researchers are vital in developing the knowledge base relevant to the pharmacy profession. Scientific breakthroughs in the basic sciences such as biology, chemistry, biochemistry, genetics, and microbiology are critical in the development of

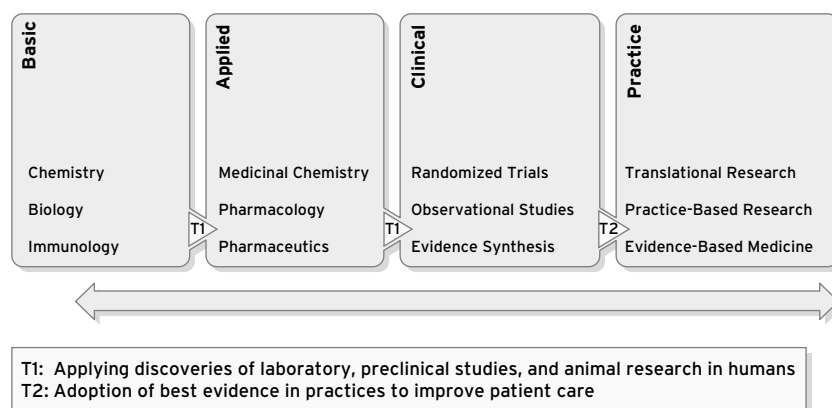


FIGURE 1-6 Research and practice continuum of biomedical sciences.

applications in biomedical sciences. The research support by the NSF and the NIH has been instrumental in transforming the basic biomedical research landscape in the United States.²⁴ Pharmacists can indirectly or directly contribute to basic sciences because they have a broad understanding of basic and applied sciences relevant to pharmacy practice.

Applied scientists in pharmaceutical sciences such as medicinal chemistry, pharmaceutics, and pharmacology are instrumental in developing innovative healthcare products and services. The NIH and the pharmaceutical industry have played an important role in funding the applied biomedical sciences.²⁴ Foundations such as the American Cancer Society (ACS) and the American Heart Association (AHA) are also making a difference in advancing healthcare research. Pharmaceutical scientists have made immense contributions in developing and applying biomedical knowledge to products and services. Pharmacists have made enormous contributions to applied biomedical sciences and have great potential to influence the future landscape of pharmaceutical sciences. Although advanced training such as graduate degrees or fellowships is recommended to directly participate in applied research areas, pharmacists can make a difference in applied research because of their broad understanding of basic and clinical sciences.

Clinical research is the pathway to evaluate the safety and effectiveness of products and services. With increasing patient care responsibilities, the pharmacists' role in clinical research has evolved. The 1975 Millis Commission Report recognized the importance of clinical scientists who are well versed in pharmacotherapy and biomedical research and recommended the development of training programs for clinical scientists.²⁵ National organizations, such as the American Association of Colleges of Pharmacy (AACP) and the American College of Clinical Pharmacy (ACCP), followed up on these recommendations and developed educational and training agendas for clinical scientists.

In 2008, the ACCP Task Force report on research in the PharmD curriculum detailed research content areas and competencies. It required pharmacy students to (1) identify problems and research gaps, (2) design research to test hypotheses within the regulatory and ethical framework, (3) conduct analyses, (4) disseminate research findings, and (5) apply study findings to practice.²⁶ The latest curriculum standards by the Accreditation Council for Pharmacy Education (ACPE) require pharmacist education and training to incorporate (1) principles of research design and methodology, (2) regulatory and ethical principles of research, (3) methods in data management and statistical analyses, (4) principles of drug literature evaluation, and (5) practice implications of research.²⁷ These content areas not only emphasize the drug literature evaluation component, but also principles of research design. Sound understanding of the scientific

basis of evidence creation and provision of patient care is essential for pharmacists to succeed in the highly competitive healthcare arena.

With the recent impetus in clinical and translational research, there is increased interest in training clinical scientists. In the past decade, the NIH has created the National Center for Advancing Translational Sciences (NCATS) to support clinical and translational research.²⁸ Specifically, the Clinical and Translational Science Awards (CTSA) program was initiated as part of NCATS to (1) develop academic infrastructure for translating biomedical research to treatments, (2) involve community practitioners and industry in translational research, and (3) train the next generation of clinical and translational researchers. Such programs are creating exciting collaborative opportunities across medicine, pharmacy, nursing, public health, and other disciplines. There are 60 academic programs in 30 states funded by the NIH as part of a CTSA consortium. Several colleges of pharmacy are part of the CTSA consortium. These programs are helping to create clinical research curriculum, training, and mentorship for pharmacy faculty and practitioners.

Practice-based research networks (PBRNs) have been instrumental in conducting clinical and translational research. A PBRN consists of a group of clinicians or practitioners involved in translational research who adopt best practices and conduct clinical research.²⁹ PBRNs started with primary care physicians; they now incorporate discipline-specific networks such as dentists, nurses, pharmacists, and others. These networks can be instrumental in (1) identifying problems in patient care, (2) testing effectiveness of treatments in real-world settings, and (3) evaluating patients who can benefit from treatments. PBRNs are considered the “blue highway” that links basic, clinical, and translational research.³⁰ The ACCP PBRN is one of the first clinical pharmacy-based research networks of clinical pharmacists in inpatient and outpatient settings. The research findings from such networks are vital for developing evidence-based practices in pharmacy.

The healthcare industry is a highly competitive marketplace with competing interests from providers, payers, and policy makers. With the increasing pressure of costs and efficiency, there is a need for providers to demonstrate value for their services based on scientific evidence. Several recent studies demonstrated the value in terms of cost, quality, and outcomes for pharmacists’ services. The Ashville Project demonstrated the effect of pharmacist services for asthma on decreased costs and improved quality.³¹ The Fleetwood Project showed the pharmacists’ positive effect on quality and costs in long-term care.³² A study by Chisholm-Burns et al. provided the best evidence for pharmacists’ value in health care based on the data from 298 studies.³³ The meta-analyses found that pharmacist-directed patient care services have a positive effect on patient outcomes across settings and diseases. Such strong scientific evidence is vital to demonstrating pharmacists’ contributions and to be recognized as healthcare providers. With increasing need for evidence for practice and policy, clinical and translational research and evidence-based practices are imperative for new models of pharmaceutical care.

SUMMARY AND CONCLUSIONS

The pharmacy profession is based on knowledge and evidence derived from scientific research. Sound understanding of the research process is critical for applying drug literature evaluation techniques for evidence-based practices. On the other hand, practice- or patient-based considerations have become paramount in research due to emerging research paradigms of clinical and translational research and patient-centered outcomes research. Pharmacists are integral to both the creation and application of evidence relevant to pharmacy practice. The goal of research is to provide evidence to

improve clinical practice based on the following steps: (1) pose a research question and hypothesis, (2) develop and implement a research plan, (3) perform data collection and analysis, and (4) present a research report. Each of these steps is critical for scientific inquiry and discourse. The core of evidence-based practices is to translate evidence to patient care based on the following steps: (1) asking appropriate and answerable questions, (2) finding evidence, (3) appraising evidence, and (4) applying evidence to practice. These steps ensure that relevant evidence is obtained and combined with clinical expertise and patient values to provide EBM. New paradigms of clinical research are emerging due to payer, patient, provider, and policy considerations. Pharmacists can immensely contribute to the research and practice continuum because of their broad range of understanding of basic and applied sciences. With changes in patient care models and evolving research evidence, it is critical that pharmacists be part of the creation and application of research evidence to improve healthcare outcomes.

REVIEW QUESTIONS

1. Describe basic, applied, clinical, and translation research, using examples.
2. What are the steps in the scientific research process? Use an example.
3. What are the components of the IMRaD research report?
4. What steps are involved in evidence-based medicine? Use an example.
5. Why is it important for pharmacists to be involved in research?

ONLINE RESOURCES

Academy of Managed Care Pharmacy. Evidence-Based Medicine Training/Learning: Resources/Tools: <http://amcp.org/Tertiary.aspx?id=10365>

American College of Clinical Pharmacy (ACCP) Research Institute: <http://www.accpri.org/>

ASHP Foundation Research Resources: <http://www.ashpfoundation.org/MainMenuCategories/ResearchResourceCenter/ResearchResources>

University of Washington's Institute for Translational Health Sciences Clinical and Translational Sciences. Research Toolkit: <http://www.researchtoolkit.org/>

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