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New assessment of the effects of birth order and socioeconomic status on birth weight

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Abstract

A survey of the 20 698 singleton births occurring in one year to women resident in the Greater Dublin area provided information on birth weight, birth order, and social class. Low (≤ 2500 g), suboptimal (≤ 3000 g), and optimal (3001-4499 g) birth weights all showed a linear relation with social class. The incidence of low and suboptimal birth weight was highest in first, fifth, and subsequent births, and conversely optimal weight was commonest in second, third, and fourth births. Analysis indicated that a major part of the birth-order effect was attributable to social class.

Birthweight categories give information which may be distorted when using mean weight alone. The use of suboptimal and optimal weight offers the possibility of more accurate assessment of trends in performance, particularly in small samples, than does the conventional sole use of low birth weight. Low and suboptimal birth weights are uncommon in Dublin.

Introduction

Birth weight is generally acknowledged as the single most potent indicator of the risk of both mortality and handicap in the neonate. It is therefore important to understand as far as possible the factors which influence birth weight. Two such factors are birth order and social class.

Bakketeig and Hoffman¹ reopened the whole question of the effect of birth order on the outcome of pregnancy, particularly its effect on perinatal mortality. They found that in Norway mortality was higher in all birth orders among babies born to mothers who had three or four, as opposed to one or two, births during the seven-year study period. They noted that socioeconomic differences probably existed between the two groups of mothers. A WHO report² showed a consistent trend towards higher parities in the lower socioeconomic groups in all countries from which data were available. Hence it seemed important to make a new assessment of the effects of birth order and socioeconomic factors on the outcome of pregnancy, using a reference population with sufficient high parity to enable the birth-

order effect to be fully investigated. Birth weight is used as the indicator of outcome in this study.

The Republic of Ireland offers a special opportunity to examine the influence of birth order. High parity is common, and as a result many high-order births may be studied over a short period during which there is unlikely to have been any dramatic change in obstetric practice or socioeconomic conditions. Secondly, the standard of antenatal and obstetric care is high, and most births in Dublin take place in large, well-staffed maternity hospitals.

This study is the first based on the whole population of women in Greater Dublin (that is, Dublin City and County and Dun Laoghaire Borough). It is therefore not subject, as individual hospital studies may be, to distortion of proportions of socioeconomic groups and of cases coming from outside the area, some as high-risk referrals.

Methods and data sources

The study covers singleton births, both live and dead, after gestation of at least 28 weeks, which occurred during 1 April 1978 to 31 March 1979. All such births to mothers normally resident in the Greater Dublin area are included. The population of this area was assessed as 983 683 in the national census on 1 April 1979.³

All births to unmarried mothers which took place in the area are included. It was not possible to ascertain the home address in these cases. An unknown number of unmarried mothers come from other parts of the country to have their babies in Dublin; however, a further, also unknown number of unmarried mothers normally resident in Dublin leave the area to have their babies or to obtain a termination.

By law hospitals and midwives must notify the health board of all births to mothers normally resident in its area. Information for the study was obtained from files of notification forms at the Eastern Health Board, which covers the Dublin area. Almost 4% of cases were without birth weights. The birth weights for these cases were obtained by searching patients' charts and delivery ward records in the various hospitals. All cases with weight still missing were excluded from analysis.

The father's occupation was classified according to the British Registrar General's social classes I, II, IIIN, IIIM, IV, and V, referred to here as social groups 1 to 6. The unemployed were classified separately (group 7), as were the never married and unsupported mothers (group 8). This group consisted almost entirely of never-married mothers. Military personnel and unclassified occupations are listed separately.

"Birth order" includes the present pregnancy and all other pregnancies lasting 28 weeks or more. The large number of cases facilitated detailed comparison of the birth weights by social group and by birth order. This was done by using mean weights and classifying birth weights into four categories: low birth weight (≤ 2500 g), suboptimal birth weight (≤ 3000 g), optimal birth weight (3001-4499 g), and

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above-optimal birth weight (≥ 4500 g). The suboptimal category includes all babies of less than 3001 g. With these categories contingency tables listing the numbers in each social and birth order group by weight were used to make comparisons between the groups. The frequencies of the weight categories within each birth order or social group are given as percentages of all births in the particular birth order or social group.

Results

A total of 20 698 births were recorded for the year of the study. Birth weight was obtained in 20 669.

Table I shows the numbers of cases in each of the birth order and social groups. The percentages of higher-order births were 22.3% for birth order 4 or higher, 5.8% for 6 or higher, 2.0% for 8 or higher, and 0.7% for 10 or higher. The highest birth order was 15. In analysis of the data birth orders of 7 and above are treated as a single category.

TABLE I—Numbers of cases used to construct figures 1 and 2*

Birth order:	1	2	3	4	5	6	7*	
Cases included	6774	5286	3994	2272	1130	537	658	
Weight missing	7	13	2	2	2	1	2	
Social group:	1	2	3	4	5	6	7	8
Registrar General's social classes	I	II	IIIN	IIIM	IV	V	†	†
Cases included	1191	2608	2917	6614	2116	1727	1162	1815
Weight missing	3	6	2	5	5	3	3	3

*Cases belonging in the armed services (461) or where occupation was unclassified (41) are excluded from analysis by socioeconomic group.

†Groups 7 and 8 include unemployed and unmarried respectively.

FIG 1—Distribution of births by weight category and birth order. (Broken horizontal lines represent means for all births.) Table I explains groups.

BIRTH ORDER

Figure 1 shows the frequency of the various weight categories within each birth order. The frequency for each category in the population as a whole is shown by a broken line across each graph. A total of 4.7% of births were of conventional low birth weights of 2500 g or less; 17.6% were suboptimal, being of 3000 g or less; 79.6% were in the optimal range between 3001 and 4499 g; and 2.8% were of above-optimal weight, being 4500 g or more.

The occurrence of both low and suboptimal birth weights showed a clear and consistent U-shaped trend with birth order. Both weight categories occurred with highest frequency in first and the highest-order births. Minimal values for low birth weight were found in second to fourth births, and for suboptimal birth weight in third and fourth births. Optimal weight showed a reverse trend. The frequency was low in first births, at a maximum in second births, slightly lower in third and fourth, followed by a steep decline to a value below that for the first birth among the highest-order births. The above-optimal weights rose steadily in frequency from birth order 1 to 6, then fell slightly.

The mean weight in all the births was $3468 \pm \text{SE } 4$ g. The mean weight rose from the first birth to a plateau from fourth to sixth births, followed by a small downward turn to the value for seventh and later births. This was still well above that for first births (table II). The mean weight did not reflect the deterioration in birth-weight performance after the fourth birth, which is shown in the analysis by weight categories (fig 1).

TABLE II—Mean weights with standard errors for social and birth order groups

Social group	Mean weight $\pm$ SE (g)	Birth order	Mean weight $\pm$ SE (g)
1	3546 $\pm$ 15	1	3370 $\pm$ 7
2	3544 $\pm$ 10	2	3495 $\pm$ 8
3	3547 $\pm$ 10	3	3522 $\pm$ 9
4	3492 $\pm$ 7	4	3555 $\pm$ 12
5	3461 $\pm$ 12	5	3556 $\pm$ 18
6	3403 $\pm$ 15	6	3562 $\pm$ 26
7	3382 $\pm$ 17	7	3498 $\pm$ 21
8	3277 $\pm$ 14		

SOCIOECONOMIC STATE

Figure 2 shows the frequency within each social group of each birthweight category. Unclassifiable occupations (41 cases) are excluded. Cases where the father was a member of the armed Forces are also excluded because the number (461) was too small. Group 8, mainly unmarried mothers, was quite unlike any of the others with regard to the birth-order composition, 81% being first and 12% second births.

The proportion of low and suboptimal birth weights increased substantially as social class fell. This was reflected in a smaller proportion of optimal-birthweight babies born in lower social classes. The occurrence of above-optimal weights showed little significant variation. The incidence in unsupported mothers was significantly lower than in all other groups, presumably due to the high incidence of first births and very young age at motherhood.

The pattern shown by mean weights (table II) reflected the general deterioration in performance already evident with falling socioeconomic state. The mean showed a plateau for social groups 1, 2, and 3 which was not evident in the analysis by weight categories (fig 2).

INTERACTION OF BIRTH ORDER AND SOCIAL GROUP

The distribution of cases by social group within the weight categories appeared to be linear (fig 2). A linear regression procedure confirmed this (table III). For low, suboptimal, and optimal weights the relation showed a close fit to a straight line (correlation coefficient

TABLE III—Results of linear regression between social group number and percentage of babies in three weight categories, and between social group and mean weight

Weight (g)	Slope	Correlation coefficient (r)	Explaining power (r ²)	Intercept
≤2500	0.84	+0.95**	0.90	1.2%
≤3000	2.32	+0.97**	0.93	7.8%
3001-4499	-2.07	-0.98**	0.96	88.3%
Mean weight (g)	-30.6	-0.96**	0.91	3605

**p≤0.01.

FIG 2—Distribution of births by weight category and social group. (Broken horizontal lines represent means for all births.) Table I explains groups.

$r=0.95$ ($p\leq 0.01$) to $r=0.98$ ($p\leq 0.01$), giving "explaining" powers (r^2) of 0.90 to 0.96. The slope of the line of best fit was steep in all three distributions. It indicated an average increase in low and suboptimal birth weights of 0.8% and 2.3% per social group respectively, and a decrease in the incidence of optimal weights of 2.1% per social group.

Birth order was clearly influenced by social state. For instance, fourth and subsequent births comprised 16.9% of births in social group 1, 19.2% in group 2, 17.5% in group 3, 25.8% in group 4, 32.5% in group 5, 32.6% in group 6, and 40.0% in group 7. Social groups 6 and 7, which together contributed 14% of births, accounted for 39% of seventh and higher-order births and 51% of tenth and higher-order births.

The possible causal relation between social class, birth order, and birth weight may be summarised as:

TABLE IV—Effect of social group within first and second births (incidence as percentage of total births in each cell)

Birth weight (g)	Birth order	Social group								Regression between SE group and percentages			
		1	2	3	4	5	6	7	8	Slope	Correlation coefficient (r)	Explaining power (r ²)	Intercept at SEG 4.23†
≤2500	1	3.1	3.7	4.2	5.7	4.8	8.9	6.8	9.0	0.83	0.90**	0.81	5.6%
	2	2.0	2.7	3.7	3.7	3.9	4.5	5.7	6.0	0.54	0.98**	0.95	3.9%
≤3000	1	14.6	15.9	17.5	20.2	21.0	24.7	26.2	29.8	2.15	0.99***	0.98	20.7%
	2	11.1	10.6	13.4	15.8	15.2	19.8	23.7	26.9	2.32	0.96**	0.92	16.4%
3001-4499	1	84.6	82.3	80.5	77.8	77.3	74.0	72.8	69.9	-2.03	-0.99***	0.99	78.0%
	2	86.9	86.4	82.9	81.8	82.4	78.2	74.4	70.4	-2.25	-0.96**	0.92	81.0%

Statistical: *p≤0.05; **p≤0.01; ***p≤0.001.

†Mean SE group number for all births.

The lack of independence of social class and birth order, and the non-linear relation between birth order and birth weight, combined to make the traditional analysis by multiple regression or partial correlation procedures unsuitable for investigation of the relative influences of birth order and social class on birth weight. The linear relation of birth weight with social group, however, permits computation of a mean social group number for each birth order (according to its social group composition) which can be used to predict the percentage in each weight category on the hypothesis that the social factor "explains" all variation. (The mean social group number was calculated for each birth order as $\sum(G \times n)/N$, where G =social group, n =number of cases in the social group, and N =total number of cases in the birth order.) The values obtained for birth orders 1 to 7 and above were 4.47, 3.87, 3.80, 3.92, 4.20, 4.29, and 4.77. Correlation between the "predictor" (mean social group number) and the observed percentages in each weight category for the several birth orders showed a remarkably close fit. The results show that the social factor "explains" 86% ($r=0.93$; $p\leq 0.01$) of the variation between birth orders in the occurrence of low birth weight. It "explains" 76% ($r=0.87$; $p\leq 0.01$) of variation of occurrence of suboptimal weights, and 93% ($r=0.96$; $p\leq 0.01$) in the optimal weights.

The effect of birth order was relatively large between first and second births, but the social factor was clearly far more influential. Table IV shows weight differences by social group within first and second births. Regressions between social group number and percentage of births in each weight category, within first and second births, showed highly significant correlation coefficients ($r=0.90$ ($p\leq 0.05$) to $r=0.99$ ($p\leq 0.001$)). The effect of social group thus "explains" 81% to 99% of variation within each of the birth orders. The average difference between first and second births for all social groups is indicated by the difference between the intercepts at the mean social group number for all births, 4.23.

Discussion

The incidence of birth weights of 2500 g and under (4.7%) and of 3000 g and under (17.6%) was considerably lower than reported for England, Scotland, and Wales in 1970⁴ and 1958⁵ (table V) and for Belfast and Birmingham in 1963-5.⁶ The WHO

TABLE V—Incidence of low and suboptimal birth weights

	% ≤2500 g	% ≤3000 g
Dublin 78/79*	4.7	17.6
British births 1970*	6.8	25.7
British perinatal survey 1958*	6.7	24.7
Belfast 1963-5*	8.3	25.3
Birmingham 1964*	7.4	27.6

*Singletons only.

report² quoted national incidences for 1973 of birth weight less than 2500 g for Austria, New Zealand, USA (part of), and Japan between 5.2% and 6.0%, with almost 11% in Hungary and Cuba. The mean birth weight (3468 g) was higher than all values quoted in the WHO report. These ranged from 3130 g for Cuba to 3390 g for New Zealand. The mean birth weight in this study was almost exactly the same as the median weight, for live births only, reported from a hospital study in Ireland in 1961.⁷ The reason for the unusually high weights of the Dublin babies is not clear. The small proportion of first births

might be expected to be a contributory factor but correction of the Dublin figures to the parity distribution reported for England and Wales 1973² provides a prediction of 4.8% of birth weights below 2500 g. This is almost identical with the observed rate. Thus the parity distribution cannot explain any part of the difference between Dublin and England and Wales in the incidence of low birth weight. Data on gestation times were not available but are unlikely to account for much if any of the birthweight differences.

The series of social groups showed a linear relation with the incidence of low, suboptimal, and optimal weights. The ratio between incidence in groups of lowest and highest social states, for both low and suboptimal weights, was slightly greater than reported for 1958 in Britain.⁵ An approximate conversion of a classification by paternal level of education² to the social groups used in this study showed a similar ratio (low to high social class) for low birth weight for USA (part of) and Dublin, though Hungary reported a much lower ratio. Social gradient in mean weight was the same as in the British births survey of 1970⁴ and similar to that in USA and Hungary in 1973.² Mean weight is of limited use in assessing birthweight patterns.

The results from Dublin cannot be taken as representative of the country as a whole, since the remainder of the population is largely rural and differs in many ways from that in the capital.

The distribution of birth weights in Dublin was most favourable in births 2, 3, and 4. A deterioration was evident at birth 5, which accelerated through 6 to 7+. The British study in 1958 included sufficient high parity to warrant analysis up to birth order 5+. In low birth weights a clear minimum was seen at the second birth, followed by a progressive deterioration. The pattern in suboptimal weights resembled the Dublin result. The 1958 study found a progressive increase in average birth weight with rising birth order to 5+. The Dublin data showed an increase only as far as birth 4, followed by a plateau to 6 and a decline to 7+.

Modified statistical analysis showed that social factors "explain" 75% to 93% of the variation in occurrence of low, suboptimal, and optimal weights which is seen with birth order. "Explaining" power is highest for the optimal weight range. Birth order, and any other unidentified contributory factors, is presumed to account for the residual "explaining" power. Maternal age may account for a small part of the effect attributed to socioeconomic factors in first births. It may also account for part of the 19% of residual "explaining" power not attributable to socioeconomic influence in the occurrence of low birth weight in first births (table IV). Several factors which are known to be correlated with birth weight, such as smoking, maternal health,⁹ and birth spacing,¹⁰ are presumably components of the socioeconomic influence.

Bakketeig and Hoffman's longitudinal study of perinatal mortality in Norway¹ showed higher perinatal mortality and birthweight-specific mortality for mothers of more than two babies than for mothers of only two. It was noted that socioeconomic differences probably existed between the two groups. The effect of these differences would be seen as a turning point in quality of outcome between the second and third babies in horizontal results. In Dublin, where the average family is considerably larger than in Norway, the equivalent turning point in birth weight is found between the fourth and fifth babies, when a progressive decline below optimum birthweight performance begins. A similar degree of difference in family-building practice between the mothers in the British 1958 survey and the Dublin mothers may explain why a downward trend in birthweight performance was found two births sooner in the British than in the Irish studies. The higher birthweight-specific mortality in the babies of larger sibships, found in the Norwegian study, indicates that the major effect of socioeconomic factors on birth weight shown here may understate the socioeconomic effect on risk.

Classification of birth weight into suboptimal and optimal categories provides a powerful tool for assessing birthweight performance. Difference in social state accounts for most of the

variation in occurrence of these weights. Socioeconomic factors should be capable of improvement. It is suggested that the occurrence of the optimal weight category is the best indicator of progress achieved in the birthweight performance of a population. This weight category is particularly useful because the "explaining" power of socioeconomic factors is as high as 93%. The incidence of optimal birth weight is much higher than the more commonly employed low-birthweight category, so that reliable estimates may be made on smaller populations.

Rooth suggested that a biologically valid definition of low birth weight might be based on the population mean weight and standard deviation.¹¹ The influence of socioeconomic factors suggests that a better standard could be derived from the birthweight distribution of children born to privileged mothers in any given society.

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ONE HUNDRED YEARS AGO We have had many communications warmly supporting the view which we expressed last week on the subject of the insufficiency of the knighthood which has been bestowed on the President of the College of Physicians. The same opinion prevails outside the profession, we believe, as within it on this subject. An evening contemporary gave their expression to it last Thursday in the following words. "By the favour of the Crown, Dr Bennett is to become a knight. If the President of the Royal College of Physicians thinks that knighthood can add to his dignity, a knight no doubt he will be; but the announcement serves to show that now, as in the past, the least prized honour is held to be good enough for a leading member of the noblest of professions." Abroad, these things are managed better. We noted, a week or two ago, that Dr Baccelli, a practising physician of eminence in Rome, had been appointed Minister of Public Instruction. This week, Dr Alvarenga of Madrid has been summoned to the Privy Council, with the dignities of a Royal Counsellor. M Broca had just been nominated a Senator before his death; a dignity conferred also on Larrey, Nélaton, and Bert. The French Senate has never been without its medical members; while, in the French Chamber, the medical deputies form a distinct party, and have considerable power. (*British Medical Journal*, 1881.)