

# Structural Equation Modeling (SEM) for Dummies

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## Presentation Outline

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- Conceptual overview.
  - What is SEM?
  - Major applications.
  - Advantages of using SEM.
  - Terms, nomenclature, symbols and vocabulary.
  - Shared characteristics among the various SEM techniques.
- Analytic examples and types of software.
  - LISREL, Amos, and EQS.

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## What Is Structural Equation Modeling?

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- SEM: very general, very powerful *multivariate* technique.
  - Specialized versions of other analysis methods.
- Major applications of SEM:
  - Causal modeling or path analysis.
  - Confirmatory factor analysis (CFA).
  - Second order factor analysis.
  - Covariance structure models.
  - Correlation structure models.

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## Advantages of SEM Compared to Multiple Regression

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- More flexible assumptions.
- Uses CFA to reduce measurement error.
- Attractive graphical modeling interface.
- Testing models overall vs. individual coefficients.

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## What Are It's Advantages?

- Test models with multiple dependent variables.
- Ability to model mediating variables.
  - Enables measurement of direct and indirect effects.
- Ability to model error terms.

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## What Are It's Advantages?

- Test coefficients across multiple between-subjects groups
- Ability to handle difficult data
  - Time series with autocorrelated error
  - Non-normal data
  - Incomplete data

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## Terms, Nomenclature, Symbols, and Vocabulary (Not Necessarily in That Order)

- Variance =  $s^2$
- Standard deviation =  $s$
- Correlation =  $r$
- Covariance =  $s_{XY} = \text{COV}(X, Y)$
- Disturbance =  $D$ 
  - $X \longrightarrow Y \longleftarrow D$
- Measurement error =  $e$  or  $E$ 
  - $A \longrightarrow X \longleftarrow E$






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## Terms, Nomenclature, Symbols, and Vocabulary

- Experimental research
  - independent and dependent variables.
- Non-experimental research
  - predictor and criterion variables
- Exogenous  $\longrightarrow$  “of external origin”
  - Outside the model
- Endogenous  $\longrightarrow$  “of internal origin”
  - Inside the model

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## Terms, Nomenclature, Symbols, and Vocabulary

- Latent variable (factor or construct) 
- Observed (manifest or indicator) variable 
- Direct effects 
- Reciprocal effects 
- Correlation or covariance 

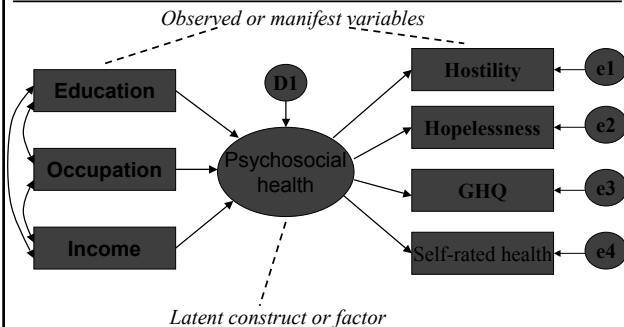
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## Terms, Nomenclature, Symbols, and Vocabulary

- Measurement model.
  - That part of a SEM model dealing with latent variables and indicators.
- Structural model.
  - Contrasted with the above.
  - Set of exogenous and endogenous variables in the model with arrows and disturbance terms.

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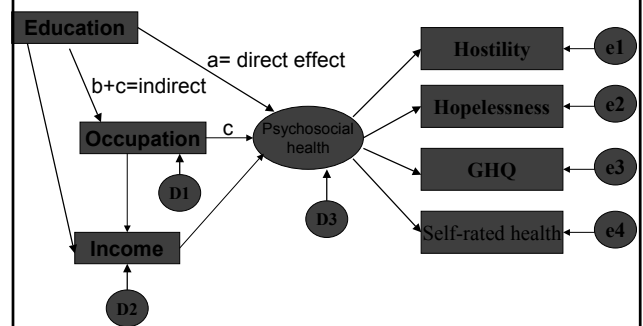
## Multiple Regression and Confirmatory Factor Analysis



Singh-Manoux, Clark and Marmot. 2002. *Multiple measures of socio-economic position and psychosocial health: proximal and distal measures.*

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## Causal Modeling or Path Analysis and Confirmatory Factor Analysis



Singh-Manoux, Clark and Marmot. 2002. *Multiple measures of socio-economic position and psychosocial health: proximal and distal measures.*

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## Terms, Nomenclature, Symbols, and Vocabulary

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- Structural or path coefficients.
  - Effect sizes calculated by the model estimation program.
- Come in two flavors:
  - Standardized.
  - Unstandardized.

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## What about effect size?

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- |           |               |            |        |
|-----------|---------------|------------|--------|
| • <0.2    | Insignificant | • <0.1     | Small  |
| • 0.2-0.5 | Small         | • near 0.3 | Medium |
| • 0.5-0.8 | Moderate      | • near 0.5 | Large  |
| • >0.8    | Large         |            |        |

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## Measures of Fit or Fit Indexes

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- Goodness of fit tests:
  - Based on predicted vs. observed covariances
  - Same as above, but penalizing for lack of parsimony
  - Comparing the given model with an alternative model
  - Based on information theory

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## Measures of Fit or Fit Indexes

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- Centrality index (CI)
- Noncentrality index (DK)
- Relative non-centrality index (RNI)
- Comparative fit index (CFI)
- Bentler-Bonnett index (BBI)
- Incremental fit index (IFI)
- Normed fit index (NFI)

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## Measures of Fit or Fit Indexes

- Model chi-square
- Goodness of Fit Index (GFI)
- Adjusted goodness-of-fit index (AGFI)
- Root mean square residuals (RMSR or RMR)
- Standardized root mean square residual, standardized RMR (SRMR)

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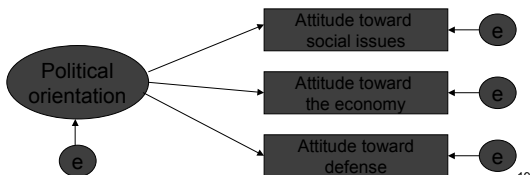
## Steps in SEM

- Specify the model.
- Determine whether the model is "identified."
- Analyze the model.
- Evaluate model fit.
- Respecify the model and evaluate the fit of the revised model.

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## Second-order Factor Analysis

- Latent variable whose indicators are themselves latent variables
  - It has no measured indicators, but some rules apply
- Example: Political orientation



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## Correlation Structure Model: A Circumplex???

1.00									
0.80	1.00								
0.60	0.80	1.00							
0.40	0.60	0.80	1.00						
0.20	0.40	0.60	0.80	1.00					
0.40	0.20	0.40	0.60	0.80	1.00				
0.60	0.40	0.20	0.40	0.60	0.80	1.00			
0.80	0.60	0.40	0.20	0.40	0.60	0.80	1.00		

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## Shared Characteristics of SEM Methods

- SEM is *a priori*
  - Think in terms of models and hypotheses
- Forces the investigator to provide lots of information
  - which variables affect others

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## Shared Characteristics of SEM Methods

- SEM allows distinctions between observed and latent variables.
- Basic statistic in SEM is the covariance.
  - Can analyze other types of data like means.
- Not just for non-experimental data.

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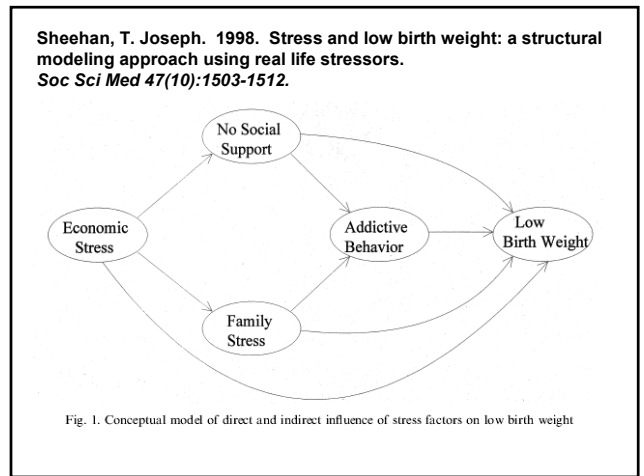
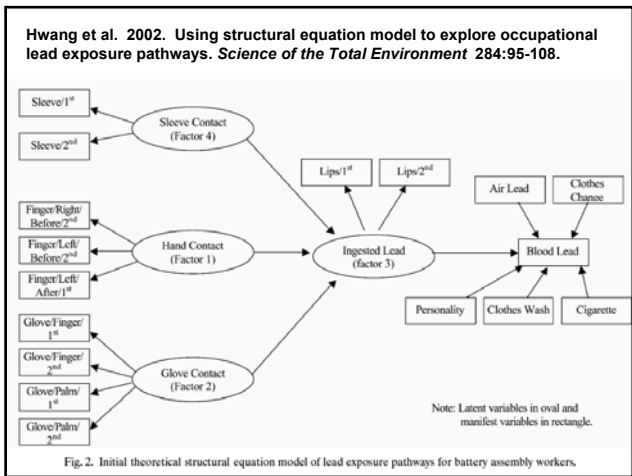
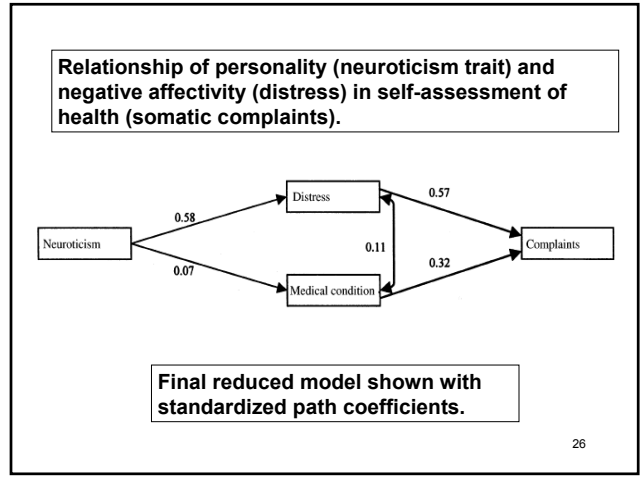
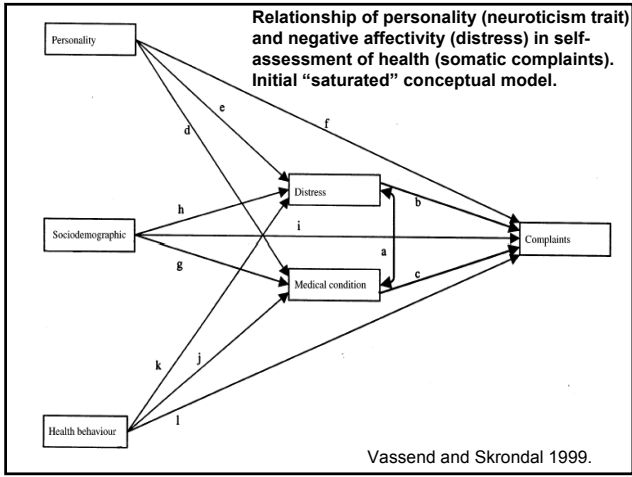
## Shared Characteristics of SEM Methods

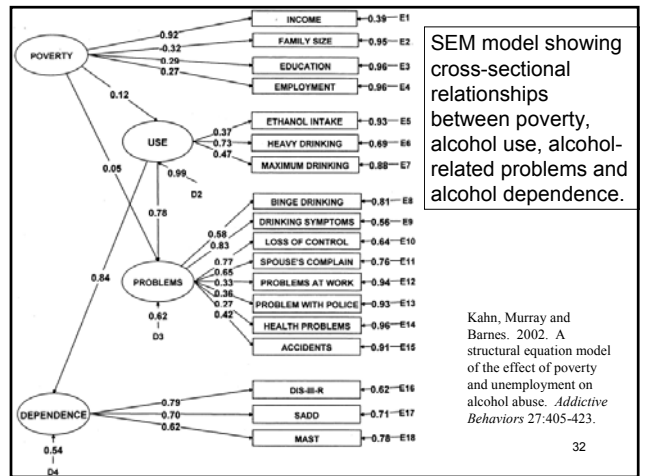
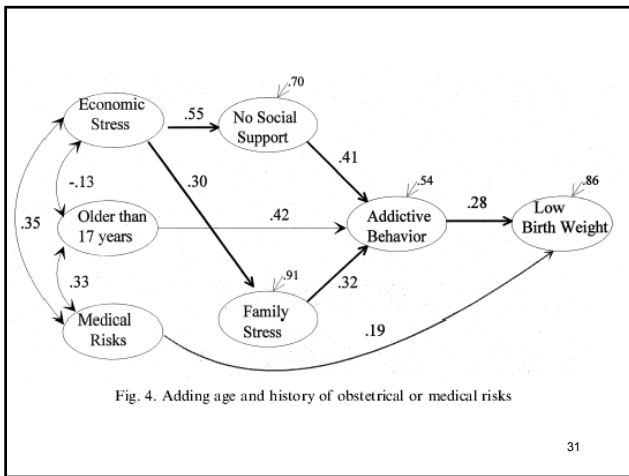
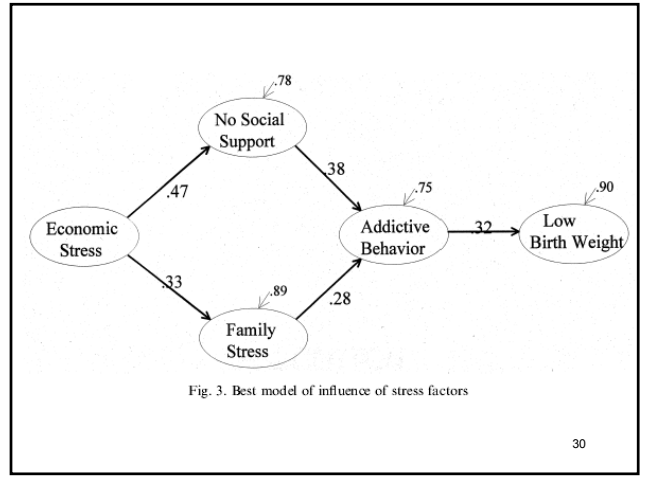
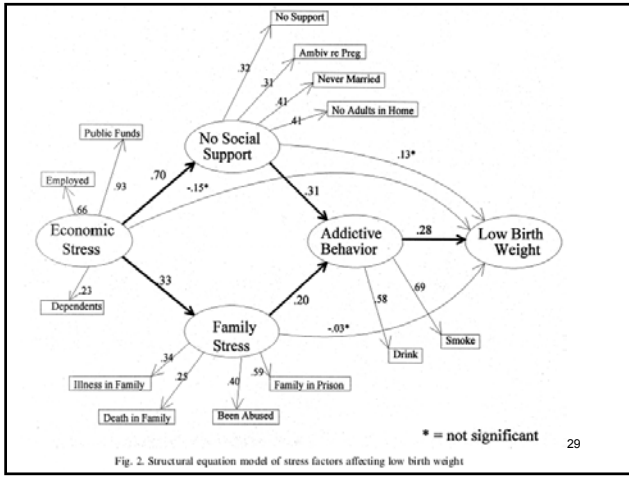
- View many standard statistical procedures as special cases of SEM.
- SEM is a large-sample technique.
- Statistical significance less important than for more standard techniques.

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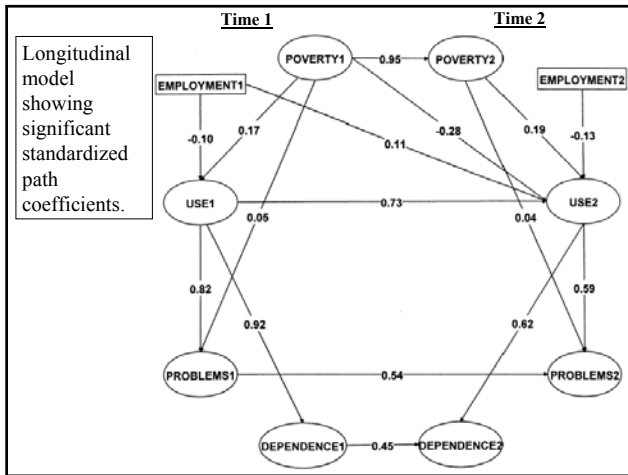
## SEM Examples from the literature

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## SEM for Dummies II (future)

- Real time software example
  - LISREL or EQS
- Single example built from scratch using longitudinal data
- Just a bit more on “identification”
- Will include discussion of fit indexes
- Decomposition of direct and indirect effects.

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## SEM References

- Kline, Rex B. 1998. *Principles and Practice of Structural Equation Modeling*. New York: The Guilford Press.
- <http://users.rcn.com/dakenny/causalm.htm>
- <http://www.mvsoft.com> (Multivariate Software, Inc.--EQS software.)
- <http://www.ssicentral.com/home.htm> (Home to the LISREL family of software.)

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