Stunting: methodological considerations for improved study design and reporting

Peter Rohloff [1,2] Peter Flom [3]

Stunting is a paediatric nutritional disorder characterised by short stature, typically presenting in the first few years of life. In recent decades, stunting has become a subject of worldwide concern and a major focus for global development targets. Stunting is closely associated with important indicators across the lifespan, including early child development, school attainment, adult economic productivity and risk factors for noncommunicable chronic diseases.

BMJ Paediatrics Open receives a large number of submissions on stunting, and we are committed to publishing high-quality research on this critical global health topic.

We have identified several recurring methodological considerations which should be addressed to improve the quality and impact of submissions.

1. The primary stunting measure is a continuous, normally distributed variable: height/length-for-age. Stunting can also be categorically defined as height/length more than 2 SD below the population mean on the WHO Child Growth Standards. We see many observational studies exploring factors associated with stunting which use a categorical stunting definition, as well as randomised clinical trials which use categorically defined stunting as a clinical trial endpoint. However, in both of these scenarios—where the focus is on determinants of short stature and individual measures are available—categorisation is usually not the best analytical strategy. Converting a continuous into a categorical variable results in significant loss of statistical power. For example, even in a simple linear regression with a linear relationship, n=100 and R=0.26, the p value for the independent variable rises from 0.01 to 0.1 when dichotomised. For this reason, it is usually preferable in the scenarios described to use ordinary least squares regression on continuous height/length-for-age. One common defence of dichotomisation is that the OLS method regresses only on the mean height/length, and we may be more interested in children who are very small (or possibly very large) for their age. One powerful but underused approach in this scenario would be quantile regression, which models the conditional distribution of the continuous stunting variable (similar to OLS regression) but then, importantly, lets us look at any quantiles of height/length-for-age. The resulting models may look quite different at these different quantiles, providing important and fine-grained information across the spectrum of height/length-for-age or, indeed, any other anthropometric indicator. For example, in prior work on low birth weight, one of the authors demonstrated how the predictors of birth weight in the 10th percentile were quite different from those at the mean.[1]

An additional point here is that, for whichever regression method is chosen for continuous height/length, restricted cubic splines of continuous independent variables (such as age) should be considered to allow for curvilinear relationships. These are not intuitive to interpret, but can be very valuable.

Finally, it is important to note that there are multiple scenarios where individual measures of height/length are not the primary focus of analysis, and these remain situations where use of a dichotomised stunting variable is the appropriate choice. Examples might include meta-analyses of changes in stunting rates globally, monitoring of progress toward Sustainable Development Goal targets, and the like.

2. Stunting is a complex, multifactorial phenomenon and the expected impact of any intervention will likely be small, often in the range of a difference of 0.1 SD or less in between-groups comparisons. Given the large body of published scientific evidence on stunting, it is ethically imperative that any new clinical trials be realistically powered to detect meaningful differences. This can be best assured by well-argued sample size and power calculations that take effect size and variance estimates from convincingly similar pilot study populations and intervention conditions. On the other hand, we often see power calculations based on comparisons to populations with fundamentally different demographics or baseline prevalence of stunting.

3. When multiple measurement points are available for subjects in a growth data set, a statistical analytical approach that appropriately incorporates multiple measures should be employed. Often we observe approaches that somewhat arbitrarily compare a single early measure to a later measure, ignoring any growth data that may have been collected at intermediate points. Such an approach may be appropriate under limited circumstances, such as a randomised controlled trial. However, in general and for observational studies in particular, multilevel models and other repeated measure approaches should be used, as they take full advantage of all existing data and are more robust to missing data.

4. Contemporary analyses of stunting should appropriately reference the WHO Child Growth Standards and comparative analyses must account for risk factors considered by the Growth Standards. The WHO's Multicentre Growth Reference Study was a major milestone in global paediatrics, which showed that young children in diverse settings and from diverse backgrounds exhibit similar linear growth in the absence of major

[1]Maya Health Alliance, Tecpan, Guatemala
[2]Division of Global Health Equity, Brigham and Women's Hospital, Boston, Massachusetts, USA
[3]Peter Flom Consulting, New York, New York, USA

Correspondence to Dr Peter Rohloff; prohloff@bwh.harvard.edu

risk factors such as extreme poverty, lack of exclusive breastfeeding, etc.[2] The growth standards have been criticised for minimising between-population and between-country variation in child linear growth, and there is some merit to this criticism.[3] However, we frequently review country-specific and region-specific analyses which attempt to contrast to the WHO Growth Standards through convenience or centre-based samples which are neither population representative nor rigorously matched for the relevant risk factors accounted for by the Growth Standards.

5. Height/length deficit may be a useful additional measure for assessing changes in linear growth over time. On the WHO's Child Growth Standards height/length curves, the measurement variance increases significantly from 0 to 5 years of age. Since the z score is calculated as the difference between the measured height/length and the median height/length divided by the population SD, increasing variance with age means that negative z-scores will drift upward towards the median over time even when the absolute height/length deficit remains constant or worsens. Others have argued that absolute height deficit may be a more important measure here, especially when the research question involves the possibility of catch-up growth.[4]

6. Stunting may not be a useful proxy for cognitive development. A major reason for the global focus on stunting is the close associations between stunting and early child development, school attainment and adult cognition and economic productivity. Given the relative ease of measuring linear growth, stunting is therefore often used as a proxy for these outcomes. However, the biological evidence that these outcomes are primarily mediated by stunting is not completely convincing; in fact a recent analysis of multiple birth cohorts has shown that the association between linear growth and adult IQ largely disappears when controlling for child IQ.[5] Therefore, studies of stunting, especially when conducted prospectively, should generally attempt to include a direct measure of early child development.

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ORCID iDs
Peter Rohloff http://orcid.org/0000-0001-7274-8315
Peter Flom http://orcid.org/0000-0002-8419-7968

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