

Algorithm for Determining the Appropriateness of Inferential Statistical Techniques

EXERCISE

12

STATISTICAL TECHNIQUE IN REVIEW

Multiple factors are involved in determining the appropriateness or suitability of the inferential statistical techniques conducted in nursing studies. **Inferential statistics** are conducted to examine relationships, make predictions, and determine differences among groups or variables in studies. When conducting data analyses for their studies, researchers consider many aspects of the study, including the study purpose, hypotheses or questions, level of measurement of the variables, design, and number of groups studied. Determining the appropriateness of the various inferential statistics reported for a particular study is not straightforward. Often, there is not necessarily *one right statistical technique* for a study.

One approach for judging the appropriateness of a statistical technique in a study is to use an **algorithm** or decision tree. The algorithm directs you by gradually narrowing the number of statistical techniques as you make judgments about the nature of the study and the data. An algorithm for judging the suitability of statistical procedures in studies is presented in Figure 12-1 that was developed by Cipher (Grove & Gray, 2019). This algorithm identifies four key factors related to the appropriateness of a statistical technique: (1) nature of the research question or hypothesis (differences or associations) for a study; (2) level of measurement (nominal, ordinal, or interval/ratio) of the dependent or research variables; (3) number of groups studied, and (4) a research design element (independent or paired samples).

Evaluating the statistical techniques reported in a study requires you to make a number of judgments about the nature of the data and what the researcher wanted to know. The study purpose and research questions or hypotheses need to be examined to determine if the focus of the study was examining associations or relationships, making predictions, or determining group differences. Research questions are often used to direct descriptive and correlational studies. However, quasi-experimental and experimental studies, focused on determining the effectiveness of an intervention or treatment, are best directed by hypotheses (Grove & Gray, 2019; Shadish, Cook, & Campbell, 2002).

You also need to determine whether the study variables were measured at the nominal, ordinal, interval, or ratio level (see Figure 12-1; review Exercise 1). You might see statistical techniques identified as parametric or nonparametric, depending on the level of measurement of the study variables. If study variables are measured at the nominal or ordinal levels, then **nonparametric statistics** are conducted (Pett, 2016). If the study variables are measured at either the interval or ratio levels and the values of the subjects for the variable studied are normally distributed, then **parametric statistics** are conducted (see Exercise 1; Kim & Mallory, 2017). Interval/ratio levels of data are often included together

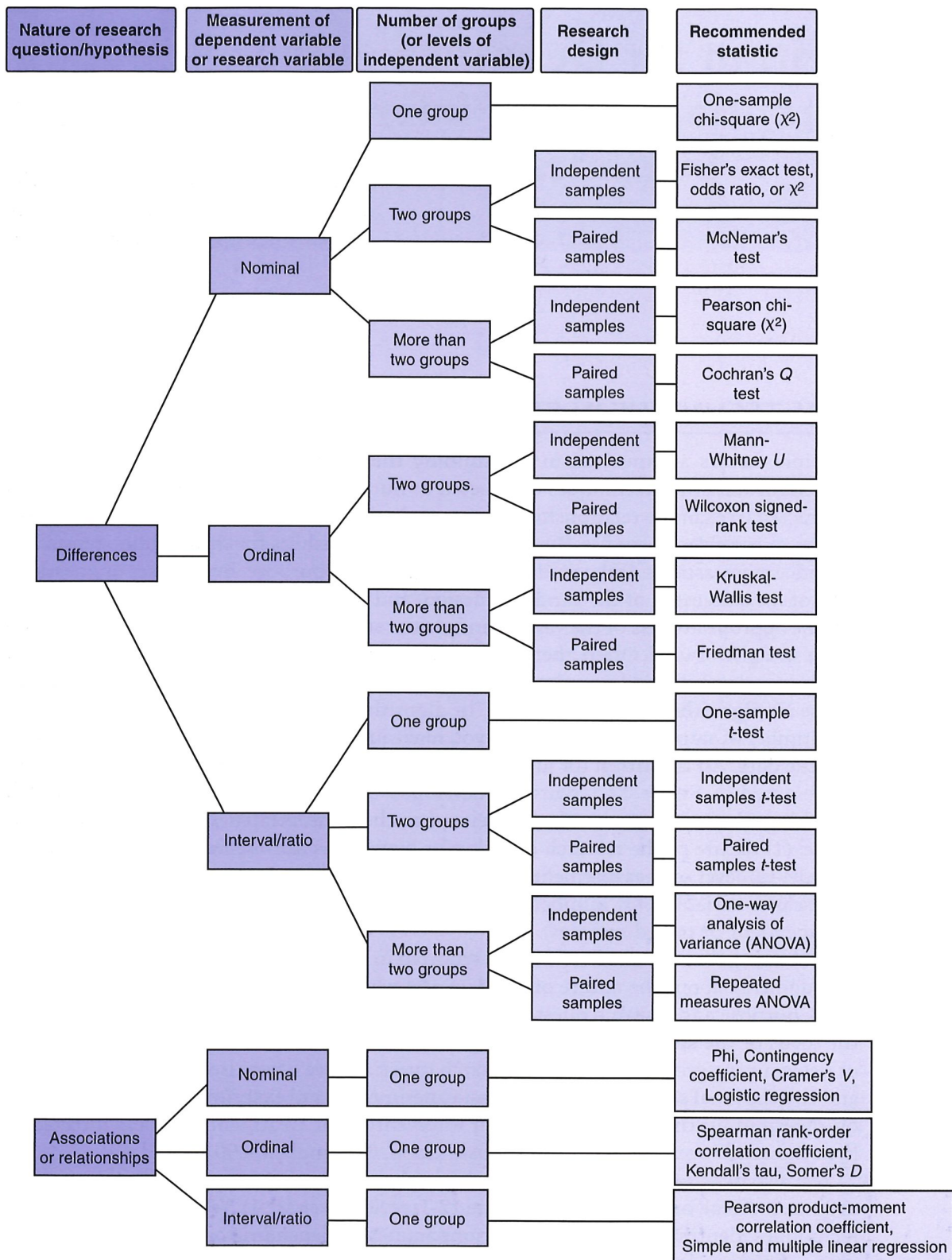


FIGURE 12-1 ■ ALGORITHM OR DECISION TREE FOR DETERMINING APPROPRIATE STATISTICAL TECHNIQUES FOR NURSING STUDIES.

(Adapted from Grove, S. K., & Gray, J. R. (2019). *Understanding nursing research: Building an evidence-based practice* (7th ed.). St. Louis, MO: Saunders, p. 311.)

because the analysis techniques are the same whether the data are interval or ratio level of measurement. Researchers run a computer program to determine if the dependent variables' frequency distributions are normally distributed (see Exercise 26). If the distribution of values or scores collected for a dependent variable are not normally distributed or are skewed, then nonparametric statistics are conducted even though the variables were measured at the interval/ratio level.

In Figure 12-1, examination of the research design element involves determining if the samples or groups in a study are independent or paired. With **independent samples or groups**, the assignment of one subject to a group is unrelated to the assignment of other subjects to groups. For example, if subjects are randomly assigned to the intervention and control groups, the samples are independent. In **paired samples or groups** (also called dependent samples or groups), subjects or observations selected for data collection are related in some way to the selection of other subjects or observations. For example, if subjects serve as their own control by using their pretest data as a control group, the observations (and therefore the groups) are considered to be paired. Some studies require repeated measures of the dependent variable on the same group of subjects, resulting in paired samples or groups (Gray, Grove, & Sutherland, 2017; Shadish et al., 2002).

To apply the algorithm in Figure 12-1, you would perform the following steps: (1) determine whether the research question or hypothesis focuses on differences or associations (relationships); (2) determine the level of measurement (nominal, ordinal, or interval/ratio) of the study variables; (3) select the number of groups that were included in the study; and (4) determine the design, with either independent or paired samples, that most closely fits the study you are critically appraising. The lines on the algorithm are followed through each selection to identify an appropriate statistical technique for the data being analyzed. The recommended statistic is identified in the far right column in Figure 12-1.

Regression analysis is focused on the prediction of a dependent variable using one or more independent variables. A study with one dependent variable and one independent variable (predictor) is analyzed using simple linear regression (see Exercises 14 and 29). If the study has one dependent variable and more than one independent variable, then the data are analyzed with multiple linear regression (see Exercises 15 and 30; Gray et al., 2017; Kim & Mallory, 2017; Plichta & Kelvin, 2013).

STUDY QUESTIONS

Directions: Answer the following questions using the algorithm or decision tree in Figure 12-1 and its description.

1. What are the reasons for conducting inferential statistics in nursing research?
2. Discuss the independent and paired samples or groups reported in studies. Why is knowing the type of samples or groups important in critically appraising the statistical technique in a research report?
3. Which statistic was probably conducted for a study focused on examining differences that had variables measured at the ordinal level and included two independent samples or groups? Provide a rationale for your answer.
4. Which statistic was probably conducted for a study focused on examining relationships that had variables measured at the ratio level? Provide a rationale for your answer.
5. Which statistic was probably conducted for a study focused on examining differences that had variables measured at the nominal level and included one group? Provide a rationale for your answer.

6. A study was focused on examining differences among the randomly assigned intervention, placebo, and standard care groups and the dependent variable perception of pain was measured at the interval level with a Likert pain scale. However, the data on pain perception were skewed or not normally distributed. What statistic was probably conducted to analyze the study pain perception data? Provide a rationale for your answer.
7. Study hypothesis: Women taking calcium 1,200 mg plus vitamin D₃ 2,000 International Units (INU) have higher bone density scores than women taking only calcium 1,200 mg. The women were randomly selected and assigned to the intervention and standard care groups. Which statistical technique would researchers probably conduct to test this hypothesis? Provide a rationale for your answer.
8. Robinson et al. (2018) examined the effectiveness of a coloring intervention on the anxiety levels of parents at two points in time, before and after surgery for their child. Anxiety was measured with the Spielberger State Trait Anxiety Inventory (STAI), which is a Likert scale that produces a total anxiety score for each subject. What statistical technique did these researchers conduct in analyzing the parents' anxiety scores? Provide a rationale for your answer.
Source: Robinson, E. M., Baker, R., & Hossain, M. (2018). Randomized trial evaluating the effectiveness of coloring on decreasing anxiety among parents in a pediatric surgical waiting area. *Journal of Pediatric Nursing*, 41(1), 80–83.

9. Guvenc et al. (2013) randomly selected and assigned women to receive an educational program to promote Pap smear testing or to receive standard care. The two groups were examined for differences and the data collected were “yes—I got a Pap smear” or “no—I did not get a Pap smear” over the past 12 months. What statistical technique did these researchers conduct to analyze the Pap smear data? Provide a rationale for your answer.

Source: Guvenc, G., Akyuz, A., & Yenen, M. C. (2013). Effectiveness of nursing interventions to increase Pap smear test screening. *Research in Nursing & Health*, 36(2), 146–157.

10. Eckhardt and colleagues (2014) conducted a study to determine if age, income, history of smoking, and depressive symptoms were predictive of fatigue intensity in individuals with coronary heart disease. What statistical technique did these researchers conduct to analyze these data and predict fatigue? Provide a rationale for your answer.

Source: Eckhardt, A. L., DeVon, H. A., Piano, M. R., Ryan, C. J., & Zerwic, J. J. (2014). Fatigue in the presence of coronary heart disease. *Nursing Research*, 63(2), 83–93.

Answers to Study Questions

1. Inferential statistics are conducted to analyze data in nursing studies for the following purposes: (1) to examine relationships (associations), (2) to make predictions, and (3) to determine differences among groups. Inferential statistics are usually conducted to analyze data in quantitative, mixed-methods, and outcomes studies (Gray et al., 2017; Leedy & Ormrod, 2019; Shadish et al., 2002).
2. Independent samples or groups exist when the assignment of a subject to a group is unrelated to the assignment of other subjects to groups. For example, samples are independent when participants are randomly assigned to the intervention or control groups. With paired samples or groups, the subjects or observations selected for data collection are related in some way, such as participants serving as their own control in a one-group pretest–posttest design or repeated measures design. The analysis techniques conducted vary based on whether the groups are independent or paired in a study (see Figure 12-1; Grove & Gray, 2019).
3. The statistical technique conducted in this study was probably the Mann-Whitney U (see Exercise 21 for more details; Kim & Mallory, 2017; Pett, 2016). Applying the algorithm in Figure 12-1, you note the research question or hypothesis is focused on differences, the variables are measured at the ordinal level, the study has two groups, and the samples or groups are independent. This information assists you in identifying the Mann-Whitney U as an appropriate analysis technique.
4. The statistical technique conducted in this study was probably the Pearson product-moment correlation coefficient (see Exercises 13 and 28 for more details). Applying the algorithm in Figure 12-1, you note the research question is focused on relationships or associations and the variables are measured at the ratio level. This information assists you in identifying the Pearson correlation as an appropriate analysis technique.
5. The statistical technique conducted in this study was probably the one-sample chi-square test. Using the algorithm in Figure 12-1, you note the research question is focused on differences, the variables are measured at the nominal level, and the study included one group. This information assists you in identifying the one-sample chi-square test as the appropriate analysis technique (Kim & Mallory, 2017; Pett, 2016).
6. The statistical technique conducted in this study was probably the Kruskal-Wallis test. Applying the algorithm in Figure 12-1, you note the study hypothesis is focused on differences, the variable pain perception is measured at the interval level, and the study included three independent groups (intervention, placebo, and standard care). This information assists you in identifying the one-way analysis of variance (ANOVA) statistical technique; however, the data were not normally distributed so the nonparametric Kruskal-Wallis test is the most appropriate analysis technique (Kim & Mallory, 2017; Pett, 2016).
7. The statistical technique conducted in this study was probably the independent samples t -test (see Exercises 16 and 31 for more details). Applying the algorithm in Figure 12-1, you note

the hypothesis is focused on differences, the dependent variable bone density value is measured at the ratio level, and the study included two independent groups (subjects randomly assigned to either the intervention or standard care group). This information assists you in identifying the independent samples t -test as an appropriate analysis technique to test this hypothesis (Gray et al., 2017).

8. The paired sample t -test was conducted to analyze the anxiety data in this study (see Exercises 17 and 32 for more details). Applying the algorithm in Figure 12-1, you note the study hypothesis is focused on differences, the dependent variable (anxiety scores before and after surgery) is measured at the interval level, and the study included one sample or group. This information supports the researchers analyzing their data with a paired sample t -test.
9. A chi-square test or a Fisher's exact test could be conducted to analyze the Pap smear data. Applying the algorithm in Figure 12-1, you note the study hypothesis is focused on differences, Pap smear was measured at the nominal level (yes I got a Pap smear or no I did not get a Pap smear), and the study had two groups (one receiving the educational intervention and the other receiving standard care). This information supports the researchers analyzing their data with the chi-square test (Kim & Mallory, 2017; Pett, 2016).
10. Multiple linear regression was conducted to analyze the study data and predict fatigue in patients with coronary heart disease (CHD). Eckhardt et al. (2014) used four independent variables (age, income, history of smoking, and depressive symptoms) to predict the dependent variable fatigue intensity in a single sample of CHD patients. This information supports Eckhardt et al.'s (2014) analysis of their data with multiple linear regression. You can review Exercises 15 and 30 in this text for more information on multiple linear regression.

Questions to Be Graded

EXERCISE 12

Name: _____ Class: _____

Date: _____

Follow your instructor's directions to submit your answers to the following questions for grading. Your instructor may ask you to write your answers below and submit them as a hard copy for grading. Alternatively, your instructor may ask you to submit your answers online.

Directions: Answer the following questions by reviewing the statistical content and applying the algorithm in Figure 12-1 of this exercise.

1. Discuss the differences between parametric and nonparametric statistical techniques. Provide an example of a parametric statistical technique and a nonparametric statistical technique applying the algorithm in Figure 12-1.
2. What statistical technique was probably conducted for a study focused on examining associations or relationships that had variables measured at the ordinal level? Provide a rationale for your answer.
3. What statistical technique was probably conducted for a study focused on examining differences that had variables measured at the ratio level and included three independent groups (intervention, placebo, and control)? Provide a rationale for your answer.

4. What statistical technique was probably conducted for a study focused on predicting a dependent variable using one independent variable that was measured at the interval/ratio level in a sample of patients with heart failure? Provide a rationale for your answer.

5. What statistical technique was probably conducted for a study focused on examining differences that had variables measured at the ordinal level and included three paired samples or groups? Provide a rationale for your answer.

6. Study hypothesis: *Nurses working in healthcare organizations with magnet status have higher job satisfaction than nurses working in organizations without magnet status.* Job satisfaction was measured with a multi-item Likert scale. What statistical technique would researchers probably conduct to test this hypothesis? Provide a rationale for your answer.

7. Lee et al. (2018) examined selective symptoms (dyspnea, anxiety, depression, and fatigue) to predict their contribution to impaired physical performance in patients with chronic obstructive pulmonary disease (COPD). Dyspnea was measured with FEV1 (forced expiratory volume in 1 second) and anxiety, depression, and fatigue were measured with multi-item Likert scales. Physical performance was measured with the 6-minute walk test (6MWT), which was the distance patients could walk in six minutes. What is the level of measurement for each of the study variables? Provide a rationale for your answer.
Source: Lee, H., Nguyen, H. Q., Jarrett, M. E., Mitchell, P. H., Pike, K. C., & Fan, V. S. (2018). Effect of symptoms on physical performance in COPD. *Heart & Lung, 47*(2), 149–156.

8. The focus of the Lee et al. (2018) study was presented in Question 7. What type of inferential statistical technique did Lee and colleagues conduct in their study? Provide a rationale for your answer.
9. Smith and colleagues (2014, p. 68) developed the following question to guide their study: “What are the relationships among the variables of perceived stress, sleep quality, loneliness, and self-esteem among obese young adult women?” The variables were measured with multi-item Likert scales, and the data were considered at the interval level. What inferential statistical technique did these researchers conduct to analyze their study data? Provide a rationale for your answer. Source: Smith, M. J., Theeke, L., Culp, S., Clark, K., & Pinto, S. (2014). Psychosocial variables and self-rated health in young adult obese women. *Applied Nursing Research*, 27(1), 67–71.
10. Hersch et al. (2018) conducted a randomized controlled trial (RCT) that examined the effect of a web-based stress management intervention on nurses’ stress. The study included 104 subjects that were randomized into an intervention or control group. Nurses’ stress was measured with the Nursing Stress Scale, a multi-item Likert scale, that provided a total stress score. What inferential statistical technique was conducted to examine the effect of the web-based intervention? Provide a rationale for your answer. Source: Hersch, R. K., Cook, R. F., Deitz, D. K., Kaplan, S., Hughes, D., Friesen, M. A., & Vezina, M. (2016). Reducing nurses’ stress: A randomized controlled trial of a web-based stress management program for nurses. *Applied Nursing Research*, 32(1), 18–25.

Understanding Pearson Product-Moment Correlation Coefficient

STATISTICAL TECHNIQUE IN REVIEW

Many studies are conducted to identify relationships between two or more variables. The correlational coefficient is the mathematical expression of the relationship or association studied. Two common analysis techniques are used to examine relationships in health-care studies: Pearson product-moment correlation coefficient, or r ; and Spearman rank-order correlation coefficient, or rho (see the algorithm in Exercise 12). The **Pearson correlation coefficient** is a parametric analysis technique conducted to examine bivariate correlations between continuous variables measured at the interval or ratio level (Gray, Grove, & Sutherland, 2017; Kim & Mallory, 2017). **Bivariate correlation** measures the extent of the relationship between two variables at a time in a study. The purpose of Pearson r is to examine associations or relationships and *not to determine cause and effect* between independent and dependent variables (Grove & Gray, 2019; Shadish, Cook, & Campbell, 2002). The Spearman correlation coefficient (see Exercise 20) is a nonparametric analysis technique conducted to examine relationships when variables are measured at the ordinal level or do not meet the normality assumption of the Pearson r (Pett, 2016).

Relationships are interpreted in terms of direction and strength. The direction of the relationship is expressed as either positive or negative. A **positive or direct relationship** exists when one variable increases as the other variable increases or when one variable decreases as the other decreases. For example, a moderate increase in calorie intake per day is related to an increase in weight gain. Conversely, a **negative or inverse relationship** exists when one variable increases as the other variable decreases. For example, an increase in minutes of exercise per day is related to a decrease in weight.

The strength or magnitude of a relationship is described as weak, moderate, or strong. Pearson r is never less than -1.00 or greater than $+1.00$, so an r value of -1.00 or $+1.00$ indicates the strongest possible relationship, either negative or positive, respectively. An r value of 0.00 indicates no relationship or association between two variables. To describe a relationship, the labels *weak* ($r < 0.3$), *moderate* ($r = 0.3$ to 0.5), and *strong* ($r > 0.5$) are used in conjunction with both positive and negative values of r . Thus, the magnitude of the negative relationships would be weak with $r < -0.3$, moderate with $r = -0.3$ to -0.5 , and strong with $r > -0.5$ (Cohen, 1988; Kim & Mallory, 2017; Plichta & Kelvin, 2013).

The significance of r values can be determined by examining the Table of Critical Values for r for the Pearson product-moment correlation coefficient in Appendix B at the back of this text. To use this table, you need to know the level of significance or alpha for the study, which is usually set at 0.05 . The degrees of freedom (df) for Pearson r is the sample size minus 2 ($N - 2$). For example, if a study had $r = 0.36$, a sample size of 50,