**HANDOUTS**

# Latent growth curve analysis in perinatal and pediatric epidemiology

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**Contents**

## 1. Mplus output: cubic LCG

See slides for annotation

Note: This model is presented for illustrative purposes. It has marginal model fit, which improves after adding sex subgroups and covariates. Testing of additional parameters to improve trajectory flexibility and model fit is warranted.

```
Mplus VERSION 7.2
MUTHEN & MUTHEN
06/09/2016   2:14 PM

INPUT INSTRUCTIONS

  Title:
    Cube LGM Binned;
  Data:
    File is X:\SPH\Shared\Obesity\Infants.dat;
  Variable:
    Names are
       id wt0 wt1 wt2 wt3 wt4 wt5 wt6;
    Missing are all (-9999) ;
    USEVAR =wt0-wt6;
  MODEL:
    i l q c | wt0@0 wt1@.3 wt2@.6 wt3@.9 wt4@1.2 wt5@1.8 wt6@2.4;


INPUT READING TERMINATED NORMALLY



Cube LGM Binned;

SUMMARY OF ANALYSIS

Number of groups                                                 1
Number of observations                                       21899

Number of dependent variables                                    7
Number of independent variables                                  0
Number of continuous latent variables                            4

Observed dependent variables

  Continuous
   WT0         WT1         WT2         WT3         WT4         WT5
   WT6

Continuous latent variables
   I           L           Q           C


Estimator                                                       ML
Information matrix                                        OBSERVED
Maximum number of iterations                                  1000
```

Convergence criterion 0.500D-04
Maximum number of steepest descent iterations 20
Maximum number of iterations for H1 2000
Convergence criterion for H1 0.100D-03

Input data file(s)
*X:\SPH\Shared\Obesity\Infants.dat*

Input data format FREE

SUMMARY OF DATA

Number of missing data patterns 62

COVARIANCE COVERAGE OF DATA

Minimum covariance coverage value 0.100

PROPORTION OF DATA PRESENT

Covariance Coverage

| | WT0 | WT1 | WT2 | WT3 | WT4 |
|---|---|---|---|---|---|
| WT0 | 1.000 | | | | |
| WT1 | 0.907 | 0.907 | | | |
| WT2 | 0.754 | 0.746 | 0.754 | | |
| WT3 | 0.669 | 0.661 | 0.642 | 0.669 | |
| WT4 | 0.678 | 0.666 | 0.643 | 0.609 | 0.678 |
| WT5 | 0.616 | 0.604 | 0.578 | 0.551 | 0.580 |
| WT6 | 0.480 | 0.470 | 0.449 | 0.429 | 0.451 |

Covariance Coverage

| | WT5 | WT6 |
|---|---|---|
| WT5 | 0.616 | |
| WT6 | 0.444 | 0.480 |

THE MODEL ESTIMATION TERMINATED NORMALLY

MODEL FIT INFORMATION

Number of Free Parameters 20

Loglikelihood

H0 Value -112358.709
H1 Value -108311.313

Information Criteria

| | |
|---|---|
| Akaike (AIC) | 224757.418 |
| Bayesian (BIC) | 224917.302 |
| Sample-Size Adjusted BIC (n* = (n + 2) / 24) | 224853.743 |

Chi-Square Test of Model Fit

| | |
|---|---|
| Value | 8094.792 |
| Degrees of Freedom | 15 |
| P-Value | 0.0000 |

RMSEA (Root Mean Square Error Of Approximation)

| | | |
|---|---|---|
| Estimate | 0.157 | |
| 90 Percent C.I. | 0.154 | 0.160 |
| Probability RMSEA <= .05 | 0.000 | |

CFI/TLI

| | |
|---|---|
| CFI | 0.917 |
| TLI | 0.883 |

Chi-Square Test of Model Fit for the Baseline Model

| | |
|---|---|
| Value | 96903.981 |
| Degrees of Freedom | 21 |
| P-Value | 0.0000 |

SRMR (Standardized Root Mean Square Residual)

| | |
|---|---|
| Value | 0.061 |

MODEL RESULTS

| | Estimate | S.E. | Est./S.E. | Two-Tailed P-Value |
|---|---|---|---|---|
| I \| | | | | |
| WT0 | 1.000 | 0.000 | 999.000 | 999.000 |
| WT1 | 1.000 | 0.000 | 999.000 | 999.000 |
| WT2 | 1.000 | 0.000 | 999.000 | 999.000 |
| WT3 | 1.000 | 0.000 | 999.000 | 999.000 |
| WT4 | 1.000 | 0.000 | 999.000 | 999.000 |
| WT5 | 1.000 | 0.000 | 999.000 | 999.000 |
| WT6 | 1.000 | 0.000 | 999.000 | 999.000 |
| L \| | | | | |
| WT0 | 0.000 | 0.000 | 999.000 | 999.000 |
| WT1 | 0.300 | 0.000 | 999.000 | 999.000 |
| WT2 | 0.600 | 0.000 | 999.000 | 999.000 |
| WT3 | 0.900 | 0.000 | 999.000 | 999.000 |
| WT4 | 1.200 | 0.000 | 999.000 | 999.000 |

| | | | | |
|---|---|---|---|---|
| WT5 | 1.800 | 0.000 | 999.000 | 999.000 |
| WT6 | 2.400 | 0.000 | 999.000 | 999.000 |
| Q \| | | | | |
| WT0 | 0.000 | 0.000 | 999.000 | 999.000 |
| WT1 | 0.090 | 0.000 | 999.000 | 999.000 |
| WT2 | 0.360 | 0.000 | 999.000 | 999.000 |
| WT3 | 0.810 | 0.000 | 999.000 | 999.000 |
| WT4 | 1.440 | 0.000 | 999.000 | 999.000 |
| WT5 | 3.240 | 0.000 | 999.000 | 999.000 |
| WT6 | 5.760 | 0.000 | 999.000 | 999.000 |
| C \| | | | | |
| WT0 | 0.000 | 0.000 | 999.000 | 999.000 |
| WT1 | 0.027 | 0.000 | 999.000 | 999.000 |
| WT2 | 0.216 | 0.000 | 999.000 | 999.000 |
| WT3 | 0.729 | 0.000 | 999.000 | 999.000 |
| WT4 | 1.728 | 0.000 | 999.000 | 999.000 |
| WT5 | 5.832 | 0.000 | 999.000 | 999.000 |
| WT6 | 13.824 | 0.000 | 999.000 | 999.000 |
| L WITH | | | | |
| I | -0.130 | 0.009 | -13.930 | 0.000 |
| Q WITH | | | | |
| I | 0.111 | 0.009 | 12.007 | 0.000 |
| L | -3.392 | 0.064 | -53.024 | 0.000 |
| C WITH | | | | |
| I | -0.024 | 0.003 | -9.335 | 0.000 |
| L | 0.748 | 0.017 | 44.282 | 0.000 |
| Q | -0.741 | 0.019 | -39.638 | 0.000 |
| Means | | | | |
| I | 3.457 | 0.003 | 987.975 | 0.000 |
| L | 8.843 | 0.019 | 470.592 | 0.000 |
| Q | -3.832 | 0.019 | -204.208 | 0.000 |
| C | 0.705 | 0.005 | 137.146 | 0.000 |
| Intercepts | | | | |
| WT0 | 0.000 | 0.000 | 999.000 | 999.000 |
| WT1 | 0.000 | 0.000 | 999.000 | 999.000 |
| WT2 | 0.000 | 0.000 | 999.000 | 999.000 |
| WT3 | 0.000 | 0.000 | 999.000 | 999.000 |
| WT4 | 0.000 | 0.000 | 999.000 | 999.000 |
| WT5 | 0.000 | 0.000 | 999.000 | 999.000 |
| WT6 | 0.000 | 0.000 | 999.000 | 999.000 |
| Variances | | | | |
| I | 0.268 | 0.003 | 104.640 | 0.000 |
| L | 4.532 | 0.068 | 67.141 | 0.000 |
| Q | 3.088 | 0.067 | 45.881 | 0.000 |
| C | 0.187 | 0.005 | 34.089 | 0.000 |
| Residual Variances | | | | |
| WT0 | 0.000 | 0.000 | 999.000 | 999.000 |
| WT1 | 0.698 | 0.008 | 88.064 | 0.000 |

| | | | | |
|---|---|---|---|---|
| WT2 | 0.176 | 0.003 | 61.847 | 0.000 |
| WT3 | 0.073 | 0.002 | 40.402 | 0.000 |
| WT4 | 0.118 | 0.002 | 53.096 | 0.000 |
| WT5 | 0.136 | 0.005 | 27.181 | 0.000 |
| WT6 | 0.096 | 0.025 | 3.837 | 0.000 |

QUALITY OF NUMERICAL RESULTS

Condition Number for the Information Matrix 0.681E-06
(ratio of smallest to largest eigenvalue)

DIAGRAM INFORMATION

Use View Diagram under the Diagram menu in the Mplus Editor to view the diagram.
If running Mplus from the Mplus Diagrammer, the diagram opens automatically.

Diagram output
*X:\SPH\Shared\Obesity\Infants*\binned_cube.dgm

Beginning Time: 14:14:55
Ending Time: 14:14:55
Elapsed Time: 00:00:00

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## 2. Further Reading

**4a. Structural Equation Modeling (SEM) (general)**

Kline R. *Principles and practice of structural equation modeling*. 3rd ed. New York: The Guilford Press; 2011.

Bollen KA, Noble MD, Adair LS. Are gestational age, birth weight, and birth length indicators of favorable fetal growth conditions? A structural equation analysis of Filipino infants. *Stat Med.* Jul 30 2013;32(17):2950-2961.

Dahly DL, Adair LS, Bollen KA. A structural equation model of the developmental origins of blood pressure. *Int J Epidemiol.* Apr 2009;38(2):538-548.

**4b. Latent Growth Curve models**

Bollen KA, Curran PJ. *Latent Curve Models: A Structural Equation Perspective*. Hoboken, NJ: John Wiley & Sons; 2006.

Tu YK, Tilling K, Sterne JA, Gilthorpe MS. A critical evaluation of statistical approaches to examining the role of growth trajectories in the developmental origins of health and disease. *Int J Epidemiol.* Oct 2013;42(5):1327-1339.

***Individually varying time points***

Sterba SK. Fitting nonlinear latent growth curve models with individually varying time points. *Structural Equation Modeling: A Multidisciplinary Journal*. 2014; 21:630-647.

***Ordinal dependent variables***

Masyn KE, Petras H, Liu W. Growth curve models with categorical outcomes. In: Bruinsma G, Weisburd D, eds. *Encyclopedia of Criminology and Criminal Justice*. New York: Springer; 2014:2013-2025.

Boone-Heinonen J, Howard AG, Meyer K, et al. Marriage and parenthood in relation to obesogenic neighborhood trajectories: The CARDIA study. *Health Place.* Jul 2015;34:229-240.

***Growth Mixture Modeling***

Muthen B, Muthen LK. Integrating person-centered and variable-centered analyses: growth mixture modeling with latent trajectory classes. *Alcohol Clin Exp Res.* Jun 2000;24(6):882-891.

Jung T, Wickrama KAS. An introduction to latent class growth analysis and growth mixture modeling. *Social and Personality Psychology Compass.* 2008;2(1):302-317.

**4c. Mplus**

Mplus User's Guide
https://www.statmodel.com/ugexcerpts.shtml

Byrne BM. *Structural Equation Modeling with Mplus: Basic Concepts, Applications, and Programming*. New York: Routledge; 2012.