# Workshop on Multilevel Modeling

Andy Grogan-Kaylor

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## Navigation

When this document is presented in slide show format, some slides may be long, and you may need to scroll down to see the full slide. In slide show format `b` makes text bigger, and `s` makes text smaller.

## Cross Sectional Model

### Get Data

```
. use "../multilevel-thinking/simulate-and-analyze-multilevel-data/simulated_multilevel_data.d
> ta", clear
```

### The Equation

$$\text{outcome}_{ij} = \beta_0 + \beta_1 \text{parental warmth} + \beta_2 \text{physical punishment} + \beta_3 \text{time} +$$

$$\beta_4 \text{group}_2 + \beta_5 HDI +$$

$$u_{0j} + u_{1j} \times \text{parental warmth} + e_{ij}$$

### Descriptive Statistics

```
. summarize // descriptive statistics
```

| Variable | Obs | Mean | Std. dev. | Min | Max |
|---|---|---|---|---|---|
| country | 3,000 | 15.5 | 8.656884 | 1 | 30 |
| HDI | 3,000 | 64.76667 | 17.24562 | 33 | 87 |
| family | 3,000 | 50.5 | 28.87088 | 1 | 100 |
| id | 0 | | | | |
| group | 3,000 | 1.496 | .5000674 | 1 | 2 |
| physical_p~t | 3,000 | 1.516 | 1.884744 | -2 | 5 |
| warmth | 3,000 | 2.543667 | 2.431336 | -2 | 7 |
| outcome | 3,000 | 53.45039 | 6.884502 | 25.02363 | 81.63657 |

### Spaghetti Plot

```
. spagplot outcome warmth, id(country) scheme(s1color)
.
. graph export spagplot1.png, width(1000) replace
file /Users/agrogan/Desktop/GitHub/multilevel-workshop/spagplot1.png saved as PNG format
```

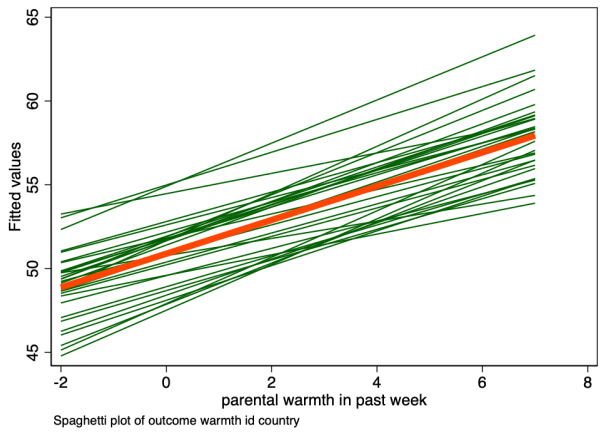


Figure 1: Spaghetti Plot of Outcome by Warmth by Country

# Unconditional Model

## Model

```
. mixed outcome || country: // unconditional model
Performing EM optimization:
Performing gradient-based optimization:
Iteration 0:   log likelihood = -9956.6096
Iteration 1:   log likelihood = -9956.6096
Computing standard errors:
Mixed-effects ML regression                     Number of obs     =      3,000
Group variable: country                         Number of groups  =         30
                                                Obs per group:
                                                              min =        100
                                                              avg =      100.0
                                                              max =        100
                                                Wald chi2(0)      =          .
Log likelihood = -9956.6096                     Prob > chi2       =          .
```

| outcome | Coefficient | Std. err. | z | P>\|z\| | [95% conf. | interval] |
|---|---|---|---|---|---|---|
| _cons | 53.45039 | .3702932 | 144.35 | 0.000 | 52.72463 | 54.17615 |

| Random-effects parameters | Estimate | Std. err. | [95% conf. | interval] |
|---|---|---|---|---|
| country: Identity | | | | |
| var(_cons) | 3.676471 | 1.062168 | 2.086944 | 6.476667 |
| var(Residual) | 43.70413 | 1.134121 | 41.53688 | 45.98446 |

```
LR test vs. linear model: chibar2(01) = 175.05        Prob >= chibar2 = 0.0000
```

## ICC

```
. estat icc
Intraclass correlation
```

| Level | ICC | Std. err. | [95% conf. | interval] |
|---|---|---|---|---|
| country | .0775944 | .0207813 | .0454528 | .129384 |

## Full Model

```
. mixed outcome warmth physical_punishment i.group HDI || country: warmth // multilevel model
Performing EM optimization:
Performing gradient-based optimization:
Iteration 0:   log likelihood = -9616.8876
Iteration 1:   log likelihood = -9616.3536
Iteration 2:   log likelihood = -9616.3475
Iteration 3:   log likelihood = -9616.3475
Computing standard errors:
Mixed-effects ML regression                     Number of obs     =      3,000
Group variable: country                         Number of groups  =         30
                                                Obs per group:
                                                              min =        100
                                                              avg =      100.0
                                                              max =        100
                                                Wald chi2(4)      =     764.27
Log likelihood = -9616.3475                     Prob > chi2       =     0.0000
```

| outcome | Coefficient | Std. err. | z | P>\|z\| | [95% conf. | interval] |
|---|---|---|---|---|---|---|
| warmth | .9826773 | .0444598 | 22.10 | 0.000 | .8955377 | 1.069817 |
| physical_punishment | -.9239791 | .0573291 | -16.12 | 0.000 | -1.036342 | -.8116161 |
| 2.group | .7280691 | .2163084 | 3.37 | 0.001 | .3041125 | 1.152026 |
| HDI | .0075692 | .0206019 | 0.37 | 0.713 | -.0328098 | .0479482 |
| _cons | 51.50019 | 1.392584 | 36.98 | 0.000 | 48.77077 | 54.2296 |

| Random-effects parameters | Estimate | Std. err. | [95% conf. | interval] |
|---|---|---|---|---|
| country: Independent | | | | |
| var(warmth) | 5.38e-17 | 4.71e-16 | 1.90e-24 | 1.53e-09 |
| var(_cons) | 3.43782 | .9775981 | 1.968931 | 6.002548 |
| var(Residual) | 34.7837 | .9026366 | 33.0588 | 36.5986 |

```
LR test vs. linear model: chi2(2) = 210.87                Prob > chi2 = 0.0000
Note: LR test is conservative and provided only for reference.
.
. est store crosssectional // store estimates
```

# Longitudinal Model

## Setup

```
. use "../multilevel-thinking/simulate-and-analyze-multilevel-data/simulated_multilevel_longit
> udinal_data.dta", clear
```

## The Equation

$$\text{outcome}_{ij} = \beta_0 + \beta_1 \text{parental warmth} + \beta_2 \text{physical punishment} + \beta_3 \text{time} +$$

$$\beta_4 \text{group}_2 + \beta_5 HDI +$$

$$u_{0j} + u_{1j} \times \text{parental warmth} +$$

$$v_{0i} + v_{1i} \times t + e_{ij}$$

## Descriptive Statistics

```
. summarize // descriptive statistics
```

| Variable | Obs | Mean | Std. dev. | Min | Max |
|---|---|---|---|---|---|
| country | 9,000 | 15.5 | 8.655922 | 1 | 30 |
| HDI | 9,000 | 64.76667 | 17.2437 | 33 | 87 |
| family | 9,000 | 50.5 | 28.86767 | 1 | 100 |
| id | 0 | | | | |
| group | 9,000 | 1.496 | .5000118 | 1 | 2 |
| t | 9,000 | 2 | .8165419 | 1 | 3 |
| physical_p_t | 9,000 | 1.517111 | 1.884289 | -2 | 5 |
| warmth | 9,000 | 2.533778 | 2.449075 | -2 | 7 |
| outcome | 9,000 | 54.43846 | 7.019933 | 25.02363 | 81.63657 |

## Alternate Plot

```
. encode id, generate(idNUMERIC) // numeric version of id
.
. * spagplot outcome t if idNUMERIC <= 10, id(idNUMERIC) scheme(s1color)
.
. twoway (lfit outcome t) (scatter outcome t) if idNUMERIC <= 10, by(idNUMERIC) scheme(s1color
> )
.
. graph export spagplot2.png, width(1000) replace
file /Users/agrogan/Desktop/GitHub/multilevel-workshop/spagplot2.png saved as PNG format
```

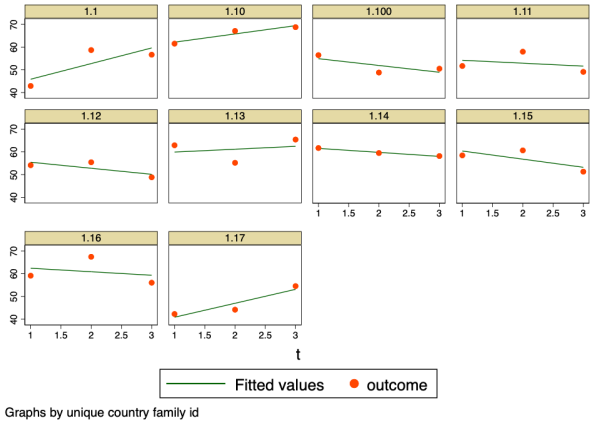


Figure 2: Alternate Plot of Outcome by Time by Individual; First 10 Observations

## Unconditional Model

### Model

```
. mixed outcome || country: || id: // unconditional model
Performing EM optimization:
Performing gradient-based optimization:
Iteration 0:   log likelihood = -29398.984
Iteration 1:   log likelihood = -29398.984
Computing standard errors:
Mixed-effects ML regression                     Number of obs     =      9,000
        Grouping information
```

| Group variable | No. of groups | Observations per group Minimum | Average | Maximum |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| country | 30 | 300 | 300.0 | 300 |
| id | 3,000 | 3 | 3.0 | 3 |

Wald chi2(0) = .
Log likelihood = -29398.984 Prob > chi2 = .

| outcome | Coefficient | Std. err. | z | P>\|z\| | [95% conf. | interval] |
|---|---|---|---|---|---|---|
| _cons | 54.43846 | .3767998 | 144.48 | 0.000 | 53.69995 | 55.17698 |

| Random-effects parameters | Estimate | Std. err. | [95% conf. | interval] |
|---|---|---|---|---|
| country: Identity | | | | |
| var(_cons) | 3.995172 | 1.099853 | 2.329182 | 6.85279 |
| id: Identity | | | | |
| var(_cons) | 16.98591 | .7068169 | 15.65556 | 18.42931 |
| var(Residual) | 28.29352 | .5165663 | 27.29897 | 29.3243 |

LR test vs. linear model: chi2(2) = 1819.49 Prob > chi2 = 0.0000

Note: LR test is conservative and provided only for reference.

### ICC

```
. estat icc
```

Intraclass correlation

| Level | ICC | Std. err. | [95% conf. | interval] |
|---|---|---|---|---|
| country | .0810797 | .0205569 | .0488675 | .1315879 |
| id\|country | .4257992 | .0163912 | .3940284 | .4581946 |

## Full Model

```
. mixed outcome t warmth physical_punishment i.group HDI || country: warmth || id: t // multil
> evel model
```

Performing EM optimization:

Performing gradient-based optimization:

```
Iteration 0:   log likelihood = -28546.535
Iteration 1:   log likelihood = -28524.928
Iteration 2:   log likelihood = -28524.635
Iteration 3:   log likelihood = -28524.601
Iteration 4:   log likelihood = -28524.598
Iteration 5:   log likelihood = -28524.598
```

Computing standard errors:

Mixed-effects ML regression Number of obs = 9,000

Grouping information

| Group variable | No. of groups | Observations per group Minimum | Average | Maximum |
|---|---|---|---|---|
| country | 30 | 300 | 300.0 | 300 |
| id | 3,000 | 3 | 3.0 | 3 |

Wald chi2(5) = 1818.96
Log likelihood = -28524.598 Prob > chi2 = 0.0000

| outcome | Coefficient | Std. err. | z | P>\|z\| | [95% conf. | interval] |
|---|---|---|---|---|---|---|
| t | .9929535 | .0658203 | 15.09 | 0.000 | .8639481 | 1.121959 |
| warmth | 1.047045 | .0338001 | 30.98 | 0.000 | .9807983 | 1.113292 |

| | | | | | | |
|---|---|---|---|---|---|---|
| physical_punishment | -.9377711 | .0381761 | -24.56 | 0.000 | -1.012595 | -.8629473 |
| 2.group | .8219777 | .1530957 | 5.37 | 0.000 | .5219157 | 1.12204 |
| HDI | .0047772 | .0205645 | 0.23 | 0.816 | -.0355285 | .0450829 |
| _cons | 50.50391 | 1.389611 | 36.34 | 0.000 | 47.78032 | 53.2275 |

| Random-effects parameters | Estimate | Std. err. | [95% conf. | interval] |
|---|---|---|---|---|
| country: Independent | | | | |
| var(warmth) | .0071126 | .0086595 | .0006542 | .0773303 |
| var(_cons) | 3.560166 | .9807369 | 2.074844 | 6.108788 |
| id: Independent | | | | |
| var(t) | 3.01e-10 | 2.17e-10 | 7.29e-11 | 1.24e-09 |
| var(_cons) | 8.722256 | .4792014 | 7.831839 | 9.713906 |
| var(Residual) | 25.98996 | .4745951 | 25.07622 | 26.93699 |

LR test vs. linear model: chi2(4) = 1331.93 Prob > chi2 = 0.0000

Note: LR test is conservative and provided only for reference.

```
.
. est store longitudinal // store estimates
```

# Nice Table of Results

```
. est table crosssectional longitudinal, ///
> b(%9.3f) star stats(N ll chi2) ///
> varwidth(20) modelwidth(15)
```

| Variable | crosssectional | longitudinal |
|---|---|---|
| outcome | | |
| warmth | 0.983*** | 1.047*** |
| physical_punishment | -0.924*** | -0.938*** |
| group | | |
| 2 | 0.728*** | 0.822*** |
| HDI | 0.008 | 0.005 |
| t | | 0.993*** |
| _cons | 51.500*** | 50.504*** |
| lns1_1_1 | | |
| _cons | -18.731*** | -2.473*** |
| lns1_1_2 | | |
| _cons | 0.617*** | 0.635*** |
| lnsig_e | | |
| _cons | 1.775*** | 1.629*** |
| lns2_1_1 | | |
| _cons | | -10.963*** |
| lns2_1_2 | | |
| _cons | | 1.083*** |
| Statistics | | |
| N | 3000 | 9000 |
| ll | -9616.347 | -2.85e+04 |
| chi2 | 764.268 | 1818.962 |

Legend: * p<0.05; ** p<0.01; *** p<0.001

# QUESTIONS???