Fixed Effects Models for Multivariate Longitudinal Data

Inspired by Behavioral Data on HIV+ and HIV-at-Risk Individuals

Robert Weiss Juan Jia

Department of Biostatistics
UCLA School of Public Health
robweiss@ucla.edu

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Fixed Effects Models for Longitudinal Data from HIV Behavioral Studies

Longitudinal data analyses can have many predictors.

- Time trend descriptors
- Predictors of interest: demographics, drug use, risk groups, HIV status, health status, psychological state.
- Interest in 3-way and 4-way interactions.
- Even after removing redundant, similar and unpredictive predictors: 30 or more predictors is hardly unusual.

Many Outcomes Too!

- Several domains: drug usage, sex behavior, feelings/psych, other behaviors
- Outcomes parsed into different subcategories
- Number of sex partners (# HIV+, # HIV-, # bisexual, # male, . . .)
- Sex acts (vaginal, anal, protected, unprotected, with HIV- partners, . . .)
- Psychometric scales (BSI, coping styles) with several subscales
- Dozen or more outcomes quite common

Many Fixed Effects Coefficients to Estimate

- With 10 predictors and 10 outcomes, there are 100 coefficients to estimate.
- Outcomes are correlated and may relate to covariates in similar fashion
- Example: Outcomes: Depression, Obsessive compulsion, Avoid things that frighten you, Somatization
- All increase as following predictors change:
  - AIDS-symptoms no to yes
  - Can-get-enough-food yes to no
  - Has-enough-money yes to no
  - Previous-suicide-attempt no to yes

Too Many Fixed Effects Coefficients?

- Can we be more efficient?
- Perhaps by sharing coefficients across outcomes?
- In the extreme, could a single linear combination of x's be used to predict all outcomes?
- Idea: For all outcomes:
  - One common set of covariates x_{ij}
  - One common set of coefficients α
  - One common combination of predictors $x_{ij}'\alpha$ to predict them all

Single Linear Predictor Model

- Y_{ijk} – i*th* subject, *j*th time point, *k*th outcome.
- x_{ij} predictors at time t_{ij}.
- α regression coefficients.
- Link function $g(E[Y_{ijk}]) = \gamma_{0k} + \gamma_{1k} x'_{ij}\alpha$.
- Link $\gamma_{0k} + \gamma_{1k} * x'_{ij}\alpha$ maps from common combination of predictors scale $x'_{ij}\alpha$ to the linear predictor for the *k*th outcome.
- Generalized linear model link $g(\cdot)$ connects mean of *k*th outcome to linear predictor.
- Plus correlation structure (omitted today).

What if some outcomes do not follow this model?

- We may try to choose predictors and outcomes to follow this model, but . . .
- Option 1: Let data cluster outcomes into subsets of outcomes that follow this model.
- Jia and Weiss (2009a). Common predictor effects for multivariate longitudinal data. Statistics in Medicine, 1793–1804.
- Used AIC/BIC to select clusters. Model selection approach to cluster outcomes. Two articles later is
- Alber and Weiss (2009). A model selection approach to analysis of variance and covariance. Statistics in Medicine 28, 1821–1840. Methodology could be used to choose clusters.

Option 2: Diagnostic Approach

Check whether predictors and covariates do indeed follow the model.

- Predictors (mostly) selected for scientific reasons.
- Outcomes to be jointly modeled could be selected for model fit.
- For each outcome in turn: check that fit isn't improved by fitting the outcomes with a separate linear predictor.
- Delete outcomes that don't fit, i.e. fit with separate model.
- For each predictor in turn: check that overall fit isn't improved by having separate coefficients for outcome.
- Can't delete predictors for statistical reasons. Allow those predictors to have separate coefficients.

Example: Brief Symptom Inventory (BSI) Outcomes in Young People Living with HIV (Project TLC)

Outcomes:

- Depression (continuous)
- Obsessive compulsive (continuous)
- BS11 (Poor appetite) (0-1)
- BS13 (Temper uncontrolled) (0-1)
- BS21 (People not friendly) (0-1)
- BS31 (Avoid things that frighten you) (0-1)
- Somatization (Poisson)
- Anxiety: failed test of fit and so omitted.

Predictors

Predictor	Mean	SD	% $\geq$ 0
Male	.05	.20	.6
Age	.01	.07	.5
Can-get-enough-food	-.58	.16	.00
Has-enough-money	-.34	.16	.02
Marijuana	.17	.17	.8
Hard Drug	.05	.21	.6
AIDS Symptoms	.58	.13	1.0

Previous suicide attempt: positively predictive of Depression, Obsessive compulsion, Avoid things that frighten you, and Somatization but not the other 3 outcomes.

A Multivariate Fixed Effects Model with Many Fewer Fixed Effect Parameters.

- 7 outcomes in final model
- 8 predictors
- 56 possible coefficients.
- Coefficients actually needed: 7 + 7 + 7 = 21.
- Approximately 23% smaller standard deviations for coefficients than with usual model.
- Bayesian model fit using WinBUGS.
- Bayesian methods generally easier to use and interpret.