Weight of all births and infant mortality

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SUMMARY Birth weight is the most important determinant of perinatal and infant mortality. The lowest mortality rates in the first week of life are recorded among newborn infants weighing 3500 g or more and the proportion of such infants may be regarded as a measure of optimality of the birth population. There is an inverse relationship between the proportion of heavy newborn infants in a country and its infant mortality rate. In both these respects Iceland, Norway, and Sweden have a better experience than England and Wales, Denmark, and the United States of America. The effects of parity, maternal age, social class, and smoking are considered, but it appears that there are still factors that inhibit the intrauterine growth potential of American, British, and Danish fetuses. Elective delivery, use of diuretics, and restriction of diet in pregnancy have shifted the birth distribution to the left and this may have more than counterbalanced the possible beneficial effects.

These other factors may adversely affect birthweight distribution in North America and Europe to such an extent as to limit or even damage the favourable position already achieved in health and social development as measured by fetal survival.

Neonatal mortality is strongly dependent on birth weight. In Scandinavia today about half of the infants weighing less than 1500 g at birth die during the first week of life compared with less than 5% of infants weighing between 1501 and 2500 g, about 0.5% of those between 2501 and 3000 g, and approximately only one in 1000 of those weighing more than 3500 g (Table 1). Discussion on how to reduce infant and neonatal mortality has therefore centred upon the reduction of the proportion of infants with a birth weight lower than 2500 g. But it should be noted that mortality is lowest in quite large babies, between 3501 g and 4500 g or 5000 g; and even in the heaviest group, over 4500 g or 5000 g, mortality is only slightly higher. Consequently, any factor which

reduces birth weight, even if it does not increase the proportion of births under 2500 g, may increase first-week deaths.

In this paper, national figures of the distribution of birth weights in selected countries are examined and compared with infant mortality rates, and trends and patterns that may affect these results are investigated.

Materials and methods

Information on the distribution of birth weight, of maternal age and parity, of infant mortality and first-week deaths was obtained from the *United Nations Demographic Yearbook 1975*¹ and from various official national publications.²⁻²⁴

In the present investigation, the choice of infant mortality instead of perinatal mortality was influenced by the fact that in Scandinavia stillbirth rates are not directly comparable. Norway, Sweden, and Denmark have all adopted the World Health Organisation criteria of live birth and fetal death, but the three countries differ in their practices. As a result, the proportions of extremely low-birthweight stillborn infants vary. In 1974, 9% of the Norwegian stillborn infants weighed less than 1000 g, 6.6% of the Swedish, but only 1.5% of the Danish. Moreover, in Norway, infant mortality is inflated by the inclusion of non-viable fetuses of extremely low birth

Table 1 Early neonatal mortality (%) by birth weight in Norway, Sweden, and Denmark

Birth weight (g)	Sweden 1973	Denmark 1974	Norway 1975-6
Under 1500	45.8	46.4	55.0
1501-2500	4.6	3.3	3.5
2501-3000	0.47	0.43	0.43
3001-3500	0.18	0.14	0.15
3501-5000	0.11	0.10	0.09*
Over 5000	0.20	—	0.18

Information for latest available year derived from the National Central Bureau of Statistics in Norway, Denmark, and Sweden.

*Birthweight interval 3501-4500 g

weight which previously would have been classified as stillborn or abortions. Between 1969 and 1972, some 20% of the first-week deaths weighed less than 1000 g and 70% of these died during the first 24 hours. On the assumption that these non-viable infants would have been classified as abortions or stillborn in Sweden, infant mortality in Norway in 1978 would be reduced from the observed 8.6 to 7.9 per 1000 births.

Results

Table 2 shows the proportion of births in five weight groups together with the infant mortality rate for 13 selected countries in about 1973. The countries are ranked in order according to the proportion of births over 3500 g. The highest proportion of these births

occurred in Iceland and the Faeroes, where the lowest proportion of births under 2501 g was also recorded. In Norway and Sweden the frequency of low birth weight is higher but the infant mortality rate remains low. Western Germany, Czechoslovakia, and Denmark have similar birthweight distributions, but very different infant mortality rates (21.1 in Germany, 20.4 in Czechoslovakia, and 10.4 in Denmark).

The proportion of heavy babies is lower and that of light babies higher in the USA, Canada, and the United Kingdom, and the infant mortality rates are similar. In Poland and Hungary there is a further shift to the left of the weight distribution and a corresponding increase in mortality.

Japan is exceptional in that although the proportion of births over 3500 g is only 23.3%, the

Table 2 Proportion of births by weight and infant mortality rates in certain countries (%)

Country	Year	<2500 g	2501-3000 g	3001-3500 g	3501-4000 g	>4000 g	Infant mortality per 1000
FAEROES	1973	3.7	8.3	26.6	38.0	23.4	12.8
ICELAND	1972	4.3	8.7	28.2	35.2	23.6	10.1
NORWAY	1972-4	4.4	11.7	32.9	34.3	16.7	10.4
SWEDEN	1973	4.6	11.9	34.0	33.7	15.8	8.6
GERMANY GFR**	1973	6.7	14.6	38.3	29.7	10.7	21.1
DENMARK	1973-4	6.8	17.6	37.1	28.5	10.0	10.7
CZECHOSLOVAKIA**	1973	6.1	17.1	39.0	28.8	9.0	20.4
USA	1973	7.6	18.2	38.2	27.0	9.0	17.7
CANADA**	1973	7.0	18.7	39.1	26.9	8.3	15.0
UNITED KINGDOM	1970	6.8	18.9	39.1	26.8	8.3	16.4
POLAND**	1974	8.0	19.7	37.3	26.7	8.3	23.5
HUNGARY**	1974	11.7	23.4	38.0	21.4	5.5	34.3
JAPAN**	1974	5.1	25.0	46.6	20.1	3.2	10.8

* Rank order by proportion of births over 3500 g.

** Live births only.

Table 3 Trend in distribution by weight of all births in selected countries (%)

Country	Year	<2500 g	2501-3000 g	3001-3500 g	3501-4000 g	>4000 g
NORWAY	1967-71	4.8	11.8	32.9	34.1	16.4
	1972-4	4.4	11.7	32.9	34.3	16.7
DENMARK*	1959	6.9	18.2	37.3	27.7	9.9
	1969-70	6.0	14.8	35.9	30.9	12.5
	1971-2	5.7	14.4	35.6	31.3	13.0
	1973-4	6.8	17.6	37.1	28.5	10.0
UNITED KINGDOM	1958	6.2	18.0	35.9	27.0	9.3
	1970	6.8	18.9	39.1	26.8	8.3
USA						
ALL BIRTHS	1960	7.7	18.4	37.9	26.7	9.0
	1966	8.1	20.9	39.4	24.4	7.1
	1973	7.6	18.2	38.2	27.0	9.0
WHITE BIRTHS	1960	6.8	17.3	38.1	28.2	9.6
	1966	7.0	19.4	39.7	25.1	8.8
	1973	6.4	16.6	38.7	28.8	10.0
NON-WHITE BIRTHS	1960	12.9	25.3	37.1	18.9	5.9
	1966	13.5	27.5	38.1	17.0	3.8
	1973	13.3	25.8	38.4	18.2	4.4

* In Denmark, repeated changes in classification from 0-499 g, 500-999 g, etc. to 0-500 g, 501-1000 g, etc. and vice versa have occurred. It is estimated that such changes would alter the proportions of neonates in the bands <1.5 kg and 1.5-2.0 kg by about 0.03% and 0.14% respectively.

Information from the National Statistical Bureaux of Norway, Denmark, and the USA and from Chamberlain *et al.*²⁶ for the United Kingdom.

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proportion under 2500 g is also low (5.1%) and the infant mortality rate is very low (10.4 per 1000). There are three problems here that prevent comparison with the Scandinavian countries. Firstly, there is an ethnic difference; secondly, the Japanese data relate to live births only; and, thirdly, there may be a difference in the recording of infant deaths, as the fetal death rate in Japan was 41.8 per 1000 compared with 10.5 per 1000 in Norway.

The first problem is to consider how consistent were the distributions by weight in individual countries? Table 3 shows the serial distributions. In Norway, there was a consistent pattern between 1967 and 1974 despite a significant decline in annual births during that period. This was not so in Denmark, where, after considerable improvement in the distribution between 1959 and 1972, there was a return to earlier patterns in 1973-4 and the birth rate had changed little. Trolle²⁵ found an inverse relationship between the annual number of births and the proportion of infants of 2500 g or less during the post-war 'baby boom' in Denmark, when the proportion of low-birthweight infants declined to 4.6% compared with 8% in the early 1940s.

In England and Wales, where birth weights are not provided regularly, the proportion of births under 2501 g declined from 7.9% in 1955 to 7.1% in 1964 concomitantly with an increase in annual births from approximately 680 000 to 890 000 in 1964. Then, from 1964 to 1970, a moderate decline in births adversely affected the proportion of low birth weights, which reached 7.5% in 1970. No information is available about the distribution by weight of all births between 1955 and 1970, but Chamberlain²⁶ and his colleagues confirm a less

favourable distribution by weight of all births in 1970 than in 1958.

In the USA a lack of consistency in the pattern of distribution by weight of all births between 1960 and 1973 is also apparent; 1966 showed the lowest proportion of heavy newborn infants together with the highest proportion of infants of low birth weight, while the more favourable distribution pattern of 1960 was more or less regained in 1973. Both white and non-white births were affected similarly by the adverse trend from 1960-6 and by the more favourable development between 1966 and 1973.

This increase in the birthweight distribution may be partly explained by the increasing age and parity of mothers as the birth rate rises and a similar fall as it declines, but the pattern is not entirely consistent. In Denmark the mean parity was steady at 2.1 between 1970 and 1974 when the birthweight distribution was changing whereas in the USA, mean parity declined year by year from 1960 to 1974, yet the birthweight distribution shifted upwards and then went down again. By contrast, in Norway parity declined between 1967 and 1974 yet birth weight remained stable. Clearly some other factors have to be considered.

This raises the questions 'Does the birthweight distribution in a country truly reflect the intrauterine growth potential of the mother and child?' and 'Are the majority of pregnancies allowed to come to full term?'

Table 4 shows the increases that can be expected with increased parity. The mean birth weight increases by about 140-150 g between parity 0 and parity 1 and then by about 50 g for subsequent pregnancies. An increase in the means of this order

Table 4 Mean increase in birth weight (g) with parity in selected countries

Country	Year	Parity 1	Parity 2-3	Parity 3-4	Mean birth weight
NORWAY	1967	140 g	40 g	40 g	3470 g
DENMARK	1970	150 g	50 g	50 g	3370 g
ENGLAND AND WALES	1935-46	145 g	27 g	—	3257 g
	1958	140 g	0 g	0 g	3332 g
UNITED KINGDOM	1970	138 g*	—	—	3310 g
SCOTLAND	1969-73	120 g	10 g	-20 g	
USA	1966	40 g	20 g	10 g	3300 g
	WHITE BIRTHS ONLY	50 g	10 g	10 g	3350 g
NEW YORK STATE					
	WHITE BIRTHS				
	1959	65 g	30 g	30 g	3372 g
	1967	50 g	23 g	22 g	3344 g

Information obtained from the following sources:

Norway: Bjerkedal and Bakketeig¹⁸

Denmark: Danish Central Bureau of Statistics

England and Wales: Karn *et al* 1951 and Butler and Alberman²⁴

United Kingdom: Chamberlain *et al.*²⁶

Scotland: Lewis²⁵

USA: US Department of Health, Education and Welfare.³

(Information on median birth weight only, calculated to nearest 10 g on basis of exact conversion of interval limits for pounds and ounces.)

New York State: Selvin and Janerich²⁷

* Increase between parity 1 and all later parities.

may be an indication that the majority of pregnancies are allowed to proceed to term. In the USA the increase between parity 0 and parity 1 is 50 g and it is negligible for later pregnancies. This reduced increase in birth weight with parity was noted by Selvin and Janerich²⁷ in 1971. This pattern suggests that American mothers are not allowed to develop their full intrauterine growth potential.

In England and Wales the figures for increase in mean birth weight with parity are not available in detail but the increase between parity 0 and all later births was only 138 g in 1970, and in Scotland in 1968–73 the increase between parity 0 and parity 1 was 120 g. With no significant decline in mean parity between 1958 and 1970, and a certain increase in the proportion of second- and third-born infants, mean birth weight declined, as did the proportion of heavy newborn infants.²⁸ The distribution pattern by weight of all births in the United Kingdom therefore incompletely reflects the intrauterine growth potential of the mothers.

Discussion

The largest discrepancy in mean birth weight and distribution by weight of all births observed within one ethnic group was described by Adams and Niswander^{28, 29} in an investigation of the North American Indian tribes. The proportion of heavy infants (3417 g or more) ranged from 54.5% in the Cheyenne to 27% in the Hopi infants, and the proportions of liveborn infants of 2508 g or less were 4.0% and 7.5% respectively. Birth weight was apparently related to food procurement and utilisation habits, and the low birth weight in certain tribes was probably due to the fact that they were living near subsistence level. Mean male stature differed significantly: 174.8 cm in the Cheyenne compared with 164.5 cm in the Hopi tribe. In these people, birth weight is therefore an indicator of health and social development.

In the Nordic countries, with their exceptionally high standard of living and with medical care available to every citizen, the proportion of infants of 3500 g or more ranges from 60% in Iceland and the Faeroe islands to 50% in Norway and Sweden and only 38.5% in Denmark.³⁰ Although birth weight is associated with length of gestation there is no evidence that in Iceland the heavy infants had an excess of postterm deliveries over 42 weeks. Mean gestation was similar at 40.1 weeks and some 16.4% of the Icelandic deliveries were postterm compared with 15% and 16% in Norway and Sweden.

Parity is another factor influencing birth weight and the distribution by parity differs significantly in Nordic countries, with an excess of fourth- and

later-born infants in Iceland. However, the estimated effect of this factor on mean birth weight is only 15–30 g, whereas the observed discrepancy in mean birth weight between Iceland and Norway and Sweden approaches 100 g. The maternal age range 25–29 is optimal as regards birth weight, and younger mothers give birth to a greater proportion of low-birthweight infants. Less than 25% of the deliveries in Iceland are to mothers aged 25–29 compared with 35–40% in Norway, Denmark, and Sweden, where there is a tendency towards postponement of pregnancy among younger women. In Iceland, more than half the deliveries are to women under 25 and more than 17% to women under 20.

The predominance of heavy newborn infants in Iceland may be partly due to the more rural character of that country.^{31, 32} The similarity in distribution by weight of all births in Iceland and some of the less urban counties in Norway also supports this. A reduction in deliveries to younger mothers would probably reduce infant mortality in Iceland to eight per 1000 births or less through a reduction in low birth weight.

The larger proportion of infants weighing more than 3500 g in Norway compared with Denmark is probably also mainly due to the greater predominance of rural areas in Norway, since the two countries do not differ in distribution by maternal age, parity, or increase in birth weight with parity. It seems reasonable to ask whether some particularly adverse factors affecting birth weight predominate in urban Denmark—for example, the growth-retarding effect of a previous termination³³ might be considered. On the basis of age-specific abortion rates in 1975, it has been calculated that legal abortion would be performed in 707 of 1000 women during their reproductive period between the ages of 15 and 49. Smoking is commoner in urban regions, particularly among young women. The effect of smoking in pregnancy on birth weight is usually of the order of 200–300 g.^{34, 35} A shift to lower birth weight could also be induced iatrogenically through a more widespread practice of limiting the mother's weight in pregnancy through diet and diuretics.^{36–38} A reduced proportion of heavy newborn infants due to an excessive use of elective delivery seems less likely because induction rates are similarly low in Denmark and Norway: under 15%. However, with an induction rate of just under 16% in Copenhagen in 1977 (Table 5) there is a shift to birth weights of 2001–3500 g compared with the city of Aarhus, where the rate was under 9% and where there is a striking excess of infants of 3500 g or more. The proportion of infants weighing 2000 g or less is higher in both cities compared with the rest of

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Table 5 Elective and instrumental delivery, distribution by weight of all births, and early neonatal plus neonatal mortality in the two largest cities in Denmark in 1974 and 1977

	DELIVERY (%)		MORTALITY (rates per 1000)		BIRTH WEIGHT (%)				
	Elective	Instrumental	Early neonatal	Neonatal	<2000 g	2001–2500 g	2501–3000 g	3000–3500 g	>3501 g
COPENHAGEN									
1974	17.2	16.3	6.5	7.4	2.4	5.0	21.0	38.2	33.4
1977	15.7	20.9	3.3	4.4	2.3	5.5	20.2	39.2	32.8
ARHUS									
1974	9.7	7.8	5.9	6.5	2.2	3.9	16.3	37.1	40.5
1977	8.3	10.7	4.5	5.6	2.3	3.6	15.0	35.2	43.8
REMAINING COUNTIES IN DENMARK									
1974	14.7	13.3	7.2	8.3	2.4	4.4	17.3	37.0	38.9
1977	14.7	16.4	4.9	5.8	1.9	4.1	17.0	36.7	40.3

Caesarean sections rose from 8.2 to 10.6% in Copenhagen, from 3.6 to 4.8% in Arhus, and from 6.1 to 8.1% in the remaining counties in Denmark.

Table 6 Mortality by birth weight (g) in Copenhagen and Arhus, 1977 (rates per 1000)

	Early neonatal			Neonatal		
	<2000	2001–3500	>3500	<2000	2001–3500	>3500
COPENHAGEN	86.9	1.9	0.5	113.0	2.4	1.1
ARHUS	146.3	1.9	0.3	189.0	2.4	0.3
DENMARK	158.5	2.4	0.7	180.9	3.1	1.1

In Copenhagen, 95% of the deliveries took place in maternity wards in hospital, 0.2% in other wards, 4.1% in maternity homes, 0.9% at home.

In Arhus, 50.3% took place in maternity wards, 22.9% in other wards, 25.9% in maternity homes, 0.9% at home.

Denmark. The two cities differ in distribution by maternal age, with an excess of younger mothers in Copenhagen.

This significant shift to lower birth weight with induction rates as low as 15–17% suggests that our uncertainty about length of gestation is probably greater than has hitherto been assumed.^{39 40} The optimal induction rate—that which confers minimal mortality without adversely affecting the distribution pattern by weight through a reduction in infants with minimal risk of mortality—is probably considerably lower than has previously been assumed.

The comparison of weight-specific neonatal mortality in Copenhagen with that in Arhus in 1977 is most interesting (Table 6). In Arhus, mortality was lower than in Copenhagen for infants weighing more than 3500 g. For those between 2001 g and 3500 g the rates were similar; below 2000 g they were higher. The extremely low rates for infants weighing under 2000 g in Copenhagen are due to the very high proportion of hospital deliveries in that city. The low mortality of heavy newborn infants in Arhus accords with Baird's statement⁴¹: 'the present mothers are younger and healthier than a generation ago and for this reason the danger of prolonged pregnancy is less'.

The present distribution by weight of all births in Britain is not known but low birth weight is routinely recorded. Between 1955 and 1974 the proportion of infants weighing 2000–2500 g remained unchanged

at 5% while that of those weighing less than 2000 g declined from 2.9% to 2%. The lack of decline in the weight group 2000–2500 g could well be related to the concomitant rise in rates of induction: from about 13% in the early 1960s⁴² to about 40% in 1974–5. The specific effect on birth weight of high rates of induction has been shown in Cardiff, where there was an adverse effect on birth weight through a reduction in the mean period of gestation.⁴³ The fall in birth weight was considered secondary to the fall in gestational age. This report from Cardiff is of particular interest because high rates of induction could also affect the discrepancy in birth weight between the sexes through the reduction in gestational age, since male and female firstborn infants differ significantly in gestational age distribution, with a striking excess of female postterm deliveries.^{19 20}

The widespread practice of restricting a mother's weight in pregnancy through diet and diuretics, and an extremely high frequency of elective deliveries, have characterised the USA for several decades.^{44 45} With the virtual elimination of increasing birth weight with parity in the USA (Table 4), a reduction would also be expected in the association between birth weight and birth order in individual families.^{46–50} This elimination has probably obscured the adverse effect on birth weight of the significant decline in mean parity from 2.92 in 1962 to 2.13 in 1973 in the USA.

The inverse relationship between the proportions of heavy newborn infants and low-birthweight neonates can be seen from the following figures in this investigation: low-birthweight infants increase from less than 4% when 60% are heavy newborns, to 7% when less than 40% weigh 3500 g or more, and reach 12% when 26.9% weigh 3500 g or more. With the present variety of uncontrollable and non-genetic factors influencing weight at birth, the present distribution pattern in several countries incompletely reflects this relationship. For example, in Japan, where the proportion of heavy newborn infants is as low as 23%, only 5.1% are of low birth weight. This strikingly low proportion of liveborn infants weighing 2500 g or less is related to the high ratio of fetal to neonatal deaths in Japan, where infant deaths constitute only one-fifth of the total early and late fetal loss.⁵⁰

Social class is a powerful determinant of birth weight. The present social class differential in birth weight is of the order of 200–300 g.^{11 26 51–53} With high rates of induction, there is reason to believe that those most at risk of being induced are the uncomplicated 'high-birthweight' pregnancies of upper and middle class women.^{42 44 54 55} These women usually have easier access to innovation in medical practice than those in the lower social classes. High rates of induction could therefore be expected to tend to diminish the social class differential through reducing the proportion of heavy infants in 'upper and middle class' families. However, the social class differential has remained the same or even increased.^{10 11} This is due to the predominance in the lower socioeconomic categories of young mothers with unwanted illegitimate pregnancies, as well as a high proportion of mothers who smoked in pregnancy and a persistently lower use of the health services.^{53 56 57}

In assessing the importance of changes in the distribution by weight, it is therefore important to take into consideration the distribution by social class. In Denmark in 1971–4, there was a shift towards lower birth weight with a reduction in heavy newborn infants in particular accompanied by a 5% decrease in the number of births. But this decrease was the result of a 7% reduction in births in social classes I and II, while in classes IV and V there was an increase of 8%. In highly urbanised countries such as Denmark, Britain, and the USA, minor changes in the annual number of births tend to be associated with changes in the distribution by birth weight, which suggests that rapidly changing differential fertility by social class is a characteristic of these countries. In sparsely populated and less urbanised countries like Norway, these rapid changes are not observed.

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