Appendix 1 Detailed description of smoothing methods

Defining small-for-gestational-age: prescriptive versus descriptive birthweight standards
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The LMS method as proposed by Cole was adopted to calculate birthweight percentiles. The LMS model has three components, each being a flexible curve as a function of GA. The L stands for the parameter λ, which determines a non-linear transformation of BW, such that its distribution approaches the normal distribution as closely as possible. The M stands for the mean (μ) of that normal distribution, and S (σ) for its coefficient of variation. If x indicates GA and y birthweight, the assumption is that

\[ Z = \left( \frac{y - \mu(x)}{\sigma(x)} \right) \]

has a standard normal distribution, with mean zero and standard deviation (SD) one [8, 40].

The optimal power to obtain normality was calculated for each GA and the trend was summarized by a smooth (L) curve, using the PBSPLINE statement in the SAS TRANSREG procedure for fitting nonlinear regression functions. Trends in the mean (M) and coefficient of variation (S) were similarly smoothed. We specified NKNOTS=2, default (i.e. 100) and 1 for the L, M and S curves, respectively. By default, SAS chooses the optimal smoothing parameter by minimizing the AICC (corrected Akaike information criterion). We calculated two sets of LMS values for both the descriptive and for the prescriptive birthweight standard. The resulting L, M and S curves contain the information to draw any centile curve (online supplementary figures S4 and S5):

\[ C = \mu(x) \times (1 + (\lambda(x) \times \sigma(x) \times Z))^{1/\lambda(x)} \]

Finally, for each of the two standards, we calculated gender-specific percentiles at each GA day between 23+3 and 42+6 weeks of gestation. For the purpose of our study the curves were truncated to 24th-42nd weeks. The percentiles were smoothed using penalized B-splines (NKNOTS=2), in order to illustrate the natural tendency of birthweight to increase with age. To facilitate comparison to other birthweight standards we also calculated the 2.3rd, 16th, 84th and 97.7th percentile, corresponding to -2SD, -1SD, +1SD and +2SD, respectively.

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Figure S4 L (A), M (B) and S (C) values for boys
Blue, descriptive birthweight reference; red*, prescriptive birthweight reference.
Figure S5 L (A), M (B) and S (C) values for girls
Blue, descriptive birthweight reference; red*, prescriptive birthweight reference.