# The utility of standardized or crude weight measures in modeling of postnatal growth trajectories: Are there differences?

Ann Von Holle, Kari North, Ran Tao, UNC, Chapel Hill, NC; Sheila Gahagan, UCSD, San Diego, CA

## Introduction

Analyses of growth trajectories are expanding in tandem with the growing interest in life course epidemiology. Z-scores are a frequent choice when modeling weight growth trajectories to standardize the sample to usually what is the CDC reference or WHO standard populations. When used for cross-sectional data, Z-scores have advantages including linear sex- and age-independent measures of weight outcomes. However, there is no appropriate rationale to use Z-scores, or an equivalent such as percentiles, when studying weight change in infancy.

## Samples

Growth trajectory parameters for baseline exposure correspond to published estimates for three samples: Italy, Portugal and Chile.

C. Pizzi et al. "Prenatal Influences on Size, Velocity and Tempo of Infant Growth: Findings from Three Contemporary Cohorts". In: *PLoS ONE* 9.2 (Feb. 27, 2014). Ed. by G. Wang, e90291. DOI: 10.1371/journal.pone.0090291

## Aim

Use simulations to assess differences in power, type I error measures, and coefficient estimates of weight change differences across three different outcome measures in child anthropometric measures: weight, weight Z-score and weight percentiles.

## Method

We simulated infant growth data using a Reed first order parametric model:

$$y = \beta_0 + \beta_1 \cdot t + \beta_2 \cdot \ln(t) + \frac{\beta_3}{t}$$

After simulating data, three models were fit with the simulated data:

**Model 1**

$$y_{ij} = \beta_0 + \beta_1 \cdot t + \beta_2 \cdot \text{group} + \beta_3 \cdot t \cdot \text{group} + e_{ij}$$

**Model 2**

$$y_{ij} = \beta_0 + \beta_1 \cdot t + \beta_2 \cdot \text{group} + \beta_3 \cdot t \cdot \text{group} + \beta_4 \cdot t^2 + e_{ij}$$

**Model 3**

$$y_{ij} = \beta_0 + \beta_1 \cdot \text{month.6} + \beta_2 \cdot \text{group} + \beta_3 \cdot \text{month.6} \cdot \text{group} + e_{ij}$$

**Model Terms**

- $y_{ij}$ — the outcome: weight, Z-score or percentile
- **group** — a binary exposure factor
- **month.6** — a binary variable for time with 1=month 6 and 0=month 0
- $e_{ij}$ — error term with a autocorrelation structure, $\rho$=0.5 and $\sigma$=0.75

## Results

Figure 1: Simulated weight growth curves with corresponding Z-score and percentile outcomes using Chilean growth parameters

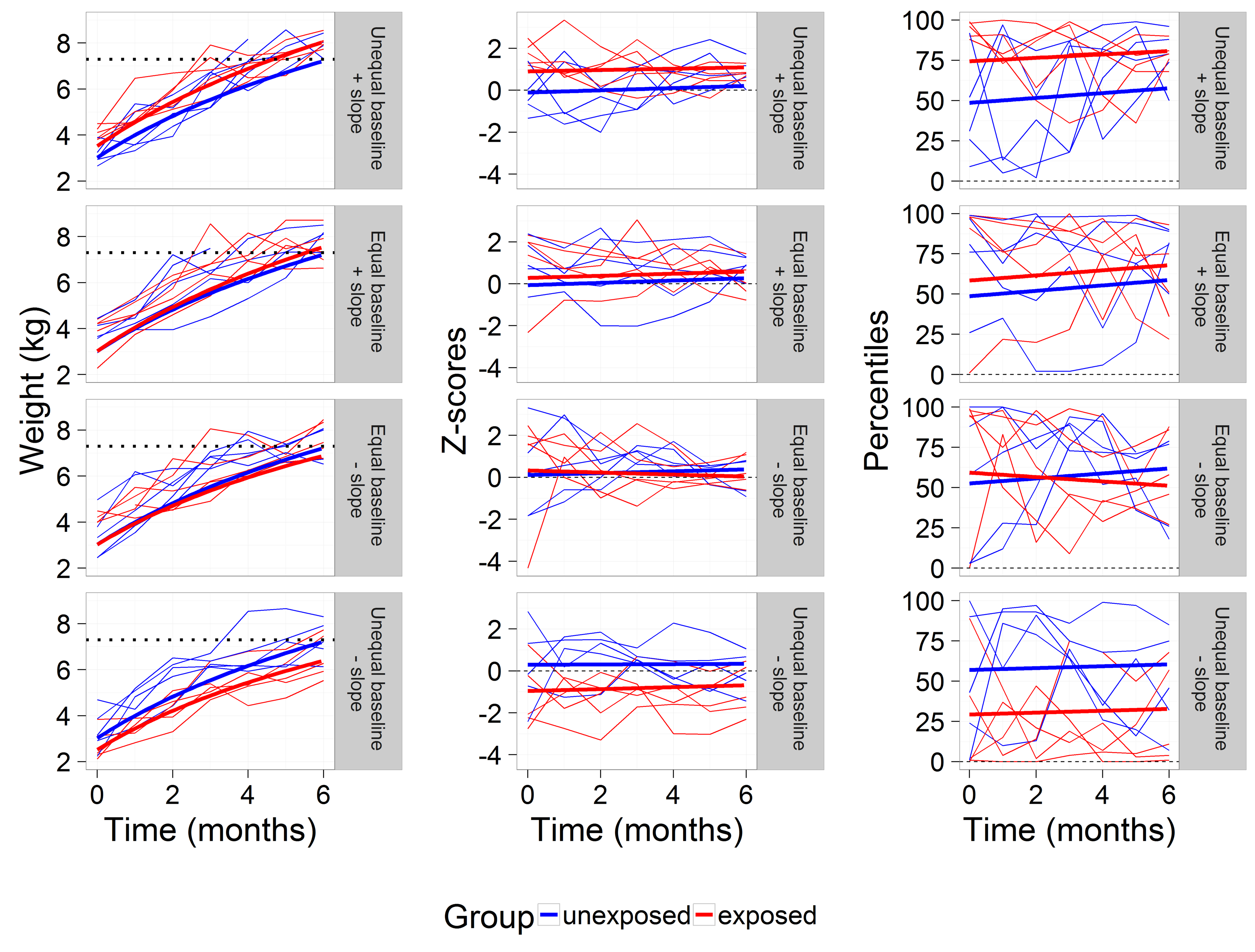
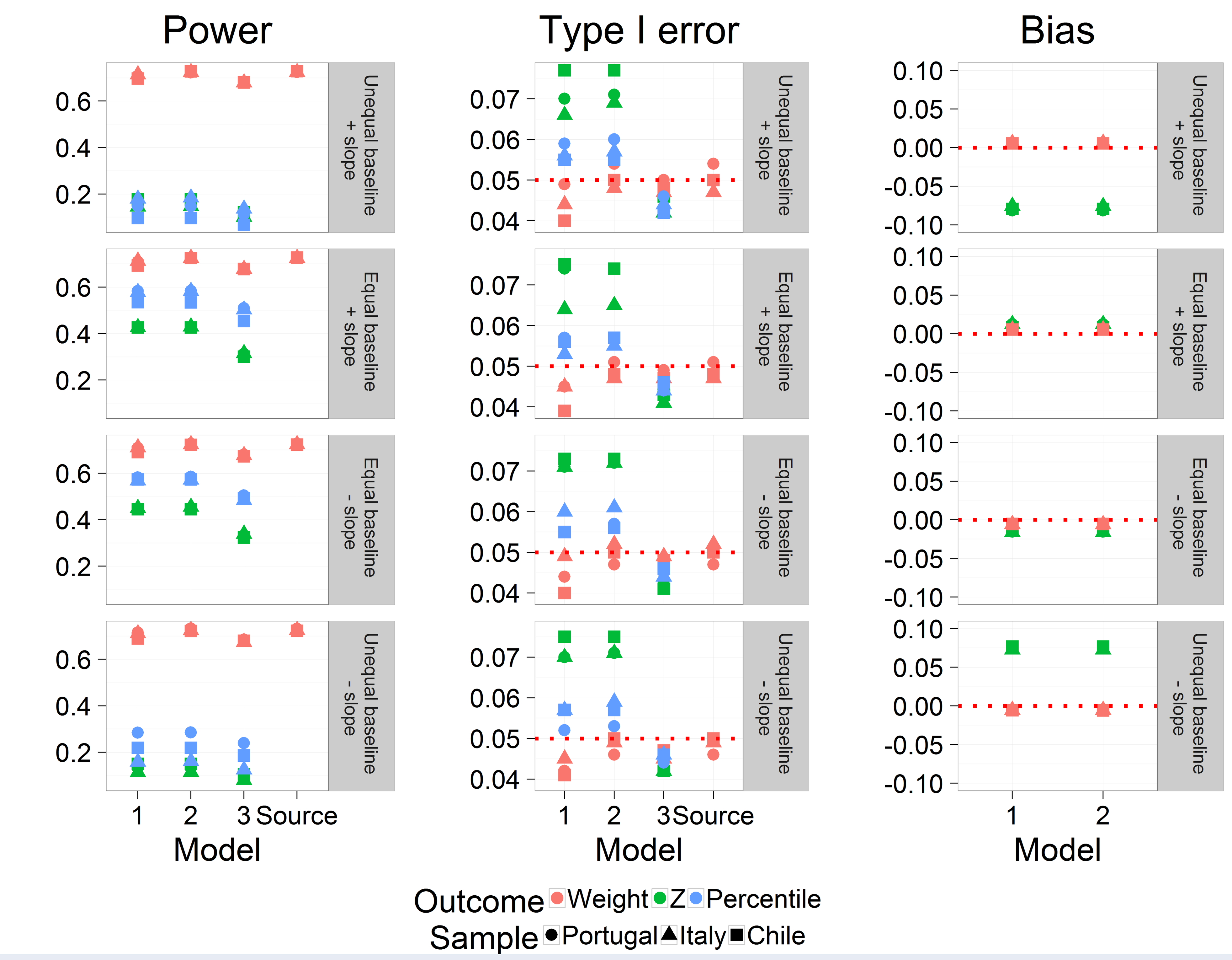



Figure 2: Comparison of power, type-I error and bias for product term for time and exposure effect, $\beta_3$.




## Results, cont . . .

**Power** Consistently greater with crude weight.

- Weight difference at baseline results in larger differential.

**Type I error** Crude weight measure closest to nominal Type I error of 0.05.

- Z-scores have greatest type I error for models 1 and 2.

**Bias** Baseline weight differences lead to opposite direction of effect for Z-score vs crude weight outcomes.

- No weight differences at baseline leads to similar estimates between Z-score and original weight outcomes.

## Summary

**Disadvantages of standardization**

- There are several disadvantages to the use of Z-scores or percentiles when examining longitudinal within-subject change in child weight.
- Use of Z-scores meant for cross-sectional weight measures can lead to opposite effects leading to conflicting inference when comparing trajectories across groups.
- Simulations show evidence of lower power and greater type I error when using Z-scores.

**Alternatives?**

- Use crude weight scores and adjust for gender and age.


vonholle@email.unc.edu