HLM — An Introduction

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Multilevel Regression Modeling, 2009

HLM — An Introduction

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Introduction

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Introduction

Today we look back at some of the analyses we did in the last lecture, and recast them in the analytic framework of the popular statistics program HLM.

Introduction The HLM Program

Fitting Our Radon Models – An Introduction Varying Intercepts, Fixed Slope, Floor Predictor Varying Slopes, Fixed Intercept, Floor Predictor Varying Slopes, Fixed Intercept, Floor Predictor Adding a Level-2 Predictor

The HLM Program

The HLM Notation System

HLM is a popular software program that makes construction of basic multilevel models relatively straightforward. In particular, it does not require combination of models from two or more levels into a single regression model. Consequently, many find it very convenient and (relatively) easy to use, which has contributed to its popularity. In this introduction, we will revisit the models that we examined, and set them up and analyze them in HLM.

We assume that you have the HLM6 program (full or student version) installed on your computer.

The HLM Notation System

Two-Level Models in HLM

HLM uses a consistent notation for its models. Since this notation is displayed while models are being specified, it is easier to see precisely what has been specified.

Note that unlike the Gelman and Hill notation, the HLM notation implicitly assumes that data are broken into files by level, and therefore finds it convenient to specify the level 2 unit explicitly in the notation.

The HLM Notation System

The General Level-1 Model

Consider, for example, our radon data, in which houses are nested within counties, and at level-1 we wish to predict radon level from floor.

In this notational scheme, Y_{ij} stands for the outcome score (radon level) of the *i*th level-1 unit (i.e., the *i*th house) within the *j*th level-2 unit (county). So, for example, $Y_{1,13}$ would refer to the first house in the 13th county.

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The HLM Notation System

The General Level-1 Model

The basic model is

$$Y_{ij} = \beta_{0j} + \beta_{1j} X_{1ij} + \beta_{2j} X_{2ij} + \ldots + \beta_{Qj} X_{Qij} + r_{ij} \qquad (1)$$

In this model, the β_{qj} are level-1 coefficients, X_{qij} is the qth level-1 predictor for level-1 unit *i* within level-2 unit *j*. (The HLM manual refers to this as the predictor for the "*i*th case in unit *j*.") r_{ij} is the level-1 random effect, and σ^2 is the variance of r_{ij} . It is assumed that $r_{ij} \sim N(0, \sigma^2)$. By giving the β 's a second subscript we allow them to vary across level-2 units, so we can have variable slopes, variable intercepts, both, or neither.

The General Level-2 Model

The general level-2 model is

$$\beta_{qj} = \gamma_{q0} + \gamma_{q1} W_{1j} + \gamma_{q2} W_{2j} + \ldots + \gamma_{qS_q} W_{S_qj} + u_{qj} \quad (2)$$

The γ 's are *level-2 coefficients*, the W's are level-2 predictors, and the *u*'s are level-2 random effects. The *u*'s have a covariance matrix T with typical element $\tau_{qq'}$.

Special Cases

The HLM Notation System

The general two-level model allows for numerous special cases. For example, we can have

- A fixed level-1 coefficient, i.e., $\beta_{qj} = \gamma_{q0}$
- ③ A randomly varying level-1 coefficient with no level 2 predictors, i.e., $\beta_{qj} = \gamma_{q0} + u_{qj}$, or
- The full level-2 system $\beta_{qj} = \gamma_{q0} + \sum_{s=1}^{S_q} \gamma_{qs} W_{sj} + u_{qj}$.

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 Introduction

 The HLM Program

 Fitting Our Radon Models – An Introduction
 One-Way ANOVA with Random Effects

 Data Preparation

 Varying Intercepts, Fixed Slope, Floor Predictor

 Varying Slopes, Fixed Intercept, Floor Predictor

 Varying Slopes, Fixed Intercept, Ploor Predictor

 Adding a Level-2 Predictor

One-Way ANOVA with Random Effects – The Model

As we saw in the previous lecture, an extremely simple multilevel model has no predictors at either level-1 or level-2. In the HLM scheme, this may be written simply as follows. The level-1 model is

$$RADON_{ij} = \beta_{0j} + r_{ij} \tag{3}$$

The level-2 model is

$$\beta_{0j} = \gamma_{00} + u_{0j} \tag{4}$$

These can be combined into a single model,

$$RADON_{ij} = \gamma_{00} + u_{0j} + r_{ij} \tag{5}$$

which you can see is of the classic random-effects ANOVA form

 $\langle \alpha \rangle$

One-Way ANOVA with Random Effects Data Preparation Constructing the MDM File Outcome Variable Specification Model Analysis

Data Preparation and Input

HLM has limited (and somewhat disguised) data input capabilities. In practice, you will probably input most of your data as either SPSS *.sav* files, or comma-delimited ASCII files with a header containing column names. Since R writes ascii files routinely using the write.table() function (and the sep = ',' option), and also has extensive data manipulation capabilities, you may find it convenient to use R to construct your HLM files.

One-Way ANOVA with Random Effects Data Preparation Constructing the MDM File Outcome Variable Specification Model Analysis

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Data Preparation and Input

The link between the level-1 and level-2 models in the HLM parameterization is the subscript j, which refers to the county variable. To set up the data for HLM, we need two files, one for the level-1 variables, one for the level-2 variables. Each file has to be sorted in ascending order of the ID variable.

We include county, a log-transformed radon, and the floor predictor in the level-1 file, and county and uranium in the level-2 file.

Since (unlike R), HLM does not have built-in data transformation capabilities, we log-transform **radon** prior to saving the level-1 file.

One-Way ANOVA with Random Effects Data Preparation Constructing the MDM File Outcome Variable Specification Model Analysis

Constructing the MDM File

Setting up the Multivariate Data Matrix (MDM) file is a key first step to using HLM2 to analyze a 2-level model problem.

Make sure you have downloaded the files radon1.txt and radon2.txt from the course website. Begin by starting up HLM. Then click on the *Make New MDM File -> Stat Package Input* menu option. (This is counterintuitive and very poor human factors design, since we are loading an ASCII file. Of course, this should be available under the ACII file input node.)



One-Way ANOVA with Random Effects Data Preparation Constructing the MDM File Outcome Variable Specification Model Analysis

Constructing the MDM File

Next, you will be asked to select a program.

Select HLM2.

Then click on the OK button.

elect mom type	
Hierarchical I	_inear Models
HLM2	HLM3
Hierarchical I	Multivariate Linear Models
○ HMLM	C HMLM2
Cross-classif C HCM2	ied Linear Models
ОК	Cancel

One-Way ANOVA with Random Effects Data Preparation Constructing the MDM File Outcome Variable Specification Model Analysis

Constructing the MDM File

A large dialog box will open. Go to the drop-down list for file type, and select *Anything else (Stat/Transfer)*.

MDM template file	MDM File	Name (use .mdm suffix)
File Name:		
Open mdmt file Save mdmt file Edit mdmt file	Input File Type	Anything else (Stat/Transfi 🗣
Necting of input data		SPSS/Windows
Nesting of input data		ISYSTAT
(• persons within groups (• measures within perso	ons	Stata
Level 4 One difference		Anything else (Stat/Transfer)

One-Way ANOVA with Random Effects Data Preparation Constructing the MDM File Outcome Variable Specification Model Analysis

Constructing the MDM File

Use the drop-down box to select the delimited ASCII file type.

Multilevel

Choose Level-	1 File			? 🔀
Look in	: 🔁 HLMIntro	- 🗧 主	🗃 🔟 -	
My Recent Documents Desktop My Documents	New Folder			
	File name:	".sd7;".sas7bdat	- [Open
My Network	Files of type:	SAS Data File- Versions 7/8/9	•	Cancel
Places	owse Level-2 F	SAS Data File-Versions 7/8/9 SAS V6 Data File-HP,IBM,SGI & SUN Unix Excel SPSS Data File 1-2-3		c

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One-Way ANOVA with Random Effects Data Preparation Constructing the MDM File Outcome Variable Specification Model Analysis

Constructing the MDM File

If you are not already there, go to the directory where the data files are.

Select *radon1.txt* and click on the *Open* button.

One-Way ANOVA with Random Effects Data Preparation Constructing the MDM File Outcome Variable Specification Model Analysis

Constructing the MDM File

Look in the dialog box for the grouping that is titled *Level-1* Specification. I've highlighted the group in red in the picture below.

On the right side of that grouping is a button Choose Variables.

Multilevel

0	0 1 0				
	Make MDM - HEM2				
	MDM template file MDM File Name (use .mdm suffb)				
	File Name:				
	Open mdmt file Save mdmt file Edit mdmt file Input File Type Anything else (Stat/Transfi 🗸				
	Nesting of input data C persons within groups C measures within persons				
	Level-1 Specification Browse Level-1 File Name: CVIIICurrent Projects/IMLExtUnestures/HLMintrolrad Choose Yariables Missing Data? Polete missing data when: PiNe ^ Yes ^ making mdm ^ running analyses				
	Level-2 Specification Browse Level-2 File Name: Choose Variables				
Click on it.	Make MDM Check Stats Done	₽ ► ∢	≡ ▶	< ≣ >	

HLM — An Introduction

One-Way ANOVA with Random Effects Data Preparation Constructing the MDM File Outcome Variable Specification Model Analysis

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Constructing the MDM File

A dialog box will open up that will allow you to select and classify level-1 variables. The variable that spans the two levels of your model is **county**, and this variable is designated an ID variable. The variables **radon** and **floor** are in the level-1 model, so they are checked off as being in the MDM. When you are ready to exit the dialog, it should look like this:

county	ID 🔽 in MDM	🖂 ID 厂 in MDM
radon	ID 🔽 in MDM	D D ID MDM
floor	🗆 ID 🔽 in MDM	🔲 🗆 🗖 in MDM
		🗖 D 🗖 in MDM
		D D T in MDM
		D D D in MDM
		D D D in MDM
		D D T in MDM
		D D ID ID MDM
		D D D in MDM
		D D D in MDM
		D D D In MDM

One-Way ANOVA with Random Effects Data Preparation Constructing the MDM File Outcome Variable Specification Model Analysis

Constructing the MDM File

Next, go to the *Level-2 Specification* group and first, click on the *Browse* button. Select the file *radon2.txt*. Second, click on the *Choose Variables* button.

IDM template file	MDM File Name (use .mdm suffb)
Open mdmt file Save mdmt file Edit mdmt file	Input File Type Anything else (Stat/Transfi 👻
Vesting of input data	ons
.evel-1 Specification Browse Level-1 File Name: C:\IIICurrent Projects\ML Missing Data? Delete missing data when:	RMLecturesVHLMIntroVrad Choose Variables
No C Yes C making mdm C running:	mayses
C No C Yes C making mdm C running: evel-2 Specification Brones Level-2 File Name: First	Second Choose Variables

One-Way ANOVA with Random Effects Data Preparation Constructing the MDM File Outcome Variable Specification Model Analysis

Constructing the MDM File

This will take you to another variable selection dialog. Again county is the ID variable, and uranium, a level-2 predictor, is added to the MDM file. We will not use all the variables in the MDM file in our first model, but we can re-use this file for other more complicated models.

Choose varia	bles - HLM2	
county	D in MDM	D 🗖 in MDM
uranium	ID 🔽 in MDM	D 🗖 in MDM
[D D II IN MDM	D 🗖 in MDM
	D D T in MDM	ID 🔽 in MDM
	D D D In MDM	ID 🔽 in MDM
	D D T IN MDM	D D 🗂 in MDM
	D D ID ID MDM	D D m in MDM
	D D in MDM	D D T in MDM
	E ID E in MDM	D 🗖 in MDM
		F ID F In MDM
		L ID L IN WDM
	D D In MDM	D D D in MDM
	e. Seminaria es	1
Page 1	of 1 🕢 🗡	OK Cancel

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One-Way ANOVA with Random Effects Data Preparation Constructing the MDM File Outcome Variable Specification Model Analysis

Constructing the MDM File

At this point, the HLM program again exhibits poor human factors design. The necessary next step is to save a mdmt "template file." However in order to do that, you have to enter the name of the mdm file you want to save! You enter *radon.mdm* in the appropriate edit field, then click on *Save mdmt file*.



One-Way ANOVA with Random Effects Data Preparation Constructing the MDM File Outcome Variable Specification Model Analysis

Constructing the MDM File

Once you've done saved the mdmt file, you can make the MDM file by clicking on the *make MDM* file at the bottom left.

MDM template file	MDM File	Name (use .mdm suffix)
File Name: C:\!!!Current Projects\!MLRM\Guided Tours\Gel	Radon.mdm	
Open mdmt file Save mdmt file Edit mdmt file	Input File Type	Anything else (Stat/Transfi 💌
Nesting of input data		
	ns	
evel-1 Specification		
Browse Level-1 File Name: C:)IIICurrent Projects)MLR	Mil ectures)HI Min	mirad Choose Variables
Browse Level-1 File Name: C:\IIICurrent Projects\MLR	MiLectures/HLMIn	trolrad Choose Variables
Browse Level-1 File Name: C:\IIICurrent Projects\IMLR Missing Data? Delete missing data when:	MiLectures\HLMin	trolrad Choose Variables
Browse Level-1 File Name: C:UICurrent ProjectsUMLR Missing Data? Delete missing data when: © No C Yes C making mdm C running ar	MLectures\HLMIn	rotrad Choose Variables
Browse Level-1 File Name: C-WICurrent ProjectsWILLR Missing Data? Delete missing data when: © No C Yes C making mdm C running ar eval. 2 Specification	MiLectures\HLMIn	trotrad Choose Variables
Browse Level-1 File Name: CMIICurrent ProjectsMMLR Missing Data? Defete missing data when: @ No _ C Yes C making mdm _ running an .evel-2 Specification	MiLectures\HLMIn	trotrad Choose Variables
Browse Level-1 File Name: C:\llCurrent Projects\llLER Missing Data? Delete missing data when:	MiLecturesIHLMin nalyses MiLecturesIHLMin	trovad Choose Variables
Browse Level-1 File Name: C:\IIICurrent ProjectsINULR Missing Data? Delete missing data when: - r No Yes C making mdm - running an unwei-2 Specification Browse Level-2 File Name: C:\IIICurrent ProjectsINULR	MiLecturesIHLMin halyses MiLecturesIHLMin	rotrad Choose Variables

One-Way ANOVA with Random Effects Data Preparation Constructing the MDM File Outcome Variable Specification Model Analysis

Constructing the MDM File

At this point, you are strongly advised to Examine the basic statistics for the MDM file you have just created. You do this by clicking on the *Check Stats* button as shown below.

MDM template file	MDM File Name (use .mdm suffix)
File Name: CAUCurrent Projects/MLRM/Guided Tours/Gel	radon.mdm
Open mdmt file Save mdmt file Edit mdmt file	Input File Type Anything else (Stat/Transfi 💌
Vesting of input data	
	ons
evel-1 Specification	
Browse Level-1 File Name: C.V!!Current Projects\!MLF	RMLectures\HLMIntro\rad Choose Variables
Browse Level-1 File Name: C:\!!Current Projects\!MLF	RMLectures\HLMIntro\rad
Browse Level-1 File Name: C:\!!Current Projects\!MLR Missing Data? Delete missing data when:	RMLectures\HLMIntro\rad Choose Variables
Browse Level-1 File Name: CMICurrent ProjectsWMLF Missing Data? Delete missing data when: G No C Yes C making mdm C running a	RMLectures\HLMIntrolrad Choose Variables
Browse Level-1 File Name: CXIIICurrent Projects/MLL5 Missing Data? © No C Yes C making mdm C running a web-2 Specification	RMLecturesHLMIntrotrad Choose Variables
Browse Level-1 File Name. CMBCurrent ProjectsIMLF Missing Data? Delete missing data when: C No C Yes C making mdm C running a web 2 Spectration	RMLecturesHLMIntrolvad Choose Variables
Browse Level 1 File Name: C.WICurrent ProjectsWILL Missing Data? Delete missing data when: If No Yes If Missing Data? C.WICurrent ProjectsWILL If No Yes If No Yes If No Yes If No C.WICurrent ProjectsWILL Browse Level 2 File Name: C.WICurrent ProjectsWILL	RMLectureSHLMIntrolrad Choose Variables RMLectureSHLMIntrolrad Choose Variables
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One-Way ANOVA with Random Effects Data Preparation Constructing the MDM File Outcome Variable Specification Model Analysis

Constructing the MDM File

Examine the statistics, see if you have chosen the correct variables, and check whether the descriptive statistics make sense.

Then click Done

HLM2MDM.STS - Notepad					
File Edit Format View Help					
1					
	LEVEL	L-1 DESCRIPTIVE	STATIST	ICS	
VARIABLE NAME	N	MEAN	SD	MINIMUM	MAXIMUM
RADON	919	1.22	0.85	-2.30	3.88
FLOOR	919	0.17	0.37	0.00	1.00
	LEVEI	-2 DESCRIPTIVE	E STATIST	ICS	
VARIABLE NAME	N	MEAN	SD	MINIMUM	MAXIMUM
URANIUM	85	0.01	0.38	-0.88	0.53

Level-1 Specification

The next step is to specify the model.

Because this model is so fundamental, there isn't much specifying to do. Note that the Level-1 Button is highlighted.



One-Way ANOVA with Random Effects Data Preparation Constructing the MDM File **Outcome Variable Specification** Model Analysis

Level-1 Specification

One-Way ANOVA with Random Effects Data Preparation Constructing the MDM File **Outcome Variable Specification** Model Analysis

our first step is to choose the Level-1 outcome variable. Click on *RADON* and a flying menu will open. Choose *Outcome* variable. You have now selected your outcome variable.

Eilo P	ILM: hlm2	MDM F	ile: Rac	lon.m
FIE D	asic betuings	Outer	permilas	RUIT
Uu	tcome			
>> Le	evel-1 <<			
Le	evel-2			
	CPT1			
FLO	Outcome v	ariable		
CLO -	add variabl	Sincen	itered	
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	add variabl	e grand	centered	í – 1
	Delete vari	able fro	m model	

One-Way ANOVA with Random Effects Data Preparation Constructing the MDM File **Outcome Variable Specification** Model Analysis

Constructing the MDM File

Next, you will see a window open up. This window will contain the current model specification in HLM notation. Note that a baseline Level-2 model has already been specified. Normally, you would next enter the Level-2 specification, but in this case, we are actually finished.

🞬 WHLM: hlm2	MDM File: radon.mdm	
File Basic Settings	Other Settings Run Analysis Help	
Outcome >> Level-1 << Level-2	LEVEL 1 MODEL RADON _{<i>ij</i>} = $\beta_{0j} + r_{ij}$	-
INTROPTI RADON FLOOR	LEVEL 2 MODEL $\beta_{0j} = \gamma_{00} + u_{0j}$	

One-Way ANOVA with Random Effects Data Preparation Constructing the MDM File **Outcome Variable Specification** Model Analysis

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Outcome Variable Specifications

The next step is to specify the characteristics of the outcome variable. Click on the *Outcome* button.

WHLM: hlm2 MDM File: Radon.mdm	
ile Basic Settings Other Settings Run Analysis Help	
>> Level-1 <<	
Level-2	
INTROPTI RADON	
FLOOR	
	Mixed

One-Way ANOVA with Random Effects Data Preparation Constructing the MDM File **Outcome Variable Specification** Model Analysis

Outcome Variable Specification

You'll see the dialog pictured below. Because we're assuming a normally distributed outcome, you don't have to do anything, although, if you wish, you could save residual files for analysis by another program.

Just click *Ok.* Note: if you don't do this, your model will not be specified! Most modern software assumes a default (in this case a normal outcome variable) but HLM does not.

Basic Model Specifications - HLM2
Distribution of Outcome Variable If Normal (Continuous) If Bernoulli (0 or 1) If Poisson (constant exposure)
C Binomial (number of trials) C Poisson (variable exposure)
C Multinomial Number of categories
Over dispersion Level-1 Residual File Level-2 Residual File
Title no title
Output file name C:VIICurrent ProjectsVMLRM\Guided Tours\Gelman
Graph file name C:VIICurrent ProjectsVMLRM/Guided Tours\Gelman
Cancel OK

One-Way ANOVA with Random Effects Data Preparation Constructing the MDM File Outcome Variable Specification Model Analysis

Constructing the MDM File

If you wish, HLM will automatically combine the two models into a single *mixed model*, which might be especially useful if you wish to use another program (like R) to analyze the model. Simply click on the *Mixed* button in the lower right corner of the main window.

In this case we can see that this model is indeed simply the 1-Way random-effects ANOVA.

Mixed Model	
$RADON_{ij} = \gamma_{00} + u_{0j} + r_{ij}$	

Analyzing the Model

One-Way ANOVA with Random Effects Data Preparation Constructing the MDM File Outcome Variable Specification Model Analysis

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Click on the *Run Analysis* button. HLM will open a DOS window and the model will run. There will be a brief pause near the end of calculations. Don't interrupt! The window will eventually shut.

🚟 WHLM: hlm2	MDM File: Radon.mdm	
File Basic Settings	Other Settings Run Analysis Help	
Outcome	LEVEL 1 MODEL	<u>^</u>
>> Level-1 << Level-2	$RADON_{ij} = \beta_{0j} + r_{ij}$	3
INTROPT1 RADON FLOOR	LEVEL 2 MODEL $\beta_{0j} = \gamma_{00} + u_{0j}$	

Viewing Output

One-Way ANOVA with Random Effects Data Preparation Constructing the MDM File Outcome Variable Specification Model Analysis

The output window will not open automatically. You need to select the $File \rightarrow View \ Output$ menu option.

🞬 WHLM: hlm2 MDM File: radon.mdm 🛛 Comman	File: newcmd.hlm
File Basic Settings Other Settings Run Analysis Help	
Create a new model using an existing MDM file Edit/Run old command(.html.rmlm) file Manually edit.command(.html.nmlm) file Save Save As	
Save model as .emf Save mixed model as .emf	
Make new MDM file Make new MDM from old MDM template(.mdmt) file Display MDM stats	
View Output	
Graph Equations	•
Preferences	
Exit	

Viewing Output

One-Way ANOVA with Random Effects Data Preparation Constructing the MDM File Outcome Variable Specification Model Analysis

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The text window has a lot of superfluous information in it.

Halfway down, we encounter the results of estimation. I've excerpted key results.

```
The value of the likelihood function at iteration 6 = -1.129721E+003
The outcome variable is
                      RADON
Final estimation of fixed effects:
                                   Standard
                                                      Approx.
   Fixed Effect Coefficient Error T-ratio d.f.
                                                              P-value
For
         INTRCPT1, BO
   INTRCPT2, G00 1.312564 0.048894 26.845
                                                          84
                                                                0.000
Final estimation of variance components:
Random Effect
                      Standard Variance df
                                                    Chi-square P-value
                   Deviation Component
INTRCPT1, U0 0.30943 0.09574
level-1, R 0.79789 0.63663
                                            84
                                                     226.17987
                                                                 0.000
Statistics for current covariance components model
Deviance
                            = 2259 442314
Number of estimated parameters = 2
```

One-Way ANOVA with Random Effects Data Preparation Constructing the MDM File Outcome Variable Specification Model Analysis

Comparing HLM and R Basic Output

Let's compare these results to comparable results in R. We can see that they are essentially the same, although HLM includes a significance test that is not reported by R.

```
Linear mixed model fit by REML
Formula: radon \sim 1 + (1 | county)
             AIC BIC logLik deviance REMLdev
      2265 2280 -1130
                                                                                                                                                2255
                                                                                                                                                                                                     2259
 Random effects:
      Groups
                                                         Name
                                                                                                                                           Variance Std.Dev.
      county (Intercept) 0.095813 0.30954
      Residual
                                                                                                                                               0.636621 0.79789
Number of obs: 919, groups: county, 85
Fixed effects:
                                                                              Estimate Std. Error t value
 (Intercept) 1.31257 0.04891
                                                                                                                                                                                                                              26.84

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Adding a Level-1 Predictor

Adding a Floor Predictor

Now we wish to add floor as a predictor at level 1. In this case, we do not center the variable. Click on the variable name as shown in the snapshot below.

🚟 WHLM: hlm2	MDM File: radon.mdm Command File: newcmd.h	ılm 📃 🗖	×			
File Basic Settings	Other Settings Run Analysis Help					
Fie Basi: Settings Outcome 3> Level-1 << Level-2 INTRCT1 RADON FLOC Outcome add vani add vani Delate v	Other Stattings: Run Analysis: Heb LEVEL 1 MODEL RADON, $g = \beta_0 + r_g$ LEVEL 2 MODEL $B_{\mu\nu} = \gamma_{\mu\nu} + k_g$ variable Call Drampion France Be over Carteria					
		Mixed	I	□→∢舂→	◆ 豊 → ◆ 3	
		Multilevel H	LM — An In	troduction		

Checking the Model

Adding a Level-1 Predictor

You'll notice the model has changed. Notice that the random component for the slope at level two is greyed out. You can toggle the random components on and off by clicking on them.

🚟 WHLM: hlm2	MDM File: radon.mdm Command File: newcmd.hlm	
File Basic Settings	Other Settings Run Analysis Help	
Outcome Level-1 >> Level-2 <<	LEVEL 1 MODEL RADON _{ij} = $\beta_{0j} + \beta_{1j}$ (FLOOR _{ij}) + r_{ij}	
INTRCPT2 URANIUM	LEVEL 2 MODEL $\begin{array}{c} \beta_{0j} = \gamma_{00} + u_{0j} \\ \beta_{1j} = \gamma_{10} + u_{1j} \end{array}$	

Adding a Level-1 Predictor

Analyzing the Output

Next, we analyze the data, after saving our model with an appropriate name. Again, I have excerpted key results.

The outcome van Final estimatio	riable is on of fix	RADON ed effects:				
Fixed Effect	t	Coefficient	Standard Error	T-ratio	Approx. d.f.	P-value
For INTRO INTRCPT2, G	CPT1, B0 00	1.461579	0.051564	28.345	84	0.000
For FLOOR s INTRCPT2, G	lope, B1 10	-0.692979	0.070430	-9.839	917	0.000
Final estimation	on of var	iance componen	ts:			
Random Effect		Standard Deviation	Variance Component	df	Chi-square	P-value
INTRCPT1, level-1,	UO R	0.32812 0.75560	0.10766 0.57093	84	277.04086	0.000

Statistics for current covariance components model

Deviance = 2169.467425 Number of estimated parameters = 2

Adding a Level-1 Predictor

Comparing with R Output

Previously, we saw that the R output from lmer() produced these virtually identical results.

```
> fit.1 ~ lmer(radon ~ floor + (1 | county))
> summary(fit.1)
```

```
Linear mixed model fit by REML
Formula: radon ~ floor + (1 | county)
 AIC BIC logLik deviance REMLdev
2179 2199 -1086
                      2164
                              2171
Random effects:
                      Variance Std. Dev.
Groups
         Name
county (Intercept) 0.108
                               0.328
Residual
                      0.571
                               0.756
Number of obs: 919, groups: county, 85
```

Fixed effects: Estimate Std. Error t value (Intercept) 1.4616 0.0516 28.34 floor -0.6930 0.0704 -9.84

```
Correlation of Fixed Effects:
(Intr)
floor -0.288
```

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Specifying the Model

Specifying the Model Analyzing the Model

Shifting to a model where the intercept is fixed across groups but the slope for a **floor** predictor varies is very simple. We simply disconnect one error term and connect the other at level-2. First, point to the first line of the level-2 model and right click, opening a window to *Toggle the error term* as shown below. Then click to grey the error term. This means the u_{0j} term will not be included in the model.

🚟 WHLM: hlm2	MDM File: radon.mdm 🛛 Command File: RandomInterceptFixedSlope.hlm 🔳 🗖 🔀
File Basic Settings	Other Settings Run Analysis Help
Outcome Level-1	LEVEL 1 MODEL
>> Level-2 <<	$RADON_{ij} = \beta_{0j} + \beta_{1j} (FLOOR_{ij}) + r_{ij}$
URANIUM	$\frac{\beta_{0j} = \gamma_{00} + u_{0j}}{1000}$ Togole error term
	$\beta_{ij} = \gamma_{i0} + u_{ij} \qquad \qquad$

Specifying the Model Analyzing the Model

Specifying the Model

Next, right click the second line of the model and toggle on the u_{1j} term. Now the model is set up to have varying slopes but a fixed intercept. When you are done, your model should look like this:

🞬 WHLM: hlm2	MDM File: radon.mdm Command File: FixedInterceptRandomSlope.hlm 🗐 🗖 🔀
File Basic Settings	Other Settings Run Analysis Help
Outcome	LEVEL 1 MODEL
Level-1	
>> Level-2 <<	$RADON_{ij} = p_{0j} + p_{1j}(FLOOR_{ij}) + r_{ij}$
INTROPT2	LEVEL 2 MODEL
URANIUM	$\beta_{0j} = \gamma_{00} + \omega_{0j}$
	$\beta_{ij} = \gamma_{i0} + u_{ij}$

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Specifying the Model Analyzing the Model

Analyzing the Model

Analyze the model, and examine the data. Here are some of the results.

The outcome v	ariable is	RADON				
Final estima	tion of fi	xed effects:				
Fixed Eff	ect	Coefficient	Standard Error	T-ratio	Approx. d.f.	P-value
For IN	TRCPT1, BO)				
INTRCPT2,	G00	1.326744	0.029321	45.248	917	0.000
For FLUUR INTRCPT2,	G10 G10	-0.554486	0.089261	-6.212	84	0.000
Final estima	tion of va	riance compone	nts:			
Final estima Random Effec	tion of va	riance compone Standard Deviation	nts: Variance Component	 df	Chi-square	P-value
Final estima Random Effect	tion of va	Standard Deviation 0.34040	Variance Component 0.11587	 df 59	Chi-square 87.04679	P-value 0.010

Note: The chl-square statistics reported above are based on only 60 of 8b units that had sufficient data for computation. Fixed effects and variance components are based on all the data.

Image: A math a math

Specifying the Model Analyzing the Model

Comparing Results with R

Compare this result with the corresponding R output.

```
Linear mixed model fit by REML
Formula: radon ~ floor + (floor - 1 | county)
  AIC BIC logLik deviance REMLdev
 2259 2278 -1125
                      2242
                              2251
Random effects:
Groups
         Name Variance Std.Dev.
county
          floor 0.115
                         0.340
 Residual
                        0.812
                0.659
Number of obs: 919, groups: county, 85
Fixed effects:
            Ectimate Std Error t walue
```

	200111000	Dog. Ditoi	· · ur uo
(Intercept)	1.3267	0.0293	45.2
floor	-0.5546	0.0892	-6.2

```
Correlation of Fixed Effects:
(Intr)
floor -0.329
```

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Specifying the Model

Specifying the Model

Simply toggle on the error term at both levels. By now this should be a snap. To double check, examine the full mixed model and see how it compares to this:

 $RADON_{ij} = \gamma_{00} + \gamma_{10} FLOOR_{ij} + u_{0j} + u_{1j} FLOOR_{ij} + r_{ij} \quad (7)$

Then analyze the model.

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Analyzing the Output

Your basic output should look like this:

The value of the likelihood function at iteration 81 = -1.083243E+003The outcome variable is RADON

Final estimation of fixed effects:

Fixed Effect		Coefficient	Standard Error	T-ratio	Approx. d.f.	P-value
For INTRC INTRCPT2, G0	PT1, B0	1.462763	0.053874	27.152	84	0.000
For FLOOR sl INTRCPT2, G1	ope, B1 .0	-0.680984	0.087669	-7.768	84	0.000
Final estimatio	on of van	riance componen	nts:			
Random Effect		Standard Deviation	Variance Component	df	Chi-square	P-value
INTRCPT1, FLOOR slope, level-1,	UO U1 R	0.34875 0.34469 0.74612	0.12163 0.11881 0.55670	59 59	231.70805 81.23290	0.000 0.029

Note: The chi-square statistics reported above are based on only 60 of 85 units that had sufficient data for computation. Fixed effects and variance components are based on all the data.

Specifying the Model

Specifying the Model

Comparing to R Output

```
> fit.3 \leftarrow lmer(formula = radon \tilde{} floor + (1 + floor | county)) > summary(fit.3)
```

```
Linear mixed model fit by REML
Formula: radon ~ floor + (1 + floor | county)
  AIC BIC logLik deviance REMLdev
 2180 2209 -1084
                      2161
                              2168
Random effects:
Groups
         Name
                      Variance Std Dev. Corr
 county
        (Intercept) 0.122
                               0.349
                               0.344
                                      -0.337
          floor
                      0.118
 Residual
                               0.746
                      0.557
Number of obs: 919, groups: county, 85
Fixed effects:
            Estimate Std. Error t value
(Intercept) 1.4628
                         0.0539
                                  27.15
floor
            -0.6811
                         0.0876
                                  -7.78
Correlation of Fixed Effects:
      (Intr)
floor -0.381
```

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Adding Predictors at Level 2

The model can be enhanced by adding soil uranium as a predictor at level 2. In this case, we predict both the level-1 slopes and the level-1 intercepts from uranium. In HLM notation, the models become, at level 1,

$$RADON_{ij} = \beta_{0j} + \beta_{1j} FLOOR_{ij} + r_{ij}$$
(8)

and, at level 2,

$$\beta_{0j} = \gamma_{00} + \gamma_{01} \text{URANIUM}_j + u_{0j}$$
(9)
$$\beta_{1j} = \gamma_{10} + \gamma_{11} \text{URANIUM}_j + u_{1j}$$
(10)

Setting Up the Model in HLM

By now, specifying the model in HLM should be a breeze for you. Simply click on the *Level-2* button, then click on each line of the level 2 model and add the **uranium** variable to it.

When you are done, your model should match that shown on the preceding slide.

Analyzing Model Results

Analyze the model, and you should see results like these:

The outcome variable is RADON

Final estimation of fixed effects:

Fixed Effect	Coefficient	Standard Error	T-ratio	Approx. d.f.	P-value
For INTRCPT1,	BO				
INTRCPT2, GOO	1.468574	0.035310	41.591	83	0.000
URANIUM, GO1	0.808049	0.090780	8.901	83	0.000
For FLOOR slope,	B1				
INTRCPT2, G10	-0.670744	0.084647	-7.924	83	0.000
URANIUM, G11	-0.418380	0.227729	-1.837	83	0.069

Final estimation of variance components:

Random Effect		Standard Deviation	Variance Component	df	Chi-square	P-value
INTRCPT1,	UO	0.12509	0.01565	58	87.02121	0.008
FLOOR slope,	U1	0.30977	0.09596	58	77.51349	0.044
level-1,	R	0.74934	0.56151			

Note: The chi-square statistics reported above are based on only 60 of 85 units that had sufficient data for computation. Fixed effects and variance components are based on all the data.

Statistics for current covariance components model
-----Deviance = 2124.742483
Number of estimated parameters = 4

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Interpreting the Output

How does the level-1 model react to changes in uranium level across counties? Let's examine the printed output and try to make a few predictions.

- Suppose soil uranium level is at the 50th percentile among counties. What would you expect the line relating floor to radon level to look like?
- How about the 87.5th percentile? The 12.5th percentile?

Interpreting the Output

How does the level-1 model react to changes in uranium level across counties? Let's examine the printed output and try to make a few predictions.

- Suppose soil uranium level is at the 50th percentile among counties. What would you expect the line relating floor to radon level to look like?
- How about the 87.5th percentile? The 12.5th percentile?

Plotting the Regression Lines in HLM

Let's use HLM to plot the regression. Go to the *Graph* Equations -> Level-1 equation graphing menu, as shown below.

Basic Settings Other Settings Run Analysis	Iel	p
Create a new model Using an existing hTM file Edit[Run old command; him/.nihn) file Havash' edit command; him/.nihn) file Sare & Sare & Sare Mark and Sare off Sare mixed model as entif Nale new HDM file Male new HDM file Male new HDM file	•	$y_{ij}^{j} + \epsilon_{ij}$ $y_{ij}^{j} + \omega_{oj}$ $y_{ij}^{j} + \omega_{ij}$
View Output	_	
Graph Equations	•	Model graphs
Graph Data	1	Level-1 equation graphing
Preferences		Level-1 residőäl box-whisker Level-1 residual vs. predicted value
EXR		Level-2 EBJOLS coefficient confidence intervals

Plotting the Regression Lines in HLM

Set the menu items as shown below, and click OK.

Level-1 equation Graphing	N 100 100 100 100 100 100 100 100 100 10
× focus Level-1 FLOOR ▼ Number of groups All groups (n = 85) ▼ Probability (0 to 1)	Categories/transforms/interactions 1 2 3 4 5 Range/Titles/Color Other settings
Z-focus URANIUM 25th/50th/75th percentiles	Cancel

Plotting the Regression Lines in HLM



Multilevel HLM — An Introduction