Childhood blood pressure, body build, and birthweight: geographical associations with cardiovascular mortality

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Abstract

Study objective—The aim was to examine whether blood pressure, body build, and birthweight differ between areas of England and Wales with widely differing adult cardiovascular mortality rates.

Design—This was a cross sectional survey of children in five towns with exceptionally high and five towns with exceptionally low current adult cardiovascular mortality.

Setting—The study was a school based survey.

Subjects—3842 children aged 5·0–7·5 years were selected by stratified random sampling of primary schools (response rate 76%).

Measurements and main results—Blood pressure, pulse rate, height, and weight were measured and birthweight was assessed by maternal recall. Children in towns with high cardiovascular mortality rates were significantly shorter than those in towns with low cardiovascular mortality rates (mean difference 0·9 cm, 95% confidence interval 0·4 to 1·4 cm) and had slightly higher body mass indices (mean difference 0·12 kg/m², 95% CI –0·03 to 0·27 kg/m²). Mean birthweights were slightly lower in high mortality towns (mean difference 34 g, 95% CI –10 to 78 g), while the proportion of children with low birthweight (<2500 g) (8·1%) was significantly higher than that in low mortality towns (5·5%) ($p=0·005$). Mean differences in blood pressure between high and low mortality towns were small and non-significant, even after adjustment for height. The differences in height between high and low mortality towns were largely independent of social class. However, differences in mean birthweight were markedly reduced once social class was taken into account.

Conclusions—No geographical relationship between childhood blood pressure and adult cardiovascular mortality was detected. Although it is possible that the differences in mean height and body mass index between towns with differing adult cardiovascular mortality may have implications for future patterns of health in these towns, the absence of marked differences in birthweight and blood pressure suggests that hypotheses proposing a direct relationship between intra-uterine experience and adult cardiovascular mortality will have limited relevance to geographical variation in cardiovascular disease in this generation.

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Understanding the reasons for variation in the average blood pressure levels of different population groups is an important aspect of the study of high blood pressure.¹ Marked differences in the average blood pressure levels of middle aged men (40–59 years) in different British towns have been observed, which are related to geographical variation in cardiovascular mortality rates.² These findings have been confirmed and extended to middle aged women and to younger subjects aged 25–29 years.³ Differences in the average blood pressure levels of 5–7 year old children have also been observed, which appeared to be related both to town mean blood pressure levels in adults and to adult cardiovascular mortality rates.⁴ The results of the latter study suggested that the geographical differences in adult blood pressure within Britain might have their origins, at least in part, in the first years of life. However, the conclusions were strongly influenced by the exceptionally low blood pressure observed in one town (Guildford) and clearly required substantiation.

A new study of childhood blood pressure levels has been conducted in 10 different towns in England and Wales; five with exceptionally high and five with exceptionally low rates of adult cardiovascular mortality. The principal aim of the study was to examine the earlier observation of a relationship between childhood blood pressure level and adult cardiovascular mortality.⁴ However, the study also provided an opportunity to examine whether there are differences in birthweight, height, and other measures of body size in children born in the 1980s in towns with widely differing adult cardiovascular mortality rates. These observations are likely to be of particular interest in the context of reports suggesting a direct connection between early life experience and later cardiovascular mortality. These include, first, reports relating adult height to mortality from ischaemic heart disease,^{5 6} and second, reports suggesting that experiences in fetal and infant life might be directly related to the development of hypertension^{7 8} and cardiovascular disease,^{9 10} and might play an important role in the explanation of geographical variations in cardiovascular disease within Britain.^{7 11 12} Trends in ischaemic heart disease to the year 2000 have recently been examined in the light of these hypotheses.¹³ The extent of differences in height and birthweight in children from geographical areas with widely different current adult cardiovascular mortality rates may provide an indication of the potential importance of these hypotheses for cardiovascular disease in the next generation.

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Methods

SAMPLING PROCEDURES

The 406 local authority districts in England and Wales were ranked on the basis of their standardised mortality ratios for all cardiovascular disease for 1979–1983, calculated for men and women aged 35–64 years. The five highest and five lowest mortality districts containing a population centre of 40 000–100 000 subjects (similar in size to those in the earlier study) were selected. However, those districts including the towns in the earlier study⁴ were excluded. One low mortality town (Cambridge) was withdrawn because of extensive existing school research commitments and replaced by the town with the sixth lowest mortality (Tunbridge Wells). The geographical distribution of the study towns is shown in the figure. The decision to include 10 towns was based on assessment of the relationship between childhood blood pressure and adult cardiovascular mortality rate in the earlier study,⁴ which suggested that a difference of more than 3 mm Hg in systolic pressure would have been expected between towns with exceptionally high and exceptionally low cardiovascular mortality. For an analysis of differences in systolic pressure between the five high and five low mortality towns, the study design had more than 80% power for detection of a systolic difference of 3 mm Hg and more than 90% power for detection of a difference of 4 mm Hg at a two sided *p* value of 0.05, given the observed standard deviation of 1.5 mm Hg for average systolic pressure within the high and low mortality town groups.

Ten Towns Study: geographical distribution of study towns

Within each town, the approval of the local ethics committee and the education authority was sought and a list of all primary schools in the town obtained. A random sample of 10 schools, stratified by denomination and, in the case of county primary schools, by size and location, was selected in each town. Of the 100 invited schools, 15 were unable to take part (five in high mortality towns and 10 in low mortality towns) and were replaced by the school matching most closely in denomination, size, and location. In each school two classes containing children aged between 5.0 and 7.5 years were randomly selected to provide 50 to 60 children who were invited to participate. This method is the same as that used in the earlier study,⁴ validated using data from the 1981 census 10% sample. All subjects received a letter of invitation from the head teacher and a reminder if they did not reply to the initial invitation.

SURVEY PROCEDURES

All measurements were made between January and July 1990 by a team of four trained nurse observers working in pairs. Towns in low and high mortality areas were examined alternately; towns in close geographical proximity were not examined consecutively. All schools in each town were examined in a five day period; individual schools were visited for one day. Each observer made approximately one quarter of all measurements in each town. Working procedures were standardised for all schools and measurements were performed in the medical room or similar accommodation. Measurements were carried out with the children dressed in light clothing without shoes, after resting for a period of at least five minutes. *Height* was measured to the last complete millimetre using either a Holtain electronic stadiometer or a CMS portable stadiometer. *Weight* was measured to the last complete 0.1 kg with a Soehnle digital electronic weighing scale. *Right arm circumference* was measured to the last complete millimetre at the midpoint between the acromial process and the olecranon with the arm pendant. *Blood pressure* was measured in the right arm with the child seated and the arm supported at chest level, using the Dinamap 1846SX automated oscillometric blood pressure recorder (Critikon, Inc)^{14 15} to record two blood pressure measurements with a one minute interval in the right arm. All measurements were made with the child cuff size (bladder dimensions 15.5 × 8 cm), ensuring that the cuff width/arm circumference ratio of 40–50% recommended by the American Heart Association¹⁶ was met for 79% of the study population. *Ethnic group* was assessed on the basis of the child's appearance. *Room temperature* was measured to the nearest 0.1°C with an RS digital thermometer and thermocouple at the time of each set of blood pressure measurements. Data on *external temperature*, recorded hourly at local meteorological stations, was provided by the Meteorological Office. A self administered questionnaire sent to the parents of all participants on the day of examination was used to provide information on *birth weight*, *parental height and weight*, and *social class*. Mothers were asked to record the child's birth weight as accurately as possible; the validity of maternal recall after a five to seven year period had previously been demon-

strated.¹⁷ *Social class* was determined for both parents on the basis of present or most recent occupation, classified according to the Registrar General's six social classes with the 1980 manual of the Office of Population, Censuses and Surveys (OPCS). Analyses in this paper refer to the head of household (male in 93%) as defined by OPCS.¹⁸

Standardisation of measurements

The two blood pressure recorders were calibrated daily against a reference mercury column. A comparison of blood pressure measurement between the two blood pressure recorders at the beginning and end of the study revealed no evidence of significant measurement drift between instruments. A comparison of the two stadiometers revealed a systematic measurement difference of 1 mm between instruments; all measurements were standardised to the Holtain instrument for the analyses presented.

STATISTICAL METHODS

The analyses presented are based on town means or, where appropriate, percentages, for each variable. However, data are also presented on the proportion of overweight subjects and the proportion of subjects of low birthweight. Age and sex standardised town mean blood pressures have been derived from analyses of covariance in which blood pressure was regressed on age (fitted as a continuous variable), town (fitted as a factor with 10 levels), and sex (two levels). The same method has been used to provide standardised estimates of town means for the other variables. Where described, social class (fitted as a factor with six levels) has also been included in analyses. In order to examine whether variables differed systematically between high and low mortality towns, the adjusted high and low mortality town means have been compared using the unpaired *t* statistic. The results of such analyses, based on

between town variance, have the advantage of allowing the findings to be generalised to all similar towns in England and Wales. Where appropriate, analyses of covariance have been used to examine whether variation between towns (irrespective of high/low mortality status) is likely to be due to chance. These analyses, which are based on both the individual and school day components of within town variance, cannot be generalised beyond the towns studied.

Weight/height² is the weight for height index used in the analyses presented here. Overweight has been arbitrarily defined as being above the 95th centile of weight/height² in the appropriate six month age-sex group. The distribution of birthweights was markedly skewed to the left. Since variation in the proportion of low birthweight (< 2500 g) is of potential clinical significance, these proportions have been presented in addition to mean birthweights. Standardisation of the proportions of low birthweight for the effect of social class have been performed using logistic regression with the marginal prediction method.¹⁹

Results

Because earlier studies have indicated that patterns of cardiovascular risk factors differ between ethnic groups in Britain,²⁰ the results presented are restricted to 3842 European children aged between 5.0 and 7.5 years. The overall response rate was 76%; similar rates were observed both in high mortality towns (75%) and in low mortality towns (76%). Data on birthweight is based on 3286 subjects (86% of those examined) for whom study questionnaires were returned. In table I the means and standard deviations of the principal variables examined are presented for boys and girls separately. Mean systolic and diastolic pressure, pulse rate, and body mass index were slightly higher in girls, but only the differences in pulse rate and body mass index are statistically significant. Mean height, weight and birthweight were higher in boys; the differences in height and birthweight are statistically significant. Sex differences in all variables are taken into account in subsequent analyses, but have no important effect on the results.

Mean blood pressures and pulse rates for individual towns and for high and low mortality town groups are presented in table II. Although both the mean systolic and diastolic pressures were higher in the high mortality town group than

Table I Sex differences in age, blood pressure (BP), pulse rate, height, weight, body mass index, and birthweight

	Boys (n=1966)		Girls (n=1876)		p (no sex difference)
	Mean	SD	Mean	SD	
Age (years)	6.37	0.63	6.37	0.63	0.98
Systolic BP (mm Hg)	103.4	10.8	104.0	11.0	0.10
Diastolic BP (mm Hg)	61.0	7.5	61.4	7.3	0.10
Pulse (beats/min)	88.7	11.3	90.5	11.3	<0.0001
Height (cm)	117.8	6.0	117.0	6.4	<0.0001
Weight (kg)	21.9	3.4	21.8	3.8	0.24
Body mass index (kg/m ²)	15.70	1.48	15.80	1.72	0.05
Birthweight (kg)	3.38	0.54	3.25	0.53	<0.0001

Table II Mean (SEM) systolic and diastolic blood pressure, pulse rate, height, weight, and body mass index by town in relation to adult cardiovascular standardised mortality ratio (SMR)

Town	SMR	n	Blood pressure (mm Hg)		Pulse (beats/min)	Height (cm)	Weight (kg)	Body mass index (kg/m ²)
			Systolic	Diastolic				
Esher	64	361	101.7 (0.6)	61.0 (0.4)	89.7 (0.6)	117.8 (0.2)	21.8 (0.2)	15.61 (0.08)
Chelmsford	71	444	105.0 (0.5)	62.1 (0.3)	90.8 (0.5)	117.6 (0.2)	21.8 (0.2)	15.69 (0.07)
Leatherhead	70	354	102.9 (0.6)	60.3 (0.4)	88.5 (0.6)	118.1 (0.3)	22.0 (0.2)	15.66 (0.08)
Bath	75	382	102.1 (0.5)	59.2 (0.4)	88.1 (0.6)	118.2 (0.2)	22.0 (0.2)	15.70 (0.08)
Tunbridge Wells	71	410	104.5 (0.5)	61.9 (0.4)	88.8 (0.5)	117.7 (0.2)	21.9 (0.2)	15.70 (0.08)
Low mortality town group	-	5	103.3 (0.7)*	60.9 (0.6)*	89.2 (0.8)*	117.9 (0.1)*	21.9 (0.1)*	15.67 (0.05)*
Wigan	140	460	106.0 (0.5)	63.5 (0.3)	92.4 (0.5)	116.7 (0.2)	21.5 (0.1)	15.70 (0.07)
Port Talbot	143	380	104.0 (0.5)	61.2 (0.4)	91.8 (0.6)	117.6 (0.2)	22.2 (0.2)	15.98 (0.08)
Burnley	131	411	102.2 (0.5)	59.4 (0.4)	89.6 (0.5)	116.8 (0.2)	21.6 (0.2)	15.78 (0.08)
Rhondda	138	360	104.7 (0.6)	61.3 (0.4)	87.6 (0.6)	116.5 (0.3)	21.7 (0.2)	15.93 (0.08)
Rochdale	136	280	102.5 (0.6)	61.0 (0.4)	87.2 (0.7)	117.0 (0.3)	21.6 (0.2)	15.64 (0.09)
High mortality town group	-	5	103.9 (0.7)*	61.3 (0.6)*	89.7 (0.8)*	117.0 (0.1)*	21.7 (0.1)*	15.81 (0.05)*
p (high-low difference)			0.54	0.66	0.66	0.002	0.24	0.10

All values are adjusted for age and sex

*Based on between town differences

in the low mortality town group the differences are small and not statistically significant (mean systolic difference 0.6 mm Hg, 95% confidence interval (CI) -1.6 to 2.8 mm Hg, $p=0.54$; mean diastolic difference 0.4 mm Hg, 95% CI -1.6 to 2.4 mm Hg, $p=0.66$). However, the marked variation in mean blood pressures between the individual towns (range 4.3 mm Hg systolic and diastolic) is statistically significant both for systolic ($p=0.03$) and for diastolic pressure ($p=0.006$). Pulse rates were marginally higher in the high mortality town group than in the low mortality town group, although the differences do not approach conventional levels of statistical significance (mean difference 0.5 beats/min, 95% CI -2.2 to 3.2 beats/min, $p=0.66$). However, variation in pulse rate between the study towns (range 5.2 beats/min) is highly significant ($p=0.001$).

Mean heights, weights, and body mass indices in the different towns are also presented in table II. Children in the low mortality town group were significantly taller than those in the high mortality town group (mean height difference 0.9 cm, 95% CI 0.4 to 1.4, $p=0.002$) and they were also slightly, though not significantly, heavier (mean difference 0.2 kg, 95% CI -0.1 to 0.5, $p=0.24$). Body mass indices were on average higher in towns with high mortality, although the differences do not achieve conventional levels of statistical significance (mean difference 0.12 kg/m², 95% CI -0.03 to 0.27, $p=0.10$). Similarly, the proportion of overweight children (defined as the proportion above the 95th centile for the study population as a whole, standardised for sex and six month age group) was slightly higher in the high mortality towns (5.7%) than in low mortality towns (4.1%); again the difference is of marginal statistical significance ($p=0.07$). Town mean birthweights (table III) were lower on average in

high mortality towns, although the mean differences do not achieve conventional levels of statistical significance (mean difference 34 g, 95% CI -10 to 78, $p=0.12$). However, the proportion of children with low birthweight (less than 2.5 kg) was higher in the high mortality towns (8.1%) than in the low mortality towns (5.5%) ($p=0.005$). Variation in leftward skew accounts for much of the variation in the prevalence of low birthweight between towns; overall birthweight variance did not differ importantly between towns. Town mean birthweights were positively correlated with town mean heights ($r=0.54$) but showed little relationship with body mass index ($r=-0.24$).

Both height and birthweight were strongly related to social class, with subjects from manual, particularly unskilled manual, occupations being of lower birthweight and shorter stature (table IV). However, there was little evidence of a relationship between social class and body mass index (table IV). Adjustment of the differences in height between high and low mortality towns for the effect of social class resulted in a slight reduction of the mean difference (from 0.9 cm to 0.7 cm; 95% CI 0.2 to 1.2) which however remained statistically significant ($p=0.02$). The small difference in mean birthweight was halved (from 34 g to 17 g; 95% CI -26 to 60, $p=0.4$). However, the difference in the proportion of low birthweights was little affected by adjustment for social class, changing only from 2.6% to 2.5% (95% CI 1.1 to 3.9, $p=0.003$).

AMBIENT TEMPERATURE AND HEIGHT: INFLUENCE ON BLOOD PRESSURE

Ambient temperature

In this study population a marked inverse relationship between room temperature and blood pressure was observed. The estimates of blood pressure change for a 1°C rise in room temperature were -0.43 mm Hg for systolic pressure and -0.39 mm Hg for diastolic pressure. Outdoor temperature showed similar relationships, which were abolished once the effect of room temperature was taken into account. However, mean room temperatures were identical in high and low mortality towns (95% CI -1.97 to 1.97°C) and adjustment for room temperature had no effect on mean blood pressure differences between high and low mortality towns.

Height

In this study population height was strongly related to blood pressure. Estimates of blood pressure change for a 1 cm increase in height were 0.64 mm Hg (SEM 0.03 mm Hg) for systolic pressure and 0.29 mm Hg (SEM 0.02 mm Hg) for diastolic pressure. These relationships were independent of age and sex. The effect on mean blood pressures in the high and low mortality town groups of taking height into account were examined in a regression model standardised for height, age, and sex. Mean differences in both systolic and diastolic blood pressure were larger than those observed when standardised for age and sex alone, but still failed to achieve conventional levels of statistical significance (mean systolic difference 1.2 mm Hg, 95% CI -1.2 to 3.6 mm Hg, $p=0.28$; mean diastolic difference 0.6, 95% CI -1.4 to 2.6 mm Hg, $p=0.5$).

Table III Mean birthweight and proportion of low birthweight (<2500 g) in towns with exceptionally high and exceptionally low adult cardiovascular mortality rates

		Birthweight (g)	
Town	n	Mean (SEM)	% <2500g
Low mortality			
Esher	333	3296 (30)	6.3
Chelmsford	410	3328 (27)	5.1
Leatherhead	296	3343 (31)	5.1
Bath	343	3339 (29)	5.0
Tunbridge Wells	354	3333 (29)	5.9
Low mortality town group	5	3328 (14)*	5.5
High mortality			
Wigan	404	3336 (27)	7.8
Port Talbot	328	3304 (30)	8.2
Burnley	360	3318 (28)	10.0
Rhondda	288	3273 (32)	8.6
Rochdale	163	3237 (42)	6.1
High mortality town group	5	3294 (14)*	8.1
p (high-low difference)		0.12	0.005

All values are adjusted for sex

*Based on between town differences

Table IV Height, body mass index and birthweight by social class

Social class	Height (cm)	Body mass index (kg/m ²)	Birthweight (g)
	Mean (SEM)	Mean (SEM)	Mean (SEM)
I	117.9 (0.3)	15.66 (0.10)	3292 (35)
II	118.2 (0.2)	15.70 (0.05)	3368 (18)
IIIN	117.7 (0.3)	15.80 (0.09)	3381 (30)
IIIM	117.3 (0.1)	15.80 (0.05)	3312 (16)
IV	116.8 (0.2)	15.72 (0.08)	3313 (27)
V	116.6 (0.4)	15.79 (0.13)	3242 (46)
ANCOVA	p<0.0001	p=0.61	p=0.02

All values are adjusted for age and sex

Discussion

We have compared the health of British children born in the 1980s living in towns with exceptionally high and exceptionally low rates of adult cardiovascular mortality. While this study includes no inner city areas, the high mortality towns included have rates of cardiovascular mortality and perinatal mortality comparable with those of many inner city districts. Children in towns with high adult cardiovascular mortality are shorter, and have slightly higher body mass indices, than those in low mortality towns. Mean birthweights are lower and the proportion of low birthweight infants is higher in high mortality towns. However, the differences are small and are partly accounted for by differences in social class. Blood pressure and pulse rate show little variation between high and low mortality towns. Overall mean heights and weights are greater than those which formed the basis for current standards,^{21 22} supporting the case for new reference data.²³ Mean blood pressures are consistent with those reported by the Brompton study in five year olds²⁴ and the second American Task Force,²⁵ once the systematic difference in systolic blood pressure measurement between the Dinamap 1846SX and the mercury sphygmomanometer¹⁵ is taken into account. The blood pressure values in this study are slightly higher than those in our earlier study⁴; this discrepancy is explained by the use of the current Dinamap child cuff size, which is slightly smaller than that used in the earlier study.

BLOOD PRESSURE AND PULSE RATE

The results of this study provided no confirmation of the earlier finding⁴ that town mean childhood blood pressure levels were related to town adult cardiovascular mortality rate. The 95% confidence intervals for the difference between high and low mortality towns (-1.6 to 2.8 mm Hg systolic, -1.6 to 2.4 mm Hg diastolic) make the presence of differences of the magnitude hypothesised on the basis of the earlier study most unlikely. The implication of this finding is that the relationship between town adult mean blood pressure and town adult cardiovascular mortality described in earlier studies in the 40–59 year age group^{2 3} and in the 25–29 age group,³ if apparent in these towns, develops after 5–7 years. A likely time of development would then be the adolescent years, during which the rate of blood pressure change with age is particularly steep.²⁵ While the findings do raise the possibility that there is statistically significant variation in blood pressure levels between towns independent of cardiovascular mortality, the importance of this variation has yet to be established. Results for pulse rate follow a broadly similar pattern. There is marked variation in pulse rates between towns, but no strong evidence that pulse rates differ between towns with high and low cardiovascular mortality.

HEIGHT AND BODY MASS INDEX

The observations that children in towns with low adult cardiovascular mortality rates are taller and slightly leaner than those in high mortality towns are broadly consistent with the results of analyses of the British Birth Survey, a cohort of children born in 1970 and examined at age 10 years, in

which the characteristics of children in areas with the highest and lowest cardiovascular mortality rates were compared.⁷ In that study, after standardisation for social class, children in the lowest mortality areas were on average 0.9 cm taller than those in the highest mortality areas and had a lower mean body mass index (mean difference 0.07 kg/m²). The reasons for the difference in height and body mass index between towns with different cardiovascular mortality patterns remain to be established. In the present study population, heights of children are strongly correlated with both maternal heights ($r=0.88$) and with paternal heights ($r=0.77$). Positive, though much weaker, correlations are also observed for body mass index both in mothers ($r=0.19$) and in fathers ($r=0.20$). Moreover, parental heights are lower in high mortality towns both in mothers (mean difference 2.3 cm, 95% CI 1.5 to 3.2) and in fathers (mean difference 2.1 cm, 95% CI 1.1 to 3.0). Differences in body mass index in parents also follow a similar pattern to those seen in children, with higher mean indices being observed in high mortality towns both in mothers (mean difference 0.60 kg/m², 95% CI 0.32 to 0.88) and in fathers (mean difference 0.63 kg/m², 95% CI 0.41 to 0.85). However, the association between parental and child heights and body mass indices is likely to reflect both genetic and shared environmental factors,²⁶ which cannot be separated in the context of the present study.

The interpretation of the differences observed in height and body mass index depend on whether they are likely to persist into adult life and whether they are tending to increase or diminish over time. Predicting whether these differences will persist into adult life is difficult, because the experience of different cohorts may vary. In the case of height, the experience of the National Child Development Study cohort of children born in 1958 has been that geographical differences in height at age seven years persist essentially unchanged into adult life (Strachan D—personal communication). No reports on the extent to which geographical differences in body mass index in childhood persist into adult life are available. However, at the individual level it has been observed that overweight at seven years is related to overweight in adult life although the association is weak.^{27 28} Thus on present evidence it is likely that the differences in height and body build will tend to persist into adult life, although the extent to which they will do so is uncertain.

The assessment of secular trends in the differences in height or body mass index is also difficult, because none of the earliest studies reported is consistent with the present study either in age group or in sample selection. However, two observations suggest that differences in childhood height between high and low mortality areas may be diminishing. First, the differences observed in children are markedly smaller than those in parents, a finding consistent with observations made in the 1970 British Birth Survey cohort at 10 years.²⁹ Second, geographical variations in height in the present study are smaller than those observed in both the National Child Development Study of children born in 1958 and the British Birth Survey of children born in 1970.²⁹

BIRTHWEIGHT

The observations that both mean birthweight and the proportion of low birthweight may differ between high and low mortality towns are supported by data from other sources, although these tend to emphasise the small size of the differences. Mean birthweights in areas of widely differing cardiovascular mortality were presented in the analysis of the British Birth Cohort referred to earlier.⁷ Although mean birthweights were higher in areas of high cardiovascular mortality, the mean difference in birthweight between the highest and lowest mortality groups was extremely small (17 g) and did not approach conventional levels of statistical significance. The validity of the findings on differences in the proportion of low birthweight between high and low mortality towns has been examined using OPCS data based on all births in the health districts corresponding to the study towns over a six year period during the 1980s.³⁰ These data, which are less influenced by the survival effects that are a potential source of bias in the study data, are consistent with the finding that the proportion of low birthweight may be higher in high mortality towns, but suggest that the difference in the proportion of low birthweight may be even smaller (1.5%) than that described in the study (2.6%).

IMPLICATIONS FOR FUTURE HEALTH AND MORTALITY

What are the implications of these findings for the future health of this cohort of children born in the 1980s? Two particular questions need to be addressed. First, to what extent are the differences in height and body mass index observed likely to influence future health and mortality? Second, what are the implications of recent hypotheses emphasising the possibility of direct relationships between fetal and infant life and adult disease, particularly cardiovascular disease, for this cohort of children?

Both the differences in height and those in body mass index may be relevant to the future health of the children studied. Relationships between short adult stature and increased mortality in adult life have been described, both for all cause mortality and for ischaemic heart disease mortality.^{5,6} The extent to which height itself is responsible for the relationship, rather than other social factors related to height, is still debated.³¹ Moreover, it is possible that lung function, rather than height itself, is the factor directly responsible for the relationship.⁶ However, even if the relationship between height and mortality is a direct one, the consequences of the differences in height described in the present study are unlikely to be large. In the British Regional Heart Study a decrease in adult height of approximately 9 cm was associated with a twofold increase in mortality from ischaemic heart disease.⁶ The strength of the relationship was halved after standardisation for social class and other standard cardiovascular risk factors; a relationship of similar magnitude was observed in the Whitehall Study.⁵ Even if the differences in height observed between high and low mortality towns in the present study (0.9 cm unadjusted, 0.6 cm adjusted for social class) increase twofold by adult life, the associated

cardiovascular risk is likely to be relatively small. The differences in body mass index may also have implications for future mortality patterns, since higher body mass indices in adult life are associated with increased mortality both from cardiovascular and non-cardiovascular causes.³² However, as argued above, the implications of the present findings in children for future differences in adult body mass index between high and low mortality towns are difficult to predict.

Recent reports have emphasised the possibility of a direct link between fetal and infant experience and the development of later disease, particularly cardiovascular disease.⁷⁻¹⁰ The demonstration of ecological associations between infant mortality and ischaemic heart disease mortality,¹¹ and between maternal mortality and stroke mortality,¹² has led to the suggestion that early life influences might play an important part in explaining geographical variation in cardiovascular disease in Great Britain.⁷ More detailed ecological analyses have led to the suggestion that both the intrauterine and postnatal environments are related to the development of ischaemic heart disease, while the intrauterine environment alone is related to stroke.¹⁰ The geographical differences in childhood height suggest that there are persistent differences between the postnatal environments of high and low mortality towns, although, as has been argued above, the differences in height are likely to be diminishing and their consequences for future mortality are likely to be limited. In the hypotheses relating the intrauterine environment to later cardiovascular disease, birthweight has occupied a central role. Low birthweight has been related to increased risk of mortality from ischaemic heart disease⁹ and to higher blood pressure levels both in childhood^{7,33} and in adulthood.⁸ However, the results of the present study imply that geographical differences, both in mean birthweights and in the proportion of low birthweight, between areas of high and low adult cardiovascular mortality are now small, a conclusion which is consistent with the findings of earlier analysis of the British Birth Survey of 1970 births⁷ and with routine statistics on the prevalence of low birthweight.³⁰ Moreover, the absence of any appreciable differences in childhood blood pressure or pulse rate, two factors suggested to link intrauterine circumstances and adult cardiovascular risk,⁷ between high and low cardiovascular mortality towns again provides no support for the view that childhood blood pressure forms an important link between intrauterine factors and cardiovascular risk on a geographical basis in this cohort. These observations suggest that, whatever the importance of intrauterine influences on geographical variation in cardiovascular disease in Great Britain in the past, the case for their continuing importance has still to be proved.

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