Quantitative Approaches to Context Heterogeneity

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Outline

- Heterogeneity in intervention effects (HIE)
- Relevance for dissemination and implementation research
- RAND study on patient safety practices
- HIE and statistical interactions
- Detection and assessment of contextual HIE
- Discussions

Heterogeneity in Intervention Effects

- How intervention effects might differ across sites with different contexts
  - IT-based patient safety practice intervention might work well in large teaching hospital with strong IT infrastructure, not so well in small rural hospital with weak IT infrastructure
- Analogous to patient level heterogeneity in treatment effects (HTE)
  - Kravitz, Duan, Braslow (2004, Milbank Quarterly)

Relevance for Dissemination and Implementation Research

- Target intervention delivery
  - Focus on sites likely to benefit from intervention
- Adapt intervention to accommodate site-specific context
  - Identify context factors associated with poor intervention effects, adapt intervention accordingly

RAND PSP Study

- Assessing the Evidence for Context-Sensitive Effectiveness and Safety of Patient Safety Practices
  - Paul Shekelle, Peter Pronovost, Robert Wachter, et al.
  - http://www.ahrq.gov/qual/contextsensitive/
  - (Chapter 12)

Key Findings and Recommendations from PSP Study

- Among PSP Study's key findings and recommendations:
  - For studies with multiple intervention sites, an assessment of the influence of context on intervention and implementation effectiveness
  - Generating empirical evidence that the contextual factors identified in this project influence the success of the PSP
- Challenge: number of sites usually limited

Five Key PSPs

- Checklists for catheter-related bloodstream infection prevention.
- The Universal Protocol for preventing wrong procedure, wrong site, wrong person surgery.
- Computerized order entry/decision support systems.
- Medication reconciliation.
- Interventions to prevent in-facility falls.

High Priority Contexts for PSP

- External factors such as regulatory requirement, the presence of public reporting or pay-for-performance, the occurrence of local “sentinel event”
- Organizational characteristics, such as size, complexity and financial status or strength
- Teamwork, leadership and patient safety culture
- Management tools such as training resources, internal organization incentives, audit and feedback, the use of quality improvement consultants, etc.

High Priority Contexts for Fall Prevention

- Patient Safety Culture, Teamwork, Leadership
  - Patient safety culture – org. level & unit level
  - Teamwork – unit level
  - Leadership – org. level & unit level
  - Less sensitive to:
    - Teamwork – org. level
- Organizational characteristics
  - Size
  - Existing quality/safety infrastructure
  - Less sensitive to:
    - Financial status
    - Academic status
    - Organizational complexity, etc.
- Etc.

HIE and Statistical Interactions

- Statistical formulation for HIE as interactions between intervention and contextual factor(s):
- $Yi = b0 + b1 \times Ti + b2 \times Ci + b12 \times Ti \times Ci + \varepsilon i,$
  - i denotes the unit of analysis (site)
  - Yi denotes the outcome measure
  - Ti denotes the intervention status
  - Ci denotes the contextual factor(s)
  - Ti × Ci denotes the "intervention × context" interaction(s)

Use Contextual Index to Reduce Dimensionality?

- Multiple contextual factors lead to multiple interaction terms for "intervention × context"
  - Lack of power, collinearity, difficult to interpret…
- Construct "contextual index", screen for presence of HIE using interaction between intervention and contextual index:
  - $b21 \times Ci1 + b22 \times Ci2 + \ldots + b2k \times Cik$
- More in Dr. Mangione-Smith's talk
- Analogous to Tukey's one-degree-of-freedom test for interaction in two-way ANOVA
  - Tukey, John (1949). "One degree of freedom for non-additivity". Biometrics 5 (3): 232–242.

Specification for HIE Depends on Evaluation Design

- Pre-post comparison
- Longitudinal comparison
- Matched comparison, post-only
- Matched comparison, pre-post
- Matched comparison, longitudinal
- Adjustment for covariates
- Validity depends on evaluation design too!

Pre-Post Comparison

- Assumes no secular trend
- Pre-intervention measure:
  - $Y0i = b0 + b2 \times Ci + \varepsilon 0i$
- Post-intervention measure:
  - $Y1i = b0 + b1 + b2 \times Ci + b12 \times Ci + \varepsilon 1i$
- Pre-Post Change (site-specific intervention effect):
  - $Di = Y1i - Y0i = b1 + b12 \times Ci + (\varepsilon 1i - \varepsilon 0i)$
- Variation: take multiple baseline measures, fit pre-intervention trend, compare post-measure with projection based on pre-intervention trend

Longitudinal Comparison

- Assumes no secular trend, gradual improvement over time under intervention
- Baseline measure:
  - $Y0i = b0 + b2 \times Ci + \varepsilon 0i$
- Repeated measures over time:
  - $Yti = b0 + b1 \times t + b2 \times Ci + b12 \times Ci \times t + \varepsilon ti$
- Rate of change (site-specific intervention effect)
  - $Ri = b1 + b12 \times Ci + \delta i$
- Variation: adjust for pre-intervention trend

Matched Comparison, Post-Only

- Comparison site:
  - $Y0i = b0 + b2 \times Ci + \varepsilon 0i$
- Intervention site:
  - $Y1i = b0 + b1 + b2 \times Ci + b12 \times Ci + \varepsilon 1i$
- Intervention effect in i-th dyad:
  - $\Delta i = Y1i - Y0i = b1 + b12 \times Ci + (\varepsilon 1i - \varepsilon 0i)$

Matched Comparison, Pre-Post

- Pre-Post change for comparison site:
  - $D0i = b0 + b2 \times Ci + \varepsilon 0i$
- Pre-Post change for intervention site:
  - $D1i = b0 + b1 + b2 \times Ci + b12 \times Ci + \varepsilon 1i$
- Intervention effect for i-th dyad:
  - $\Delta i = D1i - D0i = b1 + b12 \times Ci + (\varepsilon 1i - \varepsilon 0i)$

Matched Comparison, Longitudinal

- Rate of change in comparison site:
  - $R0i = b0 + b2 \times Ci + \delta 0i$
- Rate of change in intervention site:
  - $R1i = b0 + b1 + b2 \times Ci + b12 \times Ci + \delta 1i$
- Intervention effect for i-th dyad:
  - $\Delta i = R1i - R0i = b1 + b12 \times Ci + (\delta 1i - \delta 0i)$

Adjustment for Covariates

- Basic model:

  $Yi = b0 + b1 \times Ti + b2 \times Ci$

  $+ b12 \times Ti \times Ci + \varepsilon i$

- Expanded model:

  $Yi = b0 + b1 \times Ti + b2 \times Ci + b3 \times Wi$

  $+ b12 \times Ti \times Ci + \varepsilon i$

- Wi = site level covariates that might be confounded with intervention status

Discussions

- It is important to assess heterogeneity of intervention effects (HIE) in dissemination-implementation research
- HIE can be specified as interactions between intervention and contextual factors
- Specification for HIE depends on evaluation design, as well as validity of HIE analyses