Meta-analysis and Systematic Review

Avoiding bias in literature review and calculating effect sizes

(Advanced Research Statistics Series)

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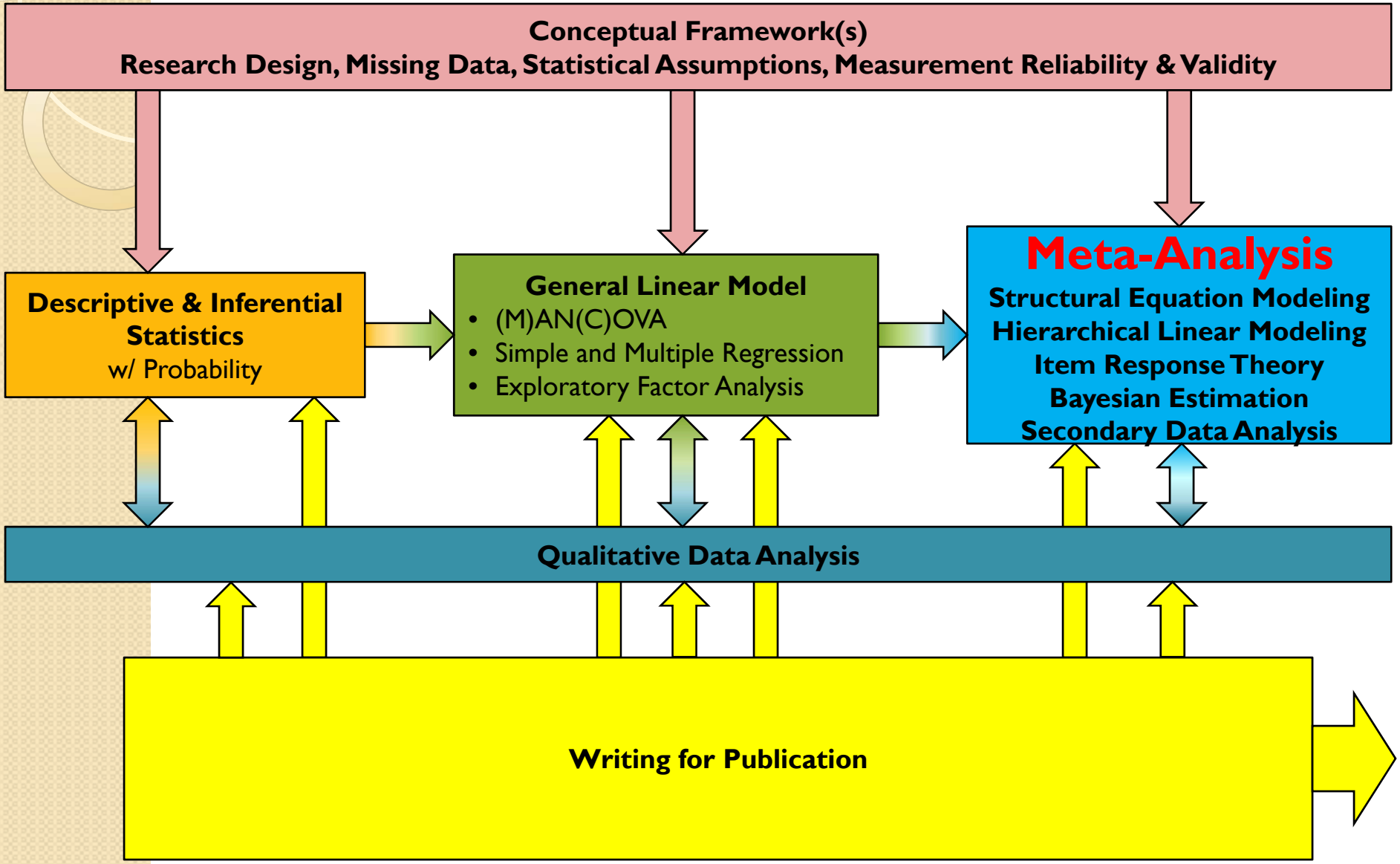
Research Statistics Framework



Why Systematic Review?

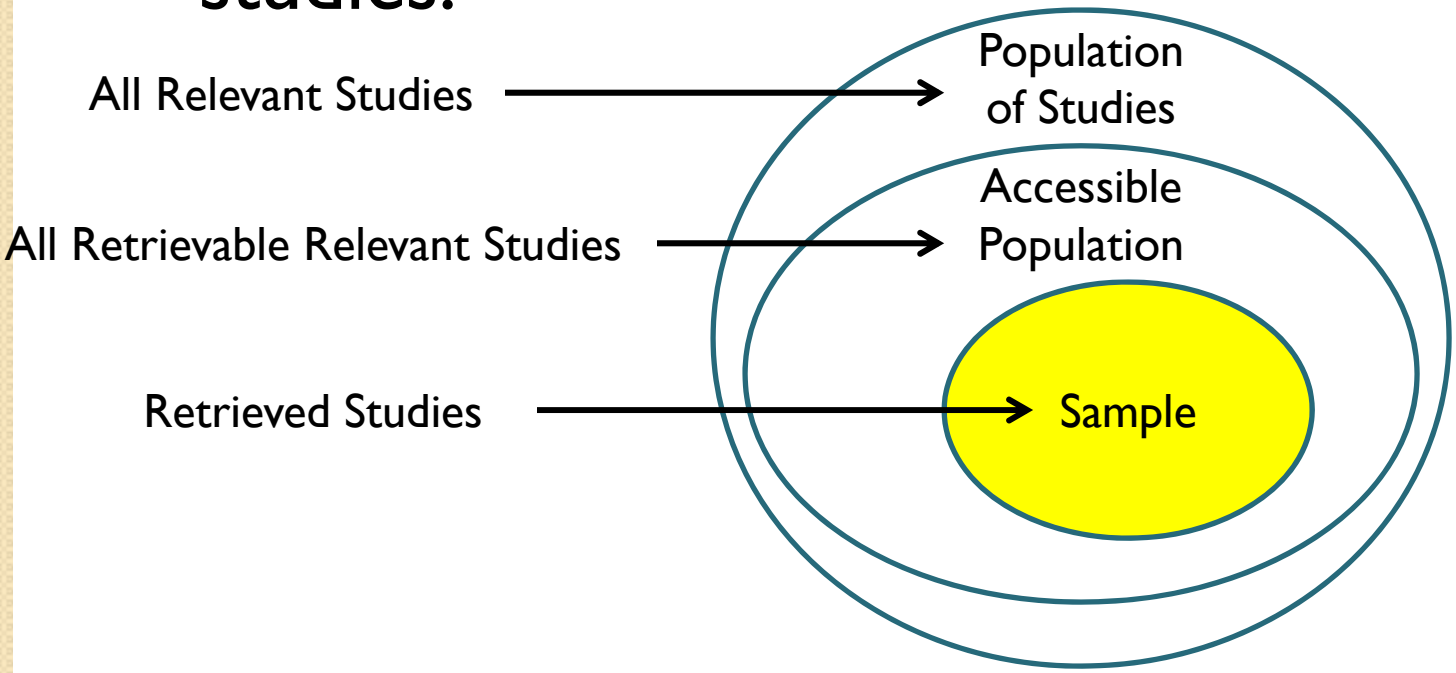
- Synthesis of results of multiple studies provides more compelling evidence than results of any single study.
  - Less effected than single studies by sampling error
  - More confidence in results: place single studies in context

Problems with Narrative Reviews

- Literature search virtually never thorough in scope or in reporting how literature was located.
- Under-reported methodology (why were certain studies included or excluded?)
  - Often unstated, virtually always arbitrary
  - Potential Confirmation Bias
- Conflate statistical significance with effect size
- Ignore Type II error in primary studies
- Ignore publication bias
- Often employ vote counts

Steps for a Systematic Review

- Goal: Uncover All Relevant Studies
- More realistic goal: Minimize differences between retrieved and un-retrieved studies.



Searching Electronic Databases

- **Always consult with a professional librarian!!!!**
- Identify potentially relevant databases.
- Search terms must appear in an indexed field.
  - Often must be exhaustive with terms
    - Deep substantive knowledge of the research questions is required to capture the relevant terms
    - Strongly susceptible to disciplinary bias (vet thoroughly)
    - Full text search capability will help some

Gray Literature

- Generic search engines such as Google and Google Scholar can sometimes help identify unpublished material
- ProQuest Dissertations and Theses will house dissertation research http://aok.lib.umbc.edu/databases/dblink.php?DBID=370
- Research Organizations in Your Field often house technical reports on their websites (e.g., CRESST)
- Bibliographies of already-identified relevant studies.

Publication Bias

- Known difference in statistical significance of published vs. unpublished studies.
- The best defense is a comprehensive, systematic search for literature.

Key Decisions in Literature Review

- Inter-Rater Agreement on Key Decisions
  - Does the study look like it might be relevant?
    - If yes, retrieve full text of article.
  - Is the study eligible for inclusion?
    - Base final decision on full text.
- Double code as much as possible.

Browse UMBC's Databases

COMPUTING EFFECT SIZES

Statistical Significance

- Interpretation of a p-value
  - Given a true null hypothesis, the probability of observing a relationship at least as large as the one being tested.
  - The confidence with which we can state the direction of a relationship (positive or negative)
  - Likelihood that a result is due to random chance (i.e., sampling error).
- A p-value is a function of sample size and effect size.

Effect Size

- Estimates the magnitude (size) of a relationship (i.e., how much impact?)
- Three families of effect size
  - Correlation Coefficients (r)
  - Odds Ratios (OR; Two Dichotomous Variables)
  - Mean Differences (d)

The role of sample size

- Any non-zero difference in means will be statistically significant given a large enough sample. Assume:
  - $M_T = 100.1, M_C = 100.0, s_p = 15$

n per group	d	t-test p-value
100	0.01	0.962
1000	0.01	0.882
10000	0.01	0.637
100000	0.01	0.136
200000	0.01	**0.035**

Two categories of Effect Sizes

- Unstandardized
  - Effects expressed directly in terms of the measured outcome (e.g., "3 points on an IQ scale")
  - Most useful when scale is well understood and relevant studies all use the same scale.
- Standardized: transforming effects to have similar meaning across scales
  - Standard Deviation Units
  - Percent Change
  - Proportion of Variance Explained

Computing an Odds Ratio

	Graduated	Didn't Graduate
Treatment	2 (a)	6 (b)
Control	9 (c)	12 (d)

- $OR = \frac{ad}{bc} = \frac{2*12}{9*6} = 0.44$
- $SE_{OR} = \sqrt{\frac{1}{a} + \frac{1}{b} + \frac{1}{c} + \frac{1}{d}} = \sqrt{\frac{1}{2} + \frac{1}{6} + \frac{1}{9} + \frac{1}{12}} = 0.928$
- $95\%CI = 0.44 \pm 1.96 * .928 = -1.38, 1.82$

Standardized Effect Size: Mean Difference (*d* or Cohen's *d*)

- $ES_{SM} = d = \frac{\bar{Y}_1 - \bar{Y}_2}{s_p}$,
  - where s_p is the pooled standard deviation.
- $s_p = \sqrt{\frac{(SD_1)^2 + (SD_2)^2}{2}}$
- $SE_d = \sqrt{\frac{n_1 + n_2}{n_1 n_2} + \frac{d^2}{2(n_1 + n_2)}}$

Computing ES: An Example

Study	n_1	$\bar{Y}_1$	s_1	$(s_1)^2$	n_2	$\bar{Y}_2$	s_2	$(s_2)^2$
1	59	17.25	3.26	10.6276	50	19.32	3.53	12.4609

- $s_p = \sqrt{\frac{10.6276+12.4609}{2}} = \sqrt{\frac{23.0885}{2}} = \sqrt{11.54425} = 3.383$
- $d = \frac{19.32-17.25}{3.383} = \frac{2.07}{3.383} = 0.54$
- $SE = \sqrt{\frac{59+50}{59*50} + \frac{.54^2}{2(59+50)}} = \sqrt{\frac{109}{2950} + \frac{.2916}{218}} = .1966$
- $95\%CI = 0.54 \pm 1.96 * .1966 = 0.2239, 0.995$

Try It! Go to http://csrakes.yolasite.com and go to "Resources" for my Excel template

n_1	$\bar{Y}_1$	s_1	n_2	$\bar{Y}_2$	s_2
5	3.3	1.2	17	4.2	0.7
35	1.5	0.5	17	4.2	0.7
5	3.3	1.2	32	3	0.5
35	1.5	0.5	32	3	0.5

Software

- Comprehensive Meta-Analysis: http://www.meta-analysis.com/index.php?gclid=CITZk8WSiroCFRCg4AodJhYA7Q
- Microsoft Excel: Home-made formulas

Questions?

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