What do we know about body composition in healthy infants? A review of the literature.

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Background

Improving nutrition in *the first thousand days*, the time between conception and a child's second birthday, is now recognized as a vital opportunity to invest in the long-term health of both individuals and societies [1].

Poor nutrition during this critical period has severe, immediate impacts on mortality and morbidity [2,3]; and long term effects on cognition, productivity, income, and non-communicable disease risk [4]. A key challenge is to develop interventions that promote healthy infant growth, mitigating the short term impacts of undernutrition, but without inadvertently increasing NCD risk [5,6].

Monitoring the *quality* of infant growth in terms of body composition will play a key role in identifying such interventions. Furthermore, infant body composition is a likely mediator or reflection of aetiological mechanisms connecting foetal and infant development with life-long health and wellbeing [7,8]. However, there are no high-quality international growth reference data for infant body composition, which inhibits further research.

To help address this gap in knowledge, we reviewed studies that measured fat and fat-free mass in healthy infants born to healthy mothers. Information from the review will inform the design of a study aimed at developing an infant body composition standard from birth to 24 months of age using criteria similar to those used in the development of the 2006 WHO Child Growth Standards [9].

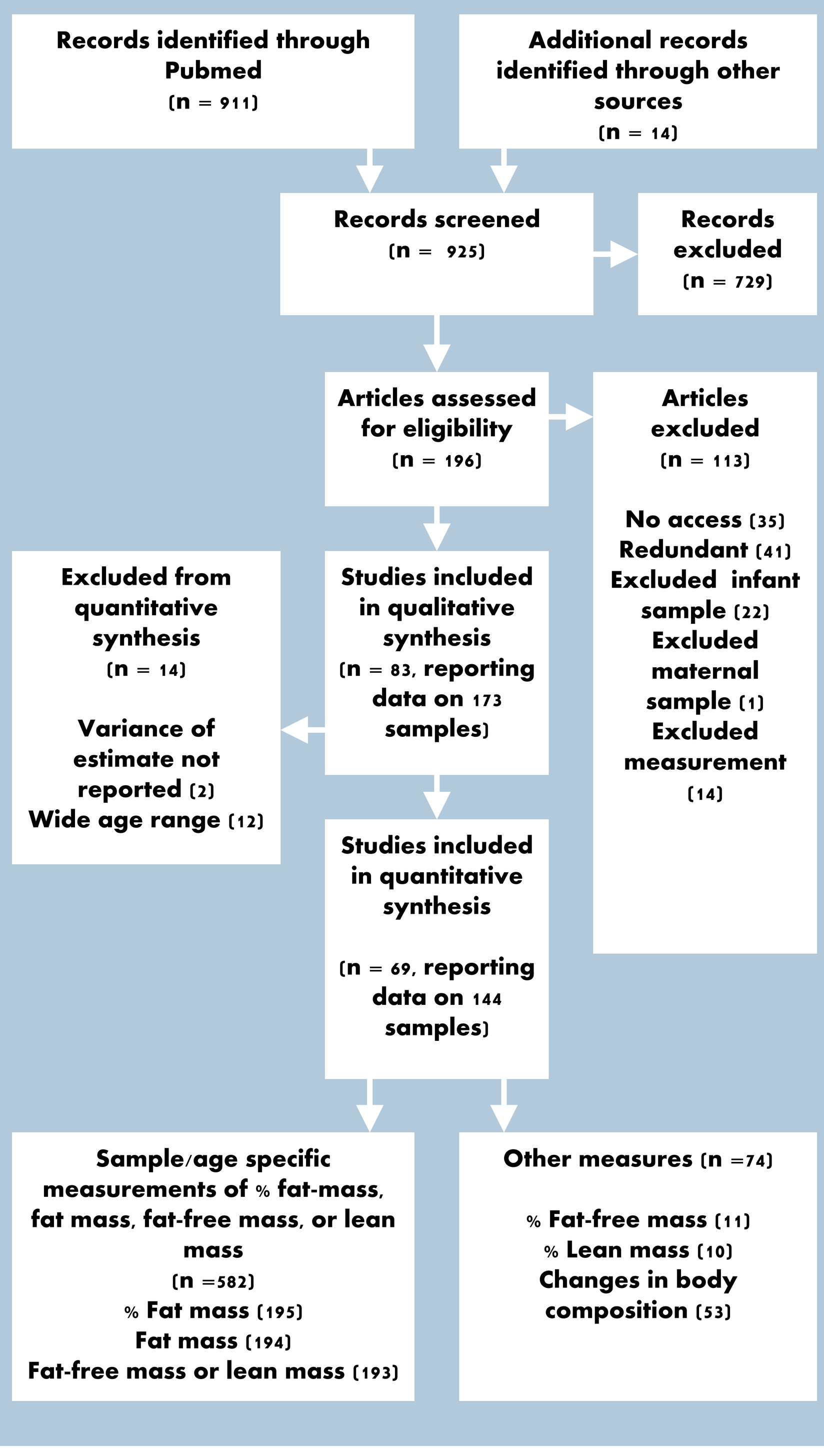
Methods

PubMed was searched for human studies meeting the following criteria:

Participants. Generally-healthy, singleton, term infants born to generally-healthy mothers, measured at least once between birth and 24 months of age (inclusive).
Instruments. Body composition measured with reference methods (excluding measurements based on anthropometry or bioelectrical impedance).
Outcomes. Whole-body fat mass, fat-free mass, or lean mass (proportionate or absolute values, including changes in these).
Study Design. Any original research, including both observational and intervention studies, meeting the above criteria.

Papers that reported means and variances in these measures within relatively narrow age groups were included in a quantitative synthesis. Random effects models were used to explore heterogeneity.

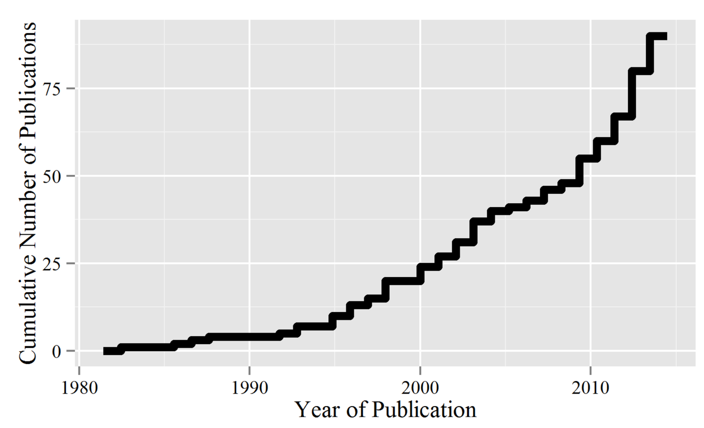
Flow Chart



Study Characteristics

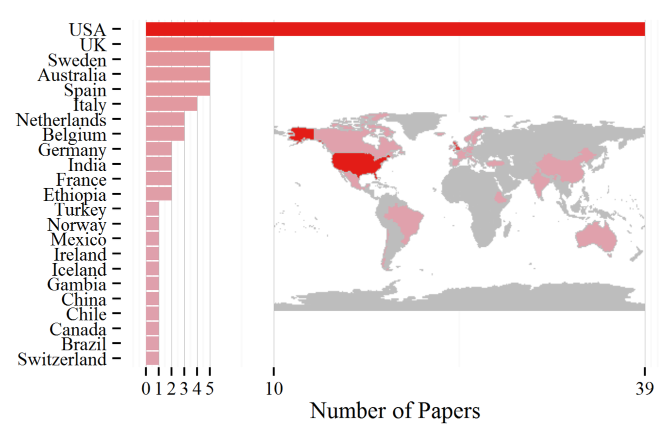
How many studies have been published, and when?

We identified 83 papers reporting data from relevant studies. The rate of publication increased from 2010, which seems driven by the development of the PEA POD air displacement plethysmography system (see below).

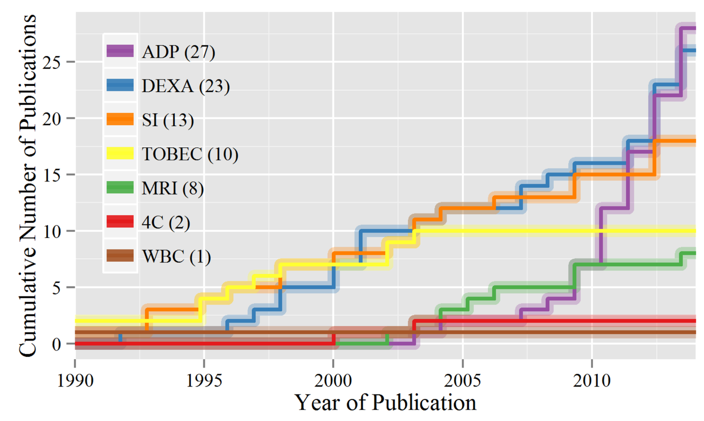


Where does infant body composition research take place?

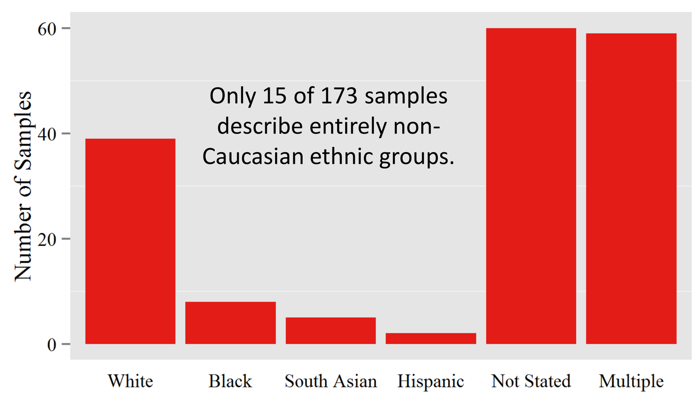
Most research has been conducted in Caucasian samples from higher income countries, particularly the United States. There were only nine papers from lower and middle income countries.



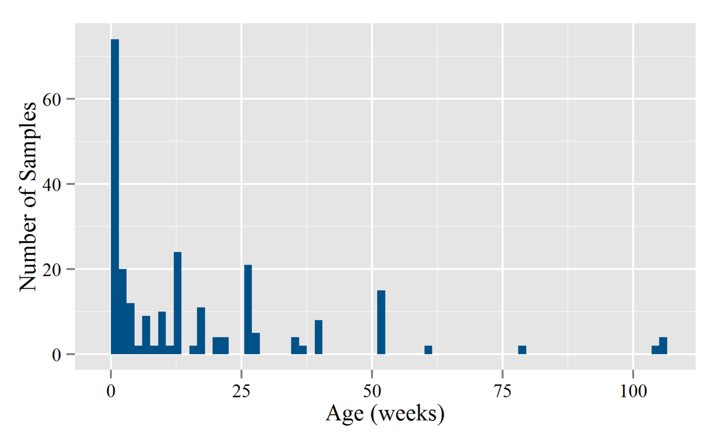
What methods are used to measure infant body composition?



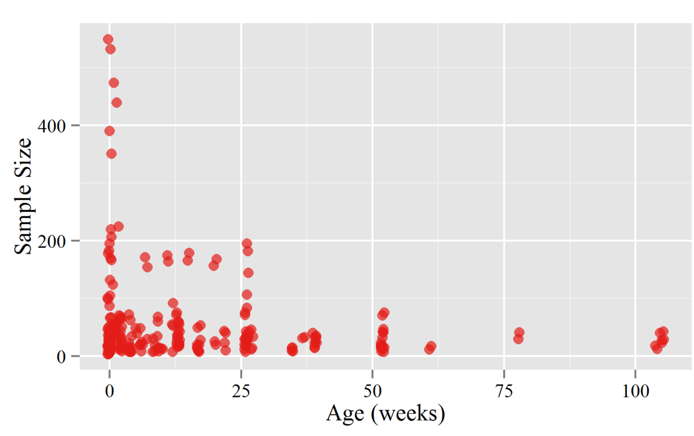
NOTE: (ADP) Air-Displacement Plethysmography; (DEXA) Dual X-Ray Absorptiometry; (SI) Stable Isotope; (TOBEC) Total Body Electrical Conductivity; (MRI) Magnetic Resonance Imaging; (4C) Four Compartment; (WBC) Whole Body Counting



Samples sizes are typically small, and describe neonates. There are very few data on infants older than six months of age.



50% of measures were taken in the first 10 weeks. Only 10 sets of measurements were taken after the 52nd week.

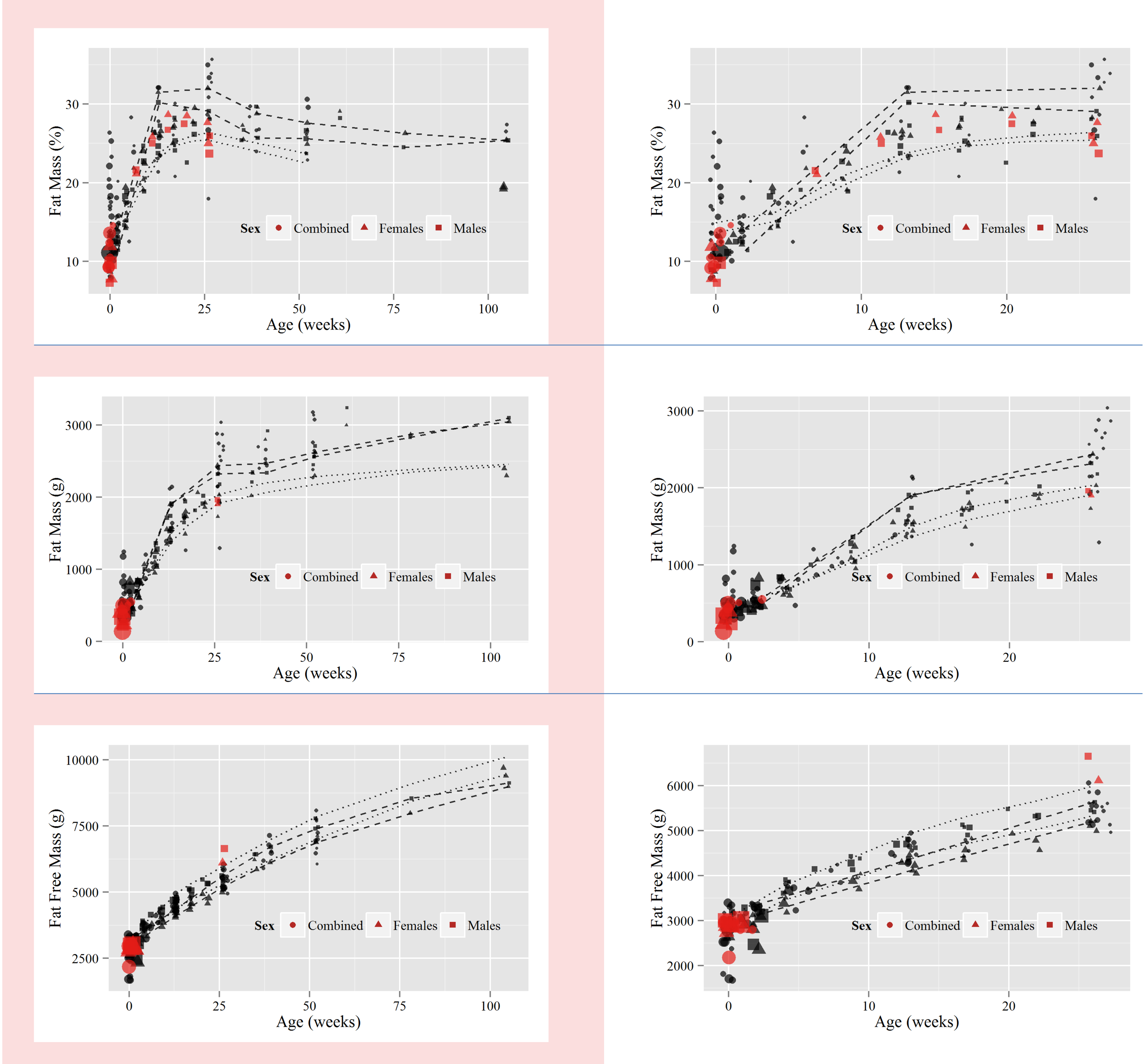


Only 9 sets of measurements were taken in samples larger than 200 participants. Only one study with measurements after 27 weeks had more than 50 participants.

Infant Body Composition

What does body composition look like in the first two years? | **What does body composition look like in the first six months?**

NOTE: Each marker shows the mean value for a body composition measurement in a given sample, at a given age. Samples with n > 100 are highlighted in red. Marker size is inversely proportional to the standard error of the mean. The dashed lines are reference data from Butte (2000), while the dotted lines are reference data from Fomon (1982, 2002).

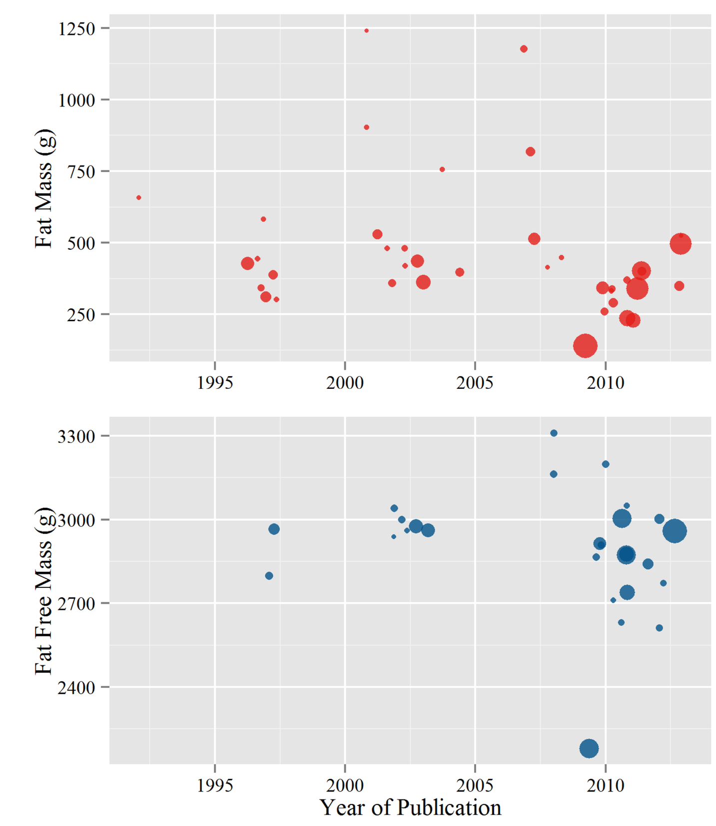


There is very little information on changes across infancy.

Only 15 of 69 papers included in the meta-analysis reported longitudinal data, contributing just 37 of 144 samples. While the longitudinal studies contributed 394 of the 660 total measurements, only 53 of these measurements (taken in 12 samples and reported in five papers) describe the distribution of observed changes in fat or fat-free mass between two time points. Of these five papers, only Butte (2000)reported changes over more than one time span.

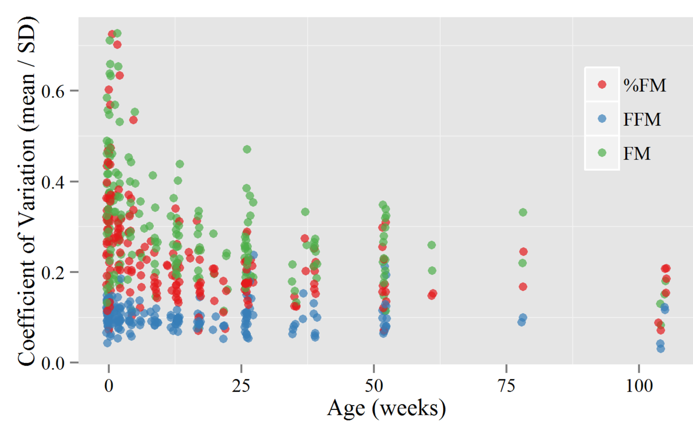
There are no obvious secular trends.

Fat and fat-free mass at birth, by year of publication.



NOTE: Marker size is inversely proportional to the standard error of the mean.

Measures of fat mass are highly variable.



NOTE: (FM) Fat Mass; (FFM) Fat-Free Mass

Between-study heterogeneity is substantial.

Using random-effects meta-analysis models, we found that between-study differences accounted for over 95% of the variance in sample estimates for % fat mass, fat mass, and fat-free mass at birth.

Removing samples that consisted entirely of infants born small or large for gestational age, as well as those born to women with abnormal glucose tolerance, did little to reduce the observed heterogeneity.

When we restricted the samples to those that appear to meet the selection criteria from the WHO Multicentre Growth Reference Study [9] the estimates were more similar, but there were too few of these to draw strong conclusions.

Conclusions

Most studies were small, conducted in the first few months after birth, and as a whole provided little information about changes in body composition during infancy. Few studies aimed to collect reference data, and the apparent variability in estimates of fat mass suggest that those that did were likely undersized for this purpose. Studies were predominately conducted in the USA, and overwhelmingly describe Caucasian populations. The between-study heterogeneity is substantial and cannot be explained by reported study level characteristics, further illustrating the need for a high-quality international standard.

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