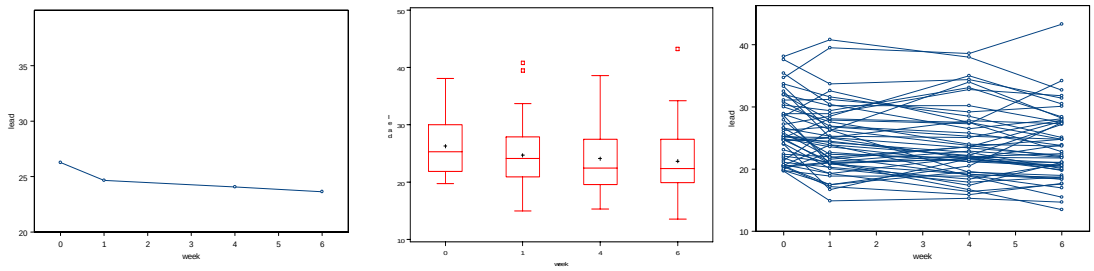
1. Purpose

This analysis is to describe individual differences in development over 6 weeks (4 time points) for the placebo group of the Lead-Exposed Children (TLC) experimental design by growth modeling in a latent variable analysis framework. Several alternative growth models such as linear, non-linear, quadratic, and piecewise growth models were carried out to find the best fit model.

2. Descriptive analysis

[Mean plots and Individual growth trajectories]



[Descriptive table]

GROUP	N	Variable	Mean	Std Dev	Minimum	Maximum
0 (Placebo)	50	leadw0	*26.272*	5.024	19.7	38.1
		leadw1	24.660	5.461	14.9	40.8
		leadw4	24.070	5.753	15.3	38.6
		leadw6	23.646	5.640	13.5	43.3

According to the mean plots and the descriptive table above, it appears that the average lead level changed over time, and tends to drop drastically between week0 and week1. However, it is not clear whether the lead levels from week 1 to week 6 actually changed. That is, the developmental growth can be explained by non-linear pattern rather than a linear pattern. Further, the individual growth trajectories plot shows that there seem to be individual variations in initial status and growth pattern. However, randomness of intercept and slope should be checked through statistical modeling.

3. Growth modeling

Linear growth model

As a first step for data analyses, linear growth modeling was applied to the data. By fixing the coefficients constant (the scores for the time variable t: 0, 1, 4, 6), linear growth modeling under a latent variable analysis framework were conducted. However, the result shows that the linear growth model does not fit well (χ^2 =13.297, p=.02), meaning that χ^2 test rejects the assumption imbedded in this linear model. Hence, as a next step, it is clearly desirable to conduct non-linear modeling by allowing some time scores free (e.g. 0, 1, t_2 , t_3 [1]), adding a quadratic term or adopting piecewise modeling.

[1] t_2 , t_3 are growth score parameters to be estimated.

Model	d.f	χ^2 (p)	Loglikelihood
Linear growth model	5	13.297(.0207)	-524.199

Alternative growth models

Model		d.f	χ^2 (p)	Loglikelihood (BIC)
Non-Linear growth model	1.Slope (no variance)	5	11.666 (.0396)	-523.384
	2. random slope	3	3.996 (.2608)	-519.549(1082.130)
	3. Slope (no var.) & correlated resid.[2]	2	2.183 (.3321)	-518.642(1084.229)
Quadratic growth model	4. Slope & quadratic term (no var.)	6	15.877 (.0144)	-525.489
	5. random slope & fixed quadratic term	4	9.499 (.0496)	-522.301
	6. random slope & quadratic term	1	5.144 (.0233)	-520.123
Piecewise model	7. fixed slopes[3](no var. of slopes)	6	11.718 (.0685)	-523.410
	8. fixed slopes & correlated residuals	3	2.256 (.52)	-518.679(1080.390)

Based on the results above, some important points were found. First, it is noticeable that the variance of slopes is not statistically significant in the non-linear growth model (model 2) or the quadratic model (model 5). It means that there is no individual difference in lead level growth for the placebo group. Also, it is found that models were fitted well in allowing the correlation between residuals. Therefore, both the non-linear growth model and the piecewise model with residual covariance would be a good fitting model considering χ^2 and p values. However, piecewise growth modeling was chosen as a final model with several reasons. First of all, the piecewise model (model 8) has more degree of freedom and less BIC scores than the non-linear growth model 3 (That is, the piecewise model better explains the data with the least number of parameters). Also, in comparing the model 3 to the random slope non-linear model (model 2), BIC values even increases in model 3 and there is no big difference in χ^2 (with 1 degrees of freedom, the chi-square difference value is 1.813, and p>.10), so that we would rather hold the restricted model. Furthermore, individual growth trajectories and similar mean values of week1-6 (24.66, 24.07, 23.65) might suggest that there would be no significant difference on lead levels after week1, and piecewise modeling can directly test this relationship.

The final analysis results based on the piecewise modeling were as follows.

	Estimate	SE	Est./SE
Initial status mean (week0)	26.287	0.711	36.986
Growth rate S1(week0-week1)	-1.638	0.425	-3.855

[2] If slopes are allowed to be random, the model is just-identified (has zero degrees of freedom).
[3] To make a piecewise model, time scores are fixed (slope1: 0, 1, 1, 1 / slope 2: 0, 0, 1, 2). However, when allowing the variance of the slopes, the model was not converged.

S2(week1-week6)	-0.505	0.277	-1.823
Variance			
Initial status (week0)	23.351	5.074	4.602
Residual variance			
Week0	2.052	2.037	1.007
Week1	4.111	2.517	1.634
Week4	7.485	2.350	3.185
Week6	11.256	2.915	3.861
Residual covariance			
Week0, Week1	-1.670	1.856	-0.900
Week1, Week4	1.394	1.176	1.186
Week4, Week6	5.185	2.259	2.296

4. Interpretation of the result

Firstly, the estimated mean value of week 0, which is the average initial status, is 26.287, and the variance of the initial status is also statistically significant. That is, starting points in lead level varied around 26.287 across individuals. Secondly, in terms of the average growth rate, the slope related to week0-week1 (S1) is -1.64 which is statistically significant (Z=-3.855). On the other hand, slope related to week 1-6(S2) is not significant with $\alpha = .05$ (Z=$|-1.826|$<1.96). This says that lead level dropped on average about 1.6 during the first week (week0-1), but after one week, the average lead level for the placebo group was not changed over time. The output also shows that residual variances and covariance of week 4 and week 6 are still significant after controlling for the initial status and growth, but others are not. This result about residual variance and covariance can be predicted since slope (S2) as a latent variable, which is not significant, is not a good predictor for lead level of week 4 and 6, indicating that there is still unexplained variance in lead level week 4 and week 6.

5. Findings

On the basis of results from several growth modeling, we can conclude that the best fit model was a piecewise model with residual covariance terms in order to explain the lead level growth especially for the placebo group. Furthermore, it turns out that starting points in lead level varied around means across individuals, but there was no individual difference in terms of lead level growth (slope). Finally, the growth pattern of lead level for the placebo group was that once the lead level dropped during the first week, there was no significant change in lead level for last 5 weeks.