# Birth weight and later socioeconomic disadvantage: evidence from the 1958 British cohort study

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## Abstract

***Objective*—To investigate the relation between birth weight and socioeconomic disadvantage during childhood and adolescence in a birth cohort study.**

***Design*—Longitudinal analysis of birth weight in relation to social class, household amenities and overcrowding, and financial difficulties as reported by parents at interview when participants were aged 7, 11, and 16 years; and receipt of unemployment or supplementary benefits as reported by participants at age 23.**

***Subjects*—Male participants in the 1958 birth cohort (national child development study) born to parents resident in Great Britain during the week of 3-9 March 1958. Data on birth weight and financial difficulties between birth and 23 years were available for 4321; data on housing conditions and social class at ages 7, 11, and 16 years were available for 3370.**

***Main outcome measures*—Socioeconomic disadvantage at later ages in men weighing 6 lb (2721g) or under at birth compared with those weighing over 6 lb and between fifths of the distribution of birth weight.**

***Results*—Cohort members who weighed 6 lb or under at birth were more likely to experience socioeconomic disadvantage subsequently. Those in lower fifths of the distribution were more likely to experience socioeconomic disadvantage.**

***Conclusion*—Low birth weight is associated with socioeconomic disadvantage in childhood and adolescence. Studies of the association of indicators of early development and adult disease need to take into account experiences right through from birth to adulthood if they are to elucidate the combination of risks attributable to developmental problems and socioeconomic disadvantage.**

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## Introduction

There is increasing evidence that events during gestation, as indicated by birth weight and placental weight, and in infancy, as indicated by growth in the first year, are associated with the risk of several important chronic illnesses in middle and later life.[1]

Two explanations have been offered for these observations. One proposes that the aetiological processes in the development of cardiovascular disease, obstructive lung disease, and diabetes, for example, are initiated early in life either in utero or in infancy, thus fixing or "programming" the person's risk long before other risk factors are encountered.[1] An alternative explanation is that birth weight and infant growth act at least in part as markers for other causal factors experienced both in childhood and later in life.[2,3]

As social and economic deprivation influence intrauterine development and early growth, birth weight may be a marker of the life chances conferred by the family of origin. Thus low birthweight babies may be at higher risk of later social disadvantage than others in the same social class. Up to the present, investigations of origins of adult disease in early life largely ignore the intervening period of childhood and young adulthood. Continuities in socioeconomic circumstances, although well documented by social research,[4-6] have only recently begun to be investigated as possible mediating factors in relation to adult health.[7-10]

The longitudinal data required for this purpose were available in the national birth cohort studies. We used data from the 1958 birth cohort (national child development study) to establish whether birth weight is associated with social circumstances in childhood, adolescence, and early adulthood.

## Subjects and methods

### SAMPLE

The 1958 birth cohort study (national child development study) has its origins in the perinatal mortality study, which recorded birth weight for all children born to parents resident in Great Britain during the week of 3-9 March 1958 (about 17 000 births).[11] In later surveys of surviving children at ages 7, 11, 16, and 23 years the social circumstances of cohort members were investigated in some detail.[12,13] Previous work has shown that despite sample attrition, in general the sample remained representative up to age 23 years, although there is some underrepresentation of the most disadvantaged groups.[10,14]

### MEASURES

*Birth weight*

Birth weight was used as a dichotomous variable of above and below 6 lb (2721 g); and because other studies seem to show a gradient of decreasing mortality with increasing birth weight the distribution of birth weight was also divided into fifths by using quintiles. In the original perinatal mortality study in 1958 the weight of the baby was recorded in ounces, and 6 lb is close to the conventional cut off point for low birth weight of 2500 g.

*Socioeconomic disadvantage*

As an indicator of disadvantage during childhood social class alone was considered to be unsatisfactory. The registrar general's social classes, while useful in the investigation of aetiology, are changing in size and composition as the British social structure changes. As increasing numbers of people spend larger amounts of time outside the labour force usual occupation becomes a less reliable indicator of living standards.[15] These problems have led to the use of alternative measures of social and economic position which combine class with the ownership of household assets.[16-18]

Two indicators of social and economic conditions in the family were derived for subjects at ages 7, 11, and 16 years. These measures combined social class with other indicators of disadvantage particularly relevant to the wellbeing of children: possession of household amenities and overcrowding in the home. In the first measure the "most advantaged" group consisted of those who at each age were in families in which the father was in social classes I or II. The middle group consisted of those children in families in which the father was in a clerical or manual occupation (social classes IIIN, IIIM, IV, and V) but the household had

sole use of a set of household amenities comprising an inside toilet, hot water supply, and a bathroom. The most disadvantaged group comprised those children whose fathers were in classes IIIN, IV, and V and the household lacked sole use of one or more of the amenities. The second measure combined social class and household overcrowding in an analogous manner. The most advantaged were those in classes I or II; the middle groups were those in classes IIIN to V with one or fewer people per room; and the most disadvantaged were those in classes IIIN to V with more than one person per room.

Two further measures were constructed to indicate hardship at any time during childhood and early adulthood. The first was a measure of financial circumstances; subjects were considered to have experienced financial difficulty if their father was in class V at the time of their birth, if the parent interviewed reported financial problems when the subject was aged 7 years, if the interviewed parent reported that any child in the family received free school meals when the cohort member was aged 11 or 16 years, or if the cohort member reported receipt of unemployment or supplementary benefit at the age of 23 years. The sample was divided into those who had reported any of these problems versus those who reported no such experience. A measure of housing inadequacy was derived in a similar way from the questions on overcrowding and possession or sole use of three household amenities which were asked of parents when subjects were aged 7, 11, and 16 years. The sample was divided into those whose parents reported no experience of either overcrowding or lacking sole use of any amenity, those with one or two instances, and those whose parents reported three or more instances.

METHODS

The analysis presented here is limited to men so that it is comparable with most other work on birth weight and health in later life.[1] Numbers vary slightly in the tables because of missing data on the relevant variables at different ages. Although birth weight as a variable comes first in time, there is no implication of a direct causal link between it and later social conditions. The objective was to assess only whether an association exists. In two tables the birthweight distribution is split into fifths by using quintiles; because of small numbers this measure was used in combination with the most evenly distributed measures of socioeconomic circumstances only. The relation between birth weight and socioeconomic circumstances was examined for the different measures separately at ages 7, 11, and 16 years. The tables show the proportions in each birthweight group who were later exposed to the different levels of socioeconomic circumstances at each sweep of the cohort. Differences between birthweight groups were tested statistically by using an overall $\chi^2$ test for association when the outcome had more than two levels and by using a $\chi^2$ test for linear trend in proportions when the outcome was dichotomous. Test statistics were calculated by using the statistical package SPSSX.[19]

## Results

*Crowding*—Table I shows the relation between birth weight and socioeconomic circumstances defined by social class and overcrowding in the household. A greater proportion of children who weighed under 2721 g (6 lb) at birth experienced the combined disadvantage of lower social class and overcrowding in the household. For example, at age 7 years 42·9% of low birthweight babies compared with 35·3% weighing 2721 g (6 lb) or over at birth were in classes IIIN to V and in overcrowded homes. This association was observed at each successive age (P=0·01, 0·01, and 0·13 at ages 7, 11, and 16 years, respectively).

*Household amenities*—Table II shows the relation between birth weight and socioeconomic circumstances defined by social class combined with lack of amenities. Children under 2721 g (6 lb) at birth were at each successive age more likely to experience the combination of lower social class without household amenities or sharing them (test of association gives P=0·008, 0·002, and 0·18 at ages 7, 11, and 16 years, respectively).

*Housing inadequacy throughout childhood*—Table III shows the relation between birth weight and a measure of housing inadequacy throughout childhood. Social class is not included in this measure, which compares those who experienced either overcrowding or no use or shared use of basic household amenities at ages 7, 11, or 16 years with those who did not. There was a strong association (P<0·001), with cohort members of low birth weight being more likely to experience housing inadequacy.

*Financial problems*—By the age of 23 years 1527 (35·3%) cohort members had experienced financial

TABLE I—*Birth weight (326 at <6 lb; 3044 at ≥6 lb (2721 g)) and socioeconomic circumstances at ages 7, 11, and 16 years defined according to social class and household overcrowding. Figures are numbers (percentages)*

| Age and birth weight (g) | Socioeconomic circumstances (overcrowding): Social classes I or II | Social classes IIIN to V, no overcrowding | Social classes IIIN to V, overcrowded | Overall test of association ($\chi^2$) |
|---|---|---|---|---|
| At 7 years: | | | | |
| <2721 | 55 (16·9) | 131 (40·2) | 140 (42·9) | 8·90; 2 df; P=0·01 |
| ≥2721 | 676 (22·2) | 1294 (42·5) | 1074 (35·3) | |
| At 11 years: | | | | |
| <2721 | 63 (19·3) | 136 (41·7) | 127 (39·0) | 9·05; 2 df; P=0·01 |
| ≥2721 | 795 (26·1) | 1263 (41·5) | 986 (32·4) | |
| At 16 years: | | | | |
| <2721 | 79 (24·2) | 178 (54·6) | 69 (21·2) | 4·12; 2 df; P=0·13 |
| ≥2721 | 843 (27·7) | 1680 (55·2) | 521 (17·1) | |

TABLE II—*Birth weight (326 at <6 lb; 3044 at ≥6 lb (2721 g)) and socioeconomic circumstances at ages 7, 11, and 16 years defined according to social class and household amenities (inside toilet, hot water supply, and bathroom). Figures are numbers (percentages)*

| Age and birth weight (g) | Socioeconomic circumstances (household amenities): Social classes I or II | Social classes IIIN to V, sole use of amenities | Social classes IIIN to V, sharing or lacking amenities | Overall test of association ($\chi^2$) |
|---|---|---|---|---|
| At 7 years: | | | | |
| <2721 | 55 (16·9) | 208 (63·8) | 63 (19·3) | 9·76; 2 df; P=0·008 |
| ≥2721 | 676 (22·2) | 1945 (63·9) | 423 (13·9) | |
| At 11 years: | | | | |
| <2721 | 63 (19·3) | 221 (67·8) | 42 (12·9) | 12·25; 2 df; P=0·002 |
| ≥2721 | 793 (26·1) | 1996 (65·6) | 255 (8·4) | |
| At 16 years: | | | | |
| <2721 | 79 (24·2) | 226 (69·3) | 21 (6·4) | 3·41; 2 df; P=0·18 |
| ≥2721 | 843 (27·7) | 2060 (67·7) | 141 (4·6) | |

TABLE III—*Birth weight and housing inadequacy. Figures are numbers (percentages) of or lacking sole use of household amenities between ages 7 and 16 years (males only)*

| Birth weight (fifths) (oz)* | Housing inadequacy (no of instances): 0 | 1-2 | ≥3 | Total No |
|---|---|---|---|---|
| Highest (≥136) | 326 (45·9) | 256 (36·0) | 129 (18·1) | 711 |
| Fourth (125-135) | 431 (45·7) | 320 (33·9) | 193 (20·4) | 944 |
| Third (115-124) | 353 (42·4) | 309 (37·1) | 170 (20·4) | 832 |
| Second (106-115) | 395 (44·5) | 297 (33·5) | 195 (22·0) | 887 |
| Lowest (≤105) | 363 (38·3) | 332 (35·1) | 252 (26·6) | 947 |
| All | 1868 | 1514 | 939 | 4321 |

Overall test of association: $\chi^2$= 26·32, 8 df; P=0·0009.
*Weight given in ounces because of historical nature of data. Approximate equivalents in g are: ≥3800; 3500-3800; 3260-3500; 3000-3260; and ≤2890 for the highest fifth; fourth; third; second; and lowest fifth of the distribution.

difficulty either in their family of origin between birth and 16 years or as young adults. Table IV shows the relation of this variable with birth weight categorised into fifths of the distribution. As was the case with inadequate housing the difference does not just occur in those with the lowest birth weight; there seems to be a graded relation throughout the birthweight distribution.

TABLE IV—*Birth weight and financial difficulties between birth and age 23 years (males only). Figures are numbers (percentages)*

| Birth weight (fifths) (oz)* | No financial difficulties | Financial difficulties at least once | Total No |
|---|---|---|---|
| Highest (≥136) | 486 (68·4) | 225 (31·6) | 711 |
| Fourth (125-135) | 626 (66·3) | 318 (33·7) | 944 |
| Third (116-124) | 541 (65·0) | 291 (35·0) | 832 |
| Second (106-115) | 565 (63·7) | 322 (36·3) | 887 |
| Lowest (≤105) | 576 (60·8) | 371 (39·2) | 947 |
| All | 2794 | 1527 | 4321 |

Test for trend: $\chi^2 = 11·6$; 1 df; $P < 0·001$.
*See footnote to table III.

## Discussion

### HISTORICAL COHORT EVIDENCE

Forsdahl[20] has shown that areas with high mortality from coronary heart disease among adults are those in which infant mortality—and hence, he infers, material deprivation—was high during the periods when those currently dying of coronary heart disease were born.[21] Barker and his colleagues showed an association between growth in very early life and later mortality and cardiovascular risk factors in subjects by using historical cohorts—for example, the births dating from 1911 to 1930 in Hertfordshire,[22] and the Preston study of births during 1935-43.[23] As the work developed, particular mechanisms were suggested for the observed relation between birth weight and later morbidity and mortality. One possibility for adult respiratory disease is poor housing conditions, with associated higher rates of respiratory infection in young children and leading to increased risk of chronic respiratory disease in adulthood. In the 1946 cohort study the risk of respiratory disease at age 2 years was associated with overcrowded and poor home circumstances,[24] and those who had suffered such illness in childhood had a higher risk of developing chest disease as adults.[25 26]

### INTRAUTERINE PROGRAMMING

Barker *et al* proposed that "programming" occurs during the intrauterine period or during early infancy, influencing lung function, glucose tolerance, blood pressure, cholesterol metabolism, and haemostatic function in adulthood.[1] Though environmental influences at later stages of life are still seen to play some part in the aetiology of adult diseases, this occurs within constraints imposed by levels of susceptibility which have been fixed during early development.[1]

A major problem in interpreting this work is that exposures occurring before and soon after birth are related to outcomes occurring 40, 50, 60, or more years later. No data are presented on socioeconomic circumstances encountered during the intervening years, which may also have an important effect and may indeed exacerbate or attenuate biological risks established earlier. In these studies, however, relations between birth weight and early growth and later risk factors were found to be independent of social class,[27 28] in those cases in which occupation could be ascertained. The interpretation offered is that this makes it unlikely that the relation could be accounted for by "continuity of disadvantage." It is now increasingly accepted, however, that social class is a crude measure of social conditions; income and living standards vary widely within class groups.[29] Furthermore, cohorts born in the 1920s and 1930s experienced great social mobility, making class in adulthood a poor indication of the conditions experienced in infancy, childhood, and early adulthood. The weight of infants at birth may itself be an indicator of family circumstances which more conventional measures of social position fail to identify.

### BIRTH WEIGHT AND DISADVANTAGE

By using cohort data from the national child development study we have shown that birth weight is associated with later socioeconomic disadvantage. Those weighing under 2721 g (6 lb) at birth were more likely at ages 7, 11, and 16 years to have a father in social classes IIIN to V and live in a household that was either overcrowded or lacked possession or sole use of basic amenities. Furthermore, the relation between birth weight and later disadvantage seems to be graded. The distribution of birth weight by fifths also showed a mainly linear relation with the number of exposures to either overcrowding or inadequate amenities in the home between ages 7 and 16 years and a strong linear relation with financial problems between birth and age 23. This is consistent with the suggestion of a graded association of birth weight with risk factors and mortality in adulthood found in some studies.[30 32] This relation may be produced by processes occurring at more than one stage of development.

There is considerable evidence of a complex pathway combining biological, socioeconomic, and behavioural risks during early life. Several studies carried out before the second world war indicate that early development and growth were strongly related to socioeconomic circumstances during this period.[31] Smoking behaviour in adulthood shows a graded relation with weight at 1 year: infants weighing less at 1 year grew to become adults with a greater chance of being smokers.[32] There is an association between birth weight and migration: men born with higher birth weights were more likely to leave their town of origin.[33] As it is known that migrants differ in many ways from non-migrants,[34] it is clear that measures of development in early life may serve as markers for different experiences during life.

The manner in which the life courses of individual

### Key messages

- Birth weight may be a highly sensitive marker of family socioeconomic circumstances during gestation and thus of future socioeconomic career as well as the biological outcomes of intrauterine development
- The implications of low birth weight for future health will be better understood if biological and socioeconomic trajectories are investigated in combination
- In this study low birth weight was associated with socioeconomic disadvantage in childhood and adolescence
- Conventional measures of social class may need to be supplemented by more sensitive indicators of deprivation in public health research and practice
- Studies which document experiences right through from birth to adulthood are required if the elucidation of mechanisms linking early life experience and disease in adulthood is to be taken forward

people of different birth weights differ is unlikely to be adequately represented by socioeconomic status as indicated by occupation. What is clear is that more research is required on the interrelation between early development, adult experiences and behaviour, and later risk of mortality. This research should be carried out in recognition of the fact that, particularly in the presence of crudely measured variables such as occupational social class, confounding can produce strong associations which are resistant to simple interpretations and are robust to attempts at statistical "control."[35 36]

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## Socioeconomic deprivation in Britain: Commentaries

### *Socioeconomic deprivation and health and the ecological fallacy*

Ken MacRae

The three papers addressing the issue of socioeconomic deprivation and health published in this week's journal all conclude that deprivation is associated with increased mortality. Two of them are ecological studies in which the unit of observation is a geographically defined group.[1 2] Such studies are susceptible to the ecological fallacy,[3] which was first explained formally by Robinson.[4] The advantages and disadvantages of ecological studies have been reviewed in depth by Morgenstern.[5]

The problem is that the correlation between two variables when the group is used as the unit of analysis may be quite different from the correlation between those two variables when individual people are used as the unit of analysis. A simple example with two dichotomous variables demonstrates the fallacy (table). When the area is the unit of observation there is an association between exposure and disease, area 2 showing both greater exposure (300/1000) and greater incidence (300/1000) of the disease than area 1 (100/1000 and 100/1000). But when individuals within the areas are the units of observation there is no such association: in each area the same proportions of exposed and non-exposed individuals have the disease (10% in area 1 and 30% in area 2).

Fortunately, substantial evidence using individuals as the unit of observation does exist to support the conclusion that ecological correlations between socio economic deprivation and health arise from associations among the relevant variables in individuals. One such piece of evidence comes from the paper by Sloggett and Joshi.[6] They used data from the longitudinal study of the Office of Population Censuses and Surveys on a 1% sample of the population of England and Wales begun at the time of the 1971 census—that is, census records for the subjects in the longitudinal study were related to the subsequent deaths of these subjects. Sloggett and Joshi found that such socioeconomic variables as access to a car, being an owner-occupier, unemployment, and lower social class explained nearly all the relation between the degree of deprivation in an area of residence in 1981 and subsequent premature death before 1990. Of course, these results add support to the Black report[7] and to the

*Relation between exposure and disease in two areas. Values are numbers of people*

| | Exposed | Not exposed | Total |
|---|---|---|---|
| Area 1: | | | |
| Disease | 10 | 90 | 100 |
| No disease | 90 | 810 | 900 |
| Total | 100 | 900 | 1000 |
| Area 2: | | | |
| Disease | 90 | 210 | 300 |
| No disease | 210 | 490 | 700 |
| Total | 300 | 700 | 1000 |

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