Are our babies becoming bigger?

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Introduction

Birthweight is one of the most important measures we have of health status of a population, being a strong predictor of both mortality and morbidity, and reflecting nutritional status and growth rates. It is, therefore, of importance to ascertain current birthweight distributions in a population and trends over time, to know which are the groups associated with the highest and lowest health risks, and to identify factors which influence the shape and position of the distributions, and how these change over time. These will be discussed in this paper.

Also to be discussed is evidence bearing on what is the 'optimal' distribution of birthweight for a given population; and, if there is any evidence of changing trends in birthweight distribution in this or other countries, are the changes in the optimal direction?

Relationship with infant mortality

Figure 1, based on data for singleton livebirths born in England and Wales in 1987, shows the strong relationship between birthweight and infant mortality. This is shown here on a logarithmic scale, and as a 3-year moving average, this falling from over 700 deaths per 1000 livebirths weighing between 500 and 799 g, to a minimum of about two per thousand in the babies weighing between 4000 and 4399 g. Similar relationships are seen in both the neonatal and postneonatal components of death rates in the first year. It is the most powerful predictor of infant survival.

Frequency distribution of birthweight

Figure 1 also shows the shape and position of the birthweight distribution. This curve, which is typical of such distributions, approaches a normal, or Gaussian distribution. Mostly these distributions are

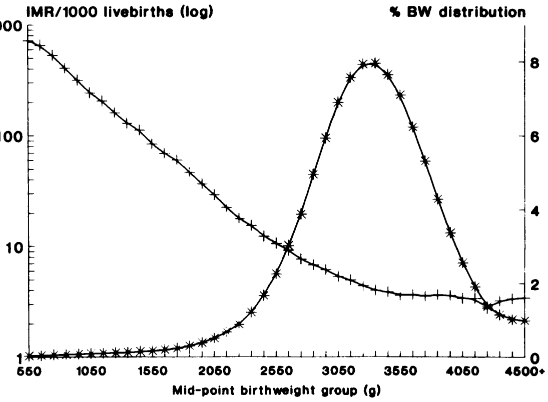

Figure 1. Infant mortality and birthweight distribution (moving averages of three birthweight groups). England & Wales: single livebirths 1987. Source: Office of Population Censuses and Surveys - unpublished data

skewed a little towards the lower end, and it is widely felt that much of the skew is due to a small secondary distribution of births with a pathologically low weight, which can be separated mathematically from the main distribution[1].

As is usually found, the weight group with the lowest risk lies about 1000 g above the modal weight. However, there is a fairly flat plateau of low mortality rates at weights from 3400 g upwards, a cut-off point which includes almost 50% of all births.

One explanation that has been put forward for the fact that the birthweight group with the lowest mortality rarely, if ever, coincides with the birthweight mode is that the main distribution is pulled downwards by the 'secondary' or 'residual' distribution mentioned above. It has been suggested that if we were really able to exclude these, the mode and the 'optimal' birthweight group in terms of mortality might coincide, but in practice it is very difficult to isolate the 'normal' births which in theory constitute the 'main' distribution.

The situation at the upper tail of the distribution is complex, for this includes as well as babies of the healthiest and best grown parents, babies of diabetic or prediabetic mothers whose babies' increased rate of growth is associated with higher than average risks, even excluding a consequent risk of feto-maternal disproportion. Whatever the reason, the mortality risk goes up, albeit very little, in the highest weight groups.

Relationship with morbidity

In survivors also, birthweight is a good predictor of the risk of having certain long-term disabilities, most importantly some form of cerebral palsy, but also sensory and intellectual deficits[2]. In addition there is increasing evidence of the important contribution made by an individual's birthweight to his or her adult height[3] and the influence it may bear upon adult cardiovascular health[4]. Characteristics of the birthweight distribution therefore have a substantial influence on the levels of mortality and morbidity of a population.

Factors influencing birthweight distribution

We know of course that birthweight is influenced by a large number of factors. Overriding all these is the length of time the fetus has spent *in utero*, an outcome which is itself affected by most of the same factors although less so than birthweight.

The large literature on this subject has been reviewed elsewhere[5]. A very simplified summary is that there are different 'norms' for different populations depending largely on the sex of the infant, males being on average some 200 g heavier than

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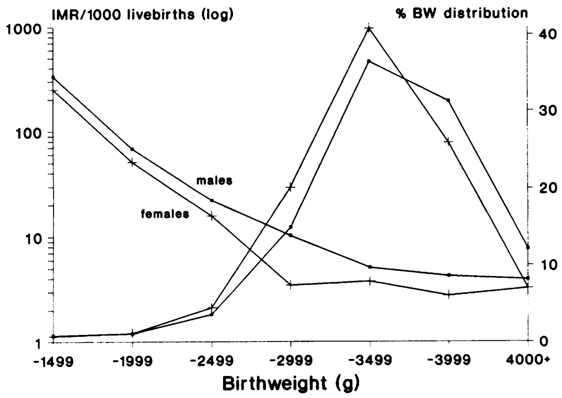

Figure 2. Infant mortality and birthweight distribution by sex (moving averages of three birthweight groups). England & Wales: single livebirths 1987. Source: Office of Population Censuses and Surveys - unpublished data

females at birth; plurality, multiple births on average being both more gestationally immature and smaller for dates than singletons; genetic predisposition, of which adult stature is a reflection; and birth order, birthweight being least in first born and tending to rise with each birth thereafter. Each of these groups have an 'optimal' birthweight which tends to minimize the numbers of births in the high mortality groups. Over and above these norms, and often confounding their effect is the influence of purely environmental factors, including the effects of childhood poverty, leading to stunting of growth; toxic effects such as of maternal smoking; and obstetric effects including uterine, and placental size and shape. For simplicity the present account has largely been restricted to singleton births.

Genetic influences are best illustrated by reference to the effect of sex. Figure 2 shows the shift to the lower birthweights in female infants compared to males, a shift which is accompanied by a consistently lower mortality risk in the females, certainly within the birthweight range shown, showing that the smaller size of females is, if anything, a genetic advantage for infant survival.

The effect of the other factors listed above is nearly always confounded by associated environmental factors which may affect the risk of infant death as well as the birthweight distribution. This is typified by the situation in different ethnic groups. Figure 3 showing data from a recent international data set compares the birthweight distribution in black and white babies from six US states, given in 100 g groups. The difference in the distributions can be seen clearly, the median birthweight of the blacks being over 200 g less than that of the white babies. The difference between the races is particularly striking in view of the fact that adult blacks in the US tend to be of large stature compared with the white population. The birthweight specific mortality rates at the lower tail are, as one might expect, lower in black than white babies, for a white baby to be at these low weights implies a greater deviation from the norm. However, 70% of black births weigh over 2800 g at birth, and above this weight they are at an increasing disadvantage compared with the white births.

Some of the excess of low birthweight seen in the US, and other black populations is almost certainly genetically determined, and is associated with a slightly shorter mean gestational age, and a relatively greater physiological maturity at birth. There is however no doubt that much of it is due to socioeconomic deprivation and more ill-health amongst the black mothers, and the increased skew to the lower tail seen in this and other ethnic minorities testifies to the effect of poverty and malnutrition.

A purely environmental effect, which reduces fetal growth rate in all populations is maternal smoking in pregnancy, particularly after the fourth month. The difference between the mean weight of babies of mothers who smoke and those who do not, approaches the magnitude of the difference found between the sexes[6,7]. The mortality rate of the infants of smokers is slightly lower than that of non-smokers at the lower tail because for non-smokers such births are more deviant from the norm and their causes tend to be of more serious types of pathology, but the risk to the 60% of babies of smokers weighing 3000 g or more is consistently raised.

Shape and position of the birthweight distribution

In order to minimize infant mortality, as many babies as possible should be born at or near the population optimal weight, and as few as possible at high risk weights. Theoretically there are two patterns to be followed to minimize the numbers of births at high risk where the weight distribution is near to normal. Each is illustrated in Figure 4 showing the birthweight

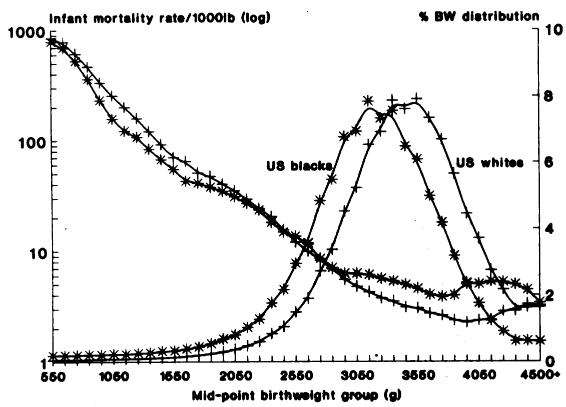

Figure 3. Infant mortality and birthweight distribution by ethnic group (moving averages of three birthweight groups). Source: International Collaborative Effort on Perinatal and Infant Mortality, USA National Center for Health Statistics

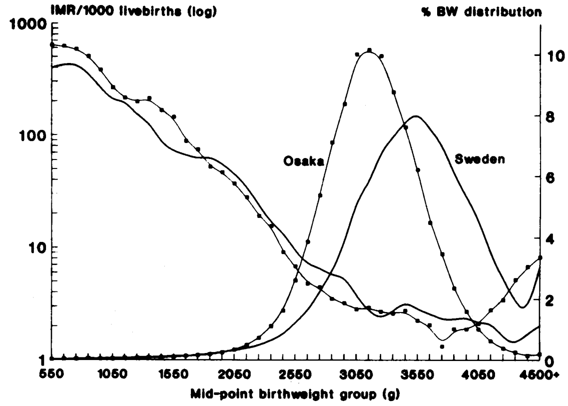

Figure 4. Infant mortality rates and birthweight distributions in Sweden and Osaka, Japan 1984 (moving averages of three birthweight groups). Source: International Collaborative Effort on Perinatal and Infant Mortality, USA National Center for Health Statistics

distributions in two of the countries with the lowest mortality rates in the world, Japan (represented by Osaka) and Sweden. One pattern, as seen in Japanese births, is to have a very tight tall distribution with a small variance, with the peak as close to the optimum weight as possible. This means that the proportion of babies exposed to risks characterized by being of either low and very high weights is minimized. The other pattern, as seen in Swedish births, is where the main distribution has a high variance and a relatively high proportion of births at very high weights. This is likely to be a safe strategy in Sweden, where adult stature is large, and materno-fetal disproportion an unlikely risk. In each of these countries the proportion of low weight births is small, even though the median in the Japanese births is well below that in the Swedish births.

Trends over time in birthweight distributions

The amazing robustness of the characteristics of national birthweight distributions over time has been described elsewhere[8]. It is however possible to detect trends by looking at the selected percentiles of birthweight for different countries over the years. When this is done for the median (50th percentile) small but fairly consistent trends can be detected for some countries. These are illustrated in Figure 5, which includes data prepared by collaborating countries for the Second Symposium of the International Collaborative Effort on Infant Mortality (in press). In keeping with expectation the most striking differences are between countries. Norway and Sweden having the highest medians, followed by the US whites, then Bavaria, Scotland and England and Wales, and then the Japanese and US blacks.

The trend within several of the countries, particularly the US whites and blacks is of an increasing median birthweight. For the few years for which we have data in this detail for England and Wales the trend is also upwards. The major surprise is that the median birthweight in Japan seems to be falling consistently.

What one would like to do is to examine as far as possible trends over the past decades in England and Wales, looking both at changes in the factors which we know affect birthweight, and then considering whether these could account for any observed changes in the birthweight distribution.

Unfortunately national data on the whole birthweight distribution for livebirths in England and Wales was not collected until 1975, and even then it

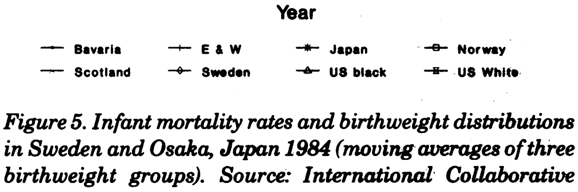

Figure 5. Infant mortality rates and birthweight distributions in Sweden and Osaka, Japan 1984 (moving averages of three birthweight groups). Source: International Collaborative Effort on Perinatal and Infant Mortality, USA National Center for Health Statistics

remained incomplete until 1983, when data became available on over 99% of livebirths. However for 1958 and 1970 we have the data from two national cohort studies[6,7] each covering about 98% of births in one week, which we can use for comparisons with current data.

What sociobiological changes may have affected birthweight over this time?

As far as the factors which influence birthweight are concerned, we know that since 1958 there has been an increase in the proportion of first born births, rising from 37% in 1958, 38% in 1970 to 43% in 1985[6,7,9], which would tend to reduce birthweight. Moreover the habit of smoking in women of reproductive age rose sharply after 1958 to 1970, and has been falling very gradually since then, which would tend to reduce birthweight between 1958 and 1970, and then increase birthweight[10,11].

Over this period there was also a sharp increase in births to mothers born outside the UK, particularly to those from the New Commonwealth where the birthweight distribution is shifted over towards low weights compared with babies of UK born mothers (see later). Data on frequency of such births are not available before 1969, but in 1969 the percentage of births to mothers born in the New Commonwealth was 5.9; it rose to a maximum of 8.5 in 1982, and has fallen to 7.3 in 1988[12]. Again this would have tended to reduce birthweight up to 1982, and then raise it.

From the follow-up of the 1958 birth cohort[13,14] we have found that there has been an increase of 3 cm in the adult stature between fathers of the cohort members and their sons, and of 1.2 cm between mothers and their daughters, a change which would tend to increase birthweight[15]. However, other analyses on the 1958 cohort follow-up (Emanuel *et al.*, in preparation) are showing that maternal birthweight itself is an important influence on the birthweight of the offspring, more so than parental stature or social class, and this is probably an important constraint on rapid change over time, given the remarkable consistency I have shown.

It is therefore not surprising that although there has been a small increase in median birthweight since 1958, the changes overall have been inconsistent (Table 1) if one considers the 10th and 90th percentile, and the median. However since 1983, the year that national birthweight data became virtually complete, there has been a steady increase in the proportion of births weighing 3500 g and over (Table 2).

This change which has effected an increase in mean birthweight, is largely restricted to the babies of mothers born in the UK, and of other Caucasian subgroups (Figure 6), and is seen in most social classes (Figure 7). Interestingly it is particularly marked in the most disadvantaged groups.

There is a variety of possible reasons for this short-term trend, one hypothesis being that it is linked with

Table 1. Measures of birthweight over time

Birthweight percentile	*1958 (g)*	*1970 (g)*	*1986 (g)*
50th	3306	3317	3347
10th	2690	2665	2684
90th	3965	3960	3975
Mean	3315	3302	3318

E & W: birth cohorts & OPCS-single livebirths

Table 2. Percentage of livebirths of 3500 g or more

Year	%
1983	35.9
1984	36.3
1985	36.4
1986	36.7
1987	37.4
1988	38.5
1989	38.6

Source: OPCS-Vols DH3 and unpublished data-E & W

the current small fall in women's smoking habits. This would fit in with the lack of increase of weight in the babies of non-Caucasian immigrant mothers who tend to smoke very little. It would be interesting to know whether in Japan, where the reverse trend is seen, there is an increase in female smoking. In England and Wales the link with decreased smoking could also explain some of the birthweight increases since 1970, together with the secular increase in height which has occurred in the current generation of reproductive age.

Summary

I have tried to show, using a contemporary international data set, the overall consistency in shape of curves of national birthweight distributions which reflect the biological and social characteristics of the population from which they are derived, and the effects of changes in these characteristics. For several countries, including the United States and England and Wales, the trends in recent years have been such as to shift the main distribution upwards, so that the median weight has increased.

Also shown has been the close and specific relationship within each population group between infant mortality and birthweight, with sharp falls of mortality with increasing birthweight. It has been shown elsewhere that similar patterns are seen with short- and long-term morbidity, thus underlining the importance to be attached to increasing birthweight particularly in underprivileged groups. In the short term this can be done by reducing the frequency of parental smoking, where this is a problem, and in the longer term by improving maternal health and nutrition. The shift towards higher birthweights if it persists, should make an important contribution towards the improvement of the public health of the next generation.

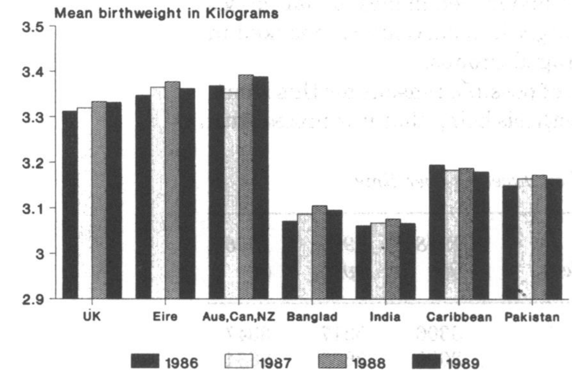

Figure 6. Mean birthweight by country of birth of mother. England & Wales: all births 1986-1989. Source: Office of Population Censuses and Surveys - unpublished data

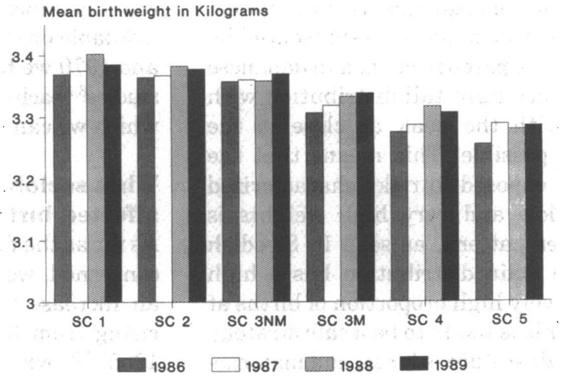

Figure 7. Mean birthweight by social class. England & Wales: 10% Sample of all Legitimate Births. Source: Office of Population Censuses and Surveys - unpublished data

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