# The use of birthweight and gestation to assess perinatal mortality risk

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SUMMARY   Using extensive international data it is shown in detail how mortality is related to birthweight and gestation. It is demonstrated that the widely used 'birthweight for length of gestation' standards can be seriously misleading. A new 'high risk' classification is proposed.

In an earlier paper (Goldstein and Peckham, 1976), data from the 1958 British Perinatal Mortality Survey were used to illustrate how neonatal and perinatal mortality rates were related to birthweight and gestation. In particular it was shown that a mortality risk classification based solely on percentiles of birthweight for gestation was both inefficient and misleading. For example, about 6% of the livebirths had a mortality rate greater than twice the average mortality, yet only one-third of these also lay below the 6th percentile of birthweight for gestation.

Although these results are useful, they are limited to British babies born in 1958, and because of sample size limitations they also cover only a restricted range of birthweight and gestation, from about 2000 to 4500g and from 35 to 43 weeks. The aim of the present paper is to bring these results up to date, using recent data from countries which took part in a collaborative project under the auspices of the World Health Organisation (WHO).

## Sources of data and definitions

In 1973, vital registration data on births and perinatal deaths were collected from eight countries with adequate reporting and analysis systems (World Health Organisation, 1976). The countries were Cuba, New Zealand, Sweden, Hungary, the United States of America (six States), Austria, Japan, and England and Wales, but comprehensive birthweight and gestation data were available only for the first five. Information on time of death was also available, allowing a separation into early neonatal and late fetal deaths. Examination of the data, however, indicated that different criteria for 'signs of life' were being used, thus destroying the possibility of valid comparisons. Therefore we use only perinatal mortality rates in this paper. Furthermore, the distributions of births by birthweight and gestation for Hungary and the United States of America differed in important respects from those of Cuba, New Zealand, and Sweden. The following results, therefore, are based on the latter three countries, and comprise in all 324 939 births and 8746 perinatal deaths, giving an overall perinatal mortality rate of 26·9 per 1000.

We have used the definition of perinatal mortality provided in the 8th revision of the *International Classification of Diseases* (World Health Organisation, 1967). The new definition for international comparisons, which is recommended for the 9th revision, would undoubtedly lead to different results. However, apart from certain difficulties associated with the new definition (Goldstein and Butler, 1977), it was not available in 1973, and we shall therefore present no results based upon it.

## Results

The following figures are based upon extensive tabulations prepared by WHO. Preliminary analysis showed that the separate patterns for Cuba, New Zealand, and Sweden were very similar, so these have been combined.

We illustrate first the percentage distribution of births by birthweight and gestation. This was derived as follows. Birthweight was categorised into 250g groups and gestation into completed weeks. For each

cell of the resulting birthweight by gestation table the percentage of births in that cell out of the total births was calculated. The midpoints of these cells, together with the cell percentages, were then marked on a birthweight by gestation diagram, and points with equal cell percentages (interpolating where necessary) were joined by continuous lines. The majority of births occur at around 40 weeks gestation and 3300g, with fewer occurring as one moves away from this modal point. Thus the lines joining the cell centres join points with equal percentages of total births, and are known as 'equal probability contours'. They form a series of 'loops' around the modal point. For each one, the percentage of births falling within the loop is estimated from the original data, and by suitable interpolation and smoothing between loops, we have arrived at the series of equal probability contours shown in Fig. 1. Thus, for example, the loop labelled 10 contains 10% of the total births within it. This is a conventional method of graphically representing a two-way, or bivariate, frequency distribution, and it shows clearly how the distribution becomes sparser or less dense as we move away from the modal point.

Turning to perinatal mortality, we wish to illustrate how the perinatal mortality rate varies with birthweight and gestation. Using a procedure similar to that used for the frequency distribution of births,
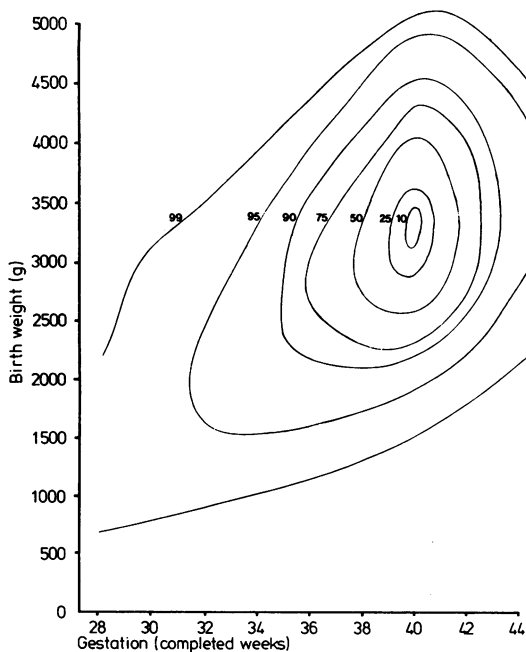
mortality rates were calculated for each cell of the birthweight by gestation table. The centres of those cells with equal mortality rates (interpolating where necessary) were joined, and a final series of 'equal *mortality* contours' was derived by interpolating and smoothing between these lines to give the contours shown by the continuous lines in Fig. 2. These mortality rates are expressed as percentages of the average mortality rate. They can be likened to contours used on maps with height above ground replaced by perinatal mortality rate. Thus, for example, a baby of 3000g at 39 weeks of gestation falls on about the 50 contour, and so has an estimated mortality of half the average (100). Although some extreme contours are presented, they should be interpreted with some caution because they are based on relatively few births and are included for completeness only. The contours up to 300 are estimated reasonably accurately. For example, at 31 weeks a simple 95% confidence interval for the 300 contour covers approximately from the 200 to the 420 contour, but since this contour is 'smoothed' in relation to the estimated mortality rates in surrounding cells, the adjusted interval will have a
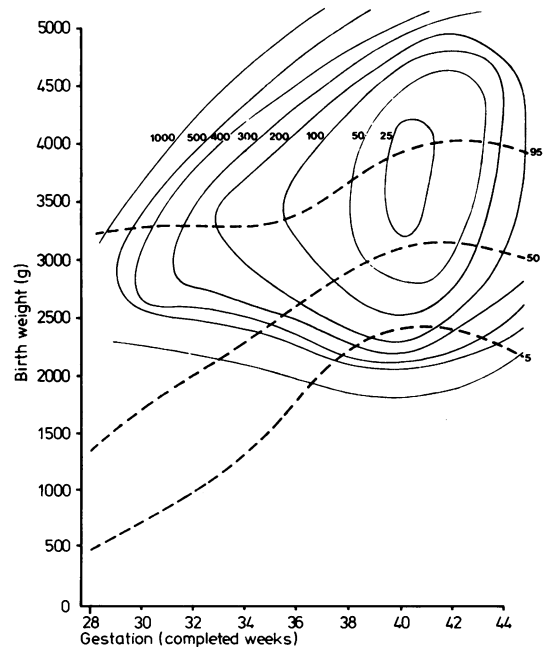


Fig. 1 *Equal probability contours for the joint distribution of birthweight and gestation length.*



Fig. 2 *Contours of perinatal mortality risk by birthweight and gestation length. Average rate = 100. Broken lines are the 5th, 50th, and 95th percentiles of the birthweight distribution for each week of gestation. (The apparently anomalous behaviour of the 95th percentile for short gestational lengths seems to be due to some misreporting of gestational length).*

range which is at most half of this. Also, above 36 weeks of gestation, the contours up to 500 are estimated with reasonable accuracy.

This figure shows a strong similarity to the contours presented by Goldstein and Peckham (1976) and Hoffman *et al.* (1974). It also shows clearly that the birthweight for length of gestation percentile lines, which are superimposed, (the broken lines), provide an inadequate basis for assessing mortality risks. To begin with, almost all babies with gestational ages outside the range 33–44 completed weeks also lie outside the 200 contour, that is, they have a mortality more than twice the average. Within the range 33–44 completed weeks we have calculated that 7% of babies lie outside the 200 contour, a similar percentage to that found by Goldstein and Peckham (1976). Of these 7% of babies, only 45% also lie below the 5th percentile, so that if we use a percentile criterion to define the 5% of babies at highest risk, as many as one half of those truly at high risk would in fact not be classified as such. On the other hand, in this range of gestation of all those babies outside the 200 contour, 82% also had a birthweight below 2500g, (and correspondingly of all those babies below 2500g, 88% were also outside the 200 contour). Thus a risk assessment using birthweight alone performs considerably better than one based on percentiles of birthweight for gestation, and the traditional 'low-birthweight' (under 2500g) risk categorisation is actually fairly efficient.

## Discussion and recommendations

Using extensive international data, we have confirmed the findings of other studies concerning both the distribution of births by birthweight and gestation and the relation of perinatal mortality risk to these variables. We have shown how the common use of percentiles of birthweight for gestation is inadequate, leading to the classification of many 'low risk' babies as 'high risk' and vice-versa. The continuing use of such percentiles for risk assessment is possibly due to their being regarded as similar to postnatal growth standards. There is, however, one major difference. Each baby has only one gestation length, whereas postnatally every child reaches every age at some time. Hence, in addition to using percentiles of birthweight for gestation, it is clear that we need to take gestation into account as well, or, more simply, to study in detail the way in which perinatal mortality varies by both birthweight and gestation.

In view of the apparent uniformity of results from different studies, we would tentatively suggest that Fig. 2 can be used for other populations, with appropriate adjustments for different mean birthweight and gestation. Experience with this Figure for a given population will also show how it needs to be modified, if at all, to take account of any particular characteristics of the population concerned.

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