An inverse relation between blood pressure and birth weight among 5 year old children from Soweto, South Africa

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Abstract

Study objective—To examine the relation between birth weight and blood pressure at 5 years in a cohort of South African children.

Design—Prospective cohort study.

Participants—849 five year old children.

Setting—Soweto, a sprawling urban area close to Johannesburg, South Africa, which was a designated residential area for people classified as “black” under apartheid legislation.

Main results—Systolic blood pressure at 5 years was inversely related to birthweight ($r = -0.05$, $p = 0.0007$), independent of current weight, height, gestational age, maternal age or socioeconomic status at 5 years. There was no relation between birth weight and diastolic blood pressure. After adjusting for current weight and height, there was a mean decline in systolic blood pressure of $3.4$ mm Hg (95% confidence intervals $1.4, 5.3$ mm Hg) for every 1000 g increase in birth weight.

Conclusions—These data from a disadvantaged urbanised community in Southern Africa extend the reported observations of an inverse relation between birth weight and systolic blood pressure. The study adds to the evidence that influences in fetal life and early childhood influence systolic blood pressure. Further research is required to assess whether efforts to reduce the incidence of low birthweight babies will attenuate the prevalence of hypertension in future generations.

Main text:

Most of the South African population, formally disenfranchised and classified as “black” has been undergoing rapid urbanisation, to the extent that it is predicted that more than 70% will live in urban areas by the year 2010.¹ This process has been accompanied by a change in the pattern of diseases from predominantly infectious to chronic, as South Africa enters the epidemiological transition.² Currently, in this urbanised community, there is a high prevalence of hypertension, a seeming rise in the prevalence of diabetes and the emergence of dyslipidaemia.³ Given the context of shrinking health resource allocation and the growing morbidity and mortality attributable to these diseases, the identification of the potential causes and hence opportunities for their prevention, is increasingly important.

Known risk factors, for example, genetic predisposition, environment and lifestyle do not fully explain the susceptibility of people to these adult chronic diseases. An emerging theory to explain the patterns of these diseases in people and populations, is that an adverse intrauterine environment programmes susceptibility to the diseases and their metabolic risk factors.⁴ ² This theory is based on epidemiological evidence of an association between measures of early life experience (predominantly birth weight) and the development of these diseases in later life.⁷ ¹⁰

A number of studies have investigated, and most found an inverse relation between birth weight and blood pressure in childhood, adolescence, and adulthood.¹¹–₂₄ Interestingly, in the only study reported in full from Africa, no relation between birth weight and blood pressure was found in 675 children aged 1 to 9 years in rural Gambia. However, a significant inverse relation between maternal weight gain in the third trimester of pregnancy and blood pressure of 8 and 9 year old offspring was interpreted as supporting the relation between poor maternal nutrition and higher blood pressures in children.¹⁷

This paper reports an investigation of the association between birth weight and blood pressure at 5 years of age in a cohort of historically disadvantaged urban children from Soweto in South Africa. Soweto, an acronym for South Western Townships, is a sprawling city of about 2 million people, situated 15 miles from central Johannesburg. It was originally established as a dormitory for Johannesburg’s “black” workers. Under the 1960 Group Areas Act, which forced different groups of people to live in demarcated areas, Soweto was reserved for people classified as “black” under apartheid legislation. Today, Soweto is a cosmopolitan city where diverse groups of “black” South Africans have culturally blended together over time.

Most Sowetans are poor, although there is a range of income groups, and large numbers are unable to find formal employment. Most people live in formal housing (mostly small two, three or four room brick or cement block houses), but almost every house has a backyard structure (corrugated iron or wood shack). This is typical of poorer areas where there is an acute housing shortage. Backyard structures are a valuable source of income. Soweto
households typically consist of six or fewer people, but are in a constant state of flux with new household members entering and/or old ones leaving. Household fluidity is a common feature in all poorer South African urban areas. Most Sowetans have access to electricity, although coal is still commonly burned. Only a third of the houses in Soweto have indoor water; the most common source of water is an outdoor faucet. About two thirds of Sowetans use an outdoor flush toilet, pit or bucket latrine, while a third have an indoor flush toilet.

Methods
The sample was drawn from the Birth to Ten (BTT) study, a prospective cohort study of determinants of growth, development, and health of children in the metropolitan area of Soweto, Johannesburg. The cohort was drawn from all 5460 singleton births during a seven week period between April and June 1990 to women who gave their permanent address within the defined area. Identification and enrolment of children into BTT took place throughout the first year of the study. The 4029 births enrolled represented about 95% of all births that occurred in the area during the seven weeks to mothers actually resident in the defined area. This is based on earlier pilot studies that found that approximately 20% of mothers who deliver babies in the BTT area were from rural areas, travelling to the metropolitan area to give birth and then returning shortly after delivery. The potential sample for this study was restricted to children whose caregivers were living in Soweto at the time of enrolment into the BTT study. This comprised 3170 “black” children. The remaining 859 children were not eligible because they were not resident in Soweto at the time of enrolment (n=632), stillborn (n=106), dying during the first month of life (n=80) or before their first birthday (n=41).

In 1992, 1994, and 1995 when the children were 2, 4, and 5 years old, all the children and caregivers were invited to attend for follow up interviews and examination. Follow up has been logistically difficult because of movement of families within the urban area and between the urban and rural areas, but contact has been maintained with approximately 60% of the enrolled cohort of children and families.

At the age of 5 years, the children and caregivers currently living in Soweto were contacted at home or work by phone, letter or a visit by a BTT research assistant for an interview appointment at health care clinics or a visit by a BTT research assistant for an interview appointment at health care clinics or a home visit. This provided a cross sectional sample of 849 “black” children and caregivers who attended for an interview and gave permission to be examined at 5 years of age, on whom blood pressure, weight and height data were available. The results are expressed as means and standard deviations. The associations between pairs of categorical variables were examined using the χ² test. Analysis of variance was applied for independent effects of the explanatory variables on systolic and diastolic blood pressure. Forward and backward selection procedures were used in separate analyses. Weight, birth
The study supports numerous previous observations demonstrating an inverse relation between birth weight and systolic blood pressure. This relation, independent of current weight, current height, gestational age, maternal age, and a crude measure of socioeconomic status.
has not previously been reported from Southern Africa. The findings from a poor urban setting in Africa add further evidence that blood pressure in childhood is related to factors operating in fetal life and infancy. The mean birth weights in this study were less than American norms but the percentage of low birth weight children of normal gestational age (7.1%) was similar to that of developed countries. Our data contrast with the only other study reported from the African continent in which no association was found between birth weight and blood pressure in rural Gambian children but support a brief report from Nigeria, from an unspecified setting. Although the reason for this difference is unclear, it is tempting to speculate that factors specific to the urban setting, whose influence start in utero, may contribute to the higher prevalence of hypertension in urban, compared with rural, areas.

The extent of changes in blood pressure in relation to birth weight observed in this study, although small, were similar to those previously reported in children. Although the contribution of birth weight to the variance in systolic blood pressure of children in this and other studies is small, studies in adults in other settings have found larger differences in blood pressure between those with low and high birth weight, particularly in those with the highest current body mass index. This tends to support the theory that higher blood pressure is initiated by processes that begin in utero and become amplified in later life. Furthermore, should this apply to communities in Southern Africa, the link between birth weight and blood pressure may have important implications for the future prevalence of hypertension.

In this 10 year longitudinal study, in which it was never planned that all participants were to be seen at each time point, the relatively small proportion of the eligible cohort followed up at 5 years could be a source of systematic bias. Indeed the major source of bias in cohort studies is loss to follow up, which is selectively related to exposure and/or outcome. This can create systematic bias and an underestimate or overestimate of the association between exposure and outcome. For example, in our study if normal/higher birth weight babies with higher blood pressure were more likely to die, migrate away or not attend the 5 year examination, this would exaggerate the size of, or create an inverse relation between low birth weight and blood pressure at 5 years. We believe that it is implausible that the relatively small variations in blood pressure reported within the cohort would have any effect on loss to follow up either non-differentially in the whole cohort, or differentially in relation to exposure status (birth weight). The high rate of loss to follow up also could create selection bias if the relation between low birth weight and blood pressure at 5 years differed between those examined at this stage and those not. This possibility cannot be excluded, although we can think of no plausible reason why this should be the case. Finally, the high rate of non-attendance at 5 years may reduce the generalisability of the findings to the whole cohort. However, the lack of significant differences between the attenders and non-attenders in all the baseline characteristics studied, except maternal age, and gravidity (neither of which had any independent association with blood pressure at 5 years of age) suggest that generalising the findings in the cohort is probably justifiable.

The question of how low birth weight induces an increase in blood pressure in children and adults is unanswered. Two hypotheses, not mutually exclusive, are the subject of intense investigation. The one suggests that birth weight may be a proxy for nutrition in utero and that undernutrition during gestation results in long term programming of the cardiovascular and endocrine systems and their responsiveness. The other suggests that fetal exposure to high glucocorticoid concentrations could affect the development of fetal vasculature, its responses to pressure agents, hypothalamo-pituitary-adrenal axis responsiveness or expression of glucocorticoid receptors.

In South Africa, the apparently inexorable increase in hypertension, diabetes, and cerebrovascular disease among the rapidly urbanising population is profoundly worrying. The association of low birth weight and higher blood pressure in this cohort of children—if maintained into adult life—may suggest one possible method of primordial prevention for adult hypertension. However, this conclusion may be premature because of uncertainties about the causal pathway linking low birth weight with raised blood pressure, and possible unforeseen adverse effects to the mother and infant of such interventions. More research is required, including intervention trials, to assess whether efforts to reduce the incidence of low weight infants and improve antenatal care will reduce the prevalence of hypertension among future generations.

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