Effects of Selective Dropout on Infant Growth Standards

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In 2006 the World Health Organization (WHO) released growth standards for children 0–5 years [1]. These standards were calculated on exclusively breastfed (EBF) infants. EBF infants have higher weight gain during the first 2 months, and grow less rapidly in the period 3–12 months. Binns and Lee [2] argued that the higher centiles in the WHO growth standards are the result of sample selection, since only those who grow well are retained. However, they provided no data to back up their claim. The present paper addresses the question whether infants that grow less well have an increased change to cease EBF.

We analyzed breastfeeding data from the SMOCC study among 2,151 Dutch children by a pattern mixture model [3, 4]. The model describes the measurements for each dropout pattern separately and provides a way to mix those patterns to reflect the population. In order to identify the model, we need extra assumption, the available case-missing value (ACMV) restriction. We study two aspects of the model. First we compare the mean weight trajectory per dropout pattern until the time of dropout. Second, we assess how realistic the ACMV assumption is for these data.

Figure 1 is the mean weight trajectory up to the moment of dropout. The figure clearly shows that infants who are lighter tend to drop-out earlier. As a consequence, those who continue to receive EBF will be heavier. Thus, if we select infants who conform to the strict WHO feeding criteria, then this group as a whole will be heavier than the group that started EBF.

Figure 2 reveals that during month 1 the EBF infant grows slightly faster (0.12 SD) than the non-EBF infants. The situation is reversed for the next two periods (2–3 and 3–6 months), where the non-EBF infant gains weight faster than EBF infants (0.20 SD in period 2–3 months, and 0.33 SD in period 3–6 months). No growth differences occur during period 6–9 months. Infants with and without EBF grow essentially the same during that period.
When taken together, the analyses yield the following picture: (1) infants who receive EBF at month 1 are heavier at birth; (2) between months 2 and 6, light non-EBF infants gain more weight than light EBF infants, and selective dropout continues to operate, and (3) no differences in weight gain were found between non-EBF and EBF infants between months 6 and 9. Selective dropout continues to operate.

Our data support the notion that higher than average growth in EBF infants during the first 2 months is attributable to selective dropout. The decision to abandon EBF strongly depends on infant weight. Furthermore, we found that the difference in weight gain between EBF and non-EBF infants depends on initial weight.

The practical consequence is that the WHO standard of weight-for-age for infants is generally higher than other references during the first half year. This begs the question whether the selection of infants has been appropriate. The MGRS study enrolled n = 1,743 newborns into the longitudinal component, where the WHO standards were calculated from the compliant subset of 903 infants (51.8% of 1,743). Most dropouts occurred because the mothers did not adhere to the strict WHO feeding protocol. If the dropout processes in the WHO study are

Fig. 1. Trajectory of mean weight SDS per dropout pattern prior to dropout. Trajectories are labeled by month of dropout from exclusive breastfeeding. The diagram shows that exclusively breastfed infants who drop out are lighter before they drop out.
Fig. 2. Regression lines to describe weight gain at four different periods during infancy. Per period, three separate models were fitted corresponding to feeding mode. Differences between feeding modes are small for periods 1–2 and 6–9 months. In periods 2–3 and 3–6 months, lighter infants receiving complementary foods gain more weight than lighter infants receiving exclusive breastfeeding. WSDS = Weight standard deviation score; excl BF = exclusive breastfeeding.
similar to those in SMOCC, then standards calculated on the 903 subset will systematically differ from standards calculated from the full set of 1,743 infants.

Infant growth and dropout are clearly interrelated processes, and should therefore be modeled simultaneously. We suggest calculating references on all 1,743 infants according to the intention-to-treat principle by multiple imputation [5]. This will lead to reference standards for all children as if they had been breastfed. These references are likely to be different from the current WHO standard, but may describe healthy infant growth more accurately. A first step to see how large this difference might be is to inspect diagnostic plots like figures 1 and 2 calculated from the WHO data.

References