Birthweight

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Abstract

This article discusses definitions of birthweight, including extreme values of birthweight distributions, factors associated with differences in birthweight distributions and their associations with the outcome of pregnancy and the development of statistical approaches to compare birthweight distributions and to detect outliers to inform clinical practice.

Background

The World Health Organization (WHO) defines birthweight as the first weight of the fetus or baby after birth. Although parents commonly include the baby's birthweight on the cards they send to friends and relatives to tell them of the new arrival, there have been times when people considered it unlucky to weigh babies[1].

Throughout the nineteenth century, `prematurity' was often cited as a cause of death among babies, but attempts at definition do not appear to have been made before the twentieth century. In his book *Infant mortality*, published in 1906, George Newman made a distinction between prematurity and immaturity, but quoted views that prematurity should be defined as having a birthweight under 2500g or perhaps 3000g[2].

Arvo Ylppo, a Finnish doctor working in Germany, suggested in 1919, in his review `On the physiology, care and fate of newborn babies that `premature birth' should be defined as having a birthweight of 2500g or less. He acknowledged, however that the term `fruhegeburt' or `premature birth' was inappropriate and suggested instead the term `unreifes kind' or `immature child'. Despite the fact that he acknowledged that the cut-off point of 2500g was arbitrary and not necessarily related to other indicators of immaturity, it was adopted internationally as a definition of `prematurity' [3]. Countries using imperial weights substituted the corresponding weight of 5 1/2 lb.

Current definitions of low birthweight
By the 1950s and 1960s, the limitations of this definition of `prematurity' were becoming increasingly apparent and in 1961, A World Health Organization Working Group recommended that low birthweight should no longer be used as a definition of prematurity [4]. To distinguish between short gestation and slow fetal growth, separate definitions of `low birthweight' and `pre-term' birth (*see* **stat06096**) were published in 1977 in the ninth revision of the International Classification of Diseases (ICD)(*see* **stat06098)** [5] and repeated in the tenth revision[6]. At the same time the definition was changed from 2500g or less to under 2500g. Because of `digit preference', that is the tendency to choose round numbers, the change affected the continuity of time series [7]. WHO recommends that birthweight should preferably be measured within the first hour of life and the actual weight should be recorded to the degree of accuracy to which it is measured [6]

Low birth weight
Less than 2500g, that is up to and including 2499g

Very low birth weight
Less than 1500g, that is up to and including 1499g

Extremely low birth weight
Less than 1000g, that is up to 999g

More recently, the term 'fetal growth restriction' has been applied to babies born at term with low birthweights, but there is no internationally agreed definition.

With increasing rates of obesity and diabetes, including diabetes in pregnancy, more attention is being given to heavy babies, but there is no internationally agreed definition of high birthweight, known as 'macrosomia. A variety of definitions have been proposed, including 4000g or over, 4500g or over or above the 90th centile of the birthweight distribution for the relevant population.

Associations with outcome and differences between populations
The mortality and morbidity of babies varies considerably according to birthweight, with very high rates among very small babies and raised rates among heavier babies (*see* **stat06097**) There has been considerable research showing that birthweight can be associated with health at later stages in life (*see* **stat06075)**, leading to debates about the relative importance of circumstances at birth..[8]

Birthweight distributions, along with average birthweights and the proportions of births defined as low weight according to WHO criteria also vary between populations and socio-economic groups within the same populations. International comparisons can be compounded by the way countries can differ in their inclusion criteria.[9,10] Within the same population, distributions vary by sex, with boys being heavier than girls. Birthweight distributions can vary according to mothers' ages, parity, socio-economic status and ethnicity and physiological characteristics, as well as the altitude of the mothers' area of residence during pregnancy. Among babies born to less favoured sections of populations there is a tendency for lower mean birthweights and higher proportions of low weight births than among babies born in more favoured circumstances. Studies using record linkage (*see* **stat06114*)***have shown that successive babies born to the some of the same women have similar birthweights.[11] Birthweight distributions for the same population can also change over time. Work in the 1980s to update early birthweight standards, based on a series of births in Aberdeen, Scotland from 1948-64, [12] highlighted a number of analytical problems.[13]

Research concerned with evaluation of maternity care tends to centre on the survival rates of low and very birthweight babies and the health status of the surviving children, although the emphasis has tended to shift to preterm birth and smallness and largeness for gestational age. [14] For both research and for clinical practice there is a need to detect babies whose birthweights are either low or high outliers with respect to their population and gestational age.

Accounting for differences between populations

An early attempt at alternative definition of low birthweight proposed using limits 2 standard deviations below, and by implication, above the mean. [15] A series of articles during the 1980s built on the observation that although the distribution is essentially normal, it has additional births in the lower tail. This means it can be divided into two components, a predominant Gaussian distribution and a residual distribution, which can be characterised by the mean and standard deviation of the predominant distribution and the proportion of births in the residual distribution, This approach was used to compare mortality of boy and girl babies and of black and white babies in North Carolina USA.[16,17]

The development of ultrasound gives the potential for a more precise estimates of gestational age than those based on the date of the woman's last menstrual period and thus more accurate estimates of birthweight distributions by gestational age. A large number of analyses from the 1990s onwards have used these data, statistically adjusted for mothers' physiological and other characteristics, including height, weight, parity, ethnic origin to produce 'customized' birthweight centiles, which can be used to detect fetuses at raised risk of fetal death.[18] Some analyses have used ultrasound to estimate the weights of fetuses antenatally, thus reducing the bias involved in using only the birthweights of babies born at very low gestational ages. [19]

Although many analyses conclude that the customized birthweight centile charts identify fetuses at risk better than population-based centiles, others have challenged this on the grounds that the benefits of customized percentiles arise mainly from their use of ultrasound-based estimates of birthweights and adjusting for mothers' characteristics add little to this.[20] An analysis of Swedish data showed that using customized centiles identified more fetuses which were small for gestational age, but those identified using population-based centiles tended to be at higher risk,[21] while a study of large for gestational age fetuses in Australia and New Zealand reached the opposite conclusion.[22]

A different approach is to fit birthweight for gestational age centiles for specific populations and ethnic groups using the LMS method, which uses Box-Cox power transformations (*see* **stat00404)** to obtain normally distributed data within each group.[23-25] This method is also used in the INTERGROWTH-21st project, the aims of which were to use data from ultrasound measurements on healthy women at low risk of adverse outcome from urban populations eight countries to derive international standards of fetal growth, birthweight and postnatal growth with which measurements of fetal growth, birthweights and postnatal growth from other populations can be compared.[26,27]

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