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Practice-Based Clinical Inquiry *in* Nursing for DNP and PhD Research

Looking Beyond Traditional Methods

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CHAPTER TEN

A STATISTICAL TOOLBOX: TIPS FOR ENGAGING IN CLINICAL INQUIRY TO IMPROVE HEALTH AND HEALTH CARE

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OBJECTIVES

After reading this chapter, readers will be able to:

1. Identify statistical tools to address practice-based clinical problems and inquiry
2. Explain how the statistical tools can be implemented
3. Discuss why, when, and how to work with statisticians

Respect for rigor and integrity of data in clinical inquiry is paramount. Robust meaningful clinical inquiry necessitates a working knowledge of statistics and practical knowledge of the ins and outs of working with statisticians. Thus, the purpose of this chapter is to provide useful tips when using statistics and working with statisticians, as nurse scholars use data to generate and translate knowledge that aims at positively impacting patient care outcomes. Written by three faculty members, two nurse faculty members (M.M. & B.S.), and a statistician (L.F.), this chapter is divided into two key sections. In the first section, a statistical toolbox is presented to serve as a practical guide. In the second section, the statistician (L.F.) provides his unique perspective and advice on working with statisticians. As a faculty member in the Rush University College of Nursing spanning two decades, he has collaborated with many PhD and DNP nursing faculty and students and served as the statistician on more than 25 funded National Institutes of Health (NIH) grants.

This chapter is included in this book to serve as a reminder of the critically important role that data have in the field of clinical inquiry. Integrated into this chapter is somewhat of a storytelling approach. Discussing statistics can be quite a dry topic, but understanding the use of statistics in the context of clinical inquiry is much more interesting. Through the stories and examples of several clinical inquiry projects, the reader is provided with a toolbox for tackling his or her clinical inquiry data and working with statisticians.

THE STATISTICAL TOOLBOX

There are three tools in the statistical toolbox of this chapter. The first is conventional hypothesis testing, which is the "meat and potatoes" of most statistics courses. The second is the use of effect sizes and simple descriptive statistics to explain one's findings. And finally, the third tool is the use of graphic representations to help learn about the relationships that exist in the data. With these three tools, it is possible to do two things: (a) learn how to make more useful clinical decisions; and (b) communicate findings more effectively to other clinical decision makers.

It is also important to keep in mind that the research conducted is not a "one size fits all" sort of enterprise. Nurse scholars use research to generate, disseminate, and translate new knowledge that is relevant to clinical inquiry. A statistical toolbox is needed because of the need for different tools for conducting and disseminating different types of nursing research and evidence-based practice.

The Counting Marbles Story

We begin with a background story that the statistician author (L.F.) of this chapter narrates about counting marbles. When a graduate student at the University of Chicago in the 1980s, he took several statistics courses and a recurring analogy that these courses used to analyze *sampling* and *probability* was the urns of marbles situation. The idea behind the urns of marbles is that you have two stone urns on a table, and you know that there are 70 red marbles and 30 green marbles in one urn, and 70 green marbles and 30 red marbles in the other urn. The problem is to draw samples of marbles from each of the two urns, and from these drawn samples of marbles, to determine the probability that urn one has the 70 reds or 70 greens. The idea behind the exercise is that if one is drawing a sample of marbles from the 70 red urn, one is more likely to have more red marbles in one's sample. And the primary characteristic that these urns have is that marbles are independently distributed (the choice of one marble at random does not influence the selection of the next) and identically distributed (each marble has an equal chance of being selected). Or as statisticians like to call it, i. i. d. (independently and identically distributed). When these assumptions are met, conclusions about the marbles in the urn would apply equally well to the entire universe of marble-filled urns.

He soon discovered, however, that one cannot be a graduate student forever, and he was forced to go out and obtain gainful employment while conducting statistical analyses for a psychiatric research project. The project examined psychiatric patients in various and sundry stages of recovery from their illnesses. These were very ill patients who had been unresponsive to more conventional treatment settings, and so they were sent to this research laboratory in the hopes that they could find a more effective experimental treatment for themselves.

So, on his first day of work, he sat down to look at the data that needed to be analyzed. But, to his great surprise, there were no marbles. How could this be? He had just obtained an excellent education on the analysis of urns of marbles, only to find out that he was not studying marbles at all! He was forced to actually analyze data about people. But people are nothing like marbles.

To make matters worse, the data were not i.i.d.! The observations were not independent. In fact, the subjects all had to have a mental illness, live in Illinois, and be treatment resistant. It was a big, complex mess. Not knowing how he was supposed to analyze data such as these is essentially one of the reasons he suggested writing this chapter for this book. Conducting nursing research is not only more complicated but also, in some ways, simpler than trying to characterize the number of different-colored marbles that are stored in an urn. Through evidence-based practice, nurses are trying to make clinical decisions for patients to maximize their well-being. Florence Nightingale, the first nurse researcher and statistician, made observations of soldiers returning from the Crimean War and reduced mortality rates from 43% (urn 1) to 2% (urn 2) by improving hygiene and environmental conditions (Palmer, 1977). This is, essentially, assuming that people are pretty much like marbles.

First Statistical Tool: Hypothesis Testing

The hypothetico-deductive model (Neyman & Pearson, 1992) underlies much of statistics in order to try to deduce what is true and what is not. The manner in which this is applied is that an assumption, called the *null hypothesis*, is made. The null hypothesis is the hypothesis that two populations of interest are not different from each other. So, for the urn example given earlier, the null hypothesis might be that there is the same proportion of red marbles in each of the two urns. It should be noted here that no statements are made to hypothesize how many red marbles are in each urn, but only that the proportion of red marbles (in our two-color marble universe—red/green) is the same.

To test this hypothesis, marbles are taken out of each urn. The drawn marbles are the *sample*. If the urns contain a very large number of marbles, a large sample can be drawn to get a better estimate of the proportion of red marbles in the urn. A parallel sample can be drawn from the other urn as well. Then, the magic of hypothesis testing is testing the null hypothesis that the two urns have the same proportion of red marbles. This is done by estimating the probability that the first sample (let us say there were 80 reds and 20 greens) is taken from an identically distributed urn as the second one (let us say there were 20 reds and 80 greens). This example represents a 2 × 2 contingency table that looks something like this (Table 10.1).

A chi-square test can be conducted to estimate the probability that the null hypothesis is true (proportion of red marbles in urn 1 equals the proportion of red marbles in urn 2). In this case, this probability is quite small ($p < .001$), and it uses a criterion probability of .05 to reject the null hypothesis that the two urns have equal proportions of red marbles. Furthermore, assuming red marbles are valued over green, urn 1 is preferred. If the marbles are relabeled as patients who recover (red marbles) and those who do not (green marbles) and the urns are relabeled as possible treatments for these patients, this pretty much describes how the hypothetico-deductive model is used in health care research.

There are a number of excellent books written about statistical analyses using the hypothetico-deductive theory. Fisher (1935/1971) wrote an excellent book on

TABLE 10.1 A 2 × 2 Contingency Table

Urns	1	2
Red marbles	80	20
Green marbles	20	80

all of this, and more recently, Snedecor and Cochrane (1989) also wrote an excellent textbook in this area. Finally, if you want to combine an education on the hypothetico-deductive theory with training on how to conduct statistical analysis in Excel, Schmuller (2013) wrote an excellent text called *Statistical Analysis With Excel for Dummies*.

So, how do the urns and marbles work in the real world of nursing practice? One way to illustrate this is by providing examples of clinical inquiry. So, essentially, instead of just talking about statistics, they are described in the larger context of studies that evolved from clinical practice and clinical inquiry. Each of the following four examples highlight how nurse scholars identified a problem, developed a project, and applied methodology and statistical tools to change practice and improve patient outcomes. Elements of these processes are outlined in Table 10.2.

Example 1: Clinical Inquiry About Taking Care of Older Adults

Identifying the Problem

The proportion of adults 65 years or older in the United States is rapidly growing and expected to reach 72 million during the next two decades (Centers for Disease Control and Prevention [CDC], 2013). As many as a third of these older adults experience hospitalizations that can pose consequences to functional well-being (Stranges & Friedman, 2009). Nurses are in a key position to evaluate system processes to improve patient outcomes. For example, it has been found that nursing staff are not always educated in geriatric patient needs and care, especially certified nursing assistants who have minimal training in special populations (Gilje, Lacey, & Moore, 2007). Therefore, this study was designed to examine the effects of a geriatric education for staff nurses and certified nursing assistants in conjunction with changes in daily staff practices to increase older patient mobility (Lee, Staffileno, & Fogg, 2013).

Methods to Address the Problem

A pre/post single-group study design was selected to address the research question and measure outcomes. Although a comparison or control group would have strengthened the design of the study, the nurse scholar determined that no other unit served a similar geriatric population; therefore, it was not feasible to employ a control group (unit within the hospital) for comparison. Instead, the single-group approach was possible by comparing discharge rate and hospital complications from the previous year to evaluate the effectiveness of the intervention. The intervention included staff education on geriatric care and infrastructural change to encourage patient mobility and function. Standard measures were used for evaluating outcomes of the intervention. For example, discharge destination and length of stay (LOS) were measured using the hospital's clinical data system for patient information. Prevalence of nosocomial pressure ulcer and fall rates were obtained from the unit's existing quality outcome measures. These outcome measures were compared from data with the same period in the previous year. Functional status was measured using the Katz activities of daily living (ADL) Index, which has established reliability and validity (Katz, Down, Cash, & Grotz, 1970). Upon hospital admissions, patients were queried about their ADL over the 2-week period just prior to admission, thus serving as a baseline assessment. Patients were again queried about ADL at the time of discharge to assess for functional status change during hospitalization.

TABLE 10.2 Developing a Practice-Based Clinical Inquiry Project

What	How	Why
Identify a problem	• Clinical experience • The literature • Previous research • National initiatives • Organizational priorities • Quality and safety data	• Have a strong interest in the problem • What is already known about this problem? • Will the outcome improve quality of patient care and outcomes? • Will the findings be applicable in clinical practice?
Identify a project team	• Establish what expertise is needed to develop and execute the project • Network with key stakeholders • Determine who is the most impacted by the problem	• Who will best serve as the leader of the project? • How many people will be involved in developing and managing the project?
Develop a project question	• Review the literature • Review pertinent data • Assess clinical relevance	• Compose an argument—what is the problem? • Who is the population of interest? • Why is the problem important? (Who are the key stakeholders?) • What will happen if you fix the problem? • What will happen if the problem is not fixed?
Develop a methodology to address the problem	• Establish how to implement the project ▪ Identify the population ▪ Identify a site/location ▪ Develop a protocol and procedures ▪ Identify instruments for data collection ▪ Identify necessary tools, instruments, and measures • Establish how to evaluate the project ▪ Create a plan for data management and analysis	• Having a clear method to address the problem is needed to determine a change • Having a mechanism for project evaluation is needed to establish sustainability
Use the statistical toolbox	• Look at your data • Describe your data using simple descriptive statistics • Test statistical hypotheses	• To examine the nature of relationships and determine if your intervention works at all • To convince your reader that your treatment or intervention actually works • To convince your reader that your results are not due to random fluctuations
Discuss and disseminate findings	• Compose a description of project findings • Present findings to key stakeholders and relevant venues • Identify next steps • Publish findings	• How does the project impact patient outcomes and extend existing knowledge? • Identify lessons learned

Consultation with a statistician was done to determine a sample size with adequate power to detect an increase in the percentage of patients returning home from hospitalization. Determination of sample size is typically a point that most clinicians will want to consult a statistician or an experienced researcher about. Another troublesome area for many is determining which statistics should be used given the type of data collected. In this case, demographic characteristics (age, gender, race, marital) were tabulated using descriptive statistics (means and standard deviations) or frequency distributions (percentages). With respect to data analysis, changes in outcomes with normally distributed mean scores, such as LOS, were compared using a paired *t*-test. Other outcomes involving changes using percentages or categorical data required the use of nonparametric testing. Therefore, change in ADL, rate of patients returning home, and the number of nosocomial pressure ulcers and fall rates were tested using chi-square analysis.

Pearls From the Toolbox

This is a wonderful example of how practicing nurse scholars can use nursing research to develop a new program to improve the health of patients. In addition, the hypothesis-testing tool was critical to demonstrate that the effect was robust, and it allows dissemination of this through a scholarly publication. In this case, a chi-square test demonstrated that the decrease in pressure ulcers (from 10.7% to 5.9%) was a statistically significant improvement, just as our two urns differed in the proportion of red marbles. (Yes—back to the counting marbles story!)

Lessons Learned From This Project

This study served as pilot work for subsequent inquiry that would involve implementing a research design with a control (or comparison) unit and randomization of patients. This preliminary work demonstrated that providing staff education and altering infrastructure support the transfer of knowledge to practice. Hence, promoting mobility and function improves outcomes for hospitalized older adults.

Second Statistical Tool: Effect Sizes and Simple Descriptive Statistics

The importance of finding an effect with a simple chi-square analysis is underscored here. Many statisticians will say that if you cannot find an effect with a chi-square test, it probably is not there. If the effect is that hard to find, it may not be worth much in the first place because the amount of benefit that a person will receive from the intervention is so negligible that it does not merit much time and energy. This point of view has led some researchers to begin reporting effect sizes, rather than probability statements. But what are effect sizes? One should read the Florence Nightingale story to fully understand how effect sizes matter when practice changes are needed (Box 10.1).

Example 2: Safe Patient Handling

Identifying the Problem

An advanced practice nurse (APN) determined that assessing staff perceptions of barriers and attitudes toward safe patient handling was paramount prior to introducing new lift equipment (Krill, Staffileno, & Raven, 2012). The APN wanted staff

BOX 10.1 The Florence Nightingale Example of How Effect Sizes Matter

Effect sizes are the simplest sorts of statistical estimates. A fine example of how effect sizes are used is found in the work of Florence Nightingale (Palmer, 1977) that was discussed earlier. Nightingale was serving with the British military in the Crimea in the mid-1800s. During this stay, she saw that the hospitals where the soldiers were treated were not very clean. The water the patients drank was not pure, and the staff did not always keep themselves and their patients clean. Nightingale instituted a program for more hygienic conditions in these hospitals, but just as importantly, she recorded the mortality rates in the hospitals both before and after she implemented her changes.

The mortality rate dropped from 43% to 2% after the hygienic practices were introduced. She did not calculate a probability value or use any other statistics other than the ones just cited. And still, her findings were so striking that her practices were followed from that time on in British military hospitals. The difference between the two mortality rates was so large that the effect was convincing without having to conduct any other statistical analyses.

The same thing is happening currently with nursing research. The hallmark of nursing research and nursing practice, in statistical terms, is that nursing research fosters interventions that have very large effect sizes. This is because nursing research begins at the point-of-patient care, and it is always primarily concerned with patient welfare. "Research is asking the right question—a question in clinical practice that will improve the care of patients" (Christman, 1965). The interventions that are geared to improve the care of patients are the ones that have the largest effect sizes.

So, there are times when the numbers speak for themselves and are convincing without having to tie a probability value or a confidence interval to themselves. For a more technical and detailed look at various effect sizes, the reader is encouraged to look at Cohen's (1988) excellent book on the subject, *Statistical Power Analysis for the Behavioral Sciences*.

to determine what handling equipment and education was needed to successfully develop a safe patient handling program.

Methods to Address the Problem

The APN proposed a descriptive study to assess staff perceptions, identify staff needs, and involve staff in selecting equipment for safe patient handling. The APN identified two widely used national survey instruments that would assess the following: (a) staff's perceived barriers and attitudes regarding safe patient handling (Silverstein & Howard, 2006); and (b) staff's needs for equipment and education (Safe Patient Handling Risk Assessment Tool Swedish Medical Center, 2007). To reach as many as possible, it was decided to administer the surveys by using an online platform. The two surveys combined consisted of 31 questions, used a Likert scale and open-ended questions, took about 15 minutes to complete, and were available for a 1-month period to accommodate staff who were taking summer vacation. Staff also participated in a 1-hour focus group. A focus group is a form of qualitative research that encourages people to express their perceptions, opinions, beliefs, and attitudes toward a particular topic. Finally, a 1-day fair was held to evaluate a variety of lift equipment from five vendors. After an equipment trial, staff were queried as to the comfort, ease of use, versatility, stability, ease of cleaning, and willingness to use the product. Descriptive statistics were used to describe sample characteristics, the narrative themes that the participants discussed in the focus groups, and the survey data from testing the equipment. In this manner, the optimal equipment was selected.

Pearls From the Toolbox
This is a marvelous use of descriptive statistics and how they can be utilized to facilitate effective nursing practice and contribute to the efficient use of resources.

Lessons Learned From the Project
This study illustrates the use of both survey data and focus group data to tap into the professional expertise of the entire staff of the institution.

Third Statistical Tool: Graphic Representations of Data

Looking at your data through graphic representations of the data can be powerful. Often, there are certain types of relationships that are easier to see as pictures than they are to estimate as statistics (Tukey, 1977). Pictures of the data can be very helpful in answering important questions in nursing research and clinical practice. Reviewing all the possible graphic ways to illustrate data is beyond the scope of this chapter, but an example using a dose–response curve will be given (DeLean et al., 1978).

The dose–response curve is explained here through an example of showing the dose of a medication that is optimal for a patient to receive. The curve is formed by two competing mechanisms: The effectiveness of the medication in reducing symptoms or treating an illness and the toxicity of the medication when given in doses that are too high. So, as the dose of the medication is increased from zero, the patient benefits from the therapeutic effects. And as long as the therapeutic benefits

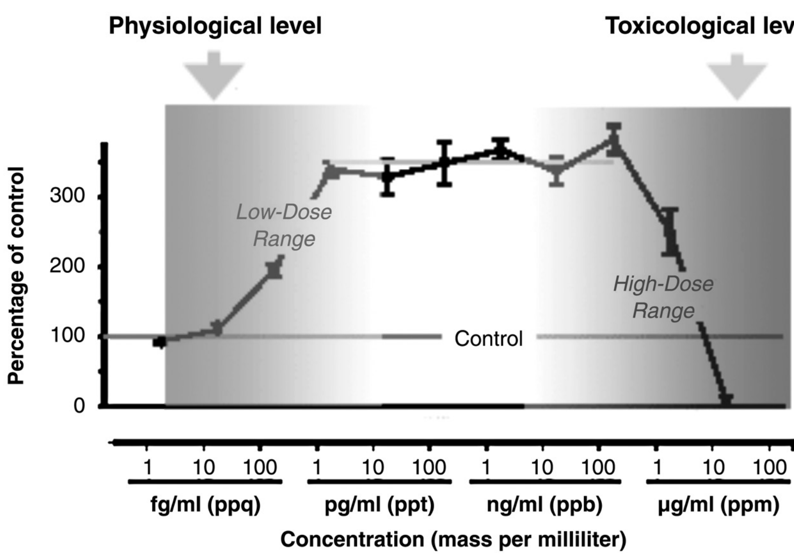

Figure 10.1 Dose–response curve.

outweigh the toxicity of the medication, the dose can be increased. At some dose, the benefits begin to wane and the toxicity increases, at which point any higher doses will not be useful for the patient (Figure 10.1). The critical characteristics of dose–response curves are that they are quite common in health care research, and that the correlation between dose and benefit will be zero. Thus, as long as researchers restrict their examination of the relationships between their measures to the correlation coefficient, they will never be able to detect a dose–response relationship (Meehl, 1978). So, there is enormous power in looking at your data.

Example 3. Clinical Inquiry About Taking Newborn Temperatures

Identifying the Problem

Newborns undergo profound physiologic changes at the moment of birth. Thermoregulation is an important first step for the newborn infant to adjust to extrauterine life. The World Health Organization (WHO, 1997) views thermoregulation as an essential component of caring for the newborn infant. Nurses caring for neonates are responsible for monitoring newborn temperatures and providing care that decreases heat loss and prevents overheating. Common practice involves taking rectal temperatures on full-term newborns, even though risks are associated with this practice, including perforation of the gastrointestinal tract (Fonkalsrud & Clatworthy, 1965).

The evidence behind this practice was questioned, and a literature review and query of similar institutions was conducted. Many institutions were using axillary temperature measurements, whereas others were still using the rectal method, suggesting inconsistencies in practice. The safest and most effective practice of obtaining a temperature in newborn infants continues to be controversial (Friedrichs et al., 2013). Thus, the question remains unanswered. Is the evidence for using rectal temperature in full-term infants strong enough to continue with this practice?

Methods to Address the Problem

The team designed an agreement study to determine the reliability of the electronic thermometer measuring temperature in the axilla compared with the rectum in full-term newborn infants. The specific research questions included the following: (a) Do axillary temperatures agree with rectal temperatures, allowing axillary temperatures to be considered the preferred alternative to rectal temperatures? (b) Is there a preference in one axilla over the other based on the levels of agreement? A study protocol was developed and within the first hour of arriving to the newborn nursery, right and left axillary temperatures were obtained first, followed by the rectal temperature.

Demographic characteristics were reported using descriptive statistics (means and standard deviations). To examine the relationship between rectal and axillary temperatures, regression analyses were conducted. To assess the agreement between rectal and axillary temperatures, a graphical representation of the temperature data was analyzed using a Bland–Altman approach (Altman & Bland, 1983; Bland & Altman, 2007). The Bland–Altman approach looks at how closely scores agree and then examines clinical/demographic factors to see if any of them might have influenced the amount of disagreement that was found. The amount of disagreement is found by examining a scatterplot, where the distance between the points (each point represents a matched pair of observations) is the distance between the point and the equivalue line (Figure 10.2).

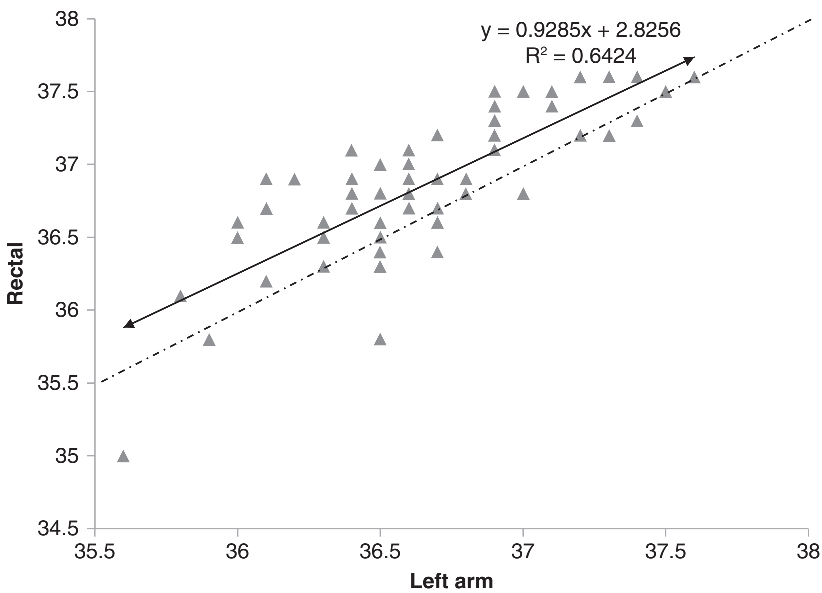

Figure 10.2 Bland–Altman analysis.

Pearls From the Toolbox

This study is an excellent illustration of the use of graphical representation of data to help explain relationships that may exist in the data. In this case, the Bland–Altman analysis (Altman & Bland, 1983) showed that both axilla could serve as sites for obtaining temperature data without loss of validity. In addition, this is also an excellent example of the use of a purposive sample. This study only works with newborns and so one is required to only choose participants from a select group, rather than from the general population. The comparison of rectal and axillary temperatures would not make sense in an adult sample.

Lessons Learned From This Project

Importantly, the clinicians challenged the status quo and searched for evidence supporting the clinical practice of rectal temperature taking in full-term newborns. The three basic tenets of evidence-based practice (research, clinical expertise, and patient preference) were used to investigate and draw conclusions for practice change. Results demonstrated that using the left axillary temperature measurements in full-term newborns was a safe alternative to rectal temperatures. This example reinforces the value of questioning current clinical practice by presenting evidence that may or may not support current practice.

The Statistical Toolbox

In most statistics courses, students only learn about the first tool (hypothesis testing) in the statistical toolbox. But for clinical inquiry research, it is important to use all three of the tools (Table 10.2). So, a quick and dirty guide to conducting statistical analysis is to use the tools in the following order. First, you should look at your data. If the data are nonlinear or have a funny distribution, this can make the statistics you calculate, even simple descriptive ones, completely useless. Again, you should think of the dose–response relationship.

Second, you should look at simple descriptive statistics. Remember how Florence Nightingale approached her data. She presented simple statistics that told her story. And finally, if there is clear evidence that you have an effect, but you want to present more compelling evidence to that effect, you should use hypothesis testing procedures to convince readers, or the audience, that your findings are real, as opposed to random findings.

One big advantage to this three-step process is that very often, our interventions or treatments just do not work. When this happens, it is usually easier to see this with a picture than it is to try to discover it from looking at summary statistics. There is much to be gained from learning what does not work, not the least of which is that it may, eventually, lead us to discover what does work.

Example 4: Using the Whole Toolbox

Cardiovascular disease (CVD) is the leading cause of death and disability in the United States with a disproportionate burden on racial/ethnic and underserved populations (Go et al., 2013). Moreover, CVD is the leading cause of death for older adults and the death rate attributable to CVD is greater for African Americans compared with Caucasians (Go et al., 2013). Sheltered homeless people constitute another vulnerable population that experiences significant health disparities (National Alliance to End Homelessness, 2013). This is particularly significant for clinicians working in such communities. The Heart Healthy Program (HHP) is an example of an APN-led initiative in such an underserved community setting. This example was the development and implementation of a HHP to improve the cardiovascular health of two underserved populations using the American Heart Association's Life Simple 7/My Life Check (MLC) tool (Murphy, Coke, Staffileno, Robinson & Tillotson, 2015).

Methods to Address the Problem

Two inner city community sites were targeted for this program. One was a senior center servicing African American older adults, and the other was a residential facility for women with histories of substance abuse and homelessness. The determination of a tool to measure cardiovascular health was the first step in identifying important data to collect. Once that was established, a protocol was developed for data collection and analysis.

The American Heart Association's Life Simple 7/MLC tool was identified as the measurement tool. The MLC tool provides a measure of overall cardiovascular health with a total score ranging from 0 to 10 based on four behavioral factors (maintaining a healthy weight, assessment of eating patterns, physical activity patterns, and smoking status) and three biomarker levels (blood pressure, blood cholesterol, and blood glucose). The MLC is a computer-based tool with an algorithm that calculates a weighted score using points based on multivariate associations with cardiovascular health (Murphy et al., 2015). Preprogram health data were collected to calculate the MLC scores.

All three statistical tools were used to describe the population and evaluate the outcomes of the HHP. Descriptive statistics (means and standard deviations) were used to describe the demographic characteristics (age, gender, and race). The mean MLC score was calculated both before and after the program was implemented to conduct hypothesis testing to determine if the program improved health. Then, the effect size of the changes was calculated based on the mean scores to evaluate whether cardiovascular health improved as a result of the program. Specific data on each health factor were displayed in a table along with a chart that graphically displayed the percentage change in the mean aggregate MLC scores for each population's overall change in cardiovascular health. All this can be found in Murphy et al.'s (2015) referenced publication.

Pearls From the Statistical Toolbox

This aforementioned example is a good example of the use of all three of our statistical tools. Hypothesis testing was used to determine if there was significant improvement among the participants from pre- to post-intervention, descriptive statistics were used to characterize the participants in this project, and charts were used to visually describe the improvement in cardiovascular health. Not all translational research projects use all three of our tools, but in the previous example they were used very effectively.

Lessons Learned From This Project

Program evaluation plan is an essential step in planning and implementing an evidence-based program to improve cardiovascular health. In this example, the first step was the determination of a tool to measure cardiovascular health. Using an established tool that was developed by the American Heart Association was useful in that the tool had been applied to multiple epidemiological data sets. Pre- and post-program data collected were used to calculate the MLC score. Descriptive statistics, specifically percentage change, were useful to determine the effectiveness of the program. The benefits of the HHP were seen in the older adults who exhibited a 37.1% improvement in their MLC score. A similar benefit was not observed in the women at the residential shelter who experienced a 10.2% decrease in their MLC score. This may be due to a constellation of social, environmental, and mental health factors that are not yet fully understood (Murphy et al., 2015).

The Statistician: The Story of How This Statistician Got to Become a Faculty Member in an Academic Nursing Unit

This section of the chapter ends with the story of how the statistician (L.F.) coauthoring this chapter became a full-time faculty member in nursing. He first started working at the Rush University College of Nursing, because he needed employment. The college needed a part-time statistician to run numbers and help with research, and he needed someone to pay half of his salary.

Through Luther Christman, who was the dean at the college at that point, he was expertly tutored on the intricacies of nursing research. Since nursing research is much more complicated than this, he states his view of three key principles that underlie nursing research. The first principle is that the goal of nursing research is getting the patient better, or making his or her life better. Nursing theory guides research with a holistic paradigm focused on optimizing wellness.

The second principle is that nursing interventions tend to be relatively simple and effective. Thus, they tend to be very cost effective. So, for example, it is simpler to help patients develop positive health behaviors to avoid disease than it is to treat most diseases once they are contracted. One big advantage of this principle is that it should make nursing research more useful to fund.

The third principle is that nursing research embraces both specialization of nursing knowledge and collaboration with researchers from a wide range of non-nursing fields. This is also consistent with Christman's (1965) view of nursing specialization as the path to expansion of knowledge in nursing. The ability of nurses to work with scholars from many different fields is one mechanism for advancing the breadth and depth of nursing knowledge.

This conceptualization of nursing research was what "hooked" this statistician (L.F.) on to the importance of conducting nursing research. This is the way the research was meant to be conducted. Intra-professional PhD–DNP (Doctor of Nursing Practice) research is very important as nursing goes forward in this century. Opportunities to make a difference through clinical inquiry are exciting. Data are plentiful; thus, using rigor in analysis is paramount, which often demands statistical services from a trained statistician. Tips on working with statisticians are described next.

WORKING WITH STATISTICIANS: WHAT NURSE SCHOLARS NEED TO KNOW

Working with statisticians, either as consultants or as collaborating researchers, can be a daunting experience. Statisticians seem to speak their own special language (e.g., *heteroscedasticity)* and very often do not seem to speak the language of nurse scholars very well. These issues can be quite frustrating when collaborating to conduct a research project. So, the purpose of this section is to present some guidelines to help a nurse scholar determine (a) if he or she needs the help of a statistician at all and (b) how to select the right statistician to work with. The good thing about putting a little work into this process at the start is that one can generally return to the same statistician for future projects. The time invested in the initial selection process can be time well spent.

Why write about this? There is actually quite a bit of literature on the role of statistical consultants in a number of social contexts (e.g., Bancroft, 1971; Boen & Zahn, 1982; Kimball, 1957; Kirk, 1991; Zabell, 2013); however, the interesting thing about the literature is that all of it was written by statisticians and directed to other statisticians. Although there is no problem with statisticians honing their communication skills, they do not have as difficult a task in selling themselves as consultants as the substantive scholar (e.g., doctorally prepared nurse) has in figuring out which statistician will be helpful. So with all due respect to my statistical colleagues and to their efforts to become a little more user friendly, it is dubious that becoming a user-friendly statistician is anywhere near as scary as being the user that the statistician is trying to befriend. And this, in a nutshell, is the purpose of this section—to introduce the innocent user to some of the perils and joys of working with a statistical expert.

When Is a Statistician Needed?

There are a couple of times when a statistician may not be needed. When primarily collecting narrative or qualitative data, a statistician either may not be needed at all or may only be needed for a very brief meeting or phone call. Generally, the statistics in narrative studies are fairly straightforward. The exceptions are mixed methods and narrative analyses where a scholar wants to examine inter-rater agreement. Many narrative analyses can be conducted without the benefit of a statistician.

The second type of study that may not require the aid of a statistician is one where the nurse scholar can conduct his or her own analyses. Amos Tversky is an example of a scholar who conducted his studies without a statistician. Tversky was a widely respected scholar whose papers were usually made up of two-by-two contingency tables that did not even present probability values with them (Twersky & Kahneman, 1981). He simply presented the frequencies and let the reader draw his or her own conclusions.

Tversky was a very eminent scholar. (For the rest of us, who are a bit less eminent, editors often want to see those probability statements. For us, it is often possible to conduct our own analysis.) There are often three ways to figure out how to conduct one's own analyses. The first is to find other published articles that are doing pretty much what you are doing, and seeing what statistical tests those authors use. Very often, nurse scholars already know how to run simple analyses. However, if it turns out that other articles are using complex or sophisticated models, this is a good indication that you might need to speak to a statistical expert.

The second method of learning about statistical modeling is to use the Internet. Although this should not be the sole source of statistical information, Wikipedia, for instance, is an excellent source of information on explaining simple statistical models in terms that may be understandable before delving deeper. Readers need to be aware that Wikipedia may not have correct information on complex or sophisticated models. But the Internet is a good place to start to learn about statistical modeling.

The third and final method of learning about statistical modeling is using a statistics textbook. Many statistical textbooks have been published over the years, but a recommended one for the non-statistician is written by Schmuller (2013) and is titled *Statistical Analysis With Excel for Dummies*. This little book has several virtues. For one, it is relatively inexpensive. For another, the author is an excellent writer and statistician. The book has simple examples of how to conduct simple statistical analyses using Excel. Because Excel is a commonly available computer program, it is a practical software application for many nurse scholars to use for data entry. The book also presents discussions of the many concepts that are central to statistical modeling (e.g., the normal distribution).

So, now that we discussed when we don't need a statistician, when do we actually need a statistician? Often, the first time one may speak to a statistician is when data are collected, but one cannot figure out how to analyze them in order to make some sense of the data. This was actually this author's (L.F.) journey to becoming a statistician (Box 10.2)

Another example when scholars often use a statistician is when writing or revising an article. Very often, editors or reviewers will recommend that you use a specific type of analysis, which may not be familiar, or specifically advise consultation with a statistician. In either case, it can be very helpful to speak with a statistician about these issues. Now, very often, statistical students can be helpful in collaborating on articles. Depending on the complexity of the study and data collected, it may be best to speak with a statistician who has a degree in statistics (either a master's or a doctorate).

Consulting with a statistician is needed when applying for a research grant, especially a federally funded grant. Many funding agencies want to see a statistician on these grants. In addition, it is usually best to get a statistician who has a

BOX 10.2 This Statistician's Story of His Journey to His PhD in Statistics

When I was working on a master's degree, I became interested in assaults that occurred in prisons. I was able to collect a substantial amount of data on assaults by extracting information from the incident reports that one prison produced to describe these assaults. The database included location, severity, time, and actors involved with each assault. Unfortunately, after collecting these data, I did not know how to analyze them.

I ended up visiting a senior statistician. He took a look at my data and said, "You know, if you want to keep analyzing data like this, you should probably get a doctorate in statistics." And I did exactly that. So, when you do not know what to do with your data, ask a statistician. It can help.

doctorate, a history of working on federal grants, and a history of publishing research in the substantive area with which the grant is concerned. In general, grant writing is the area where it is the most imperative to develop a relationship with a senior statistician.

What to Look for When Choosing a Statistician

There are two key elements to look for when seeking a statistician—competence and understandability. A competent statistician is needed to conduct the required analyses. Understandability is needed with the statistician so that he or she conducts an analysis that actually answers the question that you want answered. The tricky bit is finding these two qualities in the same individual. This is not always an easy task.

Let us consider whether there is a licensure of the certification process for ensuring competence. Well, at present there is not. The American Statistical Association (ASA) has, on occasion, put forth the idea of licensing statisticians, but it has never come to pass. Part of the problem is that statistics has become an increasingly complex field of study. The advent of the microcomputer and the Internet has caused an enormous proliferation of different statistical models that are used to assess everything from physical activity levels related to electronic monitors to the genetic diversity of the human microbiome.

So, if there are no licenses or certificates, how does one know how competent a statistician is? The first piece of information to look at is the statistician's curriculum vitae (CV) or résumé. In this document, there are three things that you can look at: education, publications, and grants. Of these, education is probably the most important. Statisticians coming out of top flight programs are probably going to be a little more skilled than those coming out of lower ranked programs. This is not a foolproof criterion, so you should look at the whole scholar before hitching your fortunes to someone.

The other excellent way to find a competent statistician is through referrals from colleagues. This method is a bit more dicey than looking at a résumé or CV. The problem with referrals is similar to finding a clinical expert. Are patients good judges of good clinicians? Not always. The problem is similar with statisticians. A colleague can think that a statistician is wonderful, but only because he or she does not understand the clinician's flaws. But referrals are quite useful nonetheless. They are good for assessing competence, but they are even better for assessing understandability.

To elaborate on understandability, it is ideal to always work with statisticians who communicate clearly. This is vitally important for answering the most important questions. Generally, you should consider statistical hypotheses as the blueprints for any analysis. But it is no trivial matter to ensure that the statistical hypotheses that are tested are the ones that will answer the most important questions.

Improved understandability is one reason for trying to maintain a stable relationship with the same statistician over time. In general, the statistician will learn more about your research over time, and will, as a result, be better able to address the questions of interest. Again, the areas of inquiry that use statistical modeling have proliferated to such an extent that just being able to keep current of these fields can be quite time consuming. So, the ideal statistician is one with whom one maintains a long-term collaboration.

The other issue with understandability is that many statisticians go into mathematical modeling, because they may be more comfortable with numbers than they are with prose. One suggestion is that it is often helpful to try to communicate with the statistician both verbally and in writing. Very often, they do better in one medium than the other.

Part of the problem is the way that statisticians are trained. One paradigm for training statisticians is using the “urns full of colored marbles” analogy. Learning statistics with examples involving pulling samples of marbles from an urn in order to infer the nature of the population of marbles that are found in that urn could be problematic when humans rather than marbles are being studied in health research. Sometimes, it may take a while to get over marble training and to adapt to the study of human beings.

When Do You Need to Call a Statistician?

In general, you should call in the statistician as early as possible. Statistical data analysis is much easier to conduct when you know what data you will need, and the format that makes it easy to analyze. The problem here is that you can start out working on a project thinking that you will not need a statistician, and then discover later on that you do need one. One of the big advantages of developing a long-term relationship with a statistician is that often you can just call him or her, explain what you are doing, and have the statistician decide if you would benefit from some early advice. And how available this type of advice is to come by is a function of how easy it is to speak with a statistician.

How Much Should a Statistician’s Time Cost?

Statisticians work either as salaried employees of an organization or as independent consultants. Organizations often hire statisticians; in this case, their cost may not be apparent, at least until they are requested to be on a grant. The difficulty that salaried statisticians have is that often colleagues imagine that their time is free, and thus can make use of it any way they like. This is actually not the case: Statisticians are not free. And when organizations do not limit access to them, they can develop overwhelming workloads that make their professional lives unpleasant.

The misuse of the statistician’s time is pretty common. This author (L.F.), while still a graduate student, took a job doing statistical analyses in a medical research lab.

The director of the lab found out that L.F. actually enjoyed performing statistical analyses, and he started sending him requests for statistical analyses, all of which were handwritten on sheets of yellow legal paper. The faster L.F. performed the analyses, the more yellow-sheeted requests he received, until, finally, he had an inbox on his desk with several inches of these requests piled up there, very few of which were ever to be conducted.

Statistical analysis and modeling is a resource that you do not want to abuse. This is the other reason why we like to recommend that nurse scholars at least consider conducting their own analyses where possible. It makes for a more efficient use of the statistician's time when you really do need it.

But for the sake of clarity, the ASA (2014) reports salaries for academic statisticians. For the 2013 to 2014 survey, the salary for an assistant professor was around $83,000 for a 9-month contract and about $110,000 for a 12-month contract. These salaries rise to $92,000 and $127,000 for an associate professor and $110,000 and $147,000 for a full professor. This translates to a base salary of about $55 per hour for an academic salaried statistician.

If seeking a statistical consultant, the fees vary widely. Almost all ethical statisticians should provide a cost estimate up front. And although fees vary widely, in general, you should expect to pay at least $100 per hour for a PhD statistician, with fees ranging upward from there. Highly sought after consultants can charge as much as $500 per hour for their time, with many charging more. In general, a master's-level statistician will charge at least $75 per hour and statistical consultants without advanced degrees start out at about $50 per hour. If money is an issue, most statistical consultants will use a sliding scale for researchers with limited resources, and many will perform pro bono work if the research represents a societal good. Most either help students pro bono or for very small amounts of money, and many work for charitable and nonprofit organizations for reduced fees.

How Much Expertise Is Needed From the Statistician?

As discussed earlier, there are three levels of a statistician: PhD statisticians, master's statisticians, and statisticians without an advanced degree in statistics. The relative costs of each are quite different, and so it probably behooves one to use just as much expertise as is needed and not pay for more expert assistance than needed.

PhD statisticians have years of training and can work either in academia or in industry. Ideally, they have a deep understanding of a few areas of statistics and an ability to work in a much broader variety of areas of statistics. One good example of an area where a PhD statistician can prove useful is in the analysis of social networks. Social network analysis (SNA) involves analysis of how interconnected social networks are, as well as how engaged in the network each person is. Generally, if the nurse scholar is interested in examining the impact of social networks on a person's health, a PhD statistician would be needed to figure out how to conduct these sorts of analyses. The other area where a PhD statistician is needed is in the arena of submitting grants, and sometimes in the submitting of papers.

Master's statisticians are not quite as well trained as PhD statisticians, but they are very skilled. The past 20 years have seen a proliferation of programs designed to provide students with master's-level training in statistics. These statisticians generally receive advanced training in terminal master's programs and then receive additional on-the-job training at the workplace. Often, they will be hired for a *stable of statisticians* sort of structure, where the stable of master's-level statisticians is overseen by one or two PhD statisticians. In such contexts, the master's-level statisticians can generally do one or two things very well (e.g., analyze randomized controlled trial [RCT] data), and have a reasonable knowledge of other areas of statistics. Master's-level statisticians can help write papers, although it may be a bit of a stretch to have them help write a grant, unless they have extensive experience doing so.

Statisticians without advanced degrees are, ideally, gifted analysts who can possess a somewhat unpredictable set of skills. Part of the unpredictability is that their training may not be curriculum based; as a result, they may not be intended to produce a specific type of statistical expertise. So the individual learns a lot of the material by the seat of his or her pants, so to speak. Ideally, these statisticians have a firm grasp of relatively simple, parametric models such as regression analysis or the analysis of variance, which can prove very useful for implementing evidence-based practice. Occasionally, a statistician without an advanced degree will have a publication history, and can be a material help in publishing papers. Thus, look at the type of analyses conducted in their published scientific papers for more insight into their analytical expertise. It is also important to remember that these levels of expertise are meant as guidelines, rather than as strict rules. An example of how misleading the degree a person possesses can misinform the reader is based on the 1964 Surgeon General's report (U.S. Public Health Service [PHS], 1964) on the health effects of smoking. The statistician on this report had only a master's degree, but the discussion of how one uses statistical analysis to draw causal inferences is absolutely brilliant and instrumental in changing the way that U.S. health care professionals look at smoking.

This 1964 report was lucidly written, because the master's-level statistician on the report was William G. Cochran, who, as it turns out, is one of the foremost experts on statistical modeling and causality. Cochran had a distinguished career, and the 1964 report was just at the start of it, before he had received his doctorate. And this is the moral of this story: The skills of the scholar are more important than the degree. It is true today, and it has always been true.

How Should a Statistician Be Accessed?

How do you actually get access to a statistician in an academic or other research setting? There are several models for getting a statistician to work with you; each model has its own strengths and weaknesses. The most effective method is to have a statistician on faculty or staff who is dedicated to working with members of the faculty. This is especially important in nursing, because nursing research tends to be a little difficult for many statisticians to understand.

The second method of providing statistical expertise is to use a stable of statisticians. Sometimes, this particular method of delivering statistical services is referred to as the *Center for Statistical Excellence*. One advantage of the Center for Statistical Excellence is that it avoids having to find a new statistician: If the one designated to your project cannot continue working on the project for a sundry of reasons (e.g. illness, other priorities), other statisticians are available to take his or her place. Another advantage is that it could be less expensive, because you can have a head statistician who has a PhD, and other master's-level statisticians who work in collaboration with the head to make sure their work is of high enough quality. But there can be problems as well.

One problem with the Center for Statistical Excellence is that the statistician who helps you is often a bit of a hired gun, who does the work for one project and then moves on after being hired by the next scholar. Sometimes, this arrangement can mean that the statistician who works with the scholar does not really have much understanding of the phenomenon that is being studied. One can view statistics as a technical skill, and the models that the statistician uses as being interchangeable from one research context to another, but there are clear limits to this mode of thinking. The nurse scholar does not get the opportunity to build a relationship with a statistician who understands the conceptual underpinnings of the program of research. So, from the next project onward, it is back to square one explaining the conceptual theoretical underpinnings of nursing research. It can be exhausting and not very efficient.

The third structure for providing statistical resources is to set up a list of recommended statisticians who have been used by the school or facility and are known and trusted. This approach is especially useful in organizations where there are insufficient resources to hire a full-time or part-time statistician, but the need for statistical services still exists. The biggest advantage of this method of obtaining statistical resources is that if you do not especially like the interactions you had with the statistician, you do not have to use him or her again. Furthermore, if the consulting work amounts to a substantial amount of money over a year, then the statistician may be motivated to try to keep the various nurse researchers happy in order to facilitate future work. The downside to the recommended statistician choice is that most statisticians who work as consultants charge more, on an hourly basis, than one would have to pay in salary. So, for instance, if the PhD statistician would earn $60 per hour for his or her labor, as a consultant, he or she will generally charge two or three times more for hourly compensation. If you are using the statistician an awful lot, this can get very expensive. But if this occurs, you may be able to offer the statistician a job, and transition him or her into dedicated statisticians.

The last method of obtaining statistical help is the "I'm afraid you're on your own, professor" approach. I do not know how many nursing programs use this approach, but it does not have much to recommend it, especially since the recommended statisticians approach discussed earlier is so much more useful. If you are working in this sort of an environment, I would recommend giving a copy of this chapter to your resource allocation decision maker. The amount of effort required to get a list of recommended statisticians (survey nurse researchers whom they have worked with successfully, obtain the CVs or résumés of the statisticians) seems so little compared to the substantial costs that can be associated with working with a difficult statistician that it seems logical to put this decision into the "no-brainer" category. Now that this opinion has been put into print, there is no doubt that it will be contradicted, but that is the nature of scholarship.

CONCLUSION WITH WORDS OF WISDOM FROM THE STATISTICIAN HIMSELF

This chapter closes with some final words on selecting a statistician from our statistician author himself (L.F.). The earlier discussion is concerned with the basic toolbox for statistics and choosing the best possible colleague to work with on nurse scholarship. I will throw one more quality that I look for in all colleagues, be they statisticians or short-order cooks. Friedrich Nietzsche famously said, "I would only believe in a god who could dance" (Nietzsche & Ludovici, 1911). I am less demanding of my colleagues than Nietzsche is of his gods, but I do like to work with colleagues who can laugh. This enterprise of finding new meaning is supposed to be fun. I realize that it has serious, real-world implications for the health of our patients, and that all of that is very important, but the simple act of discovering how the world, this giant puzzle we are able to inhabit, works is pure fun.

And so I close this chapter with Plato's parable of how we learn about the world as it is. When your soul was first created, the gods took you up on Mount Olympus and showed you the world as it really is. And then you drank from the river of forgetfulness (Halliwell, 2007). And to Plato, the discovery of new knowledge as we progress through our lives is actually just the jogging of your soul's memory to remember what the god showed you, way back when. So I close this particular chapter with the wish that you may enjoy the rediscovery of all of the truth that we already know and the hope that a statistician can help you with that rediscovery.

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