How to Choose the Right Statistical Test for the Occasion

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Questions Before You Begin...

☐ What is your primary research question?
☐ Are you interested primarily in a relationship between an outcome and a risk factor or exposure?
☐ Are you interested in prediction of an outcome, using one or more risk factors or exposures?

Questions Before You Begin...

☐ What is the study design? (Cohort, Case/Control, RCT)
☐ What kinds of inferences can be made – what are the limitations?
☐ What are the outcome measures? Is there a primary outcome measure?
☐ What are the risk factors and exposures?

Questions Before You Begin...

☐ What is the nature of the outcome measure – Continuous, Categorical, Dichotomous or Time to Event?
☐ What is the primary effect measure?
☐ Are data correlated?

Example

☐ Is BMI a significant risk factor for spontaneous preterm delivery?

Analysis

☐ What is most appropriate study design?
☐ What is the nature of the outcome measure?
☐ What is the nature of the primary risk factor?
☐ What is effect measure?
☐ What is analysis method?
Analysis

☐ Conduct logistic regression analysis relating BMI to spontaneous preterm delivery

\[ \text{OR}_{\text{BMI}} = 1.06 \]
(95% CI: 1.04-1.08)
\[ p < 0.0001 \]

☐ Are you happy with this?

Interpretation...

Overweight  BMI = 25.0-29.9
Obese  BMI ≥ 30

\[ \text{OR}_{\text{Overweight}} = 1.90 \ (1.56-2.30), p < 0.0001 \]
\[ \text{OR}_{\text{Obese}} = 2.23 \ (1.73-2.87), p < 0.0001 \]

☐ Done?

Suggestion: Explore Your Data

☐ Understand analytic sample - population at risk and outcome
☐ Generate descriptive statistics on outcome and risk factor
☐ Are there confounding factors?

Other Risk Factors/Confounders

☐ Prior preterm birth
☐ Maternal age
☐ Smoking
☐ Race
☐ Infection
☐ Alcohol & tobacco use
☐ Nutritional status

Confounding

☐ A distortion of the effect of the risk factor on outcome due to other factors
  - Confounder may account for part or all of observed effect, may mask effect
☐ How do we examine confounding?
  - Evaluate association of confounder with outcome
  - Evaluate association of confounder with primary risk factor of interest

Ways to Handle Confounding

☐ Design
  - Randomization
  - Matching
☐ Analysis
  - Stratification
  - Multivariable analysis/Statistical adjustment
Lisa Sullivan, PhD  
Professor & Chair, Biostatistics  
Assoc Dean, Education  

Multivariable Models: BMI

<table>
<thead>
<tr>
<th>OR (95% CI)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unadjusted</td>
<td>1.06 (1.04-1.08)</td>
</tr>
<tr>
<td>Adj for Maternal Age</td>
<td>1.04 (1.02-1.06)</td>
</tr>
<tr>
<td>Multivariable Adj*</td>
<td>1.02 (0.99-1.04)</td>
</tr>
</tbody>
</table>

*Adjusted for prior preterm birth, maternal age, smoking and infection

Multivariable Models: Overweight/Obesity

<table>
<thead>
<tr>
<th>Overweight</th>
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<tr>
<td>Unadjusted</td>
<td>1.90 (1.56-2.30)</td>
</tr>
<tr>
<td>Adj for Mat Age</td>
<td>1.24 (1.02-1.52)</td>
</tr>
<tr>
<td>Multivariable Adj*</td>
<td>1.11 (0.91-1.36)</td>
</tr>
</tbody>
</table>

*Adjusted for prior preterm birth, maternal age, smoking and infection

Confounding

- Compare crude (unadjusted) measure of association with adjusted measure of association
  - If comparable, then no confounding
- Is confounding an issue here?
  - If so, want to explore which risk factor(s)?

What Tests to Use When

- Continuous Outcome
  - 1 Group – CI, t Test for Mean
  - Historical control
  - 2 Independent Groups – CI, t Test for Difference in Means
  - 2 Dependent Groups – CI, t Test for Mean Difference (Post-Pre)
  - Focus on difference scores

- Discrete (proportions) – preterm labor
- Time to Event (survival) – infant death

- Number of Groups
  - One
  - Two
  - > Two

- Independent or Dependent/Matched Groups

- Continuous Outcome
  - > 2 Independent Groups – ANOVA
  - Test for difference in means
  - Specific contrasts (2 at a time) but control for Type I error rate with multiple testing
  - > 2 Dependent Groups – Repeated Measures ANOVA
  - Repeated assessments over time
  - Multiple risk factors or exposures
  - Multivariable linear regression analysis
What Tests to Use When

- **Dichotomous Outcome**
  - 1 Group – CI, Z Test for Proportion
  - 2 Independent Groups – CI, Z Test for Difference in proportions
  - 2 Dependent Groups – McNemar’s test for differences in proportions
  - > 2 Independent Groups – Chi-Square Test
  - Multiple risk factors or exposures
    - Multivariable logistic regression analysis

- **Time to Event**
  - 1 Group - Kaplan Meier Estimate of Survival
  - 2+ Independent Groups – Log Rank Test for Differences in Survival
  - Multiple risk factors or exposures
    - Cox proportional hazards regression analysis

Common Mistakes

- **Inefficient Design**
  - A badly designed study can never be retrieved, a poorly analyzed study can usually be re-analyzed!

- **Analytic Planning Issues**

- **Interpretation Issues**

Which Design is Best

- Depends on the study question
- What is current knowledge on topic
- How common is disease (and risk factors)
- How long would study take, what are costs
- Ethical issues

Common Mistakes (cont’d)

- **Misclassification of Outcome**
  - Continuous (means)
  - Discrete (proportions)
    - Ordered categories, unordered categories, dichotomous (success/failure)
  - Time to event (survival time)

- **Unit of analysis**
  - Observations are repeated on the same unit but treated as independent
  - Observations are clustered, need to take into account structure in data
<table>
<thead>
<tr>
<th>Common Mistakes (cont’d)</th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>Missing data</strong></td>
<td><strong>Multiple testing</strong></td>
</tr>
<tr>
<td>- Suppose required number are enrolled but 20% drop out over the course of follow-up;</td>
<td>- Each test has an associated Type I error (error rate per comparison, e.g. 5%)</td>
</tr>
<tr>
<td>What if 40% of the treatment group drop out and 0% of control drop out?</td>
<td>- Familywise error rate (likelihood of a false positive result over all comparisons)</td>
</tr>
<tr>
<td>- Patterns of missing data</td>
<td>- Multiple comparisons procedures control familywise Type I error rate (e.g., Tukey,</td>
</tr>
<tr>
<td>- Do everything possible to avoid missing data!</td>
<td>Dunnett)</td>
</tr>
<tr>
<td></td>
<td>- Bonferroni correction</td>
</tr>
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<td></td>
<td></td>
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<tr>
<td><strong>Correlation Vs Cause and Effect</strong></td>
<td><strong>Lack of significance</strong></td>
</tr>
<tr>
<td>- <strong>Design</strong></td>
<td>- Failure to show statistical significance is not equivalence (non-inferiority)</td>
</tr>
<tr>
<td>Observational studies – correlation</td>
<td>- Must provide evidence of power when study fails to show statistical significance</td>
</tr>
<tr>
<td>- <strong>Timing</strong></td>
<td>(equality or study is too small?)</td>
</tr>
<tr>
<td>Does A cause B or vice versa</td>
<td>- Determine sample size required BEFORE study launch</td>
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<tr>
<td><strong>Generalizability</strong></td>
<td><strong>Magnitude of Effect</strong></td>
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<tr>
<td>- Target population</td>
<td>- Statistical significance (p&lt;0.05) is only one way to interpret results</td>
</tr>
<tr>
<td>- Draw sample, analyze sample, make inferences back to target population</td>
<td>- Always look at magnitude of effect</td>
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<tr>
<td></td>
<td>- Consistency of effect in other studies</td>
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<td></td>
<td>- Biologically plausible effect</td>
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<td></td>
<td>- Dose-response relationship</td>
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Summary

- Determine appropriate study design
- Identify the types of variables you are evaluating
- Plan the appropriate analyses
  - Explore data
  - Run primary analysis
  - Assess consistency, plausibility

Study Variables

- Outcome – continuous, dichotomous, discrete, time to event
- Number of comparison groups
- Dependencies in the data

Epidemiology

**Soft Drink Consumption and Risk of Developing Cardiometabolic Risk Factors and the Metabolic Syndrome in Middle-Aged Adults in the Community**

Rui Dingas, MPH, Lisa Sullivan, PhD, Paul J. Jacques, PhD, Thomas J. Wang, MD, Carrie Post, MD, E. James R. Mada, MD, MPH, Ralph R. D’Agostino, PhD, David M. Cohn, MD, MPH, Massachusetts Institute of Technology

**Background**
- Consumption of soft drinks has been linked to obesity and diabetes, but it is unclear whether it increases metabolic risk in middle-aged adults.

**Methods and Results**
- We evaluated the association of metabolic syndrome and its components with soft drink consumption using data from the Framingham Heart Study offspring cohort (n = 3838). The metabolic syndrome was defined as the presence of ≥ 3 of the following: waist circumference ≥ 94 cm in men or ≥ 80 cm in women; blood pressure ≥ 130/85 mm Hg; high-density lipoprotein cholesterol < 40 mg/dL; and triglycerides ≥ 150 mg/dL.

**Summary**
- Generate descriptive statistics for all variables, especially outcome and primary risk factor
- Obtain crude measures of association
- Perform stratified and adjusted analyses
- Does final result make sense, given all of the above and what you know from other studies?
- What are the limitations of analysis/inferences?
Medicine Residents’ Understanding of the Biostatistics and Results in the Medical Literature

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Assoc Dean, Education

Practice Office Public Health Skills Series
July 7, 2010

Purpose: The purpose of this project is to improve residents' understanding of biostatistics and their ability to interpret clinical research. This will be achieved through a series of workshops, discussions, and case studies.

Objective: To increase residents' understanding of biostatistics and their ability to interpret clinical research.

Method: Residents will attend a series of workshops and case studies. Each workshop will focus on a specific aspect of biostatistics, such as hypothesis testing, regression analysis, or survival analysis. Following each workshop, residents will be presented with a case study that requires the application of the concepts discussed in the workshop.

Results: Residents will be assessed on their understanding of the biostatistical concepts and their ability to apply them to real-world scenarios. This will be done through a series of quizzes and practical exercises.

Conclusions: This project will improve residents' understanding of biostatistics and their ability to interpret clinical research.