

How to Come Up With a Good Research Question: Framing the Hypothesis

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Having a questioning attitude is the first step in the research process. Research begins with a question, which leads to a hypothesis. Questions abound in our daily clinical lives. Most quality research consists of comparisons. By carefully selecting a comparison group or condition, the quality of the research project can be improved. By including in the hypothesis the comparison group, the experiment can be focused and the analysis simplified. The best questions come from the investigator's subject of interest. When starting a research project, start small and choose an experienced mentor. Key words: research, study design, research methodology, scientific method. [Respir Care 2004;49(10):1195–1198. © 2004 Daedalus Enterprises]

Introduction

Respiratory care research is an important activity for the individual and the profession. Research that leads to changes in practice can improve patient outcomes, improve health care processes, and increase job satisfaction for clinicians. Though we often think of research as a

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complicated, meticulous process performed by specially trained individuals, all practitioners should bring a *research attitude* to their practice. A research attitude arises from a desire to question, evaluate, and investigate clinical practices, and it requires being open to new ideas and using other people's experience and experiments to answer the questions, "Why do we do things the way we do them?" and "Is there a better way?" A research attitude requires the assumption that, though we'll never know the whole truth, we want to gather data and get closer to the truth. It is this research attitude that has led to all improvements in respiratory care and other medical disciplines.

The Research Process

The process of research begins when the individual encounters a question that he or she thinks could and should be answered. The issues and problems that evoke a research question are encountered in various contexts—during routine

care, while talking to a colleague, or while reading a journal or textbook. A clinician who has a research attitude is rarely at a loss for an aspect of practice in which additional research is needed. One of the beauties of science is that it does not claim to identify final, absolute truths, but only testable hypotheses. From each experiment in which a new idea is tested, many new questions arise. Thus, the process of discovery is endless. A research attitude involves continuing to question what is believed to be true.

It is crucial to be able to identify and expose pseudoscience. When scientific methods are used for political or economic gain, the experiments are poorly designed and important information is often ignored or kept secret. However, even in honest research the way an experiment is designed and conducted can lead to false conclusions. When the experiment is designed to prove a particular point of view, the investigator's bias influences the outcome. However, though the investigator's bias is an important concern, it is not necessarily a fatal flaw. Recognizing and dealing with investigator bias is an important part of the research process. A mark of good research is presenting the research methods and experimental technique completely enough that someone else could reproduce the experiment and obtain their own results. It is only through repeated experimentation by different people that the value and truth of the findings are confirmed. The first component of research is a questioning attitude, and the second component is a willingness to share all of the details of the experiment and all the information the experiment yielded, so that other researchers can reproduce the experiment and possibly challenge your conclusions. A research project begins with a specific question.

Devising and Improving a Hypothesis

A formal statement of the research question is often called the *hypothesis*. The hypothesis should be stated in a way such that a "true" or "false" answer from an experiment would support or refute the hypothesis. The hypothesis focuses the experimental procedures and, more importantly, helps define the control group. Careful selection of a control group allows the most appropriate and powerful analysis, to determine the truth of the hypothesis and the value of the experiment. Consideration of the control group at the time of hypothesis development will make all of the steps in the research process easier and more powerful. *The most common problem in beginning a study is not defining the appropriate control group.* This article describes how to identify research questions and how to develop hypotheses in ways that make research, data analysis, abstract presentation, and publication easier.

An Example of Moving From a Broad Hypothesis to a Manageable Research Question

Anyone who has a research attitude encounters possible research questions daily. For example, say a department administrator faced with staff shortages decides to reorganize a respiratory care service, delegating some less important tasks to other departments. For example, the manager might hypothesize that clinicians other than respiratory therapists (eg, nurses) could titrate low-flow oxygen for patients who do not have artificial airways and are not in the intensive care unit. From that hypothesis several specific research questions arise: Would the overall use of oxygen increase (because of less aggressive weaning) or decrease (because fewer patients who needed oxygen would be getting it)? Would more patients suffer hyperoxia? Would more suffer hypoxemia? Would the department and hospital costs increase because more patients would stay in intensive care longer, or decrease because those patients could be transferred out of intensive care sooner? Would the incidence of respiratory arrest increase? Would the nurses' or respiratory therapists' job satisfaction change? Would the practice change affect the relationship of those 2 groups? Depending on your biases and beliefs, other questions could be raised related to this "natural experiment." The exploitation of these "natural experiments" I refer to as "opportunistic research." They are inexpensive to conduct, but they do require some advanced planning and time to collect data. Most importantly, they require an energized, motivated investigator or investigators who have research attitudes.

Developing the hypothesis is important for focusing the experiment. The hypothesis can be as complicated and broad as "Provision of respiratory care improves patient outcomes." That is an important hypothesis, the study of which may define the entire role of respiratory care in the clinical environment. Substantial time and money have been dedicated to investigating that question, and the truth or falsity of the hypothesis has huge implications. However, that hypothesis is not very helpful in developing a specific and manageable research question. Conversely, from the previous example hypothesis (that clinicians other than respiratory therapists could titrate low-flow oxygen for certain patients), it is fairly easy to devise several specific and manageable research questions.

Though most of us believe that weaning of low-flow oxygen is a task best carried out by knowledgeable respiratory therapists, can we obtain data that support that opinion? Our hypothesis could be, "Respiratory therapist are more efficient than nurses at weaning patients from low-flow oxygen." That hypothesis claims that there is a difference between 2 groups (nurses and respiratory therapists); a hypothesis that says, in essence, "this thing (or group) is different in this way from that thing (or group)"

FRAMING THE HYPOTHESIS

Table 1. Types of Studies and Types of Study Controls

Study Type	Control Type	Advantages, Disadvantages, and Comments
Randomized, prospective, blinded	Contemporaneous, matched patients Researchers are blinded (ie, do not know which patients are in the treatment or control group)	Minimizes the risk of bias Most difficult to conduct in clinical care
Randomized, prospective, unblinded	Contemporaneous, matched patients Researchers are not blinded	Higher bias risk (than randomized, prospective, blinded study) More common in clinical trials
Randomized groups with different treatments (blinded and unblinded)	Contemporaneous Researchers are not blinded	Easiest to conduct Subject to outside influences Cross-over of patients from one study arm to the other may improve validity
Prospective treatment, retrospective control	“Historical” control group (data taken from patient records) compared to treatment group (data collected prospectively)	Many influences must be accounted for Can’t be sure of the treatment effect
Retrospective	Many choices: best is matched controls (contemporaneous treatments) Not a controlled study	Often leads to a controlled study Identifies research questions Increases likelihood of next experiment’s success
Study of previously published reports by others	Various	First step in answering research question Helps determine what is already known and what more needs to be investigated

helps to define the control group, which in turn allows you to develop an experiment that will effectively test the hypothesis, and to determine the necessary research conditions. In this example the word “efficiency” needs to be defined. We might say, for example, that one aspect of efficiency is how long the patient remains on a higher oxygen flow. The specific research question about which we would collect data would be, “Do patients who initially have similar oxygen needs spend fewer days on a higher oxygen flow if receiving care from a respiratory therapist or from a nurse?”

Another aspect of efficiency is personnel costs and the cost of oxygen. We could investigate the relationship between type of caregiver and duration of stay following administration of low-flow oxygen. Both of those examples define an experiment. The data collected depend on how the experiment is developed. The best experiments randomize patients to receive one of several different treatments. This minimizes patient-distribution differences between the groups. If the studied groups are identical, then any differences are assumed to be due to the experimental intervention. Since a prospective randomized study is the most difficult type of clinical research, other methods are often used to prevent biasing the assignment of patients to one or other group.

Determining What Type of Controls to Use

In an experimental study the least desirable type of control group is a “historical” control group, meaning that the

control group is selected from medical records of patients treated before the study began. Whenever an intervention is made, any differences in outcome from past patients always raises the question of what really caused the change. Last year’s practice patterns may be significantly different than this year’s in many important yet unknown respects. The patient population may have changed, the caregivers have certainly changed, and unknown factors in respiratory care and the institution have also changed. If historical controls are used, great pains must be taken to identify any confounding issues that may account for the observed changes. Using a historical control group should be avoided if possible. This is one reason advance planning and hypothesis development are important first steps in opportunistic research experiments.

In our example experiment about oxygen titration, we would design the study to have 2 arms. Since it would be very difficult to randomize individual patients, the patients on different floors in one hospital could be treated differently. Concurrent treatment by respiratory therapists on one floor and nurses on another could be the experimental model. Differences between patient populations on the floors could be eliminated by a cross-over design. That is, after, say, 2 months, the floors would switch duties: the nurses would treat the patients on one floor for 2 months, then the respiratory therapists would treat the patients on that floor for 2 months, while on the other floor the opposite arrangement would be underway. Data analysis is more complicated with a cross-over design, and the effect of learning being transmitted

throughout the entire population of clinicians must be taken into account. However, the value of using concurrent control groups overrides those problems.

Table 1 describes the types of studies in relation to the types of control those studies use.

Deciding Exactly What Data to Collect

In our example oxygen-titration experiment, we have not yet determined exactly what data will be collected. The perspective and objective of the study determine which data are important. In our example experiment we might be interested in the attitudes of clinicians involved in the experiment, patient outcomes, financial outcomes, and/or departmental outcomes, and our decision of what data to collect and how to analyze it might be different for each of those subjects.

Opportunistic research is the most convenient for clinicians in active practice. Whenever a change in equipment, personnel, departmental organization, or institutional organization occurs, there are opportunities for opportunistic research. Careful preparation, hypothesis development, and identification of the control group can make opportunistic research extremely productive. Bench research, although not discussed in detail in this article, is a type of research in which respiratory therapists excel. Performance evalu-

ation of individual devices and comparative performance analyses of multiple devices are useful.

Novice Researchers Should Find and Use a Research Mentor

There are several important departmental resources that can help a research project succeed: a department director who is interested and has a research attitude, a director who wants to supply the personnel resources necessary to collect data, and a mentor who has experience with the research process. If a mentor is not available locally, one can often be located at another (perhaps geographically distant) institution. Though such a mentor would not be present for the conduct of the research, he or she can provide valuable insight and opinions about research methods, facilitate the writing of the abstract or report, and/or provide moral support.

Summary

A clinician who has a research attitude will see numerous research questions and opportunities. Proper hypothesis development will lead to a manageable research plan. With minimal support within the respiratory care department and direction from an experienced research mentor, even a beginning researcher can be successful.