Using MIMIC Models to Assess the Influence of Differential Item Functioning

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Demographic Differences in Health

- Older persons have lower physical health than younger persons.

- Mental health does not decline with age, and may even rise.

- Women report lower physical and mental health than men.

- Persons with more education report better physical health than those with less.

- Blacks report higher mental health than Whites or Hispanics.

Demographic Differences in Health

- To what extent do these observed differences reflect "true" group differences in underlying physical or mental health status, versus DIF??

Measurement Invariance

- Valid comparisons of different groups require that measures be invariant.

- Measures can be construed as reflecting a latent variable (e.g., mental health).

- Invariant item has identical relationship with latent variable in all groups.

- If relationship between item and latent variable varies across groups, DIF is present.

Unadjusted vs. Adjusted Group Differences

- Unadjusted comparisons of group means may, in part, reflect DIF.
- They may also reflect true differences between groups.
- Control for any DIF effects when comparing groups (i.e., "adjust for" DIF).
- Multiple-indicator multiple-cause (MIMIC) model as one method of adjustment.

SF-12

- Health-related quality of life is an important outcome variable in many studies.
- SF-12 is an established, reliable, validated measure of health status.
- Twelve items, conceptualized as measuring two aspects of health status
  - Physical health
  - Mental health

Data

- Medical Expenditure Panel Survey in 2000
- Nationally representative sample
- Adult respondents (>17) received self-administered questionnaire (SAQ).
- SF-12 included in SAQ.
- Response rate among eligibles: 93.5%
- Size of analytic sample: 11,682 persons

DIF Adjustment Strategies

- Examine individual items for DIF.
- Discard or revise items with DIF.
- Examine revised measure.

- Requires large pool of candidate items.
- Requires resources and opportunity to develop measures.

Constraints

- ■ Opportunity to develop measures may be limited.

- ■ Secondary analysis of existing data.

- ■ Use of established measure limits options to discard or revise items.
  - – Non-comparability with prior studies
 - – Alters content validity of measure

Modeling Strategy

- Develop statistical model that controls for the influence of DIF.

- Decompose unadjusted group difference into
  - Group difference in latent variable means
  - DIF effect

- Incorporate parameters representing DIF in model.

MIMIC Model

- Assume underlying characteristic ("latent variable") that cannot be measured directly.
- This is theta (θ) in IRT.
- Latent variable is measured indirectly, through its influence on multiple observed indicators.
- MIMIC model is confirmatory factor analysis with covariates.

Basic Factor Model
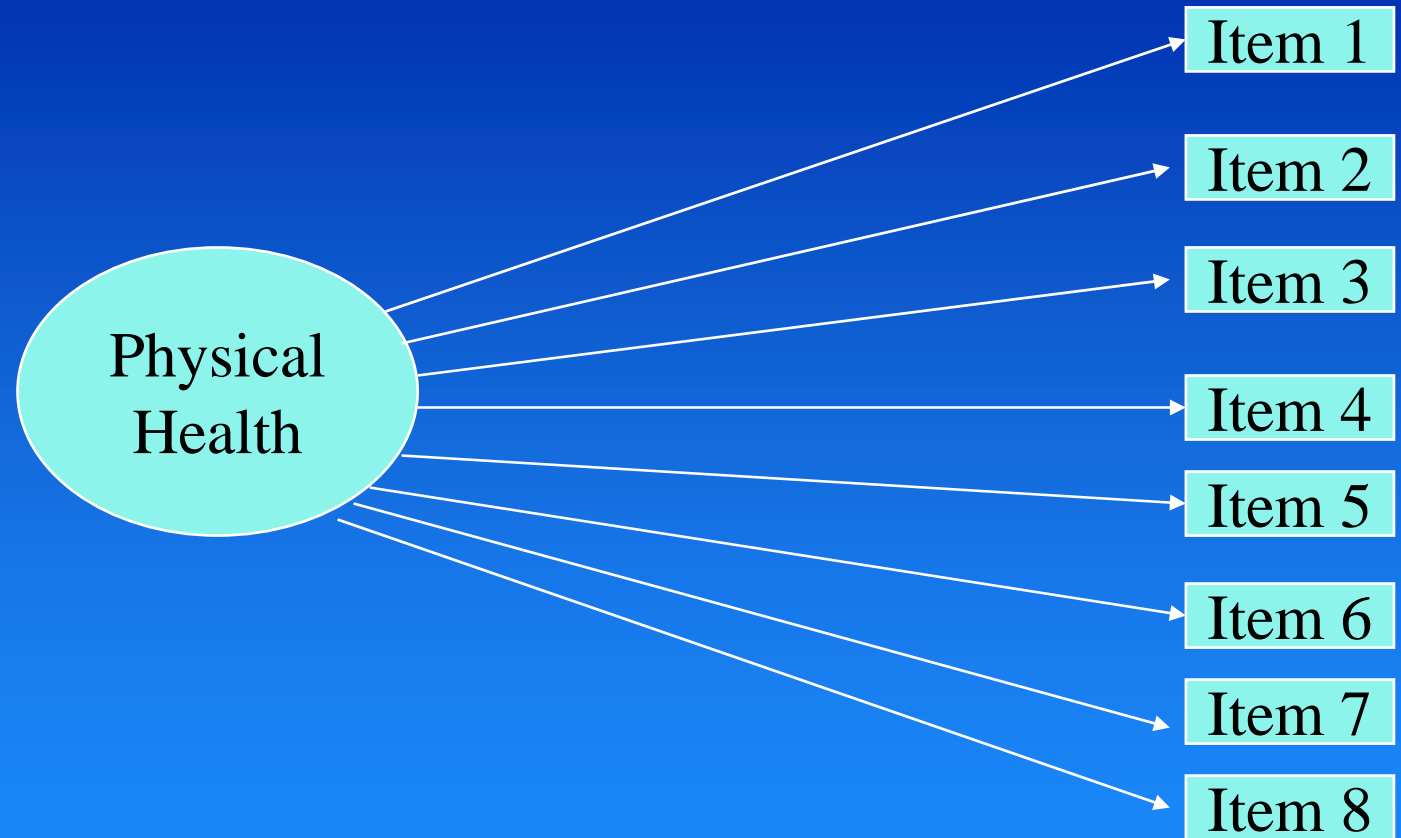
CFA and IRT

- Under certain conditions, CFA model is equivalent to IRT model.
  - Factor represents latent trait.
  - Arrows represent influence of (latent) factor on observed questionnaire items (factor loading).
  - Loading of item on factor corresponds to IRT discrimination parameter.
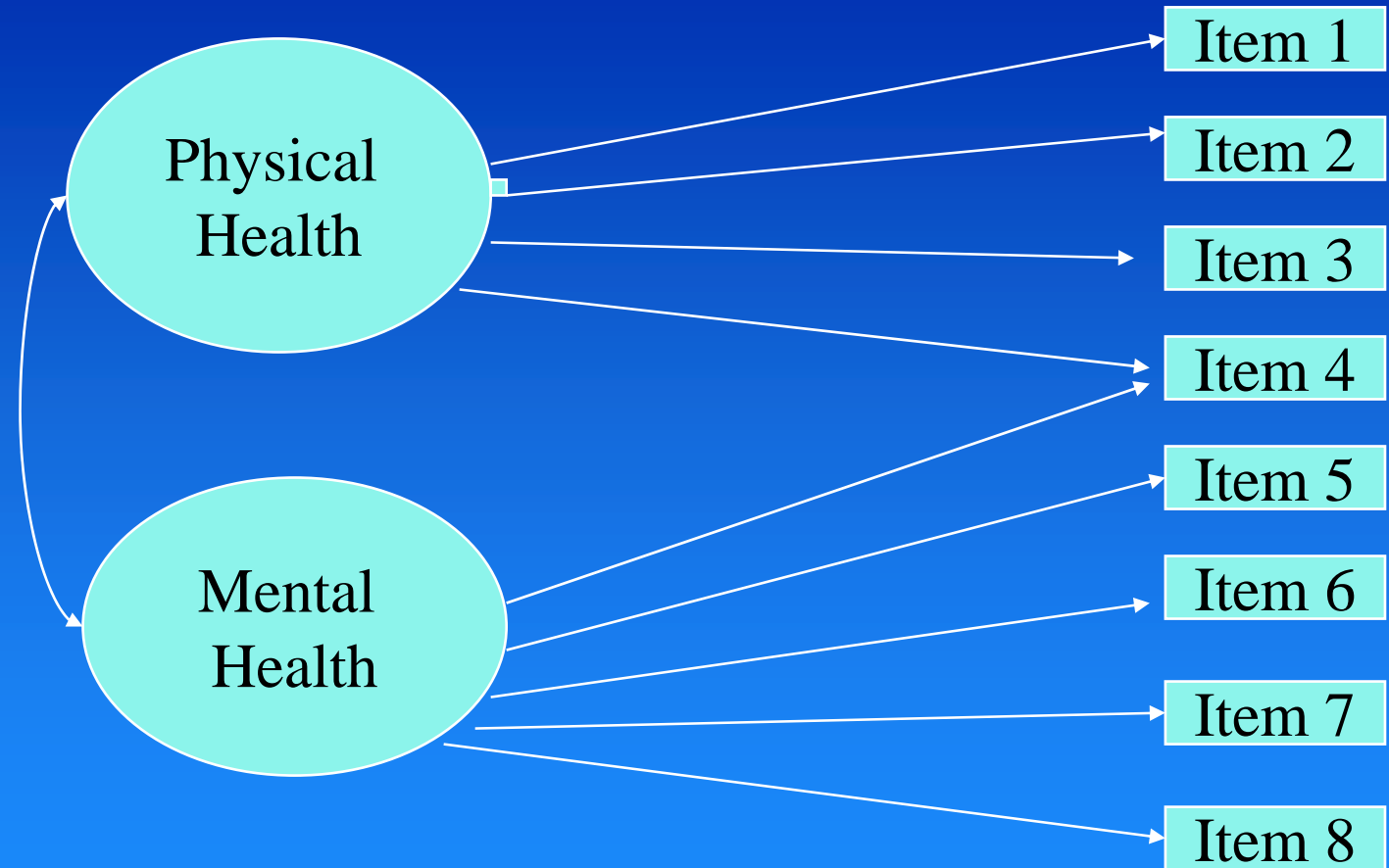 - Item intercept corresponds to IRT difficulty parameter.

CFA and IRT

- Although multidimensional IRT models have been developed, they are rarely used in practice.

- Adding more latent dimensions (factors) is straightforward in CFA/MIMIC approach.

CFA Model with Two Factors

MIMIC Model

- MIMIC model adds covariates to CFA model.
- Demographic differences in mean levels of latent factors represented by arrows from demographic variable to factor.
- Demographic differences in observed variables are mediated through latent factors (indirect effect).

MIMIC Model

- A demographic variable can also affect an observed item directly – unmediated by latent factors.

- This is a DIF effect.

- Examine DIF by adding direct effect parameters from demographic variables to items.

Full MIMIC Model
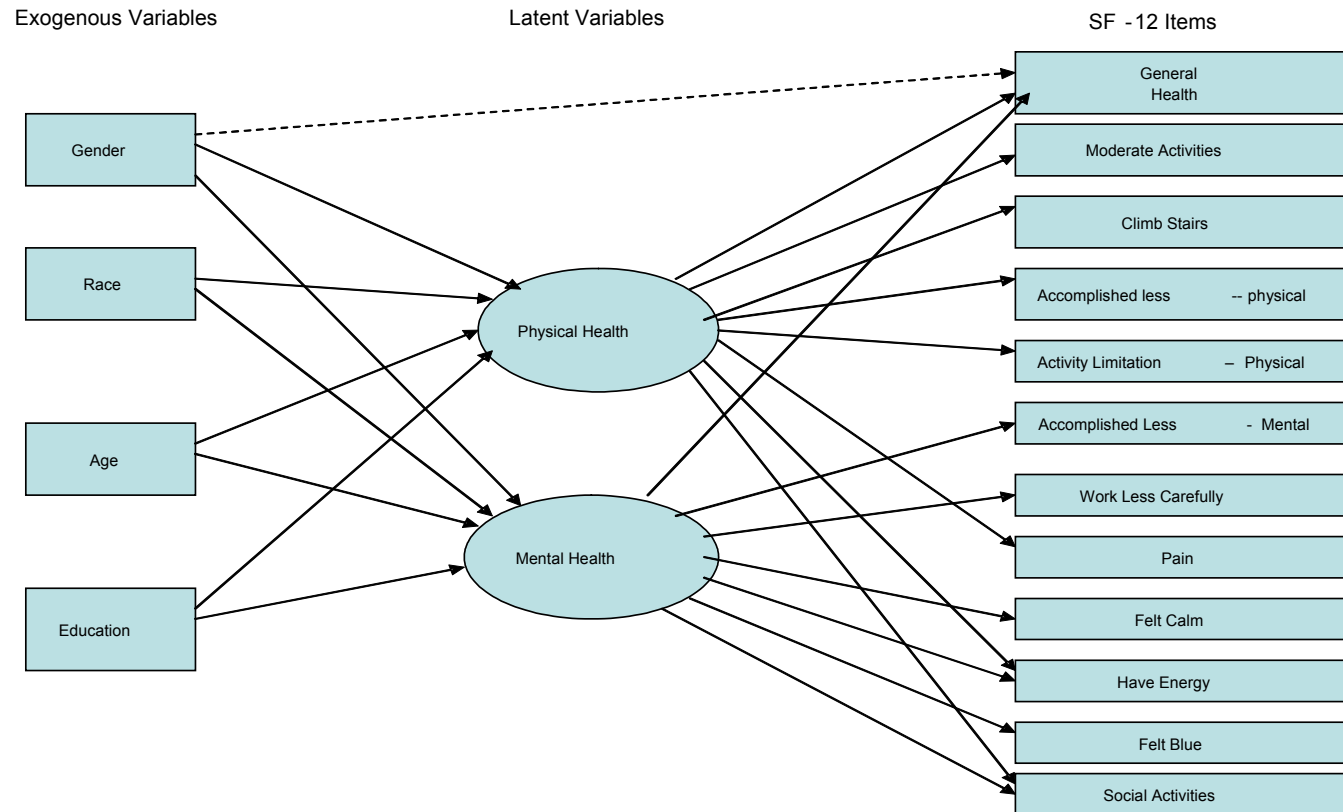
Analyses

- **SF-12 scoring algorithm yields two summary scores: PCS and MCS.**
  - Derived from principal component analysis
  - Does not involve latent variable model
- **Regressed PCS and MCS on demographic variables.**
- **Estimated and compared 2 MIMIC models:**
  - One had no DIF effects
  - Other had significant DIF effects.

Mean PCS and MCS by Demographic Variables

Variable	PCS	MCS
Female	49.35	50.69
Male	50.83	52.28
White	49.87	51.43
Black	50.25	51.62
Hispanic	50.42	50.88
Other race	51.63	51.82
Age 18-39	52.78	51.07
Age 40-59	49.76	51.16
Age 60-69	46.08	53.00
Age 70+	41.24	52.54
Less than high school	47.03	49.67
High school degree	49.27	51.46
College	51.48	51.95

Regressions of PCS and MCS on Demographic Variables

	PCS	MCS
Male	1.36 (.19)***	1.58 (.15)***
Black	0.01 (.30)	0.68 (.34)*
Hispanic	0.05 (.25)	0.23 (.33)
Other race	0.39 (.52)	0.56 (.74)
Age 40-59	- 3.24 (.19)***	-0.04 (.21)*
Age 60-69	- 6.62 (.37)***	2.00 (.35)***
Age 70+	-11.01 (.43)***	1.92 (.41)***
No high school degree	- 3.75 (.29)***	-2.56 (.30)***
High school degree	- 1.90 (.21)***	-0.57 (.22)*

Effects of Demographic Variables on Physical and Mental Health: No-DIF Model

	Physical Factor	Mental Factor
Male	0.205 (.022)*	0.186 (.018)*
Black	0.020 (.034)	0.114 (.027)*
Hispanic	0.008 (.030)	0.082 (.024)
Other race	0.072 (.068)	0.108 (.054)
Age 40-59	-0.407 (.025)*	-0.034 (.020)
Age 60-69	-0.710 (.039)*	0.099 (.032)
Age 70+	-1.062 (.039)*	0.001 (.032)
No high school degree	-0.459 (.030)*	-0.224 (.024)*
High school degree	-0.238 (.025)*	-0.059 (.021)

Goodness-of-Fit of No-DIF and DIF Models

	No DIF	DIF
Chi-square	3676.98	1845.699
DfF	135	96
CFI	0.989	0.994
RMSEA	0.047	0.039

Effects of Demographic Variables on Physical Health in No-DIF and DIF Models

Variable	No DIF	DIF
Male	0.205 (.022)*	0.193 (.023)*
Black	0.020 (.034)	0.079 (.034)
Hispanic	0.008 (.030)	0.025 (.032)
Other race	0.072 (.068)	0.073 (.068)
Age 40-59	-0.407 (.025)*	-0.348 (.026)*
Age 60-69	-0.710 (.039)*	-0.654 (.039)*
Age 70+	-1.062 (.039)*	-1.048 (.046)*
No high school degree	-0.459 (.030)*	-0.350 (.031)*
High school degree	-0.238 (.025)*	-0.158 (.028)*

Effects of Demographic Variables on Mental Health in No-DIF and DIF Models

Variable	No DIF	DIF
Male	0.186 (.018)*	0.181(.019)*
Black	0.114 (.027)*	0.056 (.029)
Hispanic	0.082 (.024)	-0.037 (.027)
Other race	0.108 (.054)	0.108 (.054)
Age 40-59	-0.034 (.020)	-0.064 (.022)
Age 60-69	0.099 (.032)	-0.111 (.040)
Age 70+	0.001 (.032)	-0.279(.040)*
No high school degree	-0.224 (.024)*	-0.237(.026)*
High school degree	-0.059 (.021)	-0.077 (.022)

Summary of DIF Influence

- DIF has minimal influence on estimates of demographic differences in physical health.

- Gender and educational differences in mental health relatively unaffected by DIF.

- Adjusting for DIF, oldest age group is lower on mental health

- Adjusting for DIF, Blacks do not differ from whites on mental health.

Major DIF Effects

SF-12 Item	Male	Age 40-59	Age 60-69	Age 70+	Black
General health	-0.076*	-0.084*	-------	-0.004	-0.165*
Moderate	-----	-0.121*	-0.186*	-0.197*	-0.128*
Climbing	0.111*	-0.173*	-0.245*	-0.278*	-----
Pain	----	-----	-----	0.278*	-----
Accomp. less - emotional	-----	-----	-0.021	-0.093	-----
Calm	-----	0.062	0.335*	0.546*	0.242*
Downhearted	-----	-----	0.276*	0.445*	-----
Energy	0.073*	-----	0.228*	0.235*	-----
Social	-----	0.106*	0.329*	0.470*	-----

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Major DIF Effects

SF-12 Item	Hispanic	Other race	Education < 12	High school
General health	-0.175*	-------	-0.303*	-0.221*
Moderate	----	------	-0.167*	-----
Climbing	----	------	-0.166*	-0.117*
Pain	-----	-----	-----	-0.089*
Accomp less - emotional	------	-----	-0.117	------
Calm	0.314*	-----	0.129*	0.082*
Downhearted	-----	-----	-----	-----
Energy	0.281*	-----	-----	-----
Social	-----	-----	-----	-----

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Advantages of MIMIC Model

- Analyses can proceed without deleting items with DIF.

- DIF detection can be embedded in larger, substantively focused model.

- Incorporates multiple groups easily.

- Can incorporate multiple latent variables simultaneously.

Disadvantages of MIMIC Model

- Assumes that DIF is uniform (i.e., no interaction between factor loadings and exogenous variables).

- Not oriented to producing a DIF-free score for each individual.

- Technical details of estimation differ from some IRT approaches.