

Statistics for Anesthesia Using OnlineStatBook.com



Anthony Giuffrida, B.S. (medical student)

Upstate Medical University

Franklin Dexter, M.D., Ph.D.

University of Iowa

Franklin-Dexter@UIowa.edu

Using Slides

- In exchange for use of this new slide show, please send comments to:
Franklin-Dexter@UIowa.edu
 - Errors in hyperlinks
 - Errors in examples
 - Improved instructions that fit on slide
 - Improved examples that fit on slide



Using Slides

- Topics selected are those needed for study of anesthesia group and OR management
 - © 2009 Franklin Dexter
 - Last updated 09/15/09
- Rice University's Online Statistics Interactive Multimedia Course contains three modes
 - Standard, if you prefer to read content
 - Multimedia, if you prefer to listen to lectures
 - Condensed, which does not apply to our use



Probability Distribution

- [Probability distribution](#)
 - Review learning objectives at top of page
 - Answer the questions at bottom
 - Check your answers by clicking the OK
 - Surgical case durations and time from end of surgery to extubation follow right-skewed distributions
 - Birth weight, ejection fractions, and S_aO_2 on room air follow left-skewed distributions



Probability Distribution

- [Cumulative frequency curve](#)
 - Answer the questions at the bottom of the web page and review answers
 - Proportions of physiologically complex pediatric procedures performed at different hospitals in a region can be viewed with cumulative frequency curve



Central Tendency

- What is central tendency?
 - Since total cost for caring for a population of patients equals the mean multiplied by the number of patients, knowing the “central tendency” of a probability distribution is important to cost accounting for anesthesia



Central Tendency

- Difference between mean and median
 - Follow web site's steps since they have been shown in studies to enhance learning
 - Take the pretest
 - Do the simulations
 - Do the post test



Central Tendency

- Absolute deviations
 - As for all future simulations, follow web site's steps to enhance learning
 - Take the pretest
 - Do the simulations
 - Do the post test
 - Absolute deviations are often used to assess the magnitude of differences between scheduled and actual OR times

Central Tendency

- Mean
 - Mean and median rarely are the same for historical OR times of similar cases, but often are the same for total hours of cases and turnovers of a specialty in an OR on a weekday
 - When considering costs, the mean OR time is economically relevant, being proportional to the total OR time used



Central Tendency

- Median
 - Median is useful when analyzing OR times because it is unaffected by very long cases



Central Tendency

- Trimmed mean
 - Trimmed mean is at bottom of web page
 - Many commercial products suggest OR case scheduling using trimmed mean of historical OR times of recent, similar cases



Variability

- Percentiles
 - Do not worry about different ways to calculate percentiles, just that there are different ways
 - The longest and shortest amounts of time to complete cases are often estimated by using the 5th and 90th percentiles of historical OR times of similar cases
 - They are about 1/3rd less and 1/3rd more than the median, respectively



Variability

- Standard deviation and mean
 - Focus on how large standard deviations reflect large absolute deviations from the mean
 - Not same as large range
 - Not same as equally spread out
 - Not increased by large mean



Correlation

- Positive and negative correlation
 - Reimbursement and total costs are positively correlated
 - Patient age and endotracheal tube size are positively correlated
 - Average pain score and satisfaction are negatively correlated



Correlation

- Linear correlation
 - Professional fee charges for anesthesia care and anesthesia time are linearly correlated
 - Height and weight are not linearly correlated
 - Altitude and hemoglobin saturation are not linearly correlated



Correlation

- Strength of correlation
 - Propofol induction dose is strongly correlated with weight among patients of all ages
 - Surgical time is very weakly correlated to anesthesia induction and emergence times



Probability

- Basic concepts
 - Probability of a single event
 - Surgeon #1 finishes case #1 with the surgical microscope within 3 hr
 - Probability of pair of events
 - Surgeon #1 finishes his case #1 with the surgical microscope within 3 hr
 - Surgeon #2 finishes her case #1 without the microscope more than 3 hr after start, and only then will need the microscope for her case #2



Probability

- Conditional probability
 - Probability that a case will finish within the next 1 hr is conditional on its having been on-going for the past 2 hr
 - Probability that mean arterial pressure will drop 10 mmHg within 10 min is conditional on its having already dropped 20 mmHg



Probability

- Statistical independence
 - Consider the probability that General Surgery has been busier than average every Monday for the past 8 weeks and yet there is in fact no overall positive trend in its workload



Probability

- Prior probability
 - Calculate the probability that a case that the surgeon has never scheduled before at the facility will take > 1 hr longer than scheduled
 - Depends on prior probabilities
 - Frequent problem with add-on cases done in afternoons keeping people working late in ORs



Probability

- Bayes' theorem
 - If temperature of child undergoing mastoidectomy has increased from 36.5°C to 38.3°C over the past 2 hr, consider malignant hyperthermia or remove blankets?



Normal Distributions

- Basic features
 - May plan staffing at 66th percentile of workload if 2 × as expensive to work overtime as during regularly scheduled hours
 - Close to 1 standard deviation above mean
 - May reduce staffing to save money while assuring that at least 95% of urgent cases start within 4 hr of submission
 - Close to 2 standard deviations above mean



Normal Distributions

- Area under normal curve
 - Area under curve from far left to X is useful for calculating probability that a case will take at most X hours
 - Also useful for probability that all the cases in an OR will finish by 4:00 PM



Normal Distributions

- Differences among normal distributions
 - If you answer all of the pretest questions correctly, you may want to skip the simulation
 - Comparison of 2 normal distributions is central to understanding Student's t -test comparison of means of 2 normal distributions



Normal Distributions

- Standard normal distribution
 - Questions at bottom of web page are especially practical for future content
 - If the total hours of cases including turnover times in an OR has a mean of 7 hr and a standard deviation of 0.5 hr, on what percentage of days will there be overtime payment for work > 8 hr?



Sampling Distributions

- Introduction

- After answering questions at bottom of web page, consider the following:

- Sampling distribution of maximum number of patients present simultaneously in the phase I post anesthesia care unit each day
 - Sampling distribution of minimum mean arterial pressure after induction of anesthesia



Sampling Distributions

- Sample size
 - When calculating mean variable costs per hour of OR time among all of a surgeon's cases, typically sample size $(N) > 200$ cases
 - When calculating mean OR time of historical cases of a certain combination of surgeon and scheduled procedure, the most common sample size at a tertiary suite is $N = 0$ cases and the second most common is $N = 1$ case



Sampling Distributions

- Central limit theorem
 - When finished simulation, consider that for total hours of cases including turnovers, sample sizes are generally $N > 30$ weeks and staffing is planned for slightly more than average workload
 - From central limit theorem, basing staffing on a normal distribution is often reasonable



Estimating Population Parameters

- Parameters and statistics
 - To estimate how much longer one anesthetist takes to do a lumbar (labor) epidural than another, you might calculate a 95% confidence interval for the difference in their mean times



Estimating Population Parameters

- Degrees of freedom
 - Our examples are less interesting than the heights of Martians on the web page



Estimating Population Parameters

- Bias
 - Questions at the bottom of the web page are especially useful for OR management, because bias in case duration prediction is a common concern
 - If a group of surgeons consistently underestimates OR times to get cases onto an OR schedule, then there is *bias*



Estimating Population Parameters

- Sampling variability
 - As you answer the pretest questions, consider that the probability distributions of OR times for similar cases are often right-skewed and that the median of historical OR times is useful since it excludes outliers



Confidence Intervals

- Introduction
 - Useful to estimate the 95% lower confidence limit for the cancellation rate of each specialty at a facility and to compare that value to a threshold for being unacceptable



Confidence Intervals

- Confidence interval for mean
 - Calculate 95% two-sided confidence interval for the average reimbursement per American Society of Anesthesiologists' Relative Value Guide billing unit of different payers contracting with an anesthesia group



Confidence Intervals

- Student t -distribution
 - Important to understand that even if you sample from a normal distribution, the mean follows a Student's t -distribution
 - For OR times, the sample sizes are often very small (e.g., $N = 3$), and thus the difference between Student's t -distribution and a normal distribution is important practically



Hypothesis Testing

- One-tailed tests
 - One-tailed tests are often practical for managerial questions
 - When evaluating the probability that a case will fit within a hole in the OR schedule, all that is of interest is whether its OR time will be less than or equal to some threshold



Student's t -Test

- Testing a single mean
 - Test whether a payer's reimbursement per American Society of Anesthesiologists Relative Value Guide unit is significantly different from the national survey value



Student's t -Test

- Student's t -distribution
 - Characteristics of tails of the distribution are important, because we rely on the 5th percentile and the 90th percentile for the shortest and longest times that cases take



Student's t -Test

- Difference of two means
 - Test whether two surgeons take different amounts of time to complete a procedure



Additional Education in Operating Room Management

- www.FranklinDexter.net/education.htm
 - Course in OR management onsite or at the University of Iowa (3.5 days)
 - Lectures on day of surgery decision making, PACU staffing, OR allocation and staffing, anesthesia staffing, financial analyses, comparing surgical services among hospitals, strategic decision making, and drug costs

