

**FAILURE TO THRIVE IN THE FIRST POSTNATAL YEAR:  
AN INNER CITY COMMUNITY SURVEY**

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## SYNOPSIS

For many years it has been suspected that faltering somatic growth during early postnatal life can be associated with the subsequent impairment of mental and psychomotor abilities. Previous research has failed to find a clear connection, largely because of the difficulty of controlling for potentially confounding variables. This study aimed to address former methodological deficiencies by means of a novel strategy.

Firstly, cases of failure to thrive were identified from a prospectively recruited whole population birth cohort (n=2610) in an inner city area of the United Kingdom, in order to increase the representativeness of the findings. Previous studies in the developed world have almost always selected cases from hospital referrals for failure to thrive. Case criteria were strictly anthropometric, and cases were identified by the independent monitoring of the growth of all Child Health Clinic attenders. Accordingly, reporting bias was avoided.

Secondly, our aim was to examine growth faltering in children who were in good health in other respects. Children in the developing world who participate in studies on the outcome of growth failure for cognitive and behavioural development frequently suffer from intercurrent infections, which may independently impair their mental and psychomotor performance.

Thirdly, the project aimed to measure a very wide range of other potentially confounding variables and to match cases more closely to a normally growing comparison sample than had previously been attempted. This was possible because of the social homogeneity of the area surveyed, and because of the potentially large number of comparison infants in the birth cohort.

Forty-seven otherwise healthy infants with persistent failure to thrive (FTT) were selected on the basis of anthropometric criteria. Cases were identified from the independent plotting of routine clinic weighings, details of which were supplied on a

regular basis to a member of the research team. Case status was confirmed by personal examination. A closely (pairwise) matched comparison group was selected from the survey population. All subjects were seen at approximately 15 months of age.

Both groups received a comprehensive home-based assessment by the research team. Measures included interviews with the index child's mother, a medical and anthropometric examination of the infant and assessment by a speech therapist with a focus on oral-motor skills. Videorecordings were made of the infant during a standard mealtime and during a structured play session with the mother. A variety of measures were taken of the quality of the home environment for promoting infant development.

Preliminary findings indicated that although they were more psychosocially advantaged the outcome for infants whose growth failure had commenced within six postnatal months was worse than those for whom the faltering commenced later, despite the fact that the children from the worse outcome group came from less psychosocially disadvantaged families.

A statistical model was constructed that enabled the timing, the duration and the severity of growth faltering to be used as predictors of mental and psychomotor functioning. Up to 37% of the variance in cognitive and psychomotor outcome at 15 months could be explained by the model on the basis of just three explanatory variables.

These were the quality of maternal stimulation in her interaction with the infant, a measure of total minor congenital abnormalities and the growth trajectory of the infant since birth. Of these the degree of growth faltering was the most important, alone accounting for 25% of the variance in outcome. Their impact on mental and psychomotor development was independent of one another.

In 1990 a search was made of child protection records pertaining to the area in which the original research had taken place. Our aim was to identify the names of all members of the original birth cohort which had subsequently been placed on a Child Protection

Register, or who had been subject to an investigation of suspected abuse or neglect without registration. in the intervening 4 years. x

Of the 2610 1986 births, 2.5% names had been placed on a Child Protection Register by 1990. A further 1.2% names had been recorded as a 'cause for concern', but they were not formally registered. Four of the failing to thrive cases' names (8.5%) had been registered and a further 4.2% case names were recorded as constituting 'a cause for concern', for reasons other than the growth problem.

Two main conclusions may be drawn from our investigation. Firstly, the early postnatal months appear to constitute a 'sensitive period' for the relationship between growth and mental development in full-term infants. Growth faltering at this time is associated with a deficit in mental and psychomotor abilities in the second year. There is a moderate correlation between the degree of growth failure and the detriment to those abilities, which is independent of the quality of the home environment. Secondly, infants who fail to thrive without organic disease or disorder are at an increased risk of otherwise being abused or neglected during the preschool years, within a socioeconomically disadvantaged population. However, the degree of risk is lower than was previously reported.

The results from this investigation may not be generalisable to other populations, either within the United Kingdom or elsewhere in the world. Others may however have longitudinal data sets upon which the hypotheses outlined here may be tested. Should our findings be confirmed in other disadvantaged populations, the implication for policy and practice are wide ranging. The potential magnitude of detriment to mental and psychomotor development, caused by preventable growth failure in chronically undernourished at-risk populations, is considerable.

## ACKNOWLEDGEMENTS

The work presented in this thesis had its origins in 1982, when I was encouraged to undertake a community survey of failure to thrive in the then Guy's Health District by Margaret Lynch, senior lecturer in community paediatrics. The design of the study was my own and a grant for the original investigation (1983-1986), which led to the presented body of work in due course, was supported by the Bethlem Royal and Maudsley Hospital Research Fund. On the basis of findings from this study, I was successful in obtaining a Wellcome Trust Senior Lectureship at the Institute of Child Health in the Department of Philip Graham in 1985. He has been consistently supportive of the research, and of myself, and has acted as supervisor of this submission.

The community survey which commenced in 1985 was designed in outline by myself, and was generously funded by the Wellcome Trust, who also funded my personal position until 1990. Additional support was provided by Newcomen's Educational Foundation, by the British Postgraduate Medical Federation, by the Child Growth Foundation, and by the Joint Research Board of the Institute of Child Health and Great Ormond Street Hospital. Funding was also obtained from the Mental Health Foundation, for a study of the next-born siblings of failing to thrive infants, the results of which are mentioned briefly in the thesis.

At the commencement of the investigation in 1985 I was joined by Dieter Wolke and Sheena Reilly who both had a major part to play both in data collection and in specific aspects of the investigation's design. As is made clear in the body of the thesis, a number of the instruments used to measure infant-mother relationships were developed by Dieter Wolke, and the preliminary analysis of their psychometric properties was done under his supervision. However, the analyses presented in the work here have all been done by myself, working from the computer files he produced. Dieter Wolke collected all the data relating to the mental and psychomotor competence of the infants, and the data on infant behaviour.

Sheena Reilly, together with Berenice Mathisen and myself, developed the Schedule for Oral Motor Assessment which was used to rate the oral-motor competence of the infants. She collected all the data on this aspect of the infants' behaviour, and also data on the diet and food intake of the subjects.

I collected data on the medical histories of the infants and made a physical examination. All these assessments were undertaken in their homes.

Subsequently, a very large number of students and other research workers have assisted in the preparation of data for analysis, but virtually all confirmatory statistical analysis of the material that has been published from this investigation, and that which is presented in this thesis, was done by myself. The only exception is the statistical model for the prediction of detriment to mental and psychomotor outcome, on the basis of the early postnatal weight gain trajectory. This non-linear regression model was developed by Andrew Pickles, at the MRC Child and Adolescent Psychiatry Unit, at my suggestion. The original observation that there appeared to be a sensitive period for mental development was my own, made in the course of exploratory analysis of the data.

I am grateful to all those who have assisted in the collection of data, in the preparation of data, and in the preliminary analyses. They include Dorothy Gill, who was responsible for an enormous contribution. She contacted the families at the initial stage of the study to gain their consent, traced missing records, collected data and played the main role in gathering the information that enabled us to undertake the investigation of risk of abuse and neglect on the birth cohort. Margaret Grocke did a large part of the initial analysis of the behavioural observation scales, and the temperament scales developed by Dieter Wolke. Margaret Sumner rated the videorecordings of feeding and play interaction. Anna Thomas also rated videorecordings and was trained at the University of Washington, Seattle, by Kathryn Barnard to use the Nursing Child Assessment Scale.

Finally, there are two people without whom the thesis could never have been written, and indeed the programme of research would never have begun. Both have been involved in one way or another since its inception. I am forever grateful to Jennifer Smith, my personal assistant, who has had a major part to play in the day to day running of the projects, and my life at work, for 16 years. Linda, my wife, was instrumental in the success of the original investigation and a co-author on several papers. Her forbearance in the face of overwhelming self-absorption, and her unfailing encouragement have been an inspiration.



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FIGURE 5.5

## ABBREVIATIONS

<b>CES D:</b>	Center for Epidemiological Studies Depression scale (Radloff, 1977).
<b>CHES:</b>	1970 Child Health and Education Study.
<b>CPR:</b>	Child Protection Register
<b>DSM-IV :</b>	Fourth Revision of the Diagnostic and Statistical Manual of the American Psychiatric Association (American Psychiatric Association, 1993)
<b>FIS:</b>	Feeding Interaction Scale (Wolke, 1987b)
<b>FTT:</b>	Failure to Thrive
<b>GCI :</b>	General Cognitive Index (McCarthy Scales of Children's Abilities; 1972)
<b>GHQ:</b>	General Health Questionnaire (Goldberg and Williams, 1988)
<b>HC:</b>	Head circumference
<b>HOME:</b>	Home Scales for the Measurement of the Environment (Caldwell & Bradley (1984) and Elardo & Bradley (1981).
<b>ICD-10 :</b>	Tenth Revision of the International Classification of Diseases (World Health Organization, 1992)
<b>ICQ:</b>	Infant Characteristics Questionnaire (Bates, 1984)
<b>IFQ:</b>	Infant Feeding Questionnaire (Skuse, 1986)
<b>LAZ:</b>	Length for age in standard deviation scores; National Center for Health Statistics growth standards (Hamill, Drizd, Johnson, Reed and Roche, 1977).
<b>MAACL:</b>	Multiple Affect Adjective Checklist (Zuckerman & Lubin, 1965).
<b>MDI:</b>	Mental Development Index (Bayley Scales of Infant Development, 1969)
<b>MUAC:</b>	Mid-upper arm circumference
<b>NCAST:</b>	Nursing Child Assessment Teaching Scales (Barnard et al., 1989).
<b>NCHS:</b>	National Center for Health Statistics
<b>NOFT:</b>	Nonorganic Failure to Thrive
<b>OFT:</b>	Organic Failure to Thrive
<b>PDI:</b>	Psychomotor Development Index (Bayley Scales of Infant Development, 1969)
<b>POSER:</b>	Play Observation Scheme and Emotion Ratings (Wolke, 1987c)
<b>SD:</b>	Standard Deviation
<b>SDS:</b>	Standard Deviation Score
<b>TRIB:</b>	Tester's Rating of Infant Behaviour (Wolke, 1987a)
<b>WAIS R:</b>	Wechsler Adult Intelligence Scales (Wechsler, 1974).
<b>WAZ:</b>	Weight for age in standard deviation scores; National Center for Health Statistics growth standards (Hamill, Drizd, Johnson, Reed and Roche, 1977).
<b>WLZ:</b>	Weight for length, for age, in standard deviation scores; National Center for Health Statistics growth standards (Hamill, Drizd, Johnson, Reed and Roche, 1977).

## **PART ONE**

### **THEORETICAL AND CONCEPTUAL ISSUES**



## CHAPTER 1. Theoretical And Conceptual Issues

### 1.1 Introduction

There cannot be many conditions in pediatric psychology that have generated quite as much discussion as failure to thrive, recently described as 'a disorder of infancy and *early* childhood, characterised by a marked deceleration of weight gain and a slowing or disruption of acquisition of emotional and social developmental milestones' (Woolston, 1991). The way in which the condition has been conceptualised has varied substantially over the past 50 years. This account commences with a historical review.

#### 1.1.1 Historical perspective

During the 1940s there were reports that emotional deprivation, as such, could influence growth, linked to claims that deprivation during the preschool years usually led to irreversible effects upon psychosocial functioning in later childhood and even adult life. Spitz (1945) described the growth of infants in a foundling home where they had received 'excellent food' yet little individual attention outside feeding times. Growth in both weight and length were severely retarded and Spitz reports "The physical picture of these children (when 2-4 years of age) impresses the casual observer as that of children half their age". Talbot et al (1947) described a series of 28 children (aged 2½ -15 years) referred to a Massachusetts General Hospital who had stunting of unknown origin. The nutritional histories of the majority indicated that they had major feeding difficulties which persisted for most of their lives, in many cases since infancy. These were associated, in 605 of the children, with some degree of socioemotional adversity within their families.

Attempts to improve the diets of the 66% of their subjects who were underweight for their height met with little success because the children could not be induced to become interested in the idea of eating more food; however, the investigators entertained the hypothesis that nevertheless a number of them had been chronically undernourished. Following 'psychiatric therapy' 3 subjects showed an improved appetite and, following that change in appetite, demonstrated catch-up growth. An example is given of such catch-up growth commencing between 7-8 years of age. Although it was not possible at the time to test the hypothesis, the investigators proposed that the ultimate cause of the children's abnormally slow growth had been a relative deficiency of growth hormone and that they had tended to adapt themselves to nutritional privation during the period in *early* life by becoming 'relatively hypopituitary', but the hypopituitarism did not usually reverse when energy intakes were improved (Money, 1992).

A third account, from the same period, on the growth of children in conditions of psychosocial deprivation or adversity was that of Widdowson (1951). The story of her serendipitous observations is well known. In 1948 she was stationed with an army medical unit in a town in the British zone of occupation where two small municipal orphanages were located. Each housed around 50 boys and girls between 4-14 years. The children had nothing except rations to eat and they were well below normal in both height and weight. The medical unit instituted a programme of physical examinations of the orphans every two weeks and continued these observations for 12 months. During the first six months the orphans continued to receive only the official rations. During the last six months the children

in orphanage A received in addition unlimited amounts of bread, an extra ration of jam and a supply of concentrated orange juice. The matron of orphanage A at the start of the study was a cheerful young woman who was fond of the children in her care. In contrast, the matron in charge of orphanage B was older, stern and a strict disciplinarian towards all the children in her care except for a small group of favourites. It so happened that at the end of the first six months the cheerful matron left orphanage A for other employment and the disciplinarian was transferred from orphanage B to orphanage A, bringing her 8 favourites with her.

The physical examinations of the children's growth revealed that during the first six months the weight gain by the children in orphanage A was substantially more than the weight gain by the children in orphanage B, yet the strict matron's favourites did much better than the rest of the children. The shift in matrons then occurred and this coincided with the provision of extra food for orphanage A. During the next six months the children of orphanage B, whose food supply had not increased but who no longer had the strict disciplinarian in charge of them showed a rapid rise in weight. Surprisingly, in spite of their improved nutrition those children who were now subject to the regime of the disciplinarian matron in orphanage A continued to gain weight at about the same rate as before. Trends in weight and height were very similar; the matron's favourites exceeded all others in terms of their rate of growth.

The prevailing view then, during the 1950s and 1960s, was that socioemotional deprivation could indeed be the cause of some cases of failure to thrive, resulting in due course in abnormally short stature, and that the most likely aetiology was 'deprivation' (or the lack of mothering in a broader sense) (Elmer, 1960; Patton and Gardner, 1962; Coleman and

Provence, 1957). The prevailing assumption was that failure to thrive was caused either by diminished intestinal absorption, inefficient utilisation of calories, or possibly because of some abnormality of endocrine function (Coleman and Provence, 1957; Blodgett, 1963; Leonard et al, 1966). No clear distinction was made between failure to thrive defined in terms of weight gain, and failure to thrive defined in terms of growth in stature. Samples of 'failing to thrive' children often included subjects selected on the basis of one or the other criterion. The distinction is important, because the mechanisms that lead to poor growth in infancy, especially within the first postnatal year, may differ from the mechanisms that lead to short stature in later childhood.

In 1969, Whitten and colleagues (1969) set out to test the hypothesis that, rather than some subtle influence of deprivation or neglect upon metabolic functioning, the ultimate aetiology of children's growth failure in conditions of socioemotional adversity was simply an inadequate caloric intake. Whitten observed that former researchers had all assumed, but did not determine, the adequacy of the children's caloric intakes during the period when 'unfavourable emotional forces were operative'. The study was of a series of 16 infants aged between 3-23 months, who were seriously failing to thrive. Their mean length at the time of being taken into the study was -3.06 SDS (1.25 SD) and their mean weight was -3.26 SDS (0.9 SD). By means of an ingenious design they showed, reasonably convincingly, that despite the protestations of the mothers of these infants that they had been feeding them sufficiently, if the children were indeed fed 'adequate calories', either during a hospital admission or at home (before or after the hospital admission) those children did gain weight, whether or not they received additional stimulation or maternal attention. The authors

conclude "maternally deprived infants are underweight because of underfeeding which is secondary to not being offered adequate food or to not accepting it, and not because of some psychologically induced defect in absorption or metabolism". They concede that "our evidence that underfeeding is the aetiologic factor in the growth failure to maternally deprived infants is based entirely upon weight gain". In fact the children's average weight for length at the time of admission to the study was -1.8 SDS (0.92 SD); they were clearly not simply stunted and the great majority (88%) were seriously underweight for their length.

The Whitten et al study's finding had the effect of changing the emphasis of research on the association between growth impairment and emotional deprivation and abuse, to focus upon nutritional influences. Accounts of what mothers claimed they fed their failing to thrive children were disbelieved, and such children were presumed to be relatively undernourished. Reviewing the current state of knowledge on the subject of 'emotional disturbance and deprivation on somatic growth' in 1974 (MacCarthy, 1974) MacCarthy concludes "hormonal dysfunction appears to be minimal ... if there is an explanation it is probably more in terms of nutrition than of endocrine disturbance".

In 1974 Krieger (Krieger, 1974) also wrote that maternal rejection could cause a 'psychosocial deprivation syndrome' in which linear growth failure and retarded bone age were associated with persistent restriction of food by mothers who abused their children physically and who had characteristic personality traits. In 1981 MacCarthy (MacCarthy, 1981) stated it was likely that 'deprivation dwarfism', commencing in the first two years of life, was likely to be due to undernutrition. He added "there are strong indicators, short of

absolute proof, that this understanding is due to 'undergiving' by the mother and the additional element is the child, who being underfed, becomes undemanding".

A reasonable consensus, then, existed in the 1970s that failure to thrive in the early preschool years was due to chronic undernutrition, although there was some perplexity about the child's role. As McCarthy (1981) put it "why did not these babies cry in hunger, or if they did why were their cries ignored?".

Another condition was also causing perplexity, for some older children who had excessively short stature and came from homes where it was thought they were likely to be being neglected or abused were reported by their caretakers to have huge appetites, eating far more than their siblings, yet they failed to grow in stature (Powell et al, 1967). This condition has been termed 'psychosocial dwarfism' but it is not found as a diagnostic category within ICD-10 (World Health Organization, 1992) or DSM IV (American Psychiatric Association, 1993). The diagnostic criteria have been summarised by Green (Green et al, 1984; 1987). The diagnosis has rarely been made before the age of 2 years. In virtually all cases there is said to be a severely disturbed relationship between the primary caretaker and the child, which is of primarily aetiological importance. Most typical behavioural symptoms include bizarre patterns of eating and drinking, including gorging and vomiting, polyphagia and polydipsia. Growth failure usually begins in infancy but in some cases growth retardation begins as late as 6 or 7 years (Ferholt et al, 1985).

Disturbed biological rhythms associated with the disorder include sleep, appetite and growth hormone release. Sleep is disrupted with frequent waking and night wandering, often in search of food. Active REM sleep may be increased and stage 3 and 4 NREM sleep decreased (Taylor and Brook, 1986). Appetite is disturbed, normal hunger and satiety rhythms are lost, and there is an apparent inability to achieve satiation. Consequently, these children habitually take food which they have been forbidden, steal food from their peers and -given the opportunity - gorge themselves until they vomit.

Growth hormone release shows a diminished pulse amplitude (Stanhope et al, 1988; Skuse et al, 1995), meaning that the cumulated 24 hour circulating levels of the hormone are severely curtailed. Disordered self-regulation means deviant patterns of defecation, urination and attention. It is not uncommon to encounter a history which goes far beyond simple encopresis and enuresis to encompass features in which those bodily functions have acquired the quality of aggressive acts. Deliberate urination over others' belongings, and the concealment of faeces or soiled clothes in public places are typical. Attention span is almost invariably brief. Receptive and expressive language skills are impaired; the children also have poor non-verbal skills and poor practical reasoning abilities (Skuse, 1993b). At school they underfunction, and may require special education for moderate learning difficulties. Mood is almost invariably characterised by depression and poor self-esteem. Social relationships are always severely impaired; these children are disliked by virtually everybody with whom they come into contact including siblings, peers, and schoolteachers as well as their parents.

A cardinal feature is the potential for reversibility of all symptoms when the child is removed from the abusing environment (Skuse et al, 1996; Skuse 1989; Money et al, 1983). The rate of change in mental growth seems to run parallel to that of physical development, and is reflected by a progressive increase in intelligence. The bizarre behavioural features are usually lost within a few weeks of the child being taken into a caring and nurturing family, but if they persist for months or years the possibility that the abuse is also persisting should be considered. The increase in height velocity is often dramatic, and pathognomonic. Children's stature 'catches up' to a trajectory far closer to their genetic potential.

Accordingly, over the past few decades two main subgroups of children with short stature associated with socioemotional deprivation or adversity have been identified. It has come to be appreciated that there could be several quite different ways, involving contrasting mechanisms, in which early experiences can have enduring effects upon linear growth. At one extreme there is growth failure of very early onset, certainly within the first two years of life, in which the aetiology is thought to be undernutrition. The infants with this condition tend not to complain that they are being undernourished, but it has been suggested that the reason they do not complain is that their malnourishment has rendered them apathetic (eg, Graves, 1976). Such children are said to show reduced activity levels which could be construed as a reductive adaptation to their nutritionally depriving environment (Waterlow, 1984). Once stunting is established within the first 3 years in such children, so it is hypothesised, they are unlikely to increase their intake even if offered more food at a later age (Martorell, 1985). The second condition is that which has been termed 'psychosocial dwarfism', or 'psychosocial short stature'.



### 1.1.2 Current perspectives

A few years ago two excellent comprehensive reviews of failure to thrive were published (Frank and Zeisel, 1988; Lachenmeyer and Davidovicz, 1987) which, between them, summarised the majority of the then available literature. Accordingly, this review will concentrate primarily on publications since 1987. Issues of definition and recent findings from epidemiological surveys will be discussed, together with the theoretical underpinning of this investigation and the conclusions to be drawn from it.

Issues to be discussed include, on what grounds should the criteria for a valid definition of failure to thrive be based? How do definitions perform when applied in the very different contexts of hospital-based and epidemiological studies? Should a clear distinction be drawn between 'organic' and 'non-organic' failure to thrive, and if not why not? Finally, what evidence is there that we could ever move beyond the notion of failure to thrive as two relatively homogeneous disorders ('organic failure to thrive' and 'non-organic' failure to thrive) to more precisely defined syndromes, which possess diagnostic validity insofar as they are more than merely collections of related symptoms?

## 1.2 Issues of definition

The term failure to thrive should refer, purely and simply, to the problem of failure to grow, in terms of weight gain, in accordance with expectations (Drotar, 1985). It is a physical sign, a presenting problem, and may have myriad causes. For the sake of clarity, and to minimise confusion with other related disorders such as psychosocial dwarfism (hereafter referred to as psychosocial short stature) the expression should be reserved for a description of the growth of infants under the age of 2 years.

Recent research (Karlberg, 1987; 1988) has broken down the normal linear growth curve mathematically, into three components: infancy, childhood and puberty. The infancy component of growth is largely responsive to nutritional control. It is only towards the end of the first year the influence of growth hormone becomes significant. Accordingly, failure to thrive, without an associated metabolic or endocrinological disorder, and with an onset during the first year of life, is likely to have a nutritional aetiology.

Children with severe failure to thrive, which has persisted for many months, may eventually show a slowing down in the rate of linear growth, in addition to their poor weight gain. The onset of stunting following infantile failure to thrive is largely determined by the chronicity of the problem (Costello, 1989). In general, the degree of stunting seen in association with failure to thrive that has no organic basis is relatively mild and is associated with near normal weight for height. Children who have persistently failed to thrive (in terms of poor weight gain) because of 'non-organic' reasons will usually be no shorter than 90% of the population mean height for age on standardised growth charts.

Heights less than 80-90% of expected mean height for age are usually due to organic pathology, such as isolated growth hormone deficiency according to epidemiological evidence (Voss et al, 1989).

If failure to thrive manifests in a failure to gain weight at a normal rate, what degree of growth failure should cause clinical concern? This is a contentious issue. First and foremost, the degree of impairment should be such that it is likely to have pathological significance (Porter and Skuse, 1991). If failure to thrive means failure to gain weight in line with expectations, those expectations need to be made explicit. For clinicians and researchers, reliance will be put on deviations from conventional growth standards. Unfortunately, in previous research next to no account has been taken of the deficiencies in those standards themselves, deficiencies which may well lead the unwary to make major errors in their attempts to ascribe pathological significance to individual growth curves.

The growth standards used in most research into failure to thrive in the United States are those of the National Center for Health Statistics (Hamill et al, 1977). Their shortcomings have been reviewed by Ryan and Martinez (1987). They include the fact that the data were collected over a wide time period between 1929 and 1975, the sample was virtually all white middle class, no exclusions were made of low birthweight infants and, perhaps most importantly, most subjects were bottle fed. Certain of these factors are more important than others. For example, the bias in ethnic origin may be mitigated by the observation that differences in growth between blacks and whites during infancy are believed to be very small (Wingero et al, 1971). However, there is substantial evidence that secular trends in feeding

practices mean that samples nowadays are likely to contain a higher proportion of breast fed infants than the cohorts which provided the growth standards, and exclusively breast fed infants have growth trajectories that differ significantly from those of formula fed infants. They tend to be substantially heavier than formula fed infants until the age of 3 months, but are relatively lighter from then on through the latter part of the first year (Cole et al, 1989; Hitchcock et al, 1985).

The growth standards used in the United Kingdom, which were prepared by Tanner (Tanner et al, 1966) do not fare any better by comparison; they are based on data collected between 1952 and 1954 on a sample of about 80 boys and 80 girls who were measured every 3 months, and who were also largely fed on infant formula rather than by breast. The actual positions of the percentile curves of the Tanner and NCHS standards are very similar during infancy and the early preschool period (Whitehead et al, 1989).

This matter has some practical significance for, if too liberal a definition of failure to thrive is taken in terms of growth, absurdly high proportions of children will be identified as cases. In the general population there is considerable centile crossing in the first year or two of life, in terms of both weight and length. Babies whose growth trajectories cross centile lines are usually normal, they are simply adopting their own genetically determined trajectory or 'finding their own line'. Evidence on this matter comes primarily from two sources (Smith et al, 1976; Berkey et al, 1983). The data from Smith et al (1976) are often misquoted (eg, Edwards et al, 1990). The sample comprised 90 middle class suburban families under private pediatric care. Individual growth curves were plotted from a retrospective

examination of clinic records. Birth length and six further measurements were used for the analysis, which concerned the following: firstly, infants who were at or below the 10th centile for length at birth and who either caught up to the 50th centile by two years or who stayed in the same growth 'channel'. Secondly, infants who were at or above the 90th centile at birth, who 'caught down' to the 50th centile by two years, or who remained in the same channel. Smith and his colleagues do not discuss infants whose growth fell from the 50th centile at birth to below the 25th centile by two years (the sort of picture to which we might ascribe the term 'failure to thrive') and they only discuss length change, not weight change. Berkey et al (1983) discuss reasons why it is not really appropriate to plot a preschool child's size at a particular age on conventional growth standards, and then to compare that percentile status (eg, 10th centile) with the percentile status (eg, 3rd centile) at a subsequent age, if one wishes to determine whether a particular growth trajectory is normal or abnormal. However, this is exactly what is done by most clinicians who are attempting to detect failure to thrive.

Healthy children frequently cross percentile lines, the amount of shifting depending on the age range under consideration, the child's sex, and whether the measurements are of length or weight. Accordingly, it has been argued that it is not good enough to consider individual patterns of development in relation to growth standards for a given population which were based upon cross-sectional data. Dynamic aspects of growth, such as individual growth patterns, or changes in growth rate as a response to some disorder or subsequent treatment, would probably be better evaluated on longitudinal standards (Tanner and Davies, 1985). Berkey and her colleagues aimed to illustrate the value of longitudinal growth standards by

estimating the probability that a child whose height or weight fell between two particular centile lines at one age (say, between the 10th and 25th centiles at 3 months) would fall between each pair of centile lines at subsequent ages (say, between the 3rd and 10th centiles at 12 months). They generated conditional growth standards from data obtained during a series of Longitudinal Studies of Child Health and Development. The sample comprised children born between 1929 and 1939, during a period of severe economic recession (Stuart and Reed, 1959); who were white, middle and lower social class.

They found (during the first two years after birth), firstly, a shift of two centiles towards the 50th centile was more likely than a shift of two centiles away from the 50th centile (regression to the mean); so, for example, no more than 1 in 2 infants whose weight was below the 3rd centile for weight at 3 months would still be below that centile at 6 months. This proportion fell to fewer than 1 in 3 by 12 months. One in 10 infants whose weight was between the 25th and 90th centiles at 3 months will have shifted two centiles downwards by 6 months, and 1 in 6 will have shifted this much by 12 months. Secondly, weight measurements shifted more than length measurements. Thirdly, by the age of 18 months to 2 years, the children appeared to be fairly well canalised and further centile shifts were uncommon. The rate of growth in weight and recumbent length during infancy is inversely related to birthweight (see Fergusson et al, 1980; Roche et al, 1989). These findings well illustrate the point that, simply to take, as a definition of failure to thrive, the criterion that there must have been (say) two major centile shifts in weight downwards over a specified period of time (eg, Dubowitz et al, 1989; Edwards et al, 1990; Newberger et al, 1986) is inadequate. Many normal infants who are relatively heavy at birth, or who were exclusively

breast fed in the first few months, show this pattern. Using a criterion for the diagnosis of a shift in weight trajectory through two major centile lines, persisting for at least a month since 4-8 weeks post-term, Wright et al (1991) found 34% of an epidemiological sample of 2393 Newcastle upon Tyne children were 'failing to thrive'.

It has often been suggested that the ideal criterion for a diagnosis of failure to thrive would be a velocity-based measure (eg, Kristiansson and Fallstrom, 1987). Unfortunately, velocity-based measures have two inherent disadvantages which make them an unattractive option in practical terms. Firstly, most physicians will be unfamiliar with velocity-based growth standards. They are awkward to compute and relatively difficult to plot. They would probably not be suitable for use in primary care settings (Sorva et al, 1990). Secondly, but more importantly, because of inevitable measurement error the confidence intervals around velocity-based measurements will be far greater than around weight or length-attained measures (see Voss et al, 1991). Furthermore, steady growth along a trajectory which is well outside the normal range may be associated with a velocity (i.e., rate of growth) which is well within it. For the clinical assessment of individual children velocity measures almost certainly cannot be made with sufficient precision and are not to be recommended other than for specialised pediatric and research undertakings.

Another proposal, which has gained currency recently, is that the really important distinguishing feature of failure to thrive is an abnormal weight for length ratio. (It is usual to refer to recumbent length in infants, as distinct from height. Babies are not measured standing up, and when they are old enough to be so measured, at two years or so, there are

significant discrepancies between length and height, the latter being a slightly lower value). Schmitt and Mauro (1989) defined failure to thrive as a weight centile that was significantly less than expected, given the child's length or height. Even weights below the third population centile, if not 20% or more below ideal weight for height, were considered to be acceptable. The authors go on to recommend that failure to thrive should not be diagnosed if height and weight are in line with one another, and the triceps skinfold thickness is normal.

Such advice ignores the well recognised phenomenon of stunting. When children are faced with chronic but moderate deficiencies in nutrients they will grow less in their height and weight but will strive to maintain normal proportions Alvear et al, 1986; Martorell 1985; Martorell and Habicht, 1986). This point is well illustrated in a study on the growth of Bedouin infants in the Negev desert (Dagan et al, 1983) where weights for length were around the 50th centile for the first eight months of life, and triceps skinfold thicknesses were above the 5th centile for 90% of the sample in the second half of the first year. Yet these infants suffered marked stunting, albeit in the presence of what was regarded as only mild to moderate malnutrition (see also Graham et al, 1977).

The defining symptom of failure to thrive should be based upon anthropometric criteria, and the criterion that is most appropriate in infancy is weight (Drotar, 1990). The longitudinal pattern of weight gain on weight-attained charts is probably good enough, although it is arguable that shifts in 'channels' on longitudinal charts would be a more sensitive measure of growth faltering (Berkey and Reed, 1987; Sorva et al, 1990). It is certainly not good enough to use weight for age at one point in time as the indicator; the inadequacies of weight for age



as markers of malnutrition are now well recognised (Waterlow et al, 1977). Specifically, a low weight-for-age may represent such fundamentally different situations as a low weight-for-height (wasting) or a low height- for-age (stunting), or a combination of both.

Should shifts in weight since birth be taken as the relevant criteria? Edwards et al (1990) have argued that it would be better to study trajectories from four to eight weeks post-term, in view of the fact that birthweight is influenced by variables such as maternal height, parity, history of tobacco and alcohol use. Accordingly, in the first few weeks after birth shifting of centiles - both upwards and downwards - are to be expected.

There is a strong argument for presenting research data on growth in terms of standard deviation scores, as was recommended many years ago by Waterlow et al (1977). A standard deviation (or Z) score of, for example, an infant's weight at a given age, expresses that weight relative to the population mean in the form of a normally distributed variable that has a mean of 0 and a standard deviation of 1. A standard deviation score (SDS) can be positive or negative depending on whether the weight is above or below the mean, and an infant growing along the 50th centile will, on a SDS graph, appear on the horizontal line corresponding to 0. The range of normal is conventionally set from -2 SDS to +2 SDS. The use of SDS is in line with the World Health Organization's recommendations on the measurement of nutritional status (WHO, 1983). Using this method it is possible, allowing for skewed data such as skinfold thicknesses, for growth to be presented in standard deviation scores across a whole range of anthropometric variables (Cole, 1988). Thereby just one graph can contain a set of standard deviation scores for multiple measurements, permitting all

the child's anthropometric data and all the factors affecting them (eg, illnesses, hospital admissions) to be viewed at once (Cole et al, 1989). The PCTL 9D anthropometry subroutine (Center for Disease Control, Atlanta, Georgia; (Goldsby, 1989) computes standard deviation scores for weight, length and weight for length automatically (see also Peterson et al, 1985). Standard deviation scores are used extensively for the analysis of growth data in this thesis.

Standardisation of birthweight should also be performed for both research and clinical purposes. Yet this procedure is practically never done in studies of failure to thrive. It can make a considerable difference to the significance one attributes to the postnatal weight gain trajectory, if it is viewed in contrast to a child's standardised birthweight, measured in terms of standard deviation scores (SDS). Many studies of failure to thrive have made exclusions on the basis of birthweight, in order to identify children with a prospectively poor rate of weight gain, using a cut-off of 2500gm. The reasoning behind the exclusion is that such a child may be born at, for example, the 3rd population centile for weight, and will grow normally along that centile postnatally. If the 3rd centile is taken as the cut-off for failure to thrive the child will be falsely classified as a 'case'.

Depending on the above maternal and child criteria a birthweight of 2500 gms may be equivalent to the 50th centile for a first born girl at 37 weeks gestation whose mother is just five foot tall. Alternatively, it could be grossly abnormal, well below the 3rd centile (i.e., less than approximately -2 SDS) for a boy at the same gestation who is second born and

whose mother is 5' 9" in height. Interpretations of the same growth trajectories of these children in the ensuing months would be very different.

#### 1.2.4 Validity of diagnostic criteria for failure to thrive

By what criteria should the validity of anthropometric characteristics of failure to thrive be judged? Certainly face validity is one. That is to say the degree of growth faltering should be such as to warrant clinical concern. Clinicians may disagree on this matter, but perhaps consensual agreement could be reached on the sort of weight or length gain trajectory that would warrant investigation and treatment. Optimism is not increased, though, by the findings of Wilcox et al (1989) that, in a series of textbooks and journal articles published on the subject in 1987, many different definitions based on various permutations of weight and height (length) were in use. Furthermore, nearly 1 in 3 publications proffered no definitions at all.

The second criterion is concurrent validity; that is to say, the extent to which infants identified as 'cases' on the basis of their anthropometry show behavioural, developmental and other characteristics which are not seen in normally growing children, who have been matched on relevant biological and social variables. This matter has barely been addressed systematically, with definitions varying so widely it is difficult to draw general conclusions.

The third criterion for the validity of anthropometric criteria should be that they have predictive validity. That is to say, infants identified as cases would have a reasonably predictable 'natural history' without intervention, in terms of their future growth, mental

development, behavioural and emotional adjustment. Once more the picture has been obfuscated by the overwhelming use of hospitalised samples, who have undergone a variety of immediate and subsequent interventions. However, some relevant data are available from a series of linked studies, based upon whole population surveys of economically disadvantaged inner-city children in London, England (see Skuse et al, 1992a). The second of these investigations comprises the content of this thesis.

### 1.3 Organic Versus Non-Organic Etiologies

The dichotomisation of failure to thrive into organic and non-organic subgroups is hard to justify, because there is often an interaction between 'organic' and 'non-organic' causes. For example, the infant with severe and persistent gastro-oesophageal reflux may refuse to eat because of the associated discomfort. Both 'non-organic' and many cases of 'organic' failure to thrive are usually due to inadequate nutrition (Frank and Zeisel, 1988). In some cases the causal relationship may be direct, as when excessive demands for energy outstrip supply because of physiological abnormalities, such as congenital heart disease (Menon and Poskitt, 1985). On the other hand, the causal relationship may be indirect. Children with minor organic disorders may also fail to thrive, not because of any direct effect upon metabolism, but because the child is thereby more difficult to feed. Such disorders may include oral-motor dysfunction (Mathisen et al, 1989).

As will be discussed in the body of the thesis a large proportion of otherwise healthy failing to thrive infants do have significant degrees of oral-motor dysfunction (Mathisen et al, 1989; Reilly et al 1995; Skuse et al 1995a). Consequently, their caretakers are likely to be faced

with a significant obstacle to ensuring the children ingest adequate nutrition for growth. Symptoms included hypotonic lips, incompetence removing food from a spoon, tongue thrust, or persistent tongue protrusion, and a weak or unsustained suck. Oral-motor difficulties have also been reported in association with this condition by Lewis (1982), Selley and Boxall (1986) and Lachenmeyer and Davidovicz (1987).

Another organic condition associated with feeding disorders and failure to thrive is that of cerebral palsy. Although it has been known for many years that infants and young children with this condition have poor growth, all too often the failure to thrive has been ascribed to underlying neurological deficits rather than to chronic malnutrition (Boyle, 1991). Such children have difficulty achieving a nutritional intake sufficient to sustain a normal rate of growth for a variety of reasons that may well have relevance to the etiology of failure to thrive in children with no overt organic disease or disorder. They include communication difficulties that inhibit or distort requests for food, impaired expression of hunger or food preferences, a lack of self-feeding skills, an inability to forage, and severe degrees of oral motor dysfunction.

Gastro-esophageal reflux has been estimated to occur in up to 75% of cerebral palsy subjects (Rempel et al, 1988). In a recent survey of domestic mealtime routines we found a sample of preschool children with cerebral palsy and known oral-motor dysfunction had very severe feeding difficulties, which were for the most part unknown to their medical advisers (Reilly and Skuse; 1992). There was substantial evidence for gross malnourishment in most cases, associated with parental psychopathology which seemed to be contingent upon the stress and

strain of managing the children's feeding behaviour. Growth trajectories showed a dire picture with severe failure to thrive in the first few months of life. At the time when demands for nutrition for physical growth were exceptionally high, ensuring an adequate intake was impossible for most caregivers.

Goldson (1976) has noted a variety of minor neurological abnormalities associated with failure to thrive, in children who had no known neurological disease. Hypotonia is an especially common physical sign in very young infants with the condition; to what extent it can be attributed to abnormalities in the mother-child relationship is debatable (Buda et al, 1972).

Gastro-esophageal reflux may be relatively common in otherwise healthy children (Bray et al, 1977). It is sometimes associated with torsion spasm and characteristic abnormal postures, giving rise to the Sandifer syndrome, which is allegedly frequently overlooked (Nanayakkara and Paton, 1985; Werlin et al, 1980). It is important to bear in mind that recent research has shown gastro-esophageal reflux of clinical significance may not be associated with obvious regurgitation or vomiting, necessitating careful evaluation of suspected cases with imaging techniques and pH studies (Paton et al, 1988).

There is also risk that children with *early* severe growth faltering may suffer detriment to their neurological development. Studies of children who have been hospitalised with failure to thrive are reported to show a wide range of 'neurodevelopmental deficits', including low scores on standardised developmental assessments (Ramey et al, 1975; Field, 1984; Singer

and Fagan, 1984; Leonard et al, 1966). However, the relationship between *early* growth faltering and persistent development impairment is complicated by the fact that nutritional deprivation is usually accompanied by other forms of socioeconomic deprivation (eg, Casey et al, 1984) which can independently influence attainments.

Frank (1985) discussed the possibility that early malnutrition during a critical period of brain growth (Dobbing, 1990) may produce structural deficits which have functional consequences. There is evidence from studies in animals that the cerebellum, which contains large populations of microneurons, might be especially vulnerable to early undernutrition (eg, Rodier, 1980). However, it is difficult to distinguish cause and effect here. Children born with subtle neurodevelopmental problems may themselves be at risk of undernourishment (for example, because of poor oral-motor skills; see Mathisen et al, 1989), and consequently of a suboptimal rate of growth. Subsequently, persistent malnutrition could of course independently contribute to neurodevelopmental disorders (see for example, Reyes et al, 1990).

For the purpose of this thesis a distinction will be drawn between 'organic' and 'non-organic' failure to thrive for heuristic purposes. The distinction will be based upon clinical judgement about whether the organic dysfunction could be a sufficient independent cause of the growth disorder, and whether it directly influences growth in terms of weight gain. For example, malabsorption syndromes, cystic fibrosis and metabolic diseases would all be regarded as 'organic' causes of failure to thrive. On the other hand, covert oral-motor dysfunction, or

gastro-oesophageal reflux, would be regarded as correlates of failure to thrive which indirectly contribute to any associated growth disorder.

#### 1.2.5 Other medical conditions associated with failure to thrive

Within the past few years some studies have shed light on the sorts of organic disease and disorders that are most commonly recorded as being of aetiological importance in failure to thrive. Most have considered only hospitalised samples. Among children admitted to hospital for investigations, the diagnostic yield of those investigations is likely to be a little higher than it would be in a community survey (Berwick et al, 1982). That a majority of hospitalised children have no simple organic etiology of their failure to thrive was reported some years ago by Homer and Ludwig (1981). A similar picture is seen when outpatient attenders are investigated (eg, Bithoney and Rathbun, 1983). Powell et al (1987) conducted a one year study at a medical center in Texas of 34 cases of failure to thrive for whom detailed records were available. Organic factors were believed to account for 50% of cases, in the sense that they directly contributed to the growth problem. The most common diagnoses were cystic fibrosis, chronic renal disease, milk allergy and cerebral palsy.

The phenomenon of sleep apnea, leading to failure to thrive in infants and young children with tonsillar and adenoidal enlargement has been the subject of a number of recent reports (Everett et al, 1987; Hodges and Wailoo, 1987; Schiffman et al, 1985; Shaw et al, 1987).

This condition may be more common than is currently acknowledged but often goes unrecognised for years. Characteristics at clinical presentation include, most often, a history of restless sleep associated with loud snoring. Diagnosis on the basis of the history is possible, but ideally the child's sleep and respiration should be monitored. In all cases the



disorder is easily rectified by adenotonsillectomy, following which rapid catch-up growth occurs. The mechanism by which intermittent hypoxia during sleep leads to failure to thrive has not yet been identified.

A further example of the blurring between the conditions of 'organic' and non-organic failure to thrive is given by the sequelae of artificial feeding. Physical interventions with nutritionally compromised children, such as the insertion of a nasogastric tube, parenteral feeding or the creation of a gastrostomy, can impede the acquisition of normal feeding skills and motivation to the point that intensive behavioural interventions are needed to overcome their resistance (see Blackman et al, 1987; Geertsma et al, 1985; Handen et al, 1986). Surprisingly little has been written on the subject of restoring oral feeds to children who have required prolonged supplementary feeds, or hyperalimentation.

#### 1.2.6 'Behavioural' distinctions between 'organic and 'nonorganic' failure to thrive.

From the foregoing discussion it should be clear that so-called organic factors are often of relevance in the etiology and persistence of apparent 'non-organic' failure to thrive, and conversely individual and environmental influences play a large part in producing many cases of 'organic' failure to thrive. Despite this overlap, there have been many attempts to try and differentiate 'organic' failure to thrive from 'non-organic' failure to thrive on the basis of affected infants' behavioural abnormalities.

For example, a study by Powell et al (1987) followed on from their earlier work (Powell and Low, 1983) and that reported by Rosenn et al (1980). In many ways the Powell et al (1987)

investigation exemplifies the muddled thinking that bedevils so much research into this subject, lack of replicability of research findings being the inevitable consequence. A hospitalised sample of infants was recruited, with either organic or non-organic failure to thrive; the mean age of the 'non-organic' failure to thrive group was 6.3 months and that of the 'organic' failure to thrive group 10.1 months. The aim was to investigate quite subtle features of behaviour that could be categorised as either 'spontaneous' or 'interactive'. Ratings were not done blind to the diagnosis of failure to thrive, no anthropometric criteria for the diagnosis were given, and inter-rater reliabilities were checked on case subjects only; these reached a barely acceptable level of agreement. Behaviours were rated during the first day of hospital admission for the case group. A comparison group was chosen from healthy attenders at a child welfare facility; their mean age was 11.4 months. A handful of behaviours differentiated the 'non-organic' failure to thrive from the 'organic' failure to thrive infants, including lack of motor activity in response to a stimulus, lack of smiling, general inactivity and gaze abnormality. Without knowing whether behavioural signs had influenced the admitting doctor's decision to bring the child into hospital we cannot tell whether these features are of any significance at all for differentiating 'non-organic' failure to thrive from 'organic' failure to thrive. The comparison group was selected by nurses on the basis of appropriate age but it is not clear where they were assessed. The comparisons could be distinguished from the 'organic' failure to thrive group because they showed more facial expression, motor activity, and appropriate gaze.

The distinction between 'organic' failure to thrive and controls could be accounted for by the impact of hospitalisation and the distinction in behaviour between 'organic' failure to thrive

and 'non-organic' failure to thrive children by a whole range of factors, including the hospital's admission policy, the age differences between the groups and even the possibility that, if the 'non-organic' failure to thrive group was more marasmic, their behavioural abnormalities might reflect 'reductive adaptation' in energy expenditure (Chavez and Martinez, 1979).

In summary, it is unlikely that any classification system could distinguish satisfactorily between organic and non-organic failures to thrive. There will be a considerable overlap between the two conditions although at the extremes there will be cases in which organic factors are by far and away the predominant ones and, at the other extreme, in which they could have practically no relevance. Woolston (1985) has proposed a scoring system for the degree of 'organicity' to take account of this overlap, and that seems a sensible suggestion. However, it is debatable whether the five points of 'physical illness' he proposes should be regarded as a scale of organicity (eg, Polan et al, 1991) or simply as a series of categories.

#### 1.4 Hospital Versus Community Perspectives

##### 1.4.1 Hospital-based studies

Viewed from the perspective of a hospital pediatric department failure to thrive may appear a rather different condition to that which is found in the community at large (O'Callaghan and Hull, 1978). Incidentally, virtually no attempt has been made to replicate Berwick's (1980) oft-cited figure of failure to thrive accounting for between 3-5% of admissions to academic pediatric hospitals. Powell et al (1987) found 2% of admissions to the medical services of a child health center at the University of Texas, Galveston, were for failure to thrive of which

two out of three cases were between 6- 24 months of age. Harris et al (1986) reported from a regional hospital in rural Australia (where most of the patients were Aboriginal), that 17.2% of admissions in the course of a year were for failure to thrive as either a primary or secondary diagnosis, and of these 21% had no definite medical basis. The remainder had a variety of diarrheal (52%) or chest diseases (20%), urinary tract infections (14%) and malnutrition (21%).

Singer (1986; 1987) reviewed a sample of infants from socioeconomically disadvantaged backgrounds who were hospitalised for extended periods in the first year of life, primarily for social reasons. They were on average just over 5 months of age on admission, and they spent between one and twelve months as inpatients. Although there was encouraging catch-up growth over this period, mean mental development scores measured at a 3 year follow-up were unchanged. This was an exceptional sample, as evidenced by the fact that, by follow-up, 42% had been removed from parental custody. Fryer (1988) conducted a meta-analysis of hospitalised samples in order to see whether there was any evidence of benefit in terms of growth and psychosocial development. Eight studies were reviewed (Haynes et al, 1984; Singer and Fagan, 1984; Field, 1984; van der Westhuysen et al, 1975; Hufton and Oates, 1977; Shaheen et al, 1968; Elmer et al, 1969; Bullard et al, 1967). He comments that there were many methodological deficiencies in those studies which had addressed this issue; a very high proportion of investigations upon which the meta- analysis could have been based were simply so flawed that they did not meet his basic requirements. Most of the studies reviewed were retrospective, and they provided relatively little detail

about the attributes of their subjects, about the profile of services provided both during and after hospitalisation, and few details of outcome.

None of the research reviewed had incorporated control groups that had obtained no intervention, although he acknowledges that such a design would probably have been ethically insupportable. Where the children were followed up some time after they had been discharged from hospital, very little if anything was said about the nature and extent of services provided to them during that period. Length of hospital stay varied between five and sixty days. He also remarked that most studies made an unreasonable and almost certainly insupportable distinction between non-organic failure to thrive and those whose growth disorder was due primarily to physical causes, and commented that it was unreasonable to treat 'non-organic' failure to thrive children as a homogeneous group.

Even though the proportion of cases of failure to thrive admitted to hospital is a biased sample of those living in the community at large the majority are likely to turn out to have no serious organic disease or disorder sufficient to account for their condition. If a major organic disorder is not apparent at the time of the initial examination it is unlikely that further intensive investigation is going to shed much light on the matter. The study usually quoted in support of this conclusion is by Berwick et al (1982) who extracted information from case records of all infants aged between 1 and 25 months for whom the diagnosis of failure to thrive had been noted at admission to or discharge from a pediatric teaching hospital during a two-year period. Cases with obvious organic disease were excluded. Barely one child in three received a physical diagnosis after the hospital evaluation, and two-thirds of those were

thought to have functional gastro-intestinal disturbances, mainly gastro- esophageal reflux or diarrhea. Of all the laboratory investigations performed, fewer than 1% showed abnormalities that could help explain the cause of the failure to thrive, results very similar to those formerly reported by Sills (1978), but they have not been replicated in recent years.

#### 1.4.2 Epidemiological studies

In contrast, epidemiological studies show a somewhat different picture. Until recently there had been virtually no community surveys on failure to thrive. That conducted by Mitchell and her colleagues (1980) is the most frequently cited, but it suffers from a number of major deficiencies. Firstly, the diagnosis of failure to thrive was made retrospectively. All records for 312 two to five year olds registered with three rural primary care centers were reviewed and cases of former failure to thrive (i.e., before 24 months of age) were identified according to clear criteria. Thirty (9.6%) were found to have had failure to thrive of whom 23% had had an obvious organic disease. The remainder of cooperating 'non-organic' failure to thrive subjects (19) were matched to a comparison group of equal size and follow-up assessments were made at 3-6 years by a researcher who was aware of the children's growth status, but only 12 cases and 16 controls underwent a complete examination. No clear evidence of occult organic disease causing FTT, which had been missed at the time of the original investigation, was discovered at follow-up. The proportion of this largely black population living in the rural area who were enrolled with the clinics in question is not discussed, and the generalisability of the findings is therefore questionable.

Batchelor and Kerslake (1990) screened a population of 2000 children in the South-West of England in order to identify cases of failure to thrive, on the basis of health clinic records upon which routine weighings were entered. They gained the impression that many cases had gone unrecognised. About half of the subjects they identified from those records had been referred for pediatric examination, but only 1 in 10 had actually been admitted to hospital. About 1 in 3 children with a severe growth problem had not been identified by the primary health care team. Prevalence in the under five population was 1.3%; the proportion of known organic problems (28%) was relatively high, probably because of the method of ascertainment.

### 1.5 Failure To Thrive And Child Abuse

The contrast between hospital-based and community-based perspectives on failure to thrive also points up considerable differences in the extent to which overt abuse and neglect are associated with the conditions, depending upon one's point of view. The earliest reports of 'non-organic' failure to thrive reflected a supposition that the condition resulted from emotional deprivation. Consequently, terms such as 'hospitalism' (Spitz, 1945) and 'maternal deprivation syndrome' (Patton and Gardner, 1963) were employed as synonyms. More recently, the trend has been continued, with the emphasis on attachment difficulties (eg, Benoit et al, 1989; Brinich et al, 1989; Derivan, 1982). Whilst many developmental difficulties and delays may result from an upbringing in severely depriving and deleterious circumstances (eg, Skuse, 1992) it is fallacious to conclude that children who are so delayed, in one aspect or another, must therefore have been subject to comparable adversity. Accordingly, the importance of 'non-organic' failure to thrive as a manifestation of abusive

and neglectful childrearing practices demands a radical reconsideration. Most reports on this matter have considered unrepresentative samples of patients, children being more likely to be referred for pediatric investigations if they were subjects of concern for other reasons as well; for example, poverty, inadequate housing, neglect of hygiene, and suspected non-accidental injuries. Such reports have also drawn exaggerated and logically insupportable generalisations from their findings.

Evidence on the relationship between abuse and failure to thrive falls into three broad categories. Firstly, there are numerous reports of children who were referred for medical attention because they had apparently suffered physical abuse or neglect and were found coincidentally to be seriously underweight for their age (eg, Claussen and Crittenden, 1991).

Secondly, there are other reports on the heightened risk of abuse at some future date among children who were known to be failing to thrive. Evidence on this matter comes almost exclusively from small scale follow-up studies of formerly failing to thrive children (eg, Goldson et al, 1989; Oates and Hufton, 1977). Thirdly, there are a few studies that have attempted to show that the same risk factors, which can be found associated with a variety of abusive parenting practices, are also relevant to failure to thrive. Such risks include child characteristics, such as temperament (Altemeier et al, 1985) and low birthweight (Hergenraeder et al, 1985); mother characteristics, such as social support (Benoit et al, 1989) and mental state (eg, Polan et al, 1988; Woolston, 1983); family characteristics such as lack of cohesion and conflict (eg, Drotar and Eckerle, 1989) and quality of housing and related factors (eg, Dubowitz et al, 1989; Newberger et al, 1986).



A study to test the hypothesis that failure to thrive should be considered in the context of an 'ecological model', which takes into account a wide range of familial and social variables, was undertaken by Newberger et al (1986). The aim was to understand the process by which children might be at increased risk of physical injury or failure to thrive, and data were gathered by interview from a large sample of mothers (209) of children who had been victims of abuse or neglect (broadly defined), or had suffered accidental injuries or ingestions, or who had failed to thrive. A hospitalised comparison group was matched on a pairwise basis. Forty-one failing to thrive subjects were identified; the criteria for the diagnosis are not given in this article although they are reported in a later re-analysis of the same data (Dubowitz et al, 1989).

A number of variables were found significantly to discriminate between the cases and controls, within the 'non-organic' failure to thrive group, although how meaningful their presence was is debatable. They included 'unhealthy', 'reactive to visual and auditory change', and 'mother sees relatives less often per week'. A total of 262 questions on suspected risk factors had been asked of the mothers. Subsequently, a discriminant function analysis permitted the correct classification of 80% of the 'non-organic' failure to thrive group into their appropriate categories (case/control), although of course such an analysis gives no indication of how distinctive such cases would be within a general population sample. A total of 34 variables seem to have been entered into the discriminant function analysis for those 82 children. Further attempts to construct a hierarchical cluster analysis that could reliably distinguish, on the basis of 63 variables, clusters of subjects who were at high and low risk of abuse, within the study population as a whole, were only moderately

successful. Only just over half the 'non-organic' failure to thrive cases were identified as being within 'at risk' clusters, and there was virtually no evidence that the families of failing to thrive infants were similar to those of the 'abused' infants.

However, in a later publication Dubowitz et al (1989) came to almost a diametrically opposed conclusion on the same data set. The former broad diagnosis of 'abuse' was tightened up, and from that large sample a small group of physically abused children was chosen (n=25). These were then compared, by a variety of statistical techniques including logistic regression, after data reduction exercises had been undertaken in order to limit the large number of variables. A number of significant differences were found in respect of demographic attributes, the physically abused sample being in general worse off socioeconomically than their 'non-organic' failure to thrive counterparts and in less stable relationships. Few of the many variables on which the groups were compared distinguished them, but the authors' conclusion that this implies similar risk factors underlay the two conditions should be treated with caution. No non-abused comparison group was used in this analysis and in terms of mother's descriptions of their own childhood, relationships and social supports, their satisfaction with their current living situations, attitudes toward their child and description of the child's characteristics there was next to no evidence of maladjustment. To conclude, as they do, that the study has 'important implications for social policy' is not justified by their findings. Certainly, the physically abused children did come from poorer, more overcrowded homes. There is indeed a significant association between socioeconomic status and maltreatment; abuse does come to the attention of the authorities more frequently among lower status families. However, the aetiologic processes that might

explain that higher rates are exceedingly complex and ill-understood (see Skuse and Bentovim, 1994). In view of these conclusions it would be probably be unwise to equate failure to thrive with maltreatment (Giovannoni, 1989). The conclusion of Koel (1969), that failure to thrive and fatal injury are on a single continuum has not been supported by any trial to date with adequate external validity.

## 1.6 Social Factors

For many years it has been assumed that poverty is one of the most important risk factors for failure to thrive, because of the close association that exists between poverty and malnutrition (see Frank and Zeisel, 1988). The assertion that, although failure to thrive may occur in all social classes, most clinical cases come from low income families is undoubtedly true but, until representative samples of cases identified from epidemiological surveys of socioeconomically diverse populations are available, it is not possible to say categorically that the condition occurs in the community primarily among the most disadvantaged sections of society.

Furthermore, it begs a number of questions to assert that there is any simple causal relationship between poverty per se and failure to thrive within the developed world. Firstly, within socioeconomically disadvantaged communities some families will have children who fail to thrive and others will not, despite the fact that their levels of disposable income are similar. Secondly, within case families not all children will be affected. If poverty were playing a major role one might expect there to be a tendency for the prevalence of failure to

thrive to rise with the children's ordinal position, the lowest prevalence being associated with first borns and the highest among, say, third or fourth born children.

The only epidemiological survey to examine this matter systematically (Skuse et al: 1994a;1994b) found no evidence for such a tendency. These data are discussed in detail in the body of the thesis. In ethnically diverse populations there may be a tendency for an interaction between sex and cultural affiliation. For example, certain Asian communities value their female infants less than male infants (Joshi et al, 1987; Luwang, 1980) and the evidence points to a considerably higher rate of failure to thrive among girls than boys in those circumstances (Skuse et al 1994c).

Evidence exists to suggest that about 20% of families living within an endemically impoverished inner city area will have at least one child who fails to thrive. In those families containing at least one case child about half will have siblings who have also been affected (para 5.9.5). Why it is that a minority of children in at-risk families fail to thrive is a question that has barely been addressed in the literature on this subject.

There is good evidence from research in the UK that the condition of failure to thrive is not confined to socioeconomically disadvantaged inner city communities. On the contrary, a recent study in the North-East of England found the prevalence to be nearly as high within a relatively affluent city suburb. Wright and Waterston (1991) compared the growth rates of children from different neighbourhoods in Newcastle upon Tyne, which they classified as predominantly affluent (11%), average (49%), deprived (22%), and very deprived (19%) on

the basis of standardised deprivation indices (Townsend et al, 1986). Their survey was of 3653 children aged 18-30 months. Weights were collected on 90% of the population and failure to thrive was defined on the basis of a 1.25 SDS fall in weight for age on internal standards subsequent to the position at 6-8 weeks post-term. Children from deprived and very deprived areas were smaller at all ages than children from more prosperous areas, and were more likely to have been born prematurely, yet, it was only children in the most deprived areas who showed higher levels of failure to thrive than within the average socioeconomic stratum. Remarkably, children from the relatively affluent areas of the city showed unexpectedly high rates and this was true even if the criteria of case definition were modified. The proportion of failing to thrive infants was 7.5% from the most deprived areas, 3.8% in the relatively deprived areas, 4.9% in the average population, and 8.2% among those from the most affluent suburbs.

## 1.7 Conclusions

Failure to thrive of infancy is a physical sign, which may in certain circumstances indicate a disorder of pathological significance with concurrent and predictive validity. The etiology of the condition is virtually always insufficient nutrition for metabolic needs, a statement as true for so-called 'organic' failure to thrive as it is for 'nonorganic' failure to thrive. In the majority of cases the subtle interplay between physical, physiological and psychological disorders is such that no clear distinction between 'non-organic' failure to thrive and 'organic' failure to thrive can be made, consequently attempts to define 'non-organic' failure to thrive on the basis of behavioural characteristics are ill-advised, and unlikely to be replicable. For the same reason it is inappropriate to classify 'non-organic' failure to thrive

as a manifestation of a Reactive Attachment Disorder (DSM-III-R; American Psychiatric Association, 1987).

Failure to thrive as a sign of disorder should be clearly distinguished from failure to thrive as a syndrome. Before we can even begin to consider the necessary and sufficient criteria for a syndromic classification agreement has to be reached on what degree of growth faltering is really significant. The answer to this question must come from epidemiological rather than clinic - or hospital referred samples. Evidence is presented in this thesis to show that the pattern of early growth may in itself be of importance for cognitive and possibly behavioural outcome (Skuse et al; 1994a, 1994b). Infants whose faltering growth commences immediately after birth may represent a distinct subtype with a poorer prognosis, independent of the duration of their growth failure. The investigation presented here was designed and built on the conclusion from a review of the preexisting literature that better longitudinal measures, and more ecologically valid samples were needed. It attempted to address the perceived deficiencies in previous studies, both in terms of the external validity of the way in which cases were to be ascertained, but also in terms of the range of measures used and the limited age range of the infants to be studied. Finally, measures were to be taken in the homes of subjects, and those of a closely matched group of comparisons, rather than in a hospital setting, in order to increase the ecological validity of the findings.

## **PART TWO**

# **POSTNATAL GROWTH AND MENTAL DEVELOPMENT:**

## **EVIDENCE FOR A SENSITIVE PERIOD**

## **CHAPTER 2. Postnatal Growth and Mental Development**

### **2.1 Introduction**

In the past few years increased attention has been given to characteristics of prenatal and early postnatal growth which may be linked to adult pathology, including hypertension (Barker et al, 1990), ischaemic heart disease (Barker et al, 1989) and other physiological measures (Barker et al, 1992). It has been hypothesised that certain processes linked to growth, acting during prenatal or early postnatal life, strongly influence the risk of such disorders. This may be because the environment in some way 'programs' the organism during a sensitive early stage in development (Barker, 1991). Other studies have found that impaired growth during the nutrition-dependent infantile phase (Tse et al, 1989) may cause later stunting (Costello, 1989) and that body size in the first postnatal year is associated with the timing of puberty in boys (Mills et al, 1986). A link between the composition of milk feeds and the subsequent developmental status of preterm babies also seems to reflect a sensitive postnatal period (Lucas et al, 1990; Lucas et al, 1992), during which relatively subtle dietary manipulations over a brief period of time have long-lasting consequences.

This study was based upon the premise that there is a sensitive period for development which persists for a short period after birth, during which the brain is especially vulnerable to adversity which influences somatic growth. There is ample evidence that children in the developing world who are stunted, on account of chronic undernutrition and related adversities, have impaired mental abilities. This evidence has accumulated over many years (eg, Hertzog et al, 1972; Galler, 1987). Now, it has long been supposed that the developing



brain is especially vulnerable, during early postnatal life, at a time when a growth spurt is taking place (Dobbing and Smart, 1974). This includes glial cell multiplication, the development of dendritic trees, and the establishment of synaptic connectivity. Consequently, developmental undernutrition during early postnatal life may have greater consequences than were it to occur later. Dobbing (1990) has emphasised the importance of taking into account the duration, severity and above all the timing of any such insult when making extrapolation about the likely impact upon development.

There are substantial regional differences in the timing of the growth spurts described in brain development. For example, glial cell multiplication, that begins about mid-gestation, continues well into the second postnatal year (Dobbing and Sands, 1973; 1979). Also the dendritic trees of the rather primitive neurons grow over the first 2 years or so to accomplish their extraordinarily complex branching (Dobbing, 1981). Concurrently, synaptic connectivity is established. It is important to remember that the effects of detrimental conditions upon the developing central nervous system will be different at different times of development, and that they will have their maximal effect upon those processes that are most active at the time of the adversity. The cerebellum, and in particular the neocerebellum, has its maximum growth spurt just at the time of birth and in the first year of life (Smart, 1991).

Myelination of nervous system pathways takes place largely postnatally (Casaer, 1993). For example, vestibular and spinal tracts, related to basic postural control, are myelinated at 40 weeks. Mid-brain cortical visual pathways are myelinated at 2-3 months of age, and descending lateral cortical spinal tracts are available at the end of the first postnatal year, when fine motor control appears (Casaer and Lagae, 1991).

Because of the difficulty studying such processes in children, most investigations which have been done into this subject have for obvious reasons not been done on humans but on laboratory animals, especially rats. Poor rates of postnatal growth have been induced by dietary manipulation during the suckling period of those rat pups (eg, Widdowson and McCande, 1960). In these circumstances early postnatal growth retardation, encompassing the suckling period, can lead to permanent restriction on the growth attainment of the whole body and to some extent this is also true for the brain itself (eg, Bedi et al, 1980a; b). However, the functional significance of these changes is by no means clear cut, even in the laboratory animal. There are many potentially confounding variables which could account for the undoubted behavioural differences observed in formerly malnourished animals (eg, Katz, 1982; Rogers et al, 1985; Smart, 1987).

Accordingly, it would seem that nutritional restriction during a critical period in the growth of rat pups can have long term consequences for somatic and brain growth. This is difficult to prove for human infants. Rat pups are born at a far earlier stage of development than primates, at an age roughly corresponding to 16 postnatal weeks in man (Tanner, 1989). Testing whether there would be an equivalent resetting downwards of the body's growth trajectory in humans would require growth restriction for most of the period from 30 weeks gestation until about the second birthday. By the same analogy, restriction for short times within this period should be recoverable, as would restriction after the age of two provided it was not too severe. As in other matters in developmental undernutrition, three factors: the

duration, severity and above all timing of growth faltering need to be taken into account in any extrapolation to the human infant (Dobbing, 1990).

That a relationship exists between somatic growth failure in early childhood and impaired mental development has been recognised for many years (eg, Stoch and Smythe, 1963; 1967) (but see commentary by Scrimshaw and Gordon, 1968; Richardson, 1976; Barrett and Frank, 1987; Cabak and Najdanovic, 1965; Lloyd-Still, 1976; Galler et al, 1983; Brockman and Ricciuti, 1971; Cravioto and Delicardie, 1972; Pollitt and Granoff, 1967).

Assessment of the effects of malnutrition on the development of the nervous system of children is complicated by at least three main difficulties (Jacobson, 1991). First, the effects of malnutrition cannot be entirely separated from the effects of other harmful conditions, such as maternal neglect, environmental impoverishment, and lack of stimulation and incentive. Secondly, malnourished children often show behavioural abnormalities which are variable and difficult to measure accurately, such as reduced social responsiveness, increased irritability and emotional disturbances. It has been suggested that motivational changes associated with undernutrition may influence test performance in experimental animals, independent of cognitive impairments arising from neural deficits or altered patterns of maternal and environmental stimulation (Cmic, 1976). Alternatively, learning may be reduced as a consequence of the effects of earlier undernutrition, but increased motivation can compensate for the deficit in certain circumstances (eg Katz et al, 1979).

The relevance of motivation to the cognitive and psychomotor performance of human infants has also attracted attention (eg, Yarrow and Messer, 1983; Morgan and Harmon, 1984). The dimensions of mastery-motivation have recently been summarised by Redding, Morgan and Harmon (1988; 1990). They include task pleasure (positive affects such as smiling, contiguous with task-directed behaviour) and task persistence, both of which were found to be relatively independent of task difficulty. Temperamental and motivational factors may play a role in the relation between early and later IQ (eg, Bornstein and Sigman, 1986; Rose et al, 1991). For example, Benson et al (1993) found that the child's Task Orientation, measured on a modified version of the Bayley Infant Behaviour Record, was a strong predictor of parental IQ.

Thirdly, the effects of malnutrition on the human brain can rarely be assessed directly by postmortem physical and chemical measurements. Instead, less reliable indices, such as physical status, ratio of height to weight, head circumference, and IQ, are generally used. These indices are themselves complex variables, and their interpretation can be difficult and frequently ends in controversy (Dobbing, 1987). In older children, who have been chronically malnourished, it is often difficult, if not impossible, to determine whether any reduction in IQ, over what would have been expected if there had been no such adversity, is the result of retarded brain development due to malnourishment and associated conditions such as disease, or whether the poor performance is largely or entirely due to social and economic disadvantages. This is a particularly acute problem when the research is being conducted in a developing country, and the deficits in question are being examined many years after the most severe period of malnutrition (which was very often during infancy,

cases having been identified retrospectively through hospital records). There will be many intervening variables such as socioeconomic status during the follow-up period which could be salient to the outcome but which were not measured, and which may not be stable over long periods of time (see Smart, 1987 p192).

## 2.2 Rationale for Study

The main aim of the present study was to test hypotheses on the relationship between postnatal growth and outcome in terms of mental and psychomotor development, in a sample of failing to thrive infants who had no organic disease or disorder that could directly account for their growth faltering.

As virtually all previous investigations of this common condition had been based upon hospitalised children there was a need to test those hypotheses on a representative sample, derived from a community base.

## 2.3 General Hypothesis

This investigation aimed to test the general hypothesis that there would be an association between failure to thrive in the first postnatal year and detriment to mental and psychomotor development, in full-term infants from a socioeconomically disadvantaged inner-city area. The rationale for the investigation was a finding from an earlier survey that persistent failure to thrive, from infancy to 4 years of age, was associated with a substantial decrement in cognitive abilities which was not clearly attributable to any other explanation (Dowdney et al, 1987).

We hypothesised on the basis of our earlier findings that, if clinically significant growth faltering does independently lead to impaired mental development, it should be possible to detect an effect earlier in the child's life than 4 years, before the potentially confounding influence of a relatively depriving environment makes a major additional contribution to any 'cumulative deficit' in mental abilities (Ramey et al, 1975; Skuse, 1987). Accordingly, we aimed to replicate the design of the earlier investigation, in the same geographical area, but on this occasion to measure outcome at the commencement of the second postnatal year.

## 2.4 Specific Hypotheses

### 2.4.1 Family Factors

#### 2.4.1.1 *Socioeconomic Status*

That the growth of inner-city infants and children is impaired where it is associated with socioeconomic disadvantage is a well recognised phenomenon (Skuse, 1989). Poverty has been described as an important risk factor for failure to thrive because of the close association between poverty and childhood malnutrition (Frank and Zeisel, 1988). Nutritional deprivation linked to poverty has been described both among children whose parents are welfare dependent and those whose parents are unemployed or whose income is near the poverty line at which income supplements are necessary (Chase and Martin, 1970).

It is less clear what mechanisms account for the observed association between impaired growth and deprivation in a population, for not all families in poverty have children whose growth is adversely affected. Parkin (1989) in a review of the epidemiology of growth failure in a deprived community asked "How important are social variables compared with

biological variables in influencing growth outcome? What is the nature of the environmental defect, related to social class, that leads to growth failure? How does it operate?".

We hypothesised that a significant proportion of infants in a socioeconomically disadvantaged inner-city community would fail to thrive. The main purpose of collecting extensive data on socioeconomic status was for the matching of a comparison group who were growing normally. By such means it was hypothesised that mechanisms linking deprivation to growth outcome would be more clearly identified, independent of the potentially confounding effect of poverty. In so doing we were cognizant of the fact that it would therefore not be possible to examine the impact of poverty as such on the prevalence of failure to thrive. In other words, because the comparison group was chosen to match the case families on socioeconomic variables they may consequently not have been representative of all families living in the survey area in socioeconomic terms. We were unable to obtain detailed data on the socioeconomic status of the entire survey population, although some summary information was available to us.

#### *2.4.1.2 Family Composition*

#### *2.4.1.3 Family Size*

#### *2.4.1.4 Ethnic Composition*

These variables were matched between the case and the comparison groups. It was nevertheless possible to discover whether the comparison children were representative of those in the community as a whole in terms of these variables, because they were recorded for all births.

We hypothesised that the cases and the comparisons would be representative of the population from which they were drawn in terms of ordinal position within the family. Differences between the ethnic groups surveyed in the prevalence of failure to thrive were anticipated

#### **2.4.1.5      *Marital Relationship***

The role of possible disharmony in the intimate relationships of the mothers we surveyed may have contributed to parenting difficulties but this hypothesis has been little explored to date in relation to failure to thrive. However, there have been many reports that indicate a mothers' personal relationship difficulties may contribute to her infant's failure to thrive (e.g. Elmer, 1960). It has also been argued that the quality of a father's relationship with his spouse and his family may have an important influence upon the longer term mental health outcome of failing to thrive children (eg, Drotar, 1985).

We hypothesised that personal relationship difficulties would be significantly more common among mothers of failing to thrive infants than among the comparison mothers.

#### **2.4.2      *Anthropometry***

##### **2.4.2.1      *Parental Anthropometry***

Our earlier survey (in the same geographical area) of persistently failing to thrive children found the parents of case children were of low average stature (Dowdney et al, 1987). Other research has shown that individuals in the developing world who are stunted still have the genetic potential to produce offspring of greater stature than themselves, as evidenced by the



fact that there is a substantial secular trend to increased stature for emigrants who move to a better from a poorer environment (Allen and Uauy, 1994). This is an important consideration, for it should not be assumed that short children of short parents, in a seriously socioeconomically deprived environment, are genetically 'destined' to be short, come what may.

We hypothesised that the parents of the failing to thrive infants in this investigation would be of low average height, reflecting the relatively short stature of adults living in the poor socioeconomic circumstances from which they were recruited. However, because of our matching procedure we further hypothesised that there would be no significant differences between the mean stature of the comparison and the case parents.

#### *2.4.2.2 Infant Anthropometry At Birth*

Grossly insufficient intrauterine nutrition may lead to growth retardation and the onset of failure to thrive in utero (Eveleth and Tanner, 1990, pp194 - 5). However, the design of the study precluded the inclusion of children who had excessively low birthweights for their gestational age on the grounds that our objective was to study the development of postnatal growth faltering, uncontaminated by the potential sequelae of intrauterine growth retardation.

We hypothesised that, within the sample of infants we surveyed, there would be no significant association between birthweight and subsequent weight gain trajectory.

### 2.4.3 Infant Medical Histories

#### 2.4.3.1 *Antenatal And Perinatal History*

It has been proposed by a number of workers (e.g., Elmer, 1960; Mitchell, Gorrell and Greenberg, 1980) that full-term infants who subsequently fail to thrive have an excess of antenatal and/or perinatal complications.

We hypothesised that there would be an excess of such complications in our case group when contrasted with the community comparisons.

#### 2.4.3.2 *Early Medical History*

On the grounds that minor recurrent medical disorders may contribute indirectly to failure to thrive, we hypothesised that there would be minor differences between cases and comparisons in respect of the nature or frequency of medical disorders, as measured by consultations at the family doctor or hospital outpatient departments in the first postnatal year. For example, there may have been a greater incidence in the case group of diarrhoeal illnesses, or of vomiting in relation to posture that might suggest a history of gastro-oesophageal reflux (Booth, 1992; Milla, 1990).

We hypothesised that medical conditions that could lead directly to failure to thrive would be relatively uncommon among the growth faltering sample as a whole.

#### 2.4.4 Postnatal Feeding History

Although the origins of 'non-organic failure to thrive are thought to lie in a complex interaction between child and family variables, it has been hypothesised on the basis of previous research that the proximal cause is likely to be inadequate nutrition for the infant's needs (Skuse, 1985).

Analysis of the longitudinal growth data from our earlier study of persistent failure to thrive (Dowdney et al, 1987) showed the onset was usually in the first postnatal year.

We hypothesised that feeding difficulties during the first postnatal year would be more frequently reported in the case than the comparison families.

### 2.5 Outcome : Infant Characteristics

#### 2.5.1 Anthropometry

By definition the case children would be underweight for their age at the time of confirmation of case status in the second postnatal year. We hypothesised that there would also be a reduction in terms of length in comparison with that at birth in the case group only, indicating the onset of stunting (Karlberg et al,1994).

We also hypothesised that the case infants would be lighter in relation to their length than the comparison, with evidence of wasting, which would be indicative of the undernutrition that had led to their failure to thrive.

### **2.5.1.1 *Other Physical Examination***

Waldrop, Pederson and Bell (1968) and Waldrop and Halverson (1971) have suggested that an inverse relationship exists between intellectual functioning and the number of anomalies in young children. Accordingly, physical anomalies that could be entered into the computation of a congenital anomalies index were sought in the course of a physical examination.

We hypothesised that, whilst infants in both the case and the comparison groups may have some congenital anomalies, there would be no significant differences between the groups in the mean total scores.

### **2.5.2 *Physiological Evidence Of Malnutrition***

Measures of malnutrition were chosen on the basis of what was feasible to assess from the analysis of 1ml of blood. This was the quantity that could be collected by finger prick with a stilette.

We hypothesised that iron insufficiency and iron deficiency anaemia would be found in approximately 25% of case and the comparison children, on the basis of findings from recent surveys in the United Kingdom (Jarvis and Waterson,1991) and that iron deficiency - indicative of inadequate nutrition - would be more frequent among the case than the comparison infants

We also hypothesised that a relationship would be found between the presence of iron deficiency (whether or not accompanied by frank anaemia) and impairment in psychomotor skills, and possibly in mental abilities too (Lozoff et al, 1991; Filer,1991),

Insufficient postnatal nutrient supply will cause growth stunting, but the case for stunting being due simply to a deficit in energy intake is weak (Allen and Uauy, 1994). Recent studies have suggested that nutrients present in animal products such as milk may be important for normal linear growth in early life. The potentially relevant nutrients in these products include animal protein, zinc, iron, retinol, riboflavin, vitamin B12 and essential fatty acids (Allen and Uauy, 1994).

We were unable to measure other than iron and B12 on the sample of blood we collected. We hypothesised that there would be significantly lower levels of these substances among case than comparison group children.

### 2.5.3 Neurodevelopmental attainments

Frank (1985) has drawn attention to the fact that some children with failure to thrive may be at 'neurodevelopmental risk'. She suggested that early biologic damage may have been inflicted on the developing nervous system by nutritional deprivation. Thus children hospitalised with failure to thrive show a wide range of 'neurodevelopmental deficits', including low scores on standardised developmental assessments (Leonard, Rhymes & Solnit, 1966; Ramey, Starr, Pallas, Whitten & Reed, 1975; Field, 1984; Singer & Fagan, 1984; Powell & Lowe, 1983). Frank acknowledges that the mechanisms mediating the relationship

between *early* non organic failure to thrive and persistent developmental impairment are complex, because nutritional deprivation is usually accompanied by other forms of socio-environmental deprivation (eg, Casey et al, 1984) which can independently produce intellectual impairment.

Whilst Frank discusses the possibility that early malnutrition during the critical period of brain growth can be associated with identifiable structural deficits in human brain growth (eg, Rosso, Omazabel & Winnick, 1980) she does not discuss the possibility that children born with neurodevelopmental problems may be more at risk for non organic failure to thrive.

We hypothesised that case children would have more anomalies in terms of gross and fine motor functioning than comparisons. However, the design of the study precluded an investigation of the direction of the causal relationship between the presence of such anomalies and the growth disorder.

#### 2.5.4 Oral -Motor Competence

Lewis (1982) suggested that oral-motor abnormalities can contribute to failure to thrive in infancy, and described difficulties with sucking, chewing and swallowing, tongue thrusting, involuntary tonic biting of the spoon or nipple, excessive drooling and intolerance of the textures of developmentally appropriate food. A pilot study (Mathisen et al, 1989) had shown an excess of apparently abnormal features in the oral-motor competence of failing to thrive infants.

We hypothesised that failing to thrive infants would have a higher prevalence of dysfunctional oral-motor skills than comparison infants without growth impairment. We aimed to develop an instrument to test this hypothesis. The Schedule for Oral Motor Assessment - SOMA (Reilly et al, 1995; Skuse et al, 1995) is the first properly evaluated and standardized system for rating the oral-motor competence of preverbal infants, and has been shown to have excellent reliability and validity. (This instrument was originally referred to in published work as the Feeding Assessment Schedule (Mathisen et al, 1989)).

We further hypothesised that there would be no clear relationship between the children's level of psychomotor or mental competence and their oral-motor skills, as no such association had been found during the course of pilot investigations.

#### 2.5.5 Cognitive And Psychomotor Attainments

The earlier survey of chronically growth retarded children, identified in the same geographical area, made detailed assessments of cognitive abilities at 4 years of age (Dowdney et al, 1987). By this time case subjects, who had failed to thrive since infancy, were stunted (proportionate weight for height) with an average stature 2 S.D. below the population mean.

Case children had significantly lower General Cognitive Index (GCI) scores (McCarthy Scales of Children's Abilities; McCarthy, 1972) than comparisons. Assessments were made blind to group membership. The mean GCI for the cases was 70.1 (SD 17.6) compared to

97.7 for the comparisons (SD 15.2,  $t = 4.3$ ,  $p < .001$ ;  $t$  test for paired data)(see Table 2.5.5).

Normally, in developed (Western) societies, the amount of variance in mental and psychomotor development during infancy (up to 2 years) that can be accounted for by variability in the quality of the home environment is quite low, no more than 5 - 10% (Rutter, 1987). Longitudinal studies of children born into deprived homes have shown that measures of the quality of the family environment have a stronger correlation with mental abilities after 2 years of age (Yeates et al, 1983). In other words, the influence of the family environment - or psychosocial factors - becomes a more powerful predictor of contemporaneous and later measures of intellectual performance after infancy. This observation holds whether or not there has been intervention to improve the quality of the cognitive stimulation during infancy (eg, Ramey, Yeates & Short, 1984; Bradley & Caldwell, 1984)



**Table 2.5.5: General cognitive index measures on cases and comparisons examined in 1984 survey of chronic growth retardation among inner city children @ 4 years of age**

McCarthy Scales of Children's Abilities

GCI	Mean	SD	t	d.f.	p
1. Cases	77.13	17.56			
Controls	99.74	15.17	4.3	22	<0.001
2. Verbal Scale					
Cases	36.08	8.25			
Controls	46.69	8.30	4.1	22	<0.001
3. Perceptual performance scale					
Cases	42.65	11.23			
Controls	51.86	10.30	2.9	22	<0.01
4. Quantitative scale					
Cases	39.13	10.13			
Controls	48.43	9.68	3.7	22	<0.002
5. Memory scale					
Cases	37.39	8.13			
Controls	47.60	9.18	3.6	22	<0.002
6. Motor scale					
Cases	37.90	9.93			
Controls	49.59	7.20	4.7	19	<0.001

Statistical analyses: t test for correlated data (Cohen & Holliday, 1982)

It has been suggested that infants brought up in very depriving homes are likely, without compensatory intervention, to suffer a 'cumulative risk' to their mental abilities (Skuse, 1987). Evidence to support the hypothesis has been found for children brought up in relatively unstimulating and deprived homes by both the Milwaukee project (see Garber, 1988) and the North Carolina Abecedarian project (Ramey, Yeates & Short, 1984). The latter project provided intensive compensatory day-care for children from poor black families, whose mothers were of low IQ. There was a deterioration in the cognitive performance of control group children, who were not receiving an intervention, from about 18 months onwards.

We hypothesised that there would be a significant difference between the mental and psychomotor abilities of cases and comparisons in at the beginning of the second postnatal year. However, because the effects of a severely deprived environment become more marked after infancy, we hypothesised that the magnitude of difference in measured abilities between failing to thrive and comparison children would not be so marked as we had found in the 4 year olds studied in the course of the earlier investigation (Dowdney et al, 1987).

#### 2.5.6 Temperament

We had a particular interest in the potential influence of infant temperament upon parenting in failure to thrive. Developmental temperament theories concern themselves with the way in which the child's behavioural style serves to regulate social relationships and reactions to the environment Rothbart and Posner (1985). Temperamental characteristics may interact with the caretaking environment to influence physical

growth. Carey (1985) showed that infants rated as temperamentally more difficult, in that they showed more crying behaviour during the day and during the night, had a higher velocity of growth between 6 and 12 months than did easier, less demanding infants. Commenting on a tantalising report by De Vries (1984) which had found that Masai infants rated as 'difficult' were more likely to survive a subsequent drought, Carey (1985) suggested that "babies who yelled probably got the most food".

We hypothesised that sleepy, undemanding infants would have, on average, poorer rates of weight gain during the first year of life than those who were reported by their mothers to be demanding.

Some authors have reported irritable infants are more difficult to manage and are therefore fed less well than average. Consequently, they are more likely to fail to thrive than contented infants (Altemeier et al, 1985; Wolke et al 1990; Frank and Zeisel, 1988; Chavez and Martinez, 1979; Powell and Lowe, 1983; Rosenn, Loeb, Bates, 1980). Kotelchuk (1980) found failing to thrive infants to be 'highly reactive', in the sense that they reacted more strongly (and negatively) to minor stimuli that would not distress most infants.

We hypothesised that there would be temperamental differences between case and comparison infants, but that no simple pattern would emerge. Two predominant styles of behaviour among case infants were predicted. Firstly, the withdrawn and apathetic style. Secondly, the 'difficult' and irritable style. Differences between the case and the comparison infants should be maximal during feeding interactions.

### 2.5.7 Dietary intake

The pattern of growth associated with failure to thrive observed in the earlier survey of four year olds (Dowdney et al, 1987; Skuse et al, 1992) suggested that persistent failure to thrive usually commenced in the first postnatal year. By the second year of postnatal life the weight gain trajectory was usually parallel to centile lines on standardized growth charts. Accordingly, it appeared as if an equilibrium between nutritional intake and growth had been achieved by the second postnatal year.

We hypothesised that differences would be found between the case and the comparison groups in their absolute intake of energy (measured in Kcals), but that the two groups would not differ significantly in their intake per unit body mass.

### 2.5.8 Risk of later abuse or neglect

Early descriptions of 'non-organic' failure to thrive suggested the condition resulted from emotional deprivation. Terms such as 'hospitalism', 'anaclitic depression', and 'institutional syndrome' were employed as synonyms (Spitz, 1945; Bowlby, 1951; Provence and Lipton, 1962). Whilst growth retardation may result from an upbringing in severely deprived circumstances, it is fallacious to conclude that cases of failure to thrive must, therefore, have been subject to equivalent adversity.

We hypothesised that the significance of 'non-organic' failure to thrive as an indicator of concurrent abusive and neglectful childrearing practices (Koel, 1969; Dietrich et al 1980; Elmer, 1960) has been overstated. We further hypothesised that children who failed to thrive would be at only moderately increased risk of future abuse or neglect,

compared to those from equivalently disadvantaged homes whose growth pattern was unremarkable.

## 2.6 Outcome: Mother characteristics

Because of the primary role assumed by mothers in child rearing, the synonym 'maternal deprivation syndrome' was used to characterise this condition at one time (Patton & Gardner, 1963). Over the past 25 years different studies have come up with different findings about the characteristics of mothers of affected children, but the general trend has been towards a more balanced view in which mother and child variables are both taken into account.

Although clinical observations have documented a variety of deficiencies and distortions in the relationships between maternal caregivers and infants who are failing to thrive (eg, Fraiberg, 1980) it is arguable that the reasons why such distortions are so commonly observed is that clinical practitioners see a biased sample of individuals, who are referred for intervention not only because the infant has a pattern of failure to thrive in terms of their growth, but because there are suspicions that other aspects of the child's development are also impaired, possibly because of inadequate caretaking.

We hypothesised that significant differences would be found between the mothers of the case and comparison mothers on key variables, but that the magnitude of those differences would be substantially less than had been reported in previous studies where comparisons were less closely matched on sociodemographic variables.

### 2.6.1 Mental state

A review by Roberts & Maddux (1982) suggested that maternal caretakers were characteristically suffering from debilitating narcissism, anxiety, depression, low self esteem and that they have dependent personalities and unmet dependency needs which themselves are related to a lack of nurturing experiences in their own childhoods. Excessive maternal anxiety has been reported by Elmer (1960) and maternal depression by Talbot, Sobel, Burke, Lindemann & Kaufman (1947) and also by Elmer (1960).

In general, maternal personality disturbances, which have been so commonly reported in clinical observations (eg, Elmer, 1960; Evans, Reinhart & Succop, 1972; Fischhoff, Whitten & Pettit, 1971; Kerr, Boagues & Kerr, 1978; McCarthy & Booth, 1979) have not been so marked in controlled studies (Kotelchuk, 1980; Pollitt, Eichler & Chan, 1975; Newberger, Reed, Daniel, Hyde & Kotelchuk, 1977). Mothers who are seriously depressed in the postnatal period may have children (especially boys) who are relatively impaired in mental abilities during later childhood (e.g. Sharp et al, 1996). This may be an important mediating variable for any association that is found between *early* failure to thrive and developmental outcome.

We hypothesised that there would be relatively high levels of minor mental disorders among mothers from both the case and the comparison groups. This prediction was based, firstly, on the nature of the inner-city area and the conditions in which the families we studied were living. Secondly, on the basis that each family contained at least one, and usually more than

one, pre-school child. Both are risk factors for maternal depression (Brown and Harris, 1978; Brown et al, 1981).

### 2.6.2 Cognitive abilities of mothers

Although there have previously been attempts to assess the intellectual level of the mothers of infants who fail to thrive (eg, Singer & Fagan, 1984) so far as we are aware there have been no previous direct measures of their intelligence using standardised tests. In view of the findings by Ramey et al (1975; 1984) that the mean IQ of a sample of poor inner city mothers was about 85, we hypothesised that the mean IQ of mothers in our survey would also be significantly below the population mean.

We hypothesised that there would be a small or non-significant difference in the mean IQ of the case and the comparison mothers, on the grounds that in the earlier survey (Dowdney et al, 1987) no differences were found between the groups on any measure of academic competence.

### 2.6.3 Social support

It has been suggested that mothers of failing to thrive infants are exceptionally socially isolated (eg, Kotelchuck, 1980) and that they lack social support (Bithoney et al, 1983; Kotelchuck and Newberger, 1983). There are reported to be fewer extended family members available for assistance with child-rearing (Bithoney and Newberger, 1987).

We hypothesised differences would be found between the case and the comparison groups in terms of social relationships outside the home, and also in terms of integration within the local community. In both instances we hypothesised that case mothers would be less well adjusted than comparisons.

## 2.7 Outcome: Infant-mother relationship

Much has been written on the subject of the mother child relationship in cases of non organic failure to thrive. Mothers are said to be ambivalent, to have negative affective communications with their children, to be inconsistent and unpredictable (see Lachenmeyer & Davidovicz, 1987). Gaensbauer & Sands (1979), Leonard et al (1966), Pollitt (1975) and Rosenn, Loeb & Bates, (1980) all state that both parties lack pleasure in the relationship.

We therefore hypothesised that there would be significant differences in the quality of the interaction between case and comparison families, and that case mothers would have a style of interaction with their infants that would be pervasively more negative, or unresponsive, than that observed between comparison mothers and their infants.

### 2.7.1 Attachment

Problems with the attachment behaviour of infants who are failing to thrive have been reported. For example, Gordon & Jameson (1979) stated that these infants had no response to separation and that fifty per cent were insecurely attached. Their findings echoed those of Ferholt & Provence (1976). But, in a study which incorporated a comparison group, Kotelchuk, Gordon, Jameson & Newberger, (1981) found no difference in separation protest



or stranger anxiety, although they do report qualitative differences in attachment behaviour.

Drotar, Malone, Devost, Brickwell et al (1985) report that attachment classifications at 12 months of age did not indicate that non organic failure to thrive was synonymous with attachment disturbance although the incidence of insecure attachment, at 45%, was higher than the estimates of 25 to 30% in comparable middle class samples (Campos, Caplovitz Barrett, Lamb, Goldsmith & Stenberg, 1983).

We hypothesised that attachment differences between case and comparison infants and their mothers were likely to reflect the sampling biases and other methodological deficiencies of former studies. However, we did not have a satisfactory measure of attachment that would allow a conventional system of attachment classification to be employed in our own investigation, as all measures were made in the children's homes.

### 2.7.2 Feeding interaction

The feeding relationship between failing to thrive infants and their mothers has rarely been studied directly (eg, Pollitt, 1975; Whitten, Pettit & Fischhoff, 1969; Pollitt & Eichler, 1976; Newberger et al, 1977; Skuse, 1985). Pollitt (1975) and Pollitt & Thompson (1977) proposed that growth faltering infants would have impaired interaction with their mothers during feeding. The importance of the feeding relationship in this condition has also been emphasised by Chatoor, Dixon, Shaefer & Egan, (1985).

In the earlier study of persistent failure to thrive to 4 years of age (Heptinstall, Puckering, Skuse, Dowdney & Zur Szpiro, 1987) mealtime observations revealed considerably more

disorganisation and negative attitudes among case than comparison families. Although the majority of families shared at least one daily meal together, case group children were more likely to eat independently without parental supervision. Case families were also less reliable about the timing of mealtimes. In a minority of such families no meals were planned at all; the provision of food occurred on a 'grab what you can' basis. There was a (nonsignificant) tendency for case children to be reported as more difficult to feed and angry confrontations were commoner at mealtimes in case group families.

We hypothesised that our observations at 4 years probably reflected a persistent pattern of family behaviour, and that similar group differences in mealtime behaviour would have been observed had the families been seen when the index children were infants.

In other words, we assumed that the observations we had made in the earlier study of persistently failing to thrive children (disorganised and stressful mealtimes) reflected a process that had been present since the probands were infants, and that the same process would account for the failure to thrive of the children studied in the present investigation.

We further hypothesised failure to thrive would be associated with feeding difficulties among the case infants, and that feeding interactions would be exemplified by high levels of negative remarks and negative tone expressed by their mothers (see reports by Hutcheson, Black and Starr (1993), by Polan, Leon, Kaplan et al (1991) and by Drotar, Eckerke, Satola et al (1990).

We also hypothesised that the mothers of case children would provide less stimulation to their infants than mothers of comparison infants during mealtime interactions. We measured the degree to which mothers were cognitively stimulating of their infants in terms of contingent responsiveness and in terms of verbal stimulation and engagement.

### 2.7.3 Play interaction

It has been suggested that the mother infant relationship might be impoverished in other aspects of their interaction as well as feeding, such as play (Fraiberg, 1980; Fraiberg, Adelson & Shapiro, 1975; Harper & Richmond, 1979; Pollitt, 1975).

We hypothesised that differences would be found between the groups in terms of style of interaction displayed by mothers during observation of a standardised play session with their infants. We hypothesised that there would be differences in the degree to which mothers would be involved in reciprocal interaction at an appropriate level with their infants and that there would be more negative tone and less positive remarks made by the mothers of case than those of comparison children.

### 2.8 Quality of home environment

It has been reported widely in previous studies that failure to thrive indicates that the family system is not functioning adaptively to meet the child's needs (e.g. Leonard, Rhymes and Solnit, 1966; Drotar, Malone, Devost et al, 1985). Parents of failing to thrive children are reported to manifest relatively low responsiveness to and acceptance of their child, and to

show an impaired ability to organize the home environment to meet their child's needs (Casey, Bradley and Wortham, 1984; Pollitt, 1975).

We hypothesised that there would be differences between the case and the comparison families on measures of the quality of the home environment, including provision of play materials and opportunity for variety in day to day activities.

## **CHAPTER 3. Study Design and Methods**

### **3.0 Introduction**

The investigation was a prospective longitudinal survey of virtually all infants born during one calendar year within an inner city health district in London, England. The district has an ethnically diverse population (140,000), which in socioeconomic terms is relatively homogeneous and quite severely disadvantaged (South East Thames Regional Health Authority, 1984).

The sampling frame comprised all 2610 births who were registered with participating child health clinics or family doctor practices, between 1 January and 31 December 1986. The planning and execution of the survey was facilitated by the good relationship built up between the research team and the local community paediatric services in the course of previous research there (eg, Dowdney, Skuse, Heptinstall, Puckering, Zur-Szpiro, 1987).

Prior to the year in question, leaflets for parents had been circulated to all health visitors, explaining the purpose of the survey and the fact that information would be abstracted from clinic records for comparative analysis. Only one mother refused to participate at this stage.

A computerised database was established and updated monthly; demographic, developmental and growth data were obtained by systematic and regular perusal of clinical records. In this way the growth trajectory of each attender could be monitored prospectively through the first year of life. A minimum schedule of visits to the clinic, or family doctor practice, for weighing, immunisations and checks of developmental progress would be at 6 weeks, 6

months and 9 months. However, many children were brought more often than this, and a small proportion were seen less frequently or not at all.

The selection of subjects who had growth faltering was made from all children who continued to live in the district until 12 months of age, and who were weighed on at least one occasion. During this period 13.8% (361) of the population moved out of the area. There were also missing data on a small minority of subjects (1.1%; 30) who were known to health visitors but were seen only at home. Other families were untraceable (3.2%; 83). There are a number of reasons for this situation. First, the district contains several unofficial encampments of travellers who may spend just a few weeks at a time on any one site.

Secondly, it is known that some women come from outside the district (often from overseas) for the express purpose of giving birth at the local teaching hospital. They live at a temporary local address but move away immediately following discharge. Thirdly, some families moving within or out of the district fail to give any notification of their whereabouts.

Clinic records for those subjects were therefore inevitably incomplete. A small proportion of infants (0.8%;20) are known to have died.

Growth trajectories were computed from weight data recorded at clinic visits; most scales in health clinics were of the lever balance type and their accuracy was subject to regular checks.

Infants were weighed nude, usually by clinic nurses. Because children were not weighed at consistent ages, weights were standardised for age and expressed in standard deviation (or Z) scores. Z scores represent the extent of a value above or below the mean of weight for age (WAZ) or length for age (LAZ) or weight for length (WLZ) of the National Center for

Health Statistics growth standards (Hamill, Drizd, Johnson, Reed and Roche, 1977).

Computation of the Z scores was undertaken by the CDC anthropometric analysis system (Center for Disease Control, Atlanta; Jordan, 1986). They have been calculated separately for age and gender. Practically, a WAZ, LAZ or WLZ score of -1.88 corresponds to the third percentile.

### 3.0.1 Definition Of Growth Faltering

Potential cases were limited to singleton deliveries at term, i.e., between 38 and 41 completed weeks gestation. Gestational age was calculated from the date of delivery, recorded by the midwife or obstetrician, based on the date of the last menstrual period and results of routine ultrasound examination. Preterm infants (gestation 37 weeks 6 days or less) were excluded because of the known association with below average growth in the early postnatal period (Brandt, 1986; Ounsted, Moar and Scott, 1982). Also excluded were infants with severe intra-uterine growth retardation (i.e., birthweights at or below the 3rd percentile, on charts standardised for gestation, sex, ordinal position, maternal height and mid-pregnancy weight; Tanner and Thomson, 1970). Confirmed cases of growth faltering had to have a WAZ of less than -1.88, this trajectory relative to population norms having been attained by 12 months of age, and sustained for 3 months or more.

All children with a suspicious weight gain trajectory, on the basis of clinic data, were traced and visited at home for confirmatory anthropometry. 'Suspiciousness' was defined as a weight trajectory that had declined from above the 10th centile at birth to below the 10th centile at the time of the last clinic weighing, or a weight at birth which was between the 3rd

and the 10th centiles of weight for age and had not increased to above the 10th centile at the time of the last clinic weighing. Weighings were routinely done at 6 weeks, at 3 months and at 9 months approximately. The investigation procedures were discussed with mothers of subjects and they were asked to give verbal informed consent.

### 3.1 Methods

#### 3.1.1 Family factors

##### 3.1.1.1 *Socioeconomic status*

A very wide range of variables measuring aspects of families' socioeconomic status was obtained, based upon those factors that were used by Osborn (1987) to compute his composite social index (see Osborn and Morris, 1979). Weighted scores are computed which were then summed across seven socioeconomic indicators to give what is claimed to be a measure of particular sensitivity to differences between families which takes into account factors such as parental education, overcrowding of the home, and the possession of key material goods such as a car, telephone and household appliances. The potential advantage of this approach to assessing socioeconomic status has been discussed by Osborn (1987).



### 3.1.1.2

#### *Marital relationship*

Mothers were asked to rate their relationship with their spouse with the Dyadic Adjustment Scale (Spanier, 1976; Spanier and Thompson, 1982; Sharpley and Cross, 1982; Antill and Cotton, 1982). Only the Dyadic Satisfaction subscale was rated.

### 3.1.2 Anthropometry

#### 3.1.2.1 *Parental Anthropometry*

Mothers, and fathers where available, were measured using techniques as recommended by Cameron (1984), with portable apparatus. Weights were not measured directly but were estimated by the child's parents. For the most part (53.2%) fathers' heights and weights were estimated by their spouses; because visits were usually made in the middle of the day it was not possible directly to measure other than a small proportion of fathers. The validity of maternal reports of their spouses' heights in an inner city population has been discussed by Rona et al (Rona et al, 1989). Theirs was a small scale study, and the generalisability of the findings is questionable. They concluded that the information provided by Caucasian mothers about their spouse's stature was usually an overestimate. A rather larger study conducted in New Zealand (Stewart et al, 1987) found that, for most participants, self-reported measures had a high degree of accuracy, and self-reported weight was, in 75% of those questioned, no more than 2.4Kg from the true value.

### 3.1.2.2 *Infant Anthropometry At Birth*

Data for ponderal indices are from Miller et al. (Miller and Hassanein, 1971), and are based on the formula: birthweight in gm , (crown-heel length cm<sup>3</sup>) x 100; this formula was derived from the observations that the weight of an object of uniform density and dimension increases as the cube of its length). Birth length standards were from Kitchen et al. (Kitchen, Bajuk, Lissenden and Yu, 1981); those for head circumference from Yudkin et al. (Yudkin, Aboualfa, Eyre, Redman and Wilkinson, 1987). Birthweights were standardised for gestation, sex, ordinal position, maternal height and mid-pregnancy weight according to the method of Tanner and Thompson (1970).

### 3.1.3 *Infant Medical Histories*

#### 3.1.3.1 *Antenatal And Perinatal History*

Antenatal and birth records were traced on 96% (90) of subjects. These were coded according to two alternative systems. Firstly, a version of Prechtl's optimality index (Prechtl, 1980), as modified by Gillberg et al. (Gillberg, Enerskog and Johansson, 1990) in their population survey of normal urban Swedish children with mental retardation. Subscale scores for prenatal, perinatal and neonatal adversity were derived; the maximum possible adversity score was 29. Secondly, the choice of variables for this comparison was based on the Collaborative Perinatal Project of the National Institute of Neurological and Communicative Disorders and Stroke in which there were 66 variables, for which we had measures, that were correlated with outcome on those dimensions. The scores were weighted in line with the recommendation of Broman et al (1975). If a mother had every one of those risk factors her antenatal/perinatal abnormality score would be approximately 110.

### 3.1.3.2 *Early medical history*

A semistructured interview was developed for the purpose of asking about the history of the infant's consultations at family doctor surgeries, at accident and emergency departments, at outpatient clinics and inpatient admissions. The form of this interview was based upon that used in the Isle of Wight epidemiological survey of children's health, education and behaviour (Rutter, Tizard and Whitmore, 1970).

### 3.1.4 Postnatal feeding history

A semistructured interview format was used, to enquire about the nature and quality of the postnatal feeding arrangements made. This interview was developed jointly by Sheena Reilly and David Skuse, in consultation with a paediatric dietitian (Kate Start).

## 3.2 Outcome: Infant

### 3.2.1 Anthropometry

Anthropometric examination undertaken to confirm diagnostic status included: nude weight (SECA digital baby scales), length (Harpenden infantometer), left subscapular and triceps skinfold thickness (Holtain skinfold calipers), head circumference (flat steel tape measure), left mid-upper arm circumference (insertion tape marked in 2mm divisions). Each measurement was taken on 2 separate occasions to ensure its accuracy, which was in most cases  $\pm 0.5\%$ . Techniques were as recommended by Cameron (Cameron, 1984); the child's mother was used as an assistant where necessary.

Cut-off points for mid-upper arm circumference (MUAC) are from Rees et al. (1987), for triceps skinfold thickness from Tanner and Whitehouse (Tanner and Whitehouse, 1984), for mid-upper arm circumference: head circumference ratio (MUAC:HC) from Kanawati and McLaren (Kanawati and McLaren, 1970) and for arm muscle area in infancy (claimed to be indicative of protein reserves) from Sann et al. (Sann, Durand, Picard, Lasne and Bethenod, 1988).

#### *3.2.1.1 Other physical examination*

A structured assessment was made of the infants general state of health, using a format that had been developed in consultation with colleagues at the Newcomen Developmental Paediatric Centre at Guy's hospital. Minor congenital anomalies were assigned weighted scores according to the method developed by Waldrop (Waldrop, Pederson and Bell, 1968).

#### *3.2.2 Physiological measures*

A 1ml (minimum) sample of capillary blood was taken from all subjects for a full blood count, haemoglobin electrophoresis, and ferritin estimation (Beckton-Dickinson immunoradiometric assay - IRMA). Analyses were also made for red blood cell folate and serum B12 (Beckton-Dickinson Simultrac).

Blood lead levels were estimated. Analyses were made using a modification of the flame microsampling atomic absorption spectrophotometric method (Delves, 1970). A measure was also obtained of serum insulin-like growth factor I, a variable that is reduced in severely malnourished children (eg, Soliman et al., 1986). The technique used to measure serum

IGF-I bioactivity was the porcine costal cartilage bioassay, as described by Taylor et al. (Taylor et al., 1990).

### 3.2.3 Neurodevelopmental attainments

An assessment of neurological functioning and maturity was based upon the work of Touwen (1976) and Amiel-Tison and Grenier (1986). A composite score of gross motor skills was derived from the ten variables for which there was the least missing data; this allowed the comparison of 18 cases of *early* FTT and 24 cases of *later* FTT. Skills such as the ability to walk or sit unsupported, visual following while sitting, optical placing, reaction of hands, were scored according to the weighting system recommended by Touwen (1976).

### 3.2.4 Oral-motor competence

Evidence from our previous research ( Mathisen et al. 1989) had shown that oral-motor skills may be impaired in infants who are failing to thrive. Accordingly, we obtained evidence of oral motor functioning from two sources; interviews with mothers about early feeding difficulties, using a semistructured interview format, and direct observations of the infants feeding in a standardized situation. Oral-motor behaviour in the latter context was rated on an instrument (Schedule for Oral Motor Assessment ) we have developed specifically for the purpose of rating skills in children with and without overt neurological disorder (Reilly et al. 1995; Skuse et al. 1995). This instrument was administered blind to all subjects and total abnormality scores for a variety of food textures were calculated. Some children have more difficulty with one texture than others (eg, semi-solids or solids rather than liquids).

### 3.2.5 Cognitive and psychomotor attainments

Infants were assessed at 15 months on the Bayley Scales of Infant Development (Bayley, 1969) from which were derived indices of mental and psychomotor competence, the Mental Development Index (MDI) and the Psychomotor Development Index (PDI). The mental scale contains language items and many types of problem solving tasks. The psychomotor scale mainly addresses gross motor development. The child's behaviour during the administration of the Bayley Scales was rated on the Tester's Rating of Infant Behaviour-TRIB (Wolke,1987) which is an instrument comprising 16 subscales. Its factorial structure has demonstrated three coherent factors, difficultness, attentiveness-competence and vigour-activity (Wolke et al., 1990). Cronbach's alpha for the internal reliability of these factors was 0.89, 0.86 and 0.87 respectively. Although the Bayley Infant Behaviour Record (Bayley, 1969) served as the basis for the development of this instrument, it was designed to yield a more thorough picture of the child's behavioural style during testing, with a view to deriving indices of mastery-motivation (Yarrow and Messer, 1983).

### 3.2.6 Temperament

The most common method of measuring temperament has undoubtedly been the questionnaire, usually filled in by a parent. Whilst open to criticisms of response bias, mothers are rightly regarded as potentially the best informants about their child's disposition. They generally have the opportunity to monitor characteristic patterns of behaviour over much longer periods of time than could independent observers, even in natural settings. However, Lancaster, Prior & Adler (1989) reported that maternal characteristics such as psychological health status, marital adjustment and confidence in mother/wife roles accounted for a significant proportion of variance in their ratings of child behaviour. Accordingly, we arranged to obtain ratings of infants' behavioural style from a variety of sources, including both maternal report and direct observation.

These included, firstly, a mother-rated temperament scale, the Infant Characteristics Questionnaire (ICQ) (Bates and Bayles (1989). Four subscales of temperament may be derived: 'difficult', 'unadaptable' 'unsociable', persistent'. The ICQ has been evaluated in a number of studies and has moderate validity and test-retest reliability.

Independent observations of the child were scored on a new instrument, the Tester's Rating of Infant Behaviour (TRIB; Wolke, 1987) which includes the New York Longitudinal Study temperament dimensions (Thomas and Chess, 1977) together with additional behaviours that were hypothesised to have relevance to the aims of this investigation. The TRIB was rated by three independent observers, in three distinct situations, on separate occasions about one week apart. The first was after administration

of the Bayley Scales of Infant Development (Bayley, 1969) (Rater 1), the second after a physical examination of the child (Rater 2), the third after a standardized examination of the infant's oral-motor skills (Rater 3). The TRIB can be scored on 8 subscales of infant behaviour. The factorial structure of the TRIB has been shown to consist in three coherent factors, difficultness, attentiveness-competence and vigour-activity.

Cronbach's alpha for the internal reliability of these factors is 0.89, 0.86 and 0.87 respectively.

### 3.2.7 Dietary intake

Information on dietary intake was obtained both from an interview, and by direct observation of feeding. First, a 24 hour recall dietary history, using household measures to estimate quantities, was obtained from the mothers (Fehily, 1983). Although this approach is likely to lead to an inflated estimate of the infant's actual intake it was thought likely to be an adequate method for the comparison of two groups (Horst et al, 1988). Secondly, all mealtimes were videorecorded, and additional notes were made by observers at the time about food loss and so on. Using these data the quantity of food actually consumed by infants was calculated by a colleague who had never visited the families, on the basis of videotape ratings. All infants were fed in spoonfuls. Accordingly, it was possible to count the number of spoonfuls actually consumed during the observed and recorded meal, and then to multiply that figure by the quantity of food presented on each spoonful. This was done from a knowledge of the capacity of the implements used to feed the child (in mls), which were examined in the course of the home visit by Sheena Reilly, where the mealtime was observed. A similar technique allowed the quantity of liquid consumed by the child to be estimated.



Analysis of dietary data was undertaken by a senior paediatric dietician blind to group status, using a computer program MICRODIET which is based on McCance & Widdowson's Composition of Foods (Paul & Southgate, 1978).

### 3.2.8 Risk of later abuse or neglect

In 1990 we aimed to gather information on all 1986 born children who were then living within the Southwark and North Lewisham Health District who had ever been subjects of a case conference, who had been placed on a Child Protection Register (CPR), who had been received into care, who had been on a Place of Safety Order or who had been subject to wardship proceedings. We then cross-tabulated the names of at-risk children with the names of children in the original birth cohort.

We know that there was a steady and substantial turnover of population in the small health district (Guy's) when the original survey was conducted. During the course of the first postnatal year (1986-7) 13,8% of the population moved out of the area. However, for a substantial proportion this was to adjacent districts, which were incorporated into the larger health district (Lewisham and North Southwark) created in 1982 (when the population was 320,000), in which this follow-up was conducted. We cannot know whether there was a bias toward 'at risk' families differentially moving out of or staying within the area surveyed.

All but two of the original 'non-organic' failure to thrive case children continued to live within the boundaries of the larger health district at follow-up; neither of those two who moved away had subsequently been a cause for concern. They were both included in the analysis as falling into that proportion of the cohort who were not abused or neglected, as were all other members of the original cohort who had moved away and for whom we had no further information.

### 3.3 Mother characteristics

#### 3.3.1 Mental state

Mental state was assessed by administering to the mothers of case and comparison infants a variety of questionnaires. Where the mother's first language was not English, a professional translator assisted her in doing so. All instruments were rated during the course of the home visit and were taken away for subsequent scoring. They included a 28-item version of the General Health Questionnaire (Goldberg and Williams, 1988) which is a scaled version of the parent instrument with four subscales which have been derived by factor analysis. These include 'somatic symptoms', 'anxiety and insomnia', 'social dysfunction' and 'severe depression'. The validity of the subscales is discussed in Goldberg and Williams (Goldberg and Hillier, 1979, p.39). These subscales represent dimensions of symptomatology and do not necessarily correspond to any psychiatric diagnosis. There is no absolute consensus about what 'threshold' score best discriminates between cases of probable psychiatric disorder and others, but the modal value has been 4/5 (Goldberg and Hillier, 1979, p.64). At this level the positive predictive value of a high score, where there is a prevalence of 30% of 'true' disorders in the population being tested, is 0.67.

Other instruments included a scale derived from the work of Pearlin & Schoolar (1978) measuring Locus of Control.

### 3.3.2 Mothers' cognitive abilities

Mothers were tested using the Wechsler Scales of Adult Intelligence (Wechsler, 1974). Prorating of the scores on the block design and picture composition (Performance), vocabulary and information (Verbal) subscales was undertaken in order to yield a full scale IQ score. Where the native language of the mother was not English, and she was not fluent in the language, no verbal score was computed

### 3.3.3 Social support

This issue was addressed with the aid of a scale devised specifically for the purpose of our own investigation, based upon the work of Tietjen and Bradley (Tietjen and Bradley, 1985). The scale was filled in by the mother, with guidance from the research worker if necessary. Typical questions ask about whether there is anybody to whom mother could turn in an emergency, or if she had a personal problem, how often there is no-one willing to talk to her, how satisfied she is with her neighbourhood, and so on.

## 3.4 Infant mother relationship

### 3.4.1 Feeding interaction

The infant's behaviour was also rated from a videorecording made of the infant's main meal of the day. Video recordings were subsequently rated according to the scale by a

researcher worker who was quite unaware of case and comparison status, and who had not visited the homes of any of the subjects. The schedule on which behaviour of both partners (mother and infant) was rated (unpublished) is the Feeding Interaction Scale (Wolke, 1986). The instrument rates infant behaviour, mother behaviour and joint behaviour on a number of Likert-type subscales.

#### 3.4.2 Play interaction

Interaction during play was assessed using the Play Observation Scheme and Emotion Ratings (POSER, Wolke, 1986). This procedure entailed mother playing with the child for six sessions of 2.5 minutes each. Sessions were video recorded in the family home and rated by an independent member of the team who had never visited the families. Three major subscales (maternal behaviour, infant behaviour and joint behaviour) are rated, according to a Likert-type format.

#### 3.5 Quality of home environment

The quality of the home environment was in general terms rated by the HOME inventory, which is designed to assess the quality of stimulation and support available to a child in this situation. Information needed to score the inventory is obtained through observation and interviews done in the home with the child and the child's primary caregiver. For the purposes of our investigation an infant version was used, which comprises 45 binary choice items clustered into six subscales: a) parental responsiveness; b) acceptance of child; c) organisation of the environment; d) play materials; e) parental involvement; and f) variety of stimulation. Information concerning the reliability and validity of HOME has been published

in Caldwell & Bradley (1984) and Elardo & Bradley (1981). This instrument has been used previously to study the home environments of failure to thrive infants (Bradley, Casey & Wortham, 1984; Casey et al, 1984).

The reliabilities of these HOME scale assessments were checked by an independent rating of 30 home environments (15 cases and 15 controls) by two sets of observers (DS and DW). Intraclass correlation between observers on the total HOME score was .83 and on the subscales ranged between .53 and .79 (Bartko & Carpenter, 1976).

Mothers' cognitive stimulation of the infants was also rated, double blind, from videorecordings of semi-structured interactions made in their homes. The cognitive growth fostering subscale of the Nursing Child Assessment Teaching (NCAST) Scales was employed for this purpose; the instrument has been widely used and possesses good concurrent and predictive validity (Barnard et al., 1989).

An experienced independent rater rescored a random 25% of the videorecordings, and excellent inter-rater reliability was obtained for individual items (Kappa > 0.95) (Fleiss, 1981).

Finally, broader measures were made of the home environment, including a Family Cleanliness Scale derived from Davie, Hutt, Vincent & Mason, (1984). This is a 13 item scale which rates items such as the smell in the infant's home, the need for interior decoration, soiling on furnishings, and so on. The interrater reliability on this item was not

calculated. Instead, the three members of the team who visited families at home each independently rated the scale, and the mean value of their rating was used in the analysis.

### 3.6 Subjects

#### 3.6.1 Selection of cases

There were 1558 potential subjects remaining after exclusion criteria had been implemented. These criteria included exclusion of preterm infants, those who were light for dates, and multiple births as well as the children for whom there were so few data it was not possible to compute weight gain trajectories. Not all variables used in subsequent analyses had been measured on all these children, so the N may differ from 1558 in some instances.

Of the 1558 potential cases of failure to thrive, 52 (3.3%) were confirmed cases of growth faltering (para 3.0.1.) at 12 months of age. Only 3/52 (5.8%) were found to have an overt organic disorder that was considered to be making a major and direct contribution to the infant's poor rate of growth. The organic diagnoses included one case of cerebral palsy, one of non-progressive congenital myopathy and one case of cystic fibrosis. At the time this study was devised we were not aware of the importance of nutritional factors in contributing to the growth disorders of infants with cerebral palsy. Our later research on this subject has suggested that in many cases failure to thrive may be an indirect consequence of the neurological condition, mediated by oral-motor and pharyngeal dysfunction which renders feeding exceptionally difficult.

All three 'organic' cases had been diagnosed previous to our contact; no further cases of organic disease that could account for failure to thrive emerged either from the results of a medical examination, blood tests or, as was the case for 30% of the sample, referral to a specialist at the local academic teaching hospital for more extensive investigations.

There was thus little or no evidence of occult organic disease contributing to the growth faltering of the majority of subjects. Accordingly, for the sake of parsimony and clarity, the group of growth faltering infants was dichotomised into those whom clinical judgment suggested were suffering from an organic disorder that was considered to be directly causal of the failure to thrive (n=3), and those who were diagnosed as suffering from 'non-organic failure to thrive' (n=49).

In two cases the family cooperated with the initial stages of the assessment, but it was not possible to complete it due to supervening circumstances. In one instance this was a bereavement in the family, in the other we did not discover the reason for the withdrawal of cooperation.

Within the 'non-organic' failure to thrive group was one child with microcephaly, hypotonia, and an action tremor or ataxia of unknown origin. His condition was not thought to be contributing directly to his growth disorder according to his paediatric attendants. He was a patient at the local centre for developmental paediatrics. All other case children were, apart from their growth problem, in good physical health (n=47).

Both the 'organic' and 'non-organic' failing to thrive groups of children were subject to the same range of assessments, but only those with 'non-organic' failure to thrive are presented in this thesis.

### 3.6.2 Selection of comparisons

A comparison group, was chosen from the population database. Comparison infants were matched pairwise with confirmed cases on the basis of sex, age, ethnic origin, birthweight (to within 300gm) and ordinal position. Socioeconomic status was matched on the basis of geographical proximity and nature of housing occupied. Three comparison families failed to complete the extensive assessment procedure and have been excluded from analyses.

All measures, except anthropometry, were made by researchers who were blind to case/comparison status. Anthropometry was measured by David Skuse, who also arranged for the medical investigations of case children at their local paediatric departments if they were not already known to them. Other measures were made by Dieter Wolke and Sheena Reilly who were blind to group status, and who did not examine the infants medically. Their estimates of group membership, recorded at the time of testing, were assessed upon completion of the investigation and were found to be no better than chance.

### 3.7 Ethical permission

Ethical permission for the investigation was obtained from the Ethics Committee of the Guys Health District.



### 3.8 Statistical analyses

In all analyses the characteristics of the data were firstly taken into consideration before formal confirmatory statistical analyses were commenced. Exploratory analyses were undertaken with the assistance of the SPSS suite of statistical software, in a variety of versions. When the scale properties of variables had been determined, parametric or nonparametric analyses were used as appropriate. The normality of interval or continuous scale data was determined by means of the Kolmogorov-Smirnov one-sample test.

The case and comparison children had been matched closely on a pairwise basis. This method has the advantage of resulting in greater power to detect a 'significant' difference between groups of a particular size (i.e. avoiding a Type II error), but it has the disadvantage that the range of statistical tests that may legitimately be used is constrained. For example, the McNemar test for the Effect of Changes would be used for categorical data rather than the more familiar Chi Square test. Unfortunately, the McNemar test is only applicable for a 2x2 cell format. Statistical opinions on the option of using unpaired analyses for paired data were sought, but no consistent view was forthcoming. The consensus was that such analyses could be done legitimately, but the increased power to detect an effect, which was the reasoning behind the pairing method in the first place, would of course be lost.

For virtually all the analyses presented in this thesis, where the cases are being analysed in contrast to the comparison children, paired analyses are used. For the within-group analyses unpaired analyses are employed.

## CHAPTER 4. Case-Comparison Contrasts

### 4.1 Background

#### 4.1.1 Family factors

##### 4.1.1.1 *Socioeconomic status*

The design of our 1986 birth cohort survey was intended to minimise gross differences between groups in terms of their socio-economic status. Thus, case and comparison samples were matched on area of residence, often by street or block of flats. The inner city district under investigation is relatively homogeneous in terms of its socio-economic deprivation (South East Thames Regional Health Authority, 1984).

A wide range of variables was coded, based upon those factors that were used by Osborn (1987) to compute his composite social index (see also Osborn & Morris, 1979). Neither on individual variables, nor on the composite index were there any significant differences between the case and comparison samples (see Tables 4.1.1.1A and 4.1.1.1B).

It is worth noting that the samples do differ from the 'most disadvantaged' 9.1% of families in the national Child Health and Education survey (see Osborn, 1987), for whom the data published in Table 4.1.1.1A were collected in 1975. It is likely the much higher ownership of telephones and cars is indicative of general social trends. There also are proportionately more single parent families.

In those families in which there was a regular male cohabitee who was employed (16%: 6 case fathers and 25%:9 comparison fathers were unemployed) the proportions within each of the three lowest OPCS (Office of Population Censuses and Surveys, 1982) social class strata are shown on Table 4.1.1.1A. There were 74.4% of the case fathers in these categories and 66.6% comparison fathers. In the CHES sample 81.7% of the 'most disadvantaged' families were in social classes IIIM (skilled manual), IV (partly skilled) and V (unskilled).

Osborn's social index (Osborn, 1987) is claimed to be a more sensitive indicator of socio-economic status than OPCS social status alone. It is computed from seven independent variables by totalling weighted scores on the items outlined in Table 4.1.1.1A. Scores on this index were used as a proxy for socio-economic status in certain analyses, where it had the advantage over the OPCS classification that it is scored as an interval scale for the purposes of statistical analysis.

#### *4.1.1.2 Family Composition*

The proportion of single parent families in both groups is very similar to that of the 'most disadvantaged' population surveyed in the Child Health and Education Study (Table 4.1.1.1A). We defined a single parent family as one in which the mother was not cohabiting, or who was not cohabiting with a partner who stayed in the house with her more than 4 days each week, on average.

**Table 4.1.1.1A: Social characteristics of sample, compared with 'most disadvantaged' families in Child Health and Education Study (CHES)\* survey†**

	Cases N=47 %	Comparisons N=47 %	CHES sample %
<b>Father's occupation (OPCS)**</b>			
III Manual	51.3	50	30.3
IV	7.7	11.1	25.1
V	15.4	5.6	26.3
<b>Father has no educational qualification</b>	25.5	23.4	82.5
<b>Single parent household</b>	21.3	19.1	(17.3)***
<b>Local authority rented accommodation</b>	68.1	66.0	82.6
<b><u>Type of accommodation</u></b>			
Flat or maisonette	78.7	72.3	43.1
Terrace house	14.9	21.3	33.9
<b><u>Person per room ratio</u></b>			
>2.0	2.1	2.1	5.8
>1.5 <2.0	6.4	6.4	16.9
>1.0 <1.5	23.5	21.2	43.4
≤1.0	68.0	70.3	33.9
<b>Has no car</b>	46.8	31.9	90.7

\* Child Health and Education Study (CHES); a national cohort survey of 16000 children born in 1970. These data refer to the most disadvantaged 9.1% in 1975 (Osborn, 1987)

\*\* Office of Population Censuses and Surveys social class

\*\*\* estimated value - may be slightly in excess of true value (Osborn, 1987)

† there are no significant differences between the case and comparison groups on any of these variables

Table 4.1.1.1B: Social characteristics of sample, compared with—‘most disadvantaged’ families in Child Health and Education Study (CHES)\* survey†

Father’s occupation (OPCS social class)**	Cases			Comparisons			'CHES' survey		
	mean	(N)	SD	mean	(N)	SD	mean	(N)	SD
I	62.3	3	2.5	56	3	3.6	66.4	842	4.4
II	58.7	3	6.4	49.4	5	3.8	59.7	2385	6.2
III non-manual	44	4	7.6	45.7	3	2.1	53.9	1058	6.7
III manual	42.4	20	3.8	40.9	18	3.6	47.1	5701	7.1
IV	37.0	3	2.6	37.3	4	4.7	43.0	1614	6.9
V	37.5	6	4.8	30.5	2	0.7	36.9	746	6.1
All	44.2	39	8.6	42.7	36	6.9			
Currently employed	38.6	8	3.8	40.4	9	7.5			

\* Child Health and Education Study (CHES); a national cohort survey of 16000 children born in 1970. These data refer to the most disadvantaged 9.1% in 1975 (Osborn, 1987)

\*\* Office of Population Censuses and Surveys social class

† there are no significant differences between the case and comparison groups on any of these variables

#### **4.1.1.3 Family Size**

Family size did not distinguish the groups to a statistically significant degree. Within the case group there was a mean of 2.26 (SD 0.94) resident adults and 2.09 (SD 1.16) resident children. The equivalent figures for the comparison group were 2.34 (SD 1.19) and 1.96 (SD 0.96).

#### **4.1.1.4 Ethnic composition**

The sample was racially mixed but there were no significant differences in the proportion of racial groups as care was taken to match them as closely as possible, on a pairwise basis. The figures are given in Table 4.1.1.4A. The Indian-Asian subjects were largely from India, Sri Lanka and Pakistan. The 'Chinese Asians' were Vietnamese or from Hong Kong. Further data on the ethnic composition of the sample are given on Table 4.1.1.4B, which shows the proportions of infants who had been identified as failing to thrive within each of the ethnic groups in the district. There are marked differences in the proportion of failing to thrive infants according to ethnicity. This matter is discussed in further detail in Skuse et al, 1994c.

### **4.1.2 Anthropometry**

#### **4.1.2.1 Parental anthropometry**

The mean heights of fathers of case and comparison children did not differ significantly (means 172.8 cm (SD 9.8) and 173.8 cm (SD 9.4) respectively). However, the mothers of

**Table 4.1.1.4A:****Ethnic composition of case and comparison groups**

	<b>Cases % (N)</b>	<b>Comparisons % (N)</b>
<b>White</b>	<b>53.2 (25)</b>	<b>61.7 (29)</b>
<b>Indian Asian</b>	<b>12.8 (6)</b>	<b>12.8 (6)</b>
<b>Chinese Asian</b>	<b>4.6 (2)</b>	<b>2.1 (1)</b>
<b>Caribbean</b>	<b>17 (8)</b>	<b>14.9 (7)</b>
<b>Mixed race</b>	<b>12.8 (6)</b>	<b>8.5 (4)</b>

**Table 4.1.1.4B: Ethnic groups in 1986 birth cohort, and proportions failing to thrive at 12 months of age**

Ethnic group	Proportion in birth cohort		Nonorganic failure to thrive at 12 months (% of ethnic group at risk)	
	N	(%)	N	(%)
White UK	905	(58.2)	26	(2.9)
Other white	28	(1.8)	0	(0.0)
Mediterranean	49	(3.2)	0	(0.0)
Indian asian	47	(3.0)	7	(14.9)
Chinese asian	57	(3.7)	2	(3.5)
African	169	(10.9)	0	(0.0)
Caribbean	170	(10.9)	8	(4.7)
Mixed race	129	(8.3)	6	(4.7)
<b>Total</b>	<b>1554</b>	<b>(100.0)</b>	<b>49</b>	<b>(3.2)</b>

\* Full term singletons, birthweight above 3rd population centile on national growth standards (Tanner and Thompson, 1970) only.



cases were shorter than those of comparisons; means 157.3 cm (SD 6.7) and 161.7 cm (SD 8.1) ( $t= 3.6$ ,  $df 46$ ,  $p<0.001$ ). Fuller information on the anthropometry of parents is given on Table 4.1.2.1.

#### 4.1.2.2 *Infant anthropometry at birth*

Data on anthropometric characteristics of case and comparison infants at birth are given on Table 4.1.2.2A and 4.1.2.2B. No significant differences between the case and comparison groups existed in standardised birthweights ( $t=1.47$ ;  $df 46$   $p=0.18$ ). Information has been found in birth records about length and head circumference for over 90% of both case and comparison infants.

There was a tendency for the distribution of the cases' and comparisons' anthropometric indices at birth to differ in respect of all 3 variables shown on Table 4.1.2.2B. 'Non-organic' failure to thrive subjects had a significantly higher ponderal index at birth (mean 2.4; SD 0.4) than comparisons (mean 2.3; SD 0.3) ( $t=2.24$ ,  $df 37$ ,  $p=0.03$ ).

Lengths and head circumferences at birth were converted into standard deviation scores, and standardized for gestation and gender. There were significant differences between the groups in terms of length, the comparisons (mean 0.74; SD 1.3) being longer than the cases (mean -0.01; SD 1.3) ( $t= 3.14$ ,  $df 37$   $p=0.003$ ). The comparisons also had larger head circumferences (mean -0.46; SD 1.3) than cases (mean -1.24; SD 0.94) ( $t=3.56$ ;  $df 42$   $p=0.001$ ). Because data were not available for all subjects on each of these variables

**Table 4.1.2.1: Anthropometric characteristics of the parents of case and comparison subjects**

	Cases			Comparisons		
	Mean	SD	(N)	Mean	SD	(N)
<b><u>MOTHER</u></b>						
Age	27.6	5.3	47	26.7	5.9	47
Height (cm)**	157.3	6.6	47	161.7	8.1	47
Weight (Kg)♦	57.8	11.6	42	62.4	12.1	46
<b><u>FATHERΦ</u></b>						
Age						
Height (cm)	172.9	9.7	47	173.8	7.3	46
Weight (Kg)	71.2	11.8	41	75.2	12.3	43

♦ A small proportion of mothers in both groups refused to be weighed. This introduced some bias, as the refusals were in all cases women who were substantially overweight.

\*\*  $p < 0.01$

Φ These anthropometric data were estimated by mothers. In some cases they were unable to provide an informed estimate.

Table 4.1.2.2A:

## Anthropometry of case and comparison infants at birth†

Variable	Pairs♦	Cases mean (SD)	Comparisons mean (SD)
Weight (gms)	47	3048 (354)	3161 (378)
Head (Occipito-frontal) circumference (cms) **	34	33.4 (1.3)	34.3 (1.4)
Length (cms)	25	50.7 (2.5)	51.7 (3.1)
Ponderal Index	23	2.38 (0.4)	2.28 (0.3)
Velocity of head circumference growth since birth (cm/yr.)	34	10.2 (1.47)	10.8 (1.24)

† There are no significant differences between groups on any variables, except where shown.

♦ Paired T-tests were used, on varying Ns, according to the availability of relevant data.

\*\*  $p < 0.01$

Table 4.1.2.2B:

## Anthropometric characteristics of cases and comparisons at birth, from birth records

Centile channel	Ponderal index				Length				Head circumference			
	Cases		Comparisons		Cases		Comparisons		Cases		Comparisons	
	N	(%)	N	(%)	N	(%)	N	(%)	N	(%)	N	(%)
> 97	5	(11.9)	1	(2.4)	6	(14.3)	10	(23.8)	0	(0.0)	2	(4.5)
90 - 96	1	(2.4)	2	(4.8)	8	(19.0)	10	(23.8)	0	(0.0)	0	(0.0)
50 - 89	6	(14.3)	6	(14.3)	11	(26.2)	12	(28.6)	6	(13.3)	12	(27.3)
10 - 49	13	(31.0)	11	(26.2)	10	(25.6)	4	(9.5)	17	(37.8)	22	(52.3)
3 - 9	5	(11.9)	4	(9.5)	2	(4.8)	2	(4.8)	8	(17.8)	2	(4.5)
< 3	12	(28.6)	18	(42.9)	5	(11.9)	4	(9.5)	14	(31.1)	5	(11.4)
Total	42		42		42		42		45		44	

the number of pairs entering the pairwise analysis is often less than 47. The pairwise matching for the above analysis led to a few subjects for whom we had missing data being excluded.

The distributions of birthweights, of birth lengths, of birth head circumferences and of ponderal indices at birth - all measured in standard deviation scores - are shown, in comparison with a normal distribution curve, on Figures 4.1.2.2A to 4.1.2.2H.

### 4.1.3 Infant medical history

#### 4.1.3.1 *Antenatal and perinatal history*

The antenatal and perinatal risk scores were very similar in both the cases and the comparisons, using the modified Gillberg et al (1990) scoring system. The mean for cases was 1.72 (SD 1.67) and that for the comparisons was 1.83 (SD 1.3). These were far lower than the total possible score of 29, of the scale employed indicating that most births were without any significant complication. Examples of individual risk factors which were used to compute the total antenatal and perinatal risk score for case and comparison subjects are shown on Table 4.1.3.1.

#### 4.1.3.2 *Early medical history*

Mothers were interviewed at home about their infant's medical histories. Twice as many case infants as comparisons (29.8%: 14 vs. 15.2%:7) had been admitted to hospital

Table 4.1.3.1: Examples of individual risk factors used to compute total antenatal and perinatal risk score for case and comparison subjects\*

Antenatal or perinatal risk factor	Cases % (N)	Comparisons % (N)
<b><u>Maternal Factors</u></b>		
Vaginal bleeding during pregnancy	11.1 (5)	8.5 (4)
Severe infection during pregnancy (eg, Rubella, Herpes)	2.1 (1)	0
Albuminuria with high BP (i.e., systolic > 140, diastolic > 90)	6.6 (3)	6.6 (3)
Diabetes	2.1 (1)	4.3 (2)
Epilepsy	0	0
<b><u>Infant Factors</u></b>		
Fetal distress	4.9 (2)	2.3 (1)
Meconium staining of amniotic fluid	8.9 (4)	19.6 (9)
Placental weight outside normal range (342-530gm)	2.1 (1)	0
Apgar score < 8 at 1 min	29.8 (14)	29.8 (14)
< 8 at 5 min	2.1 (1)	8.5 (4)
< 8 at 10 min	2.1 (1)	0

\* there are no significant differences between the subgroups on any of the above variables.

Not all data were available for all subjects; % refer to the proportion of valid cases.

Figure 4.1.2.2a

Weight at birth (SDS) - cases

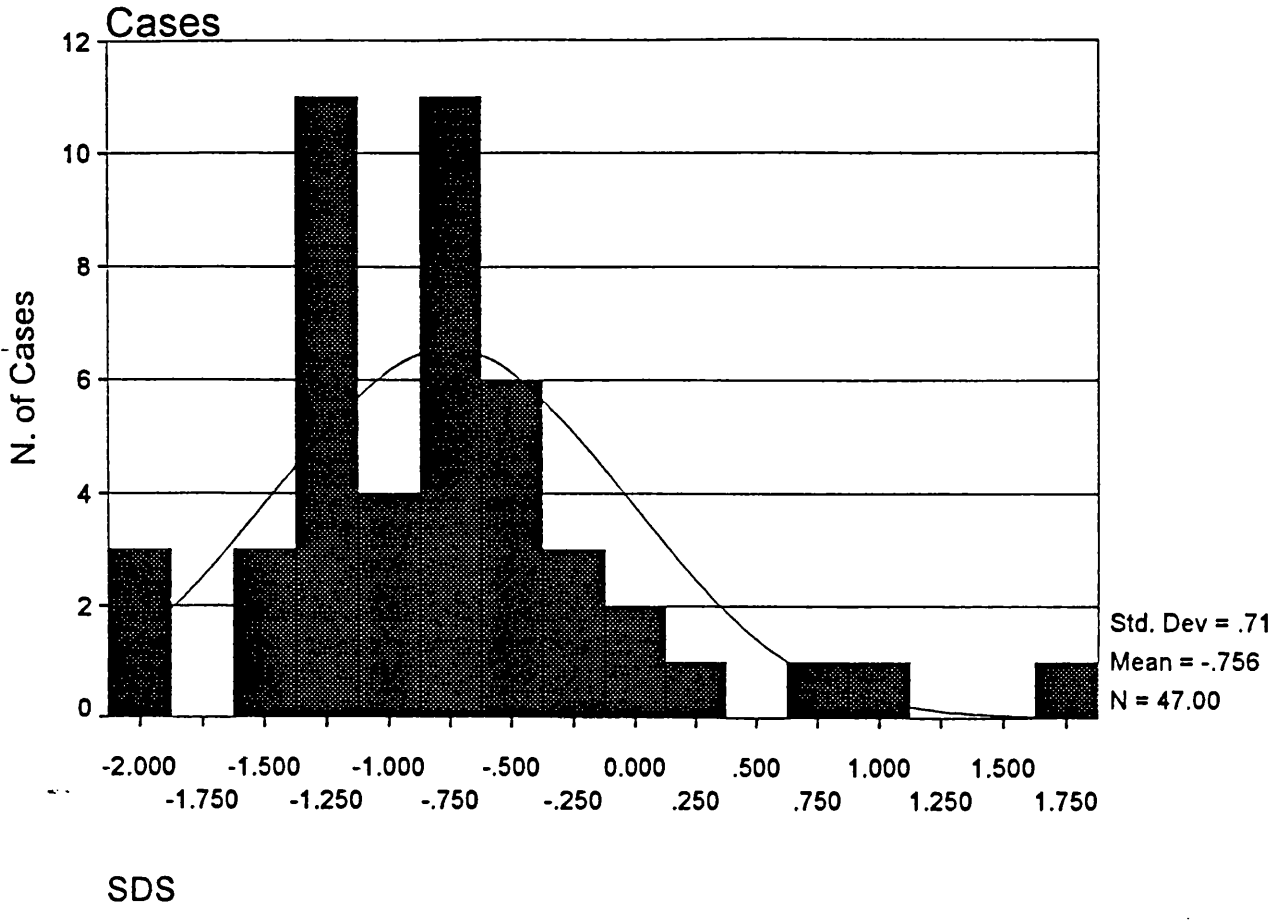


Figure 4.1.2.2b

Weight at birth (SDS) - comparisons

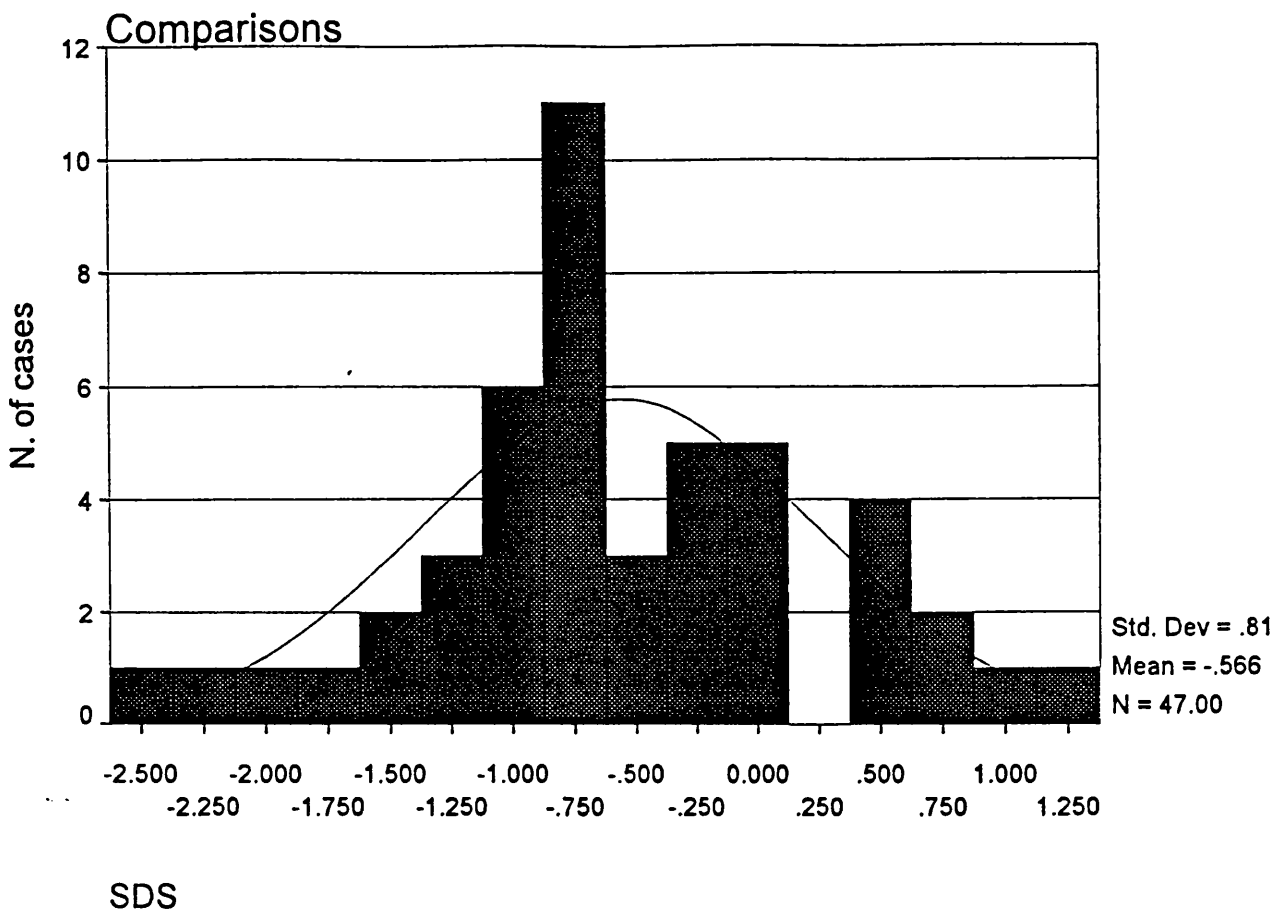




Figure 4.1.2.2c

Length at birth (SDS) - cases

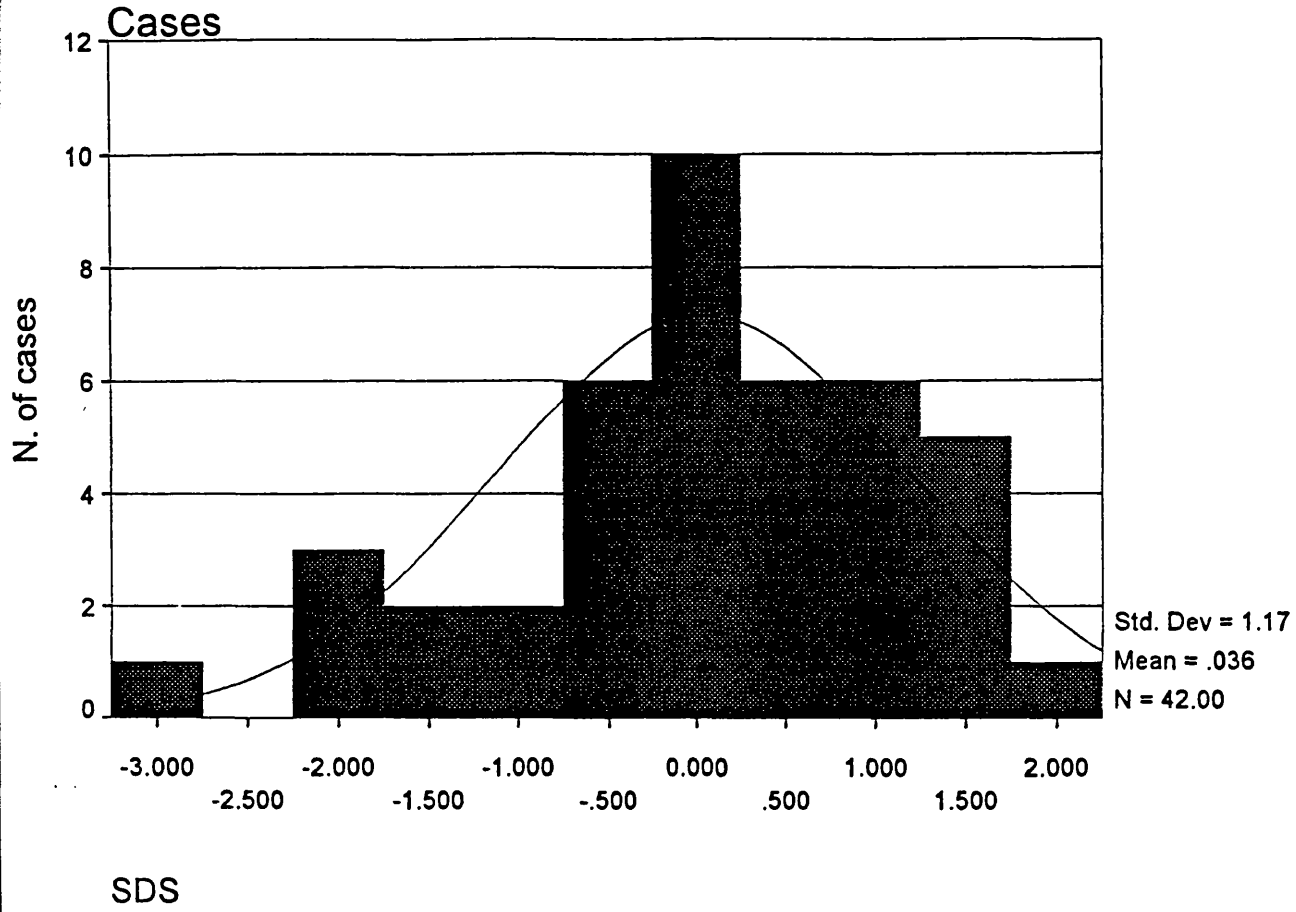


Figure 4.1.2.2d

Length at birth (SDS) - comparisons

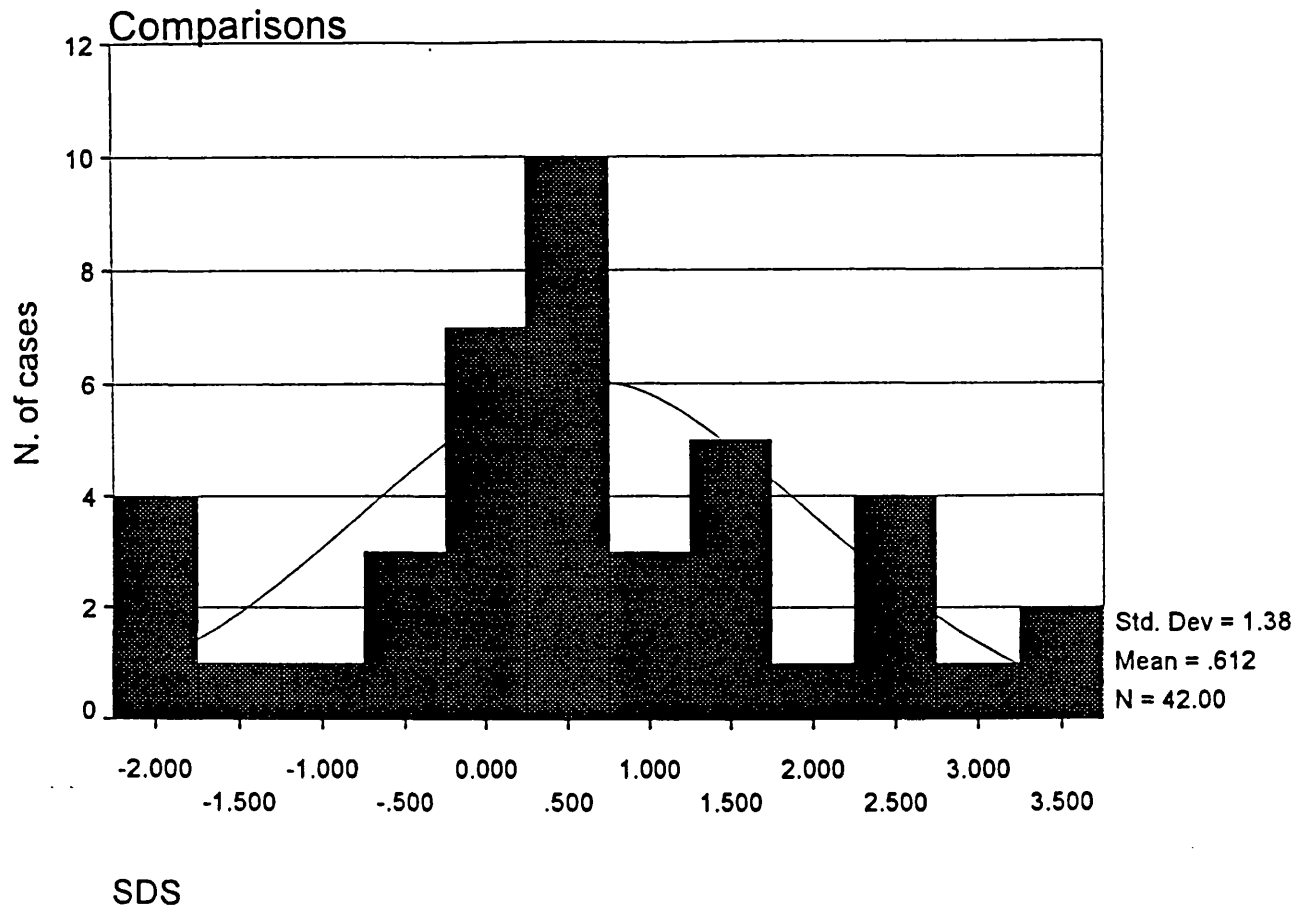


Figure 4.1.2.2e

Ponderal index at birth (SDS) - cases

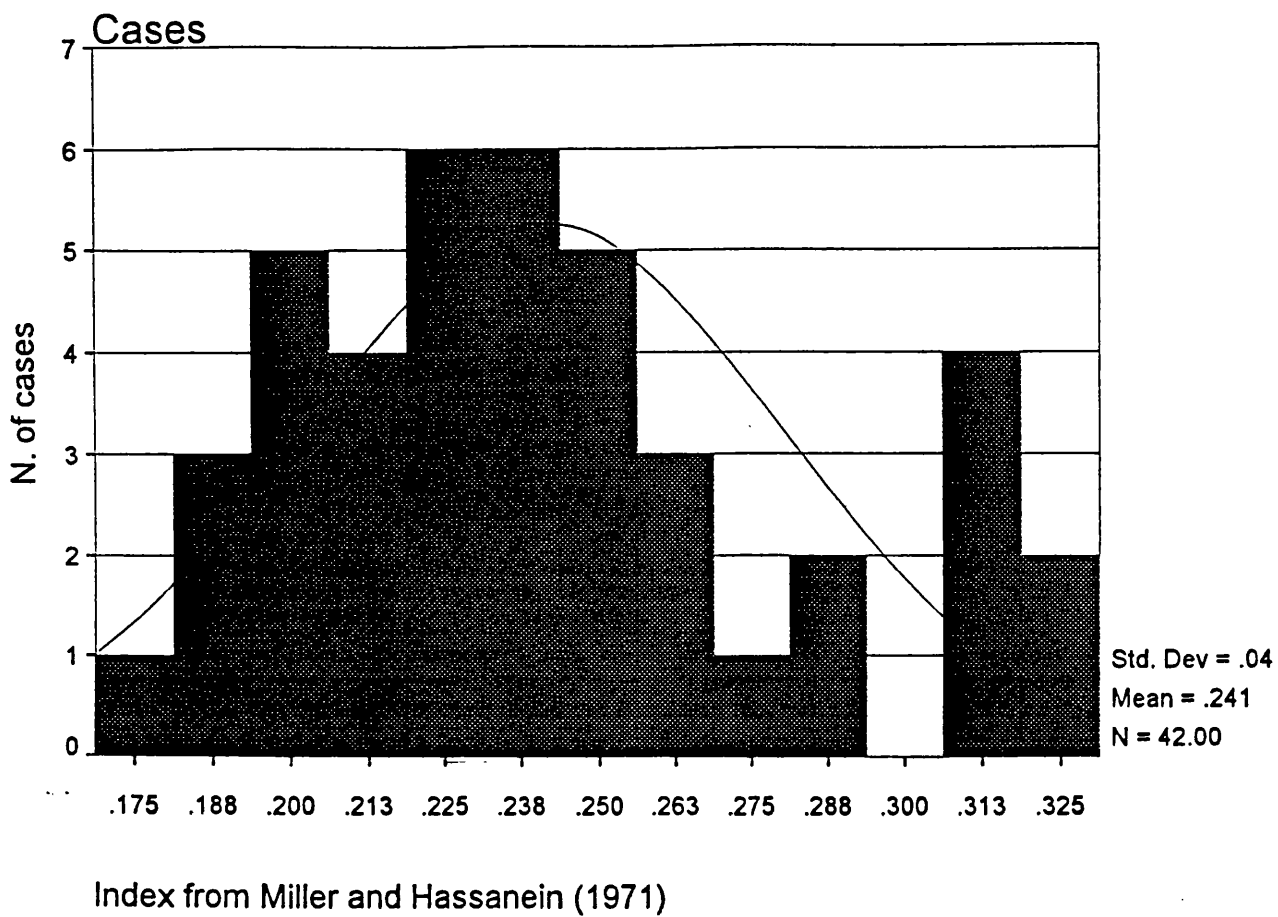


Figure 4.1.2.2f

Ponderal index at birth (SDS) - comparisons

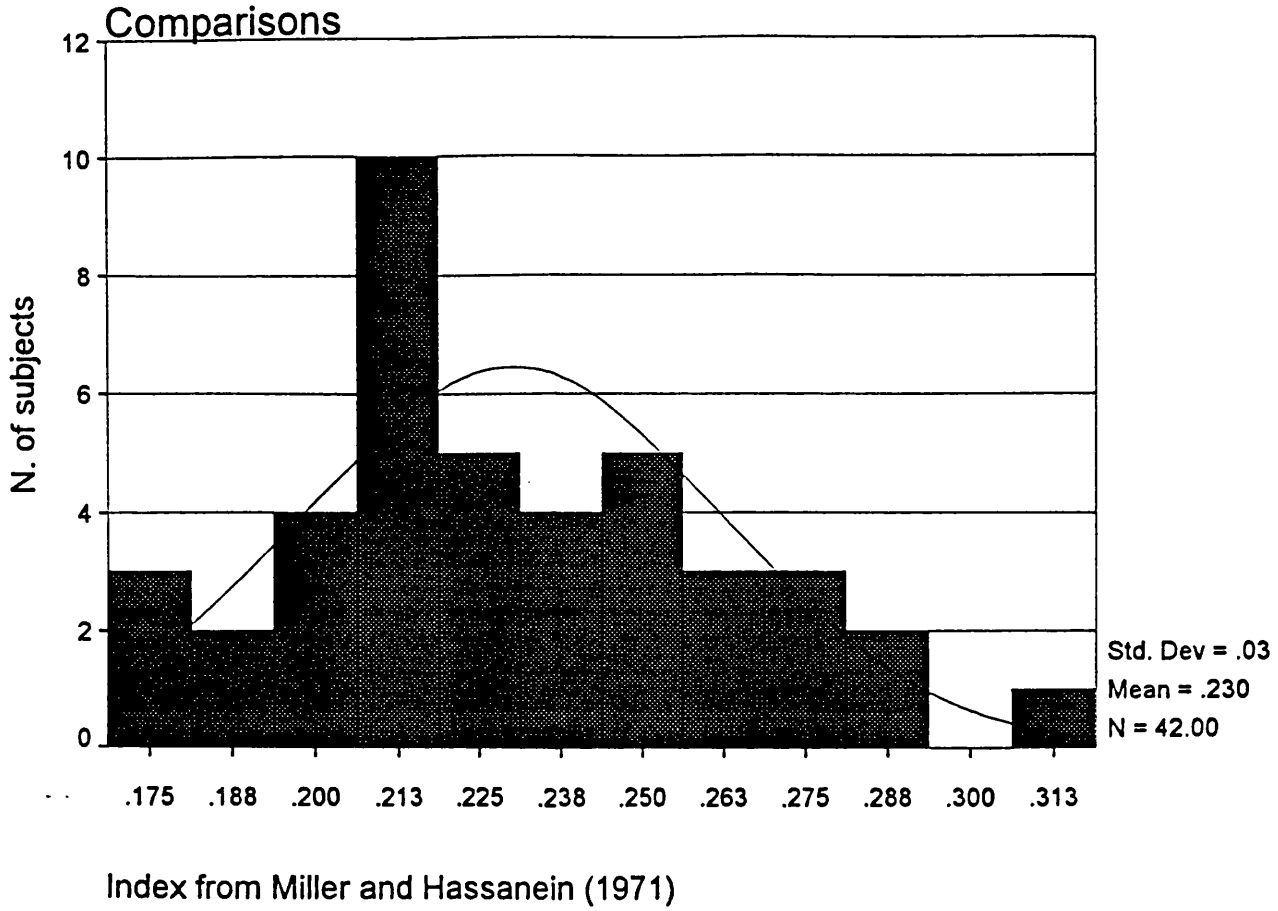


Figure 4.1.2.2g

Head circumference at birth (SDS) - cases

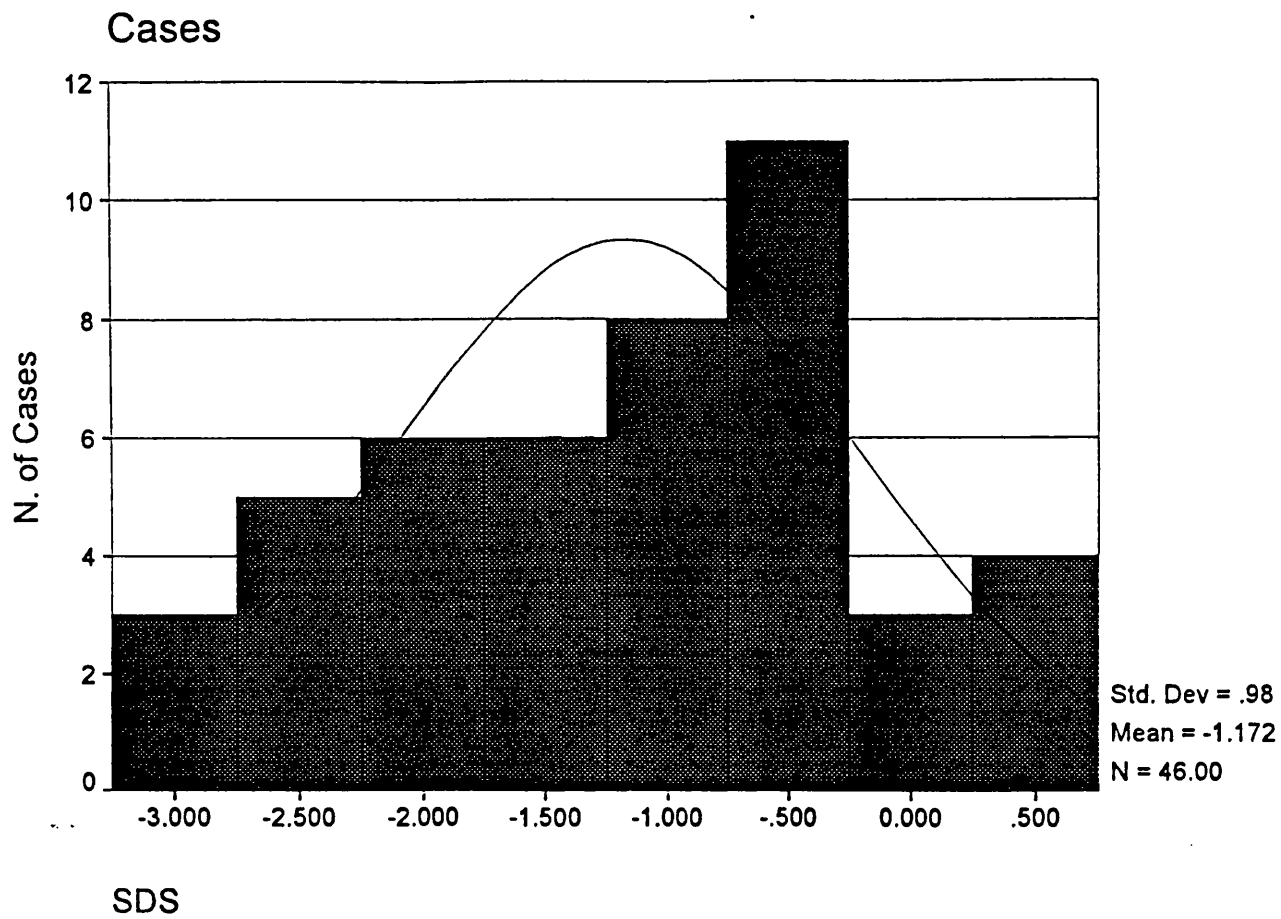
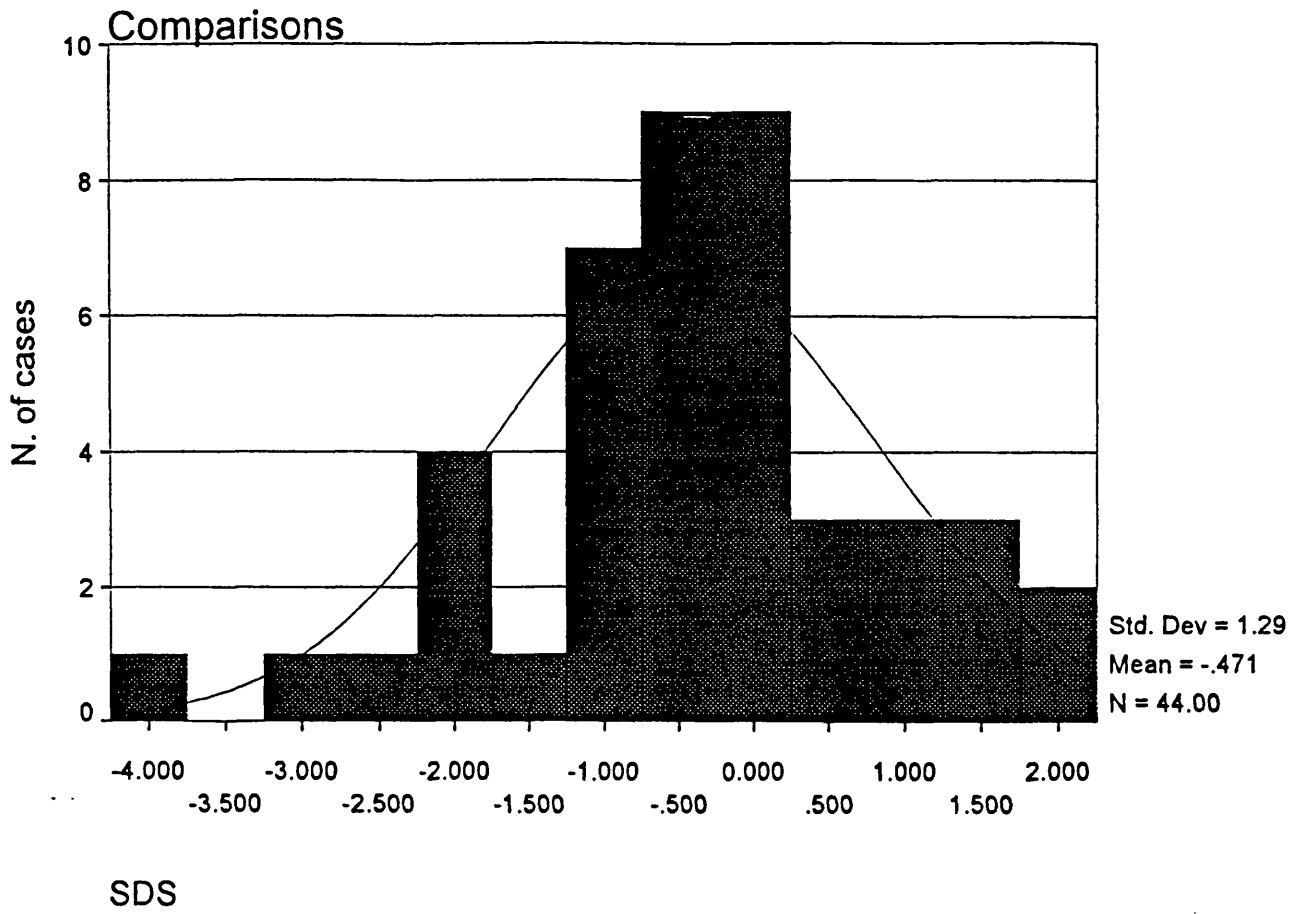


Figure 4.1.2.2h

Head circumference at birth (SDS) - comparisons



(McNemar  $p=0.17$ ) but similar proportions had attended an emergency room (39.1% : 18 vs. 41.3% : 19) or been to an outpatient clinic (36.9% : 17 vs. 26.1% : 12). Their histories of attendance at child health centers were also similar, with 89.4% (42) of cases and 85.1% (40) of comparisons being taken on at least 3 occasions in the first postnatal year. No differences were reported in the frequency of intercurrent illnesses, such as upper respiratory tract infections, otitis media, gastroenteritis, or persistent episodes of diarrhea and/or vomiting. The great majority of cases (91% : 43) and comparisons (96% : 45) had been given at least one medical prescription by their family doctor within the past year.

Proportions of infants with minor physical disorders, reported by mothers for the first postnatal year, are shown on Table 4.1.3.2.

#### 4.1.4 Postnatal feeding history

Although the study design precluded contemporaneous measurement of postnatal feeding, mothers' retrospective accounts of their early feeding practices did distinguish cases from comparisons. We examined the hypothesis that a proportion of case infants may have been failing to thrive at the breast (Habbick & Gerrard, 1984). Relatively more case mothers (72.3% : 34) started to breast feed than comparisons (61.7% : 29) and they breast fed for longer, a mean of 20.9 (SD 18.5) weeks compared with 12.9 (SD 15.1) weeks ( $P=0.06$ ).

A multiple regression analysis of postnatal standardized weights within the case group, using exclusive breast feeding as an explanatory variable, found that this was if anything associated

**Table 4.1.3.2: Proportions of infants with minor physical disorders, reported by mothers, in the first postnatal year\***

<b>Examples of Disorder</b>	<b>Cases % (N)</b>	<b>Comparisons % (N)</b>
Neonatal jaundice requiring treatment	6.8 (3)	6.8 (3)
Convulsions after 2 weeks of age	4.4 (2)	6.8 (3)
At least one episode of diarrhoea	65.2 (30)	60.9 (28)
At least one episode of vomiting	47.8 (22)	41.3 (19)
Loose bulky stools	26.7 (12)	13.3 (6)
> 5 upper respiratory tract infections	47.8 (22)	41.3 (19)

\* There are no statistically significant differences between the groups on any of these variables



with a better than average rate of weight gain. (This matter is considered in greater detail in para 5.5).

A further explanatory variable in the same analysis concerned mother's reports of whether their infant ever slept through feeds. Although similar proportions of infants from both groups were reported as tending to sleep through feeds (cases 66% : 31; comparisons 49% : 23) the proportions of mothers who said they rarely, if ever, insisted on waking their infant, or persisted with the feeds in those circumstances differed considerably (cases 83.3% : 39; comparisons 16.7% : 8 ;  $P < 0.01$ ).

X

## 4.2 Outcome: Infant

### 4.2.1 Anthropometry

Case and comparison infants were identified from weights that had been recorded during their attendances at Child Health clinics during the first few postnatal months. These records were duplicated and supplied to David Skuse, who monitored the growth of all 2610 infants in the birth cohort who attended for weighings. He followed up all those who were potentially faltering in their weight gain trajectories ( $n=97$ ), and personally examined them. There were 52 confirmed cases of failure to thrive.

Weights used to compute growth trajectories comprise data from three sources. First, the records of the child's birth weight, from the original birth records, which were examined by Dorothy Gill - a member of the survey team. Secondly, the weights recorded by clinic nurses at Child Health clinics. Thirdly, the weight of the child at the time of follow-up, usually

around 15 months of age, which was measured personally according to the procedure outlined in para. 3.2.1.

The weight gain trajectories of both groups, from birth to 15 months, were computed from these data and plotted. The mean weight gain trajectories for cases and comparisons are shown in Figure 4.2.1A. At follow-up all infants were examined at similar ages; cases at a mean age of 14.6 months (SD 1.4) and comparisons at a mean age of 14.2 months (SD 1.44). As can be seen from Table 4.2.1A there were considerable differences in both weight, length, weight for length and head circumference between the groups. There was a marked tendency for infants in the case group to be underweight for their length; 93% (44) of case infants were underweight for their length by at least -1.88 SD, whereas this was not so for any of the comparisons (Table 4.2.1B).

Other anthropometric indices also distinguished the groups at follow-up (Table 4.2.1C). More than 3 out of 4 cases were suspected of having some degree of protein-caloric malnutrition (PCM), on the basis of the ratio of their mid-upper arm circumference to their head circumference (MUAC:HC ratio) (Kanawati and McLaren, 1970)..

Table 4.2.1A: Outcome anthropometric data for cases and comparisons

Outcome	Cases n = 47		Comparisons n = 47	
	mean	(SD)	mean	(SD)
Age at examination (mths)	14.6	(1.40)	14.2	(1.40)
Standardised weight	-2.09	(0.48)	0.09	(1.01)***
Standardised length	-1.27	(0.94)	0.18	(0.73)***
Standardised weight for length	-1.67	(0.63)	0.09	(1.12)***
Standardised head circumference	-0.88	(0.99)	0.25	(0.93)***

\*\*\* p < 0.001

**Table 4.2.1B: Anthropometry of cases and comparisons in Standard Deviation scores**

	Length		Weight		Weight for Length	
	N	(%)	N	(%)	N	(%)
<b>Cases</b>						
+2.00 or more	0	(0.0)	0	(0.0)	0	(0.0)
+1.99 - +1.00	0	(0.0)	0	(0.0)	0	(0.0)
+0.99 - -0.99	18	(38.3)	0	(0.0)	5	(10.6)
-1.00 - -1.99	21	(44.7)	25#	(53.2)	28	(59.6)
-2.00 or more	8	(17.0)	22	(46.8)	14	(29.8)
<b>Comparisons</b>						
+2.00 or more	1	(2.1)	2	(4.3)	3	(6.4)
+1.99 - +1.00	5	(10.6)	6	(12.8)	5	(10.0)
+0.99 - -0.99	39	(73.0)	33	(70.2)	29	(61.7)
-1.00 - -1.99	2	(4.3)	6	(12.8)	10	(21.3)
-2.00 or more	0	(0.0)	0	(0.0)	0	(0.0)

The distribution of weights for age at 12 to 15 months is approximately normal (Tanner, 1989). Probabilities under various parts of the normal distribution can thus be summarised by an age independent measure. For example, 15.9% of a normal population are more than one SDS below the mean (50th centile), 2.3% are more than two SDS below the mean.

# scores were all in the range -1.88 ( $\cong$  3rd centile) to -1.99 SDS

Table 4.2.1C: Anthropometric Indices of Nutritional Status† at outcome

	Cases n (%)	Comparisons n(%)
<b>Mid upper arm circumference (mm)***</b>		
> 13.5	23 (48.9)	47 (100.0)
12 - 13.5	23 (48.9)	0
< 12.0	1 (2.1)	0
<b>Triceps skinfold (centile)</b>		
> 50	2 (4.5)	8 (17.0)
3 - 49	38 (80.9)	39 (83.0)
< 3	7 (14.9)	0
<b>Arm muscle area (centile)***</b>		
> 50	0	33 (70.2)
5 - 49	47 (100.0)	14 (29.8)
< 5	0	0
<b>Mid upper arm circumference: head circumference ratio***</b>		
<b>Healthy</b>		
> 0.31	11 (23.4)	40 (85.1)
<b>Mild PCM</b>		
0.31-0.28	32 (68.1)	6 (12.8)
<b>Moderate PCM</b>		
0.28-0.25	4 (8.5)	1 (2.1)
<b>Severe PCM</b>		
< 0.25	0	0

\*\*\* A chi-square test of association between group status and nutritional status with the categories combined, where appropriate, to eliminate low expected frequencies) was highly significant  $p < 0.001$

† PCM = Protein-Calorie Malnutrition (Kanawati and McLaren, 1970)

Figure 4.2.1a Growth trajectories of weight gain of non-organic failure to thrive infants and a comparison group, from birth to follow-up examination, expressed in standard deviation scores: 95% confidence intervals for mean weights are given

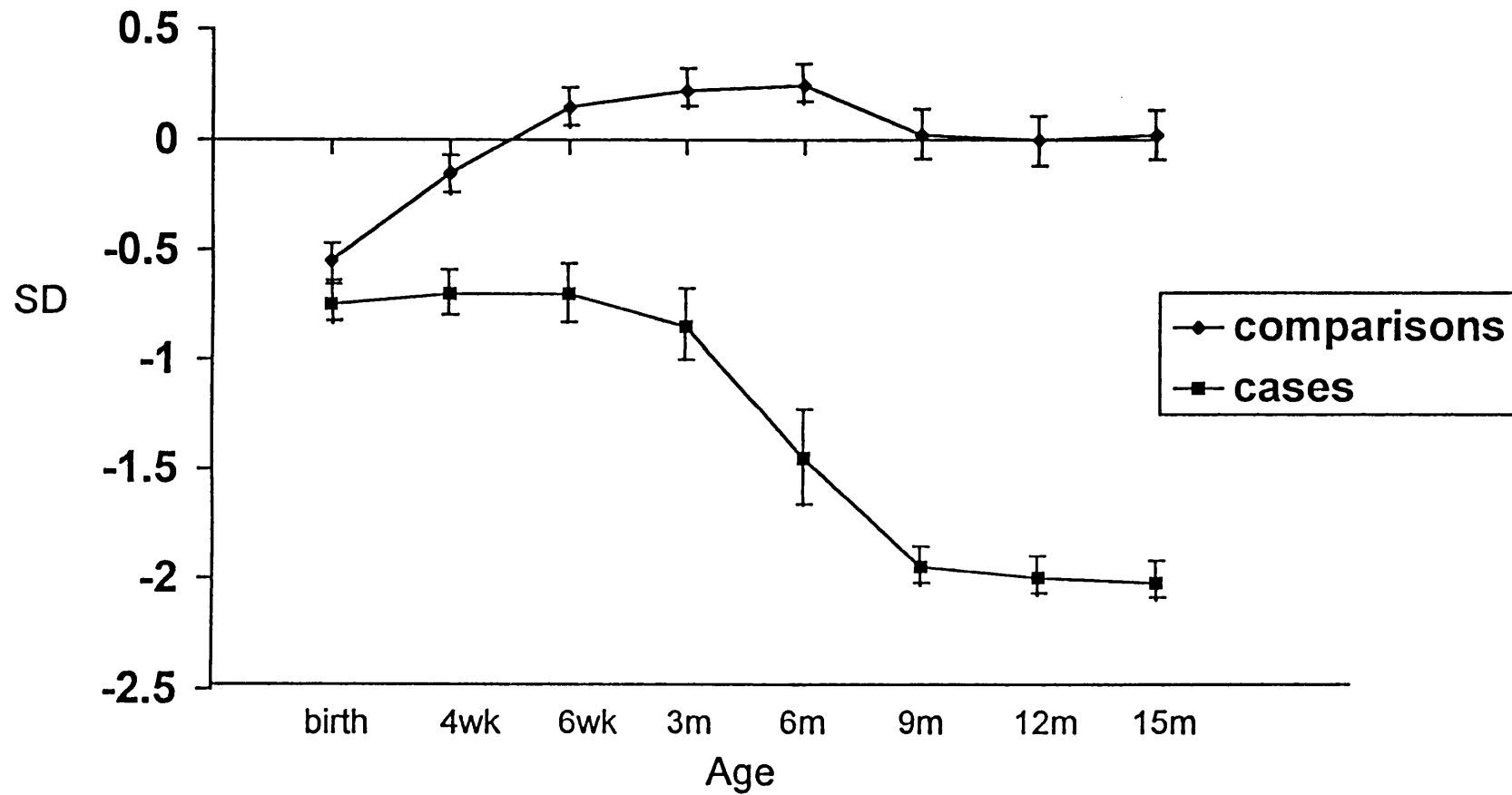


Figure 4.2.1b Weight at outcome (SDS) - cases

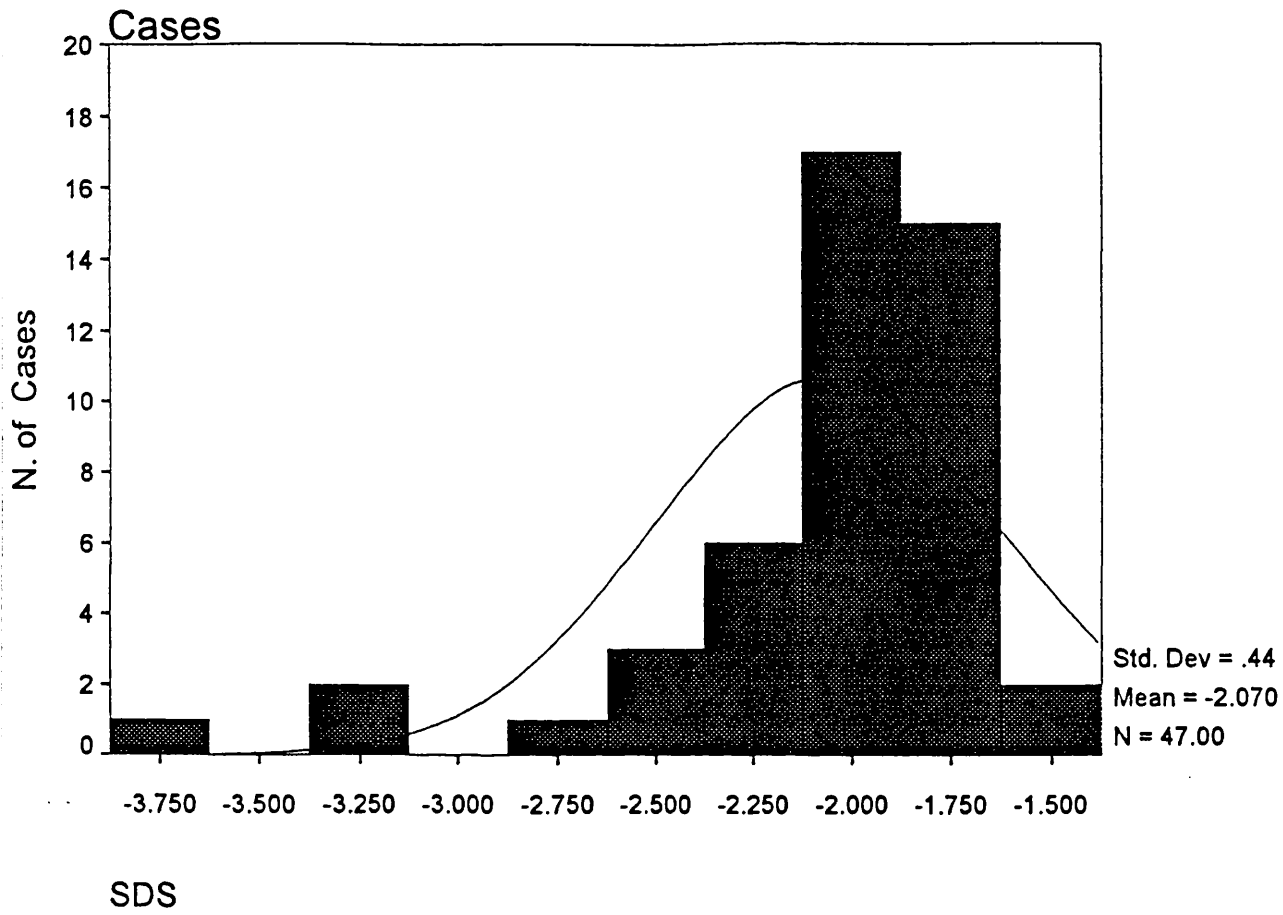


Figure 4.2.1c Weight at outcome (SDS) - comparisons

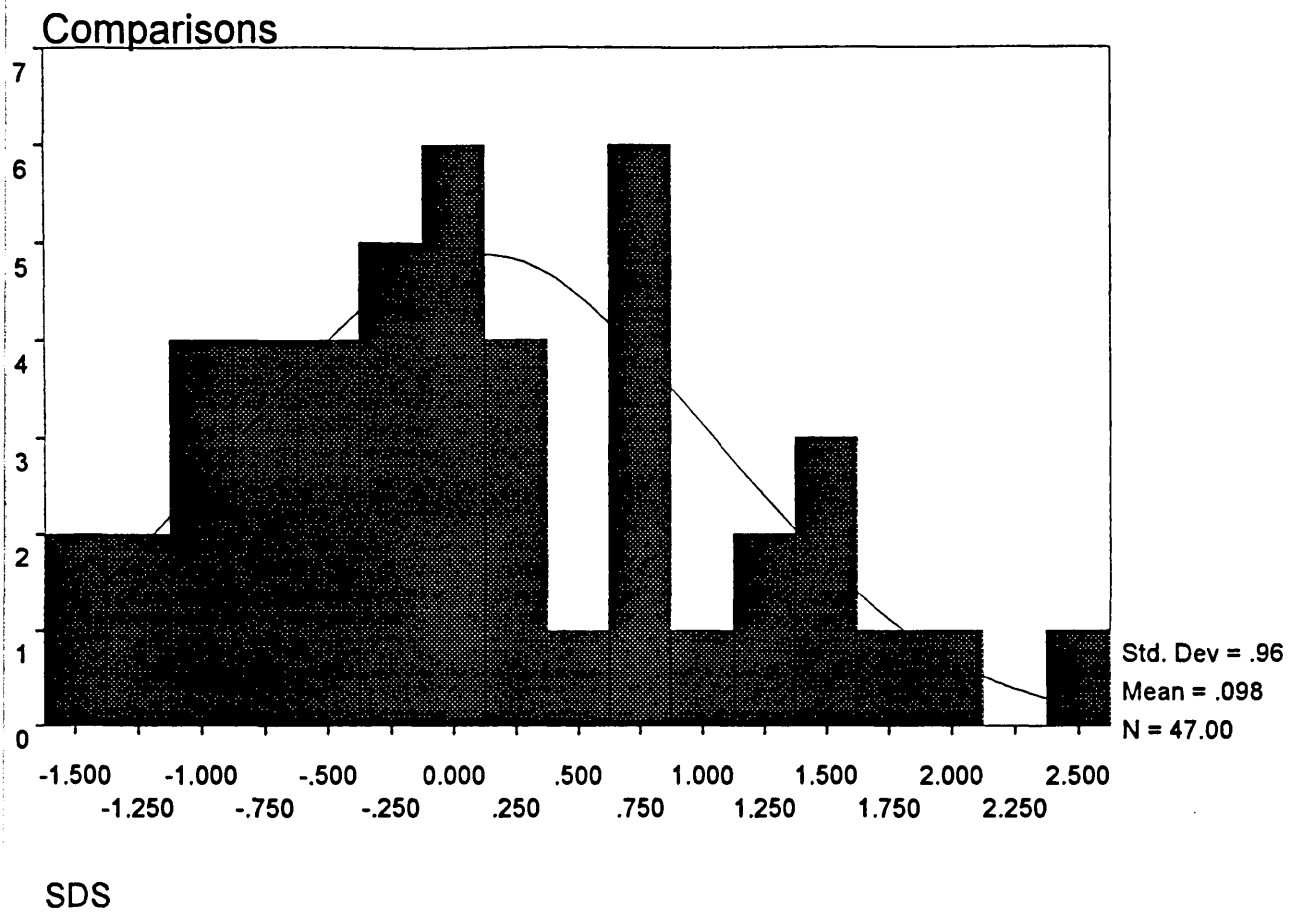




Figure 4.2.1d Length at outcome (SDS) - cases

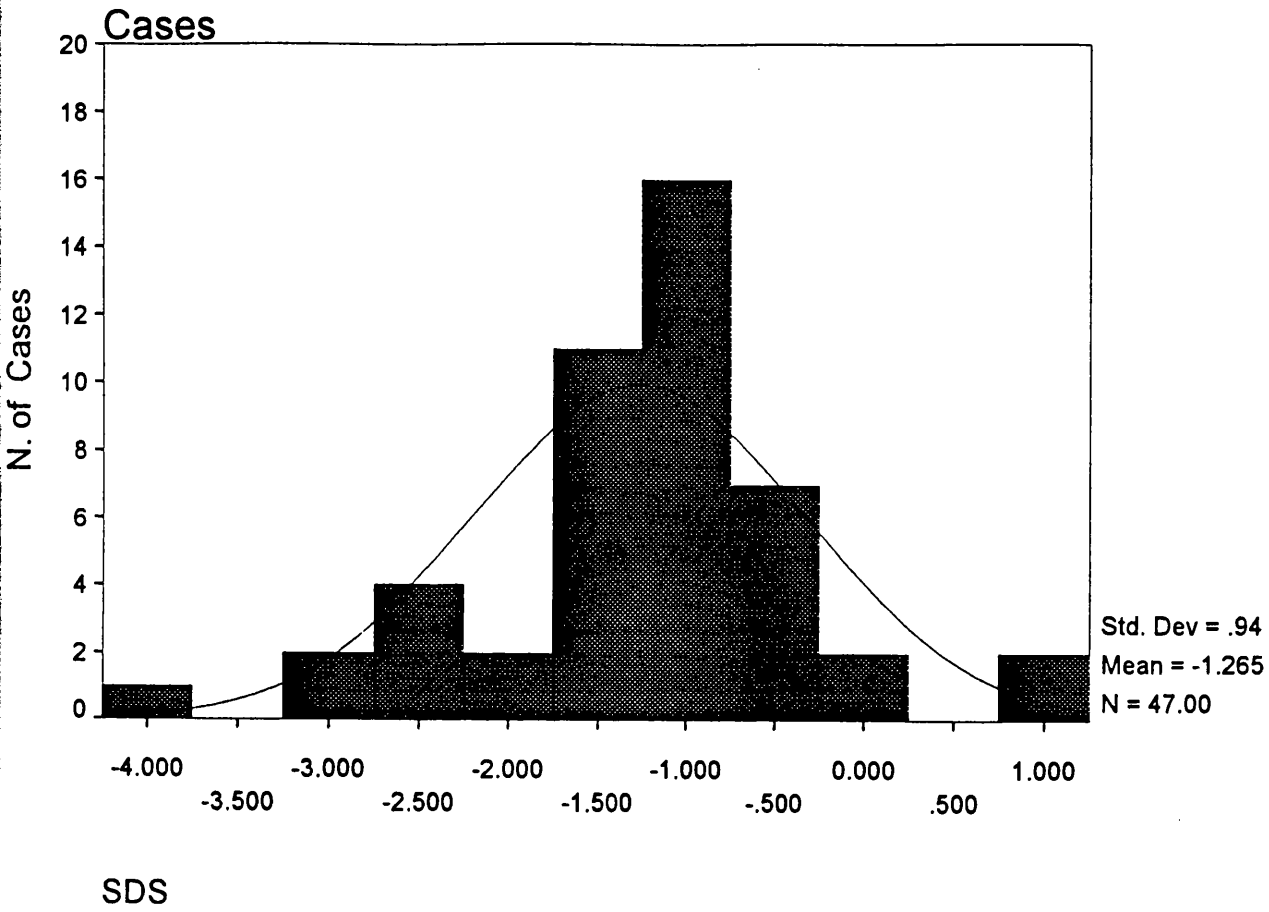


Figure 4.2.1e Length at outcome (SDS) - comparisons

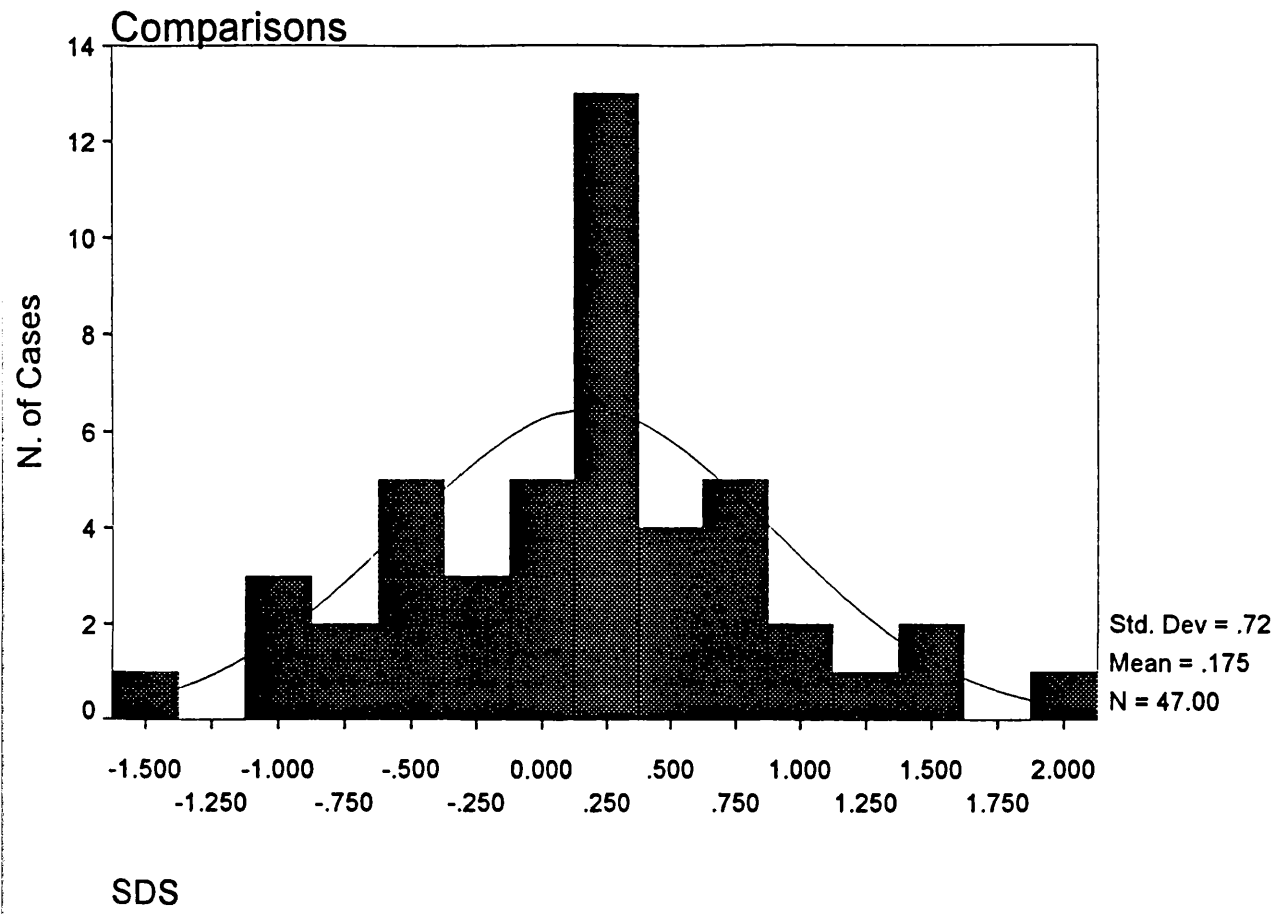


Figure 4.2.1f Weight for length at outcome (SDS) - cases

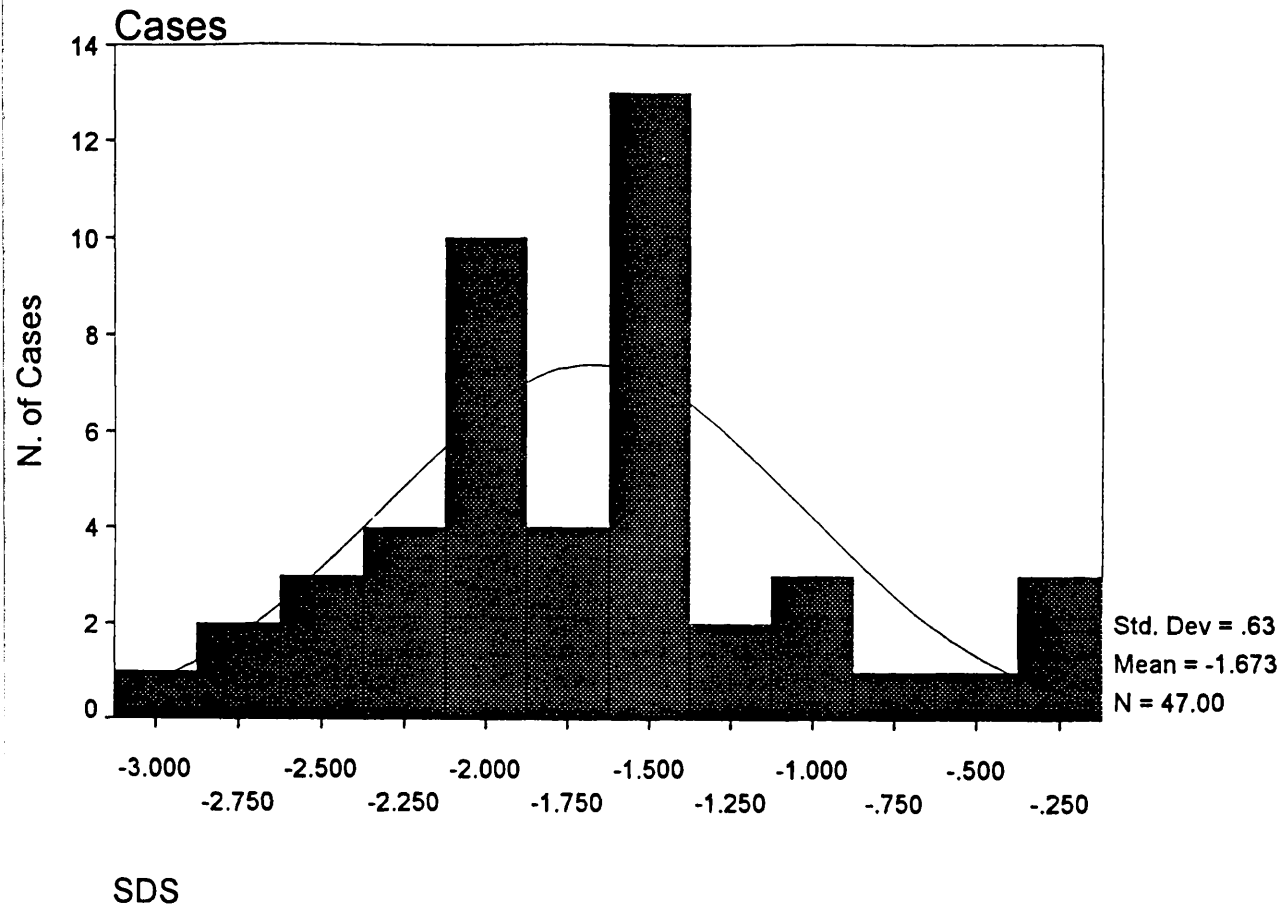


Figure 4.2.1g Weight for length at outcome (SDS) - comparisons

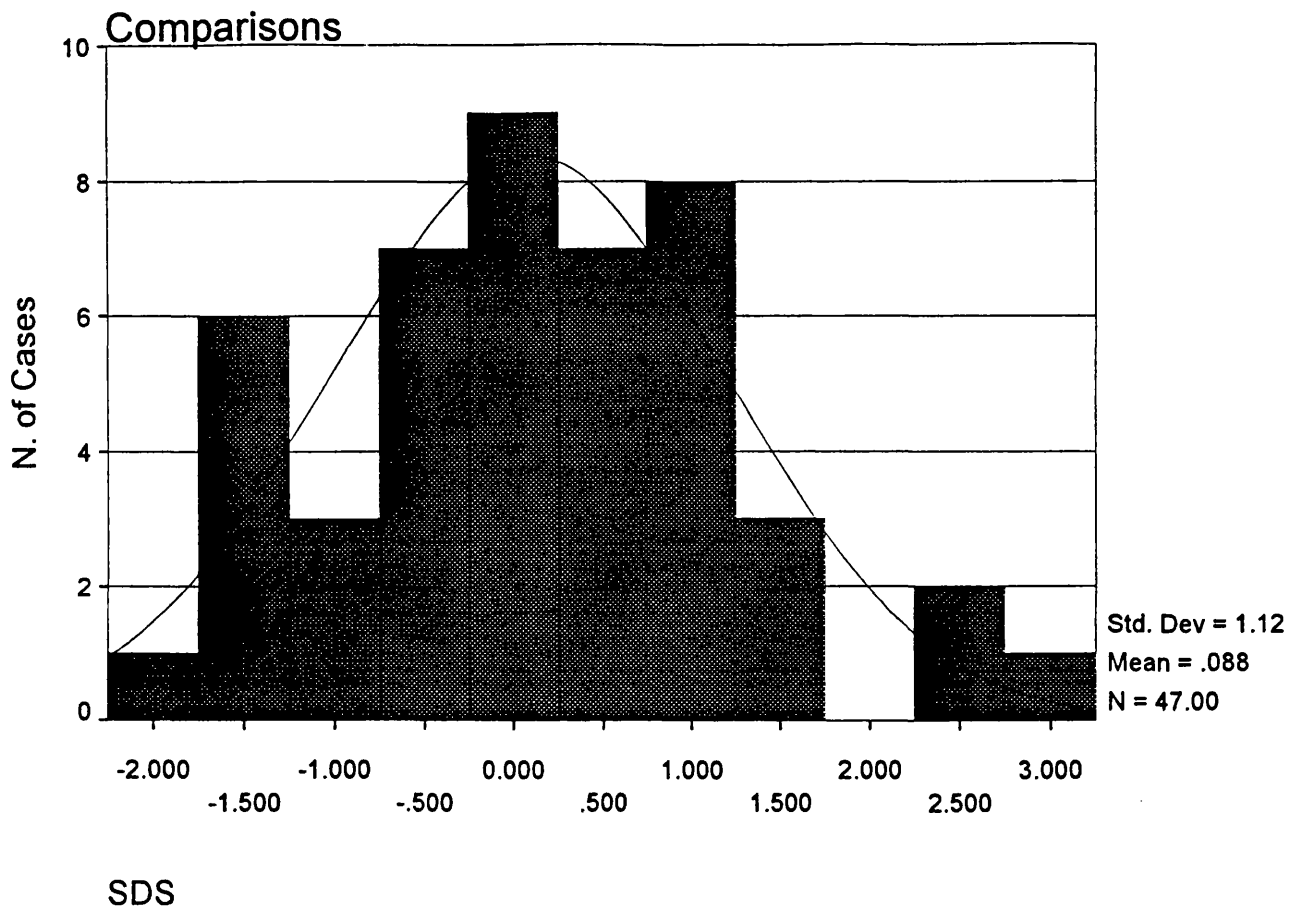


Figure 4.2.1h Head circumference at outcome (SDS) - cases

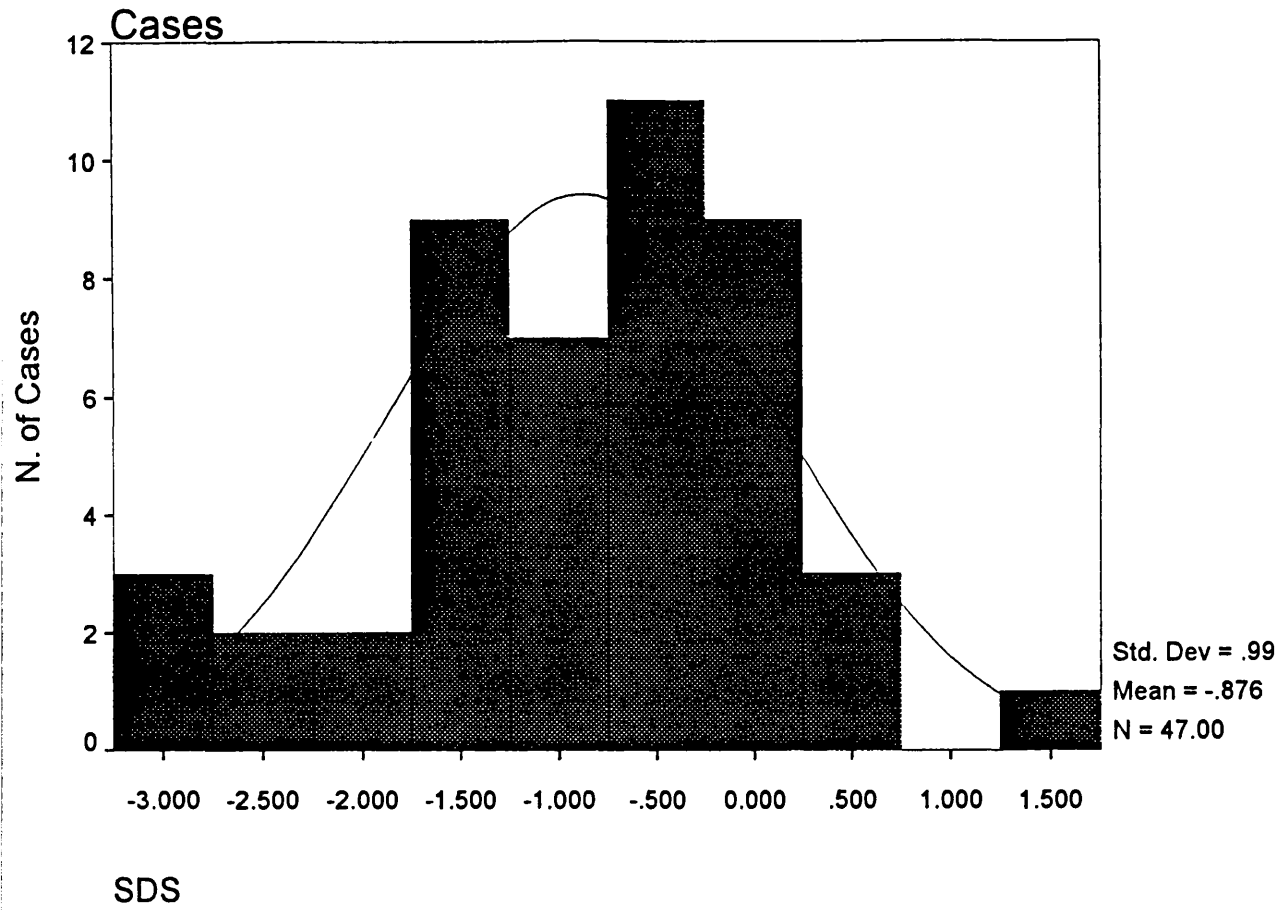
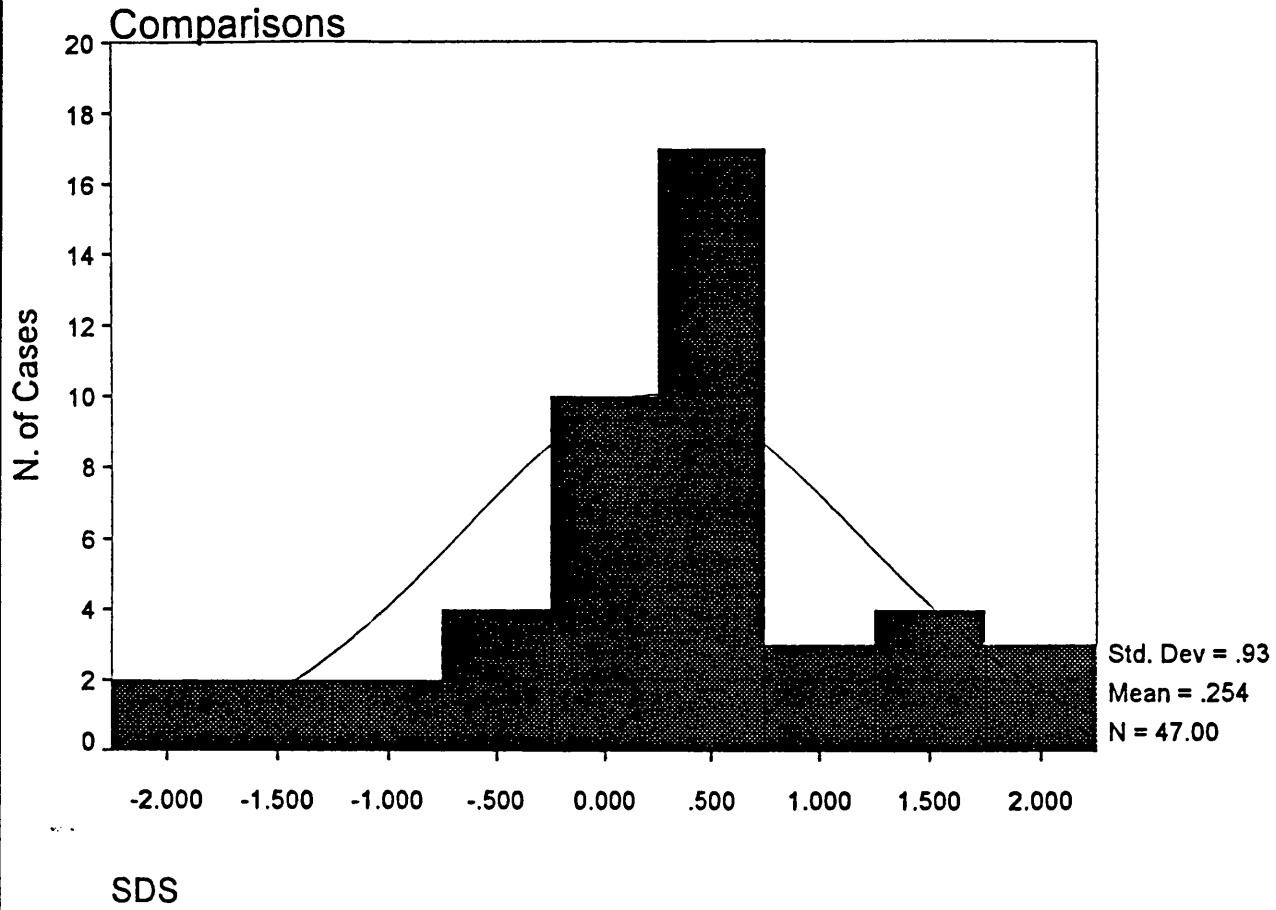


Figure 4.2.1I Head circumference at outcome (SDS) - comparisons



#### 4.2.1.1 *Other physical examination*

Physical anomalies that could be entered into the computation of a congenital anomaly score (Waldrop, Pederson and Bell, 1968; Waldrop and Halverson, 1971) were sought in the course of physical examinations. The weighted mean total scores found were, for the cases 2.00 (SD 2.36) and for the comparisons 0.89 (SD 0.89). These are lower than Waldrop et al (1968) found in a normal pre-school population (males mean = 2.24, SD 2.08; females mean = 2.00, SD 1.98). Nevertheless, taking a cut off point of 2 or less and 3 or above there was a statistically significant tendency for cases to have higher scores ( $X^2 = 8.28$ ,  $p = 0.004$ ).

A composite score comprising five variables that related to the appearance of the children - whether skin and nails were clean or dirty, whether burns or scars were visible, and whether extremities were red, puffy or shiny in appearance - also strongly distinguished between the groups (cases mean = 0.8, SD 1.1, controls mean = 0.3, SD 0.7,  $t = 2.74$ , d.f. 45,  $p = 0.009$ ). This finding is in line with the report of Glover, Nicholl and Pullan (1985).

#### 4.2.2 *Physiological evidence of malnutrition*

Hematological indices showed a high proportion of subjects in both groups had some degree of anaemia. The World Health Organization has proposed that a haemoglobin count of less than 11g/dl may be used to identify anaemia in children between the ages of 6 months and 6 years (World Health Organization, 1972). By this criterion (25.5% : 12) of cases and (23.9% : 11) of comparisons were affected. All had simple iron-deficiency anaemia, as indicated by serum ferritin  $<7$  ng/ml (Cmic, 1976) which were found in (20.9% : 10) cases

and (17.5% : 8) comparisons. Figures 4.2.2A to 4.2.2D present the distributions of haemoglobin and ferritin levels for cases and comparisons.

Values of serum B12 and red cell folate were all within the normal range for infancy. No blood lead values were elevated in the 17 children on whom this measure could be obtained. All but one were below the paediatric upper limit of 1.2 micro mol/litre.

Sera for insulin-like growth factor I were obtained on 31 subjects in total. No significant correlations were found between these values and weight or length for age, nor weight for length, mid-upper arm circumference or triceps skinfold thickness. There was however a weak negative correlation with head circumference ( $r = -0.32$   $p < 0.05$ ). There were no significant differences on this measure between cases (0.32; SD 0.16) and comparisons (0.28; SD 0.13)

#### 4.2.3 Neurodevelopmental attainments

In the course of physical examination of the children an assessment of neurological functioning and maturity was undertaken, based on the work of Touwen (1976) and Amiel Tilson & Grenier (1986). A composite score of gross motor skills was derived from the ten variables for which there was least missing data; this allowed the pairwise comparison of 35 cases and controls. Skills such as ability to walk or sit unsupported, visual following whilst



Figure 4.2.2a Haemoglobin at outcome (g/dl) - cases

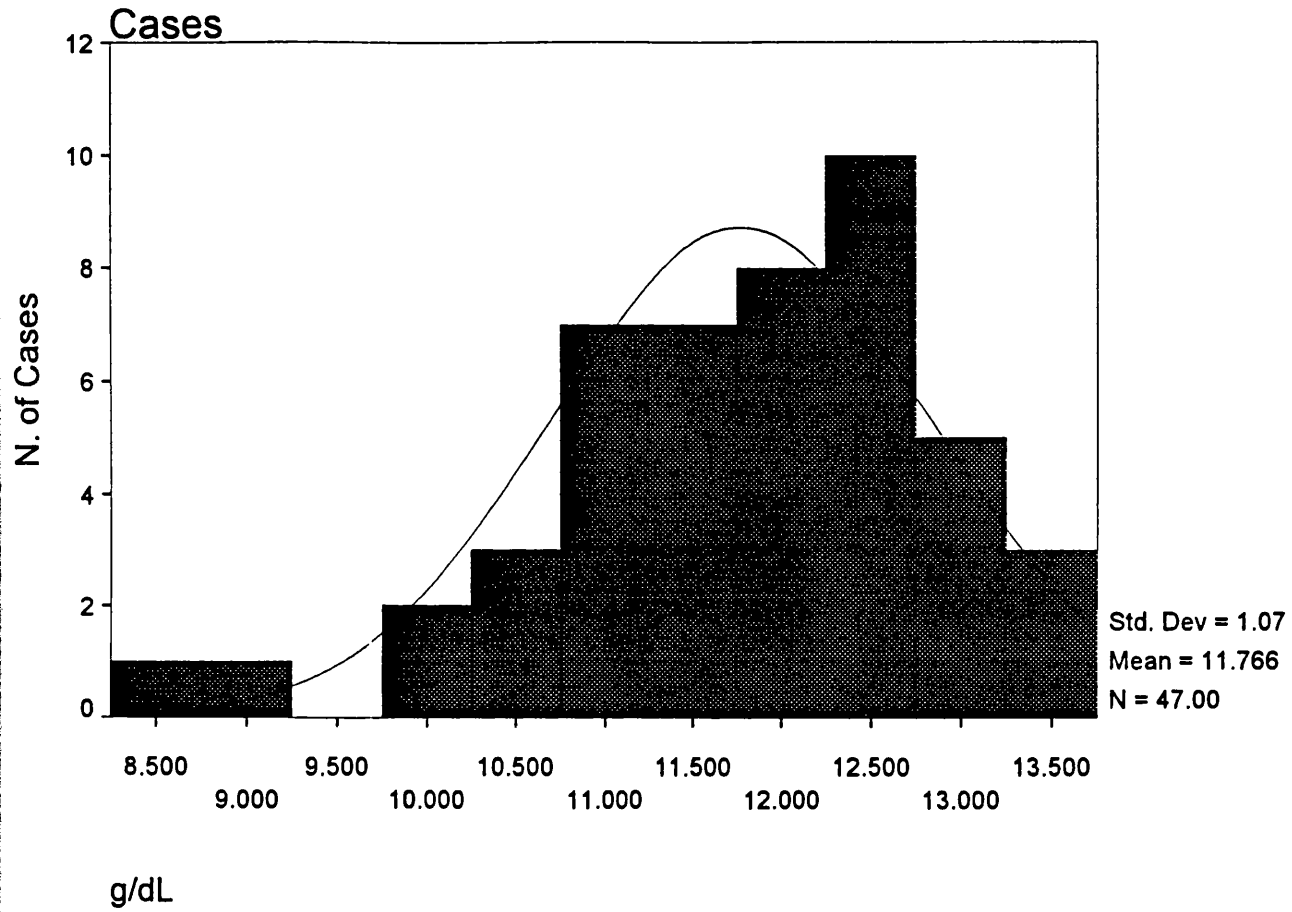


Figure 4.2.2b Haemoglobin at outcome (g/dl) - comparisons

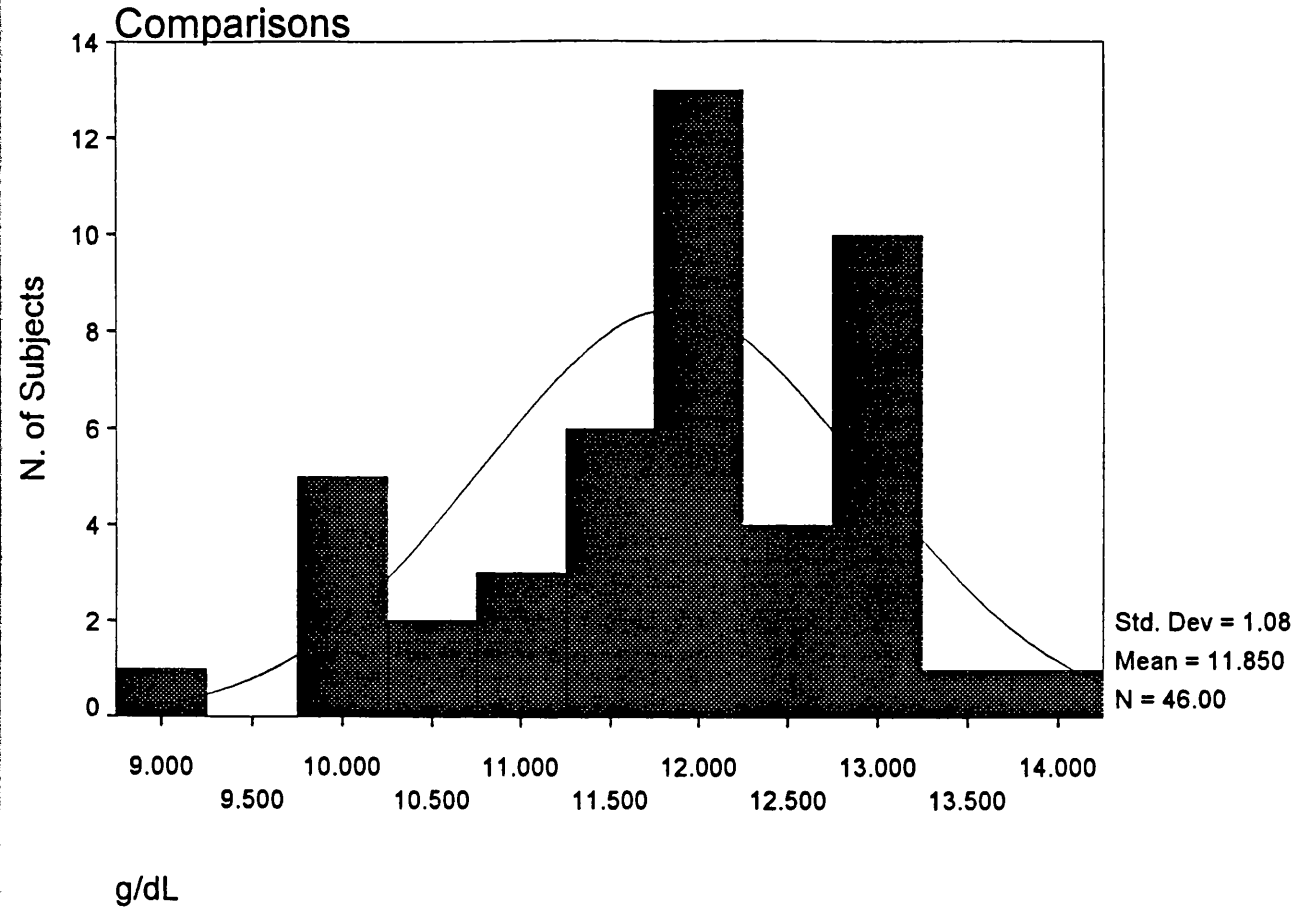


Figure 4.2.2c Serum ferritin at outcome (ng/l) - cases

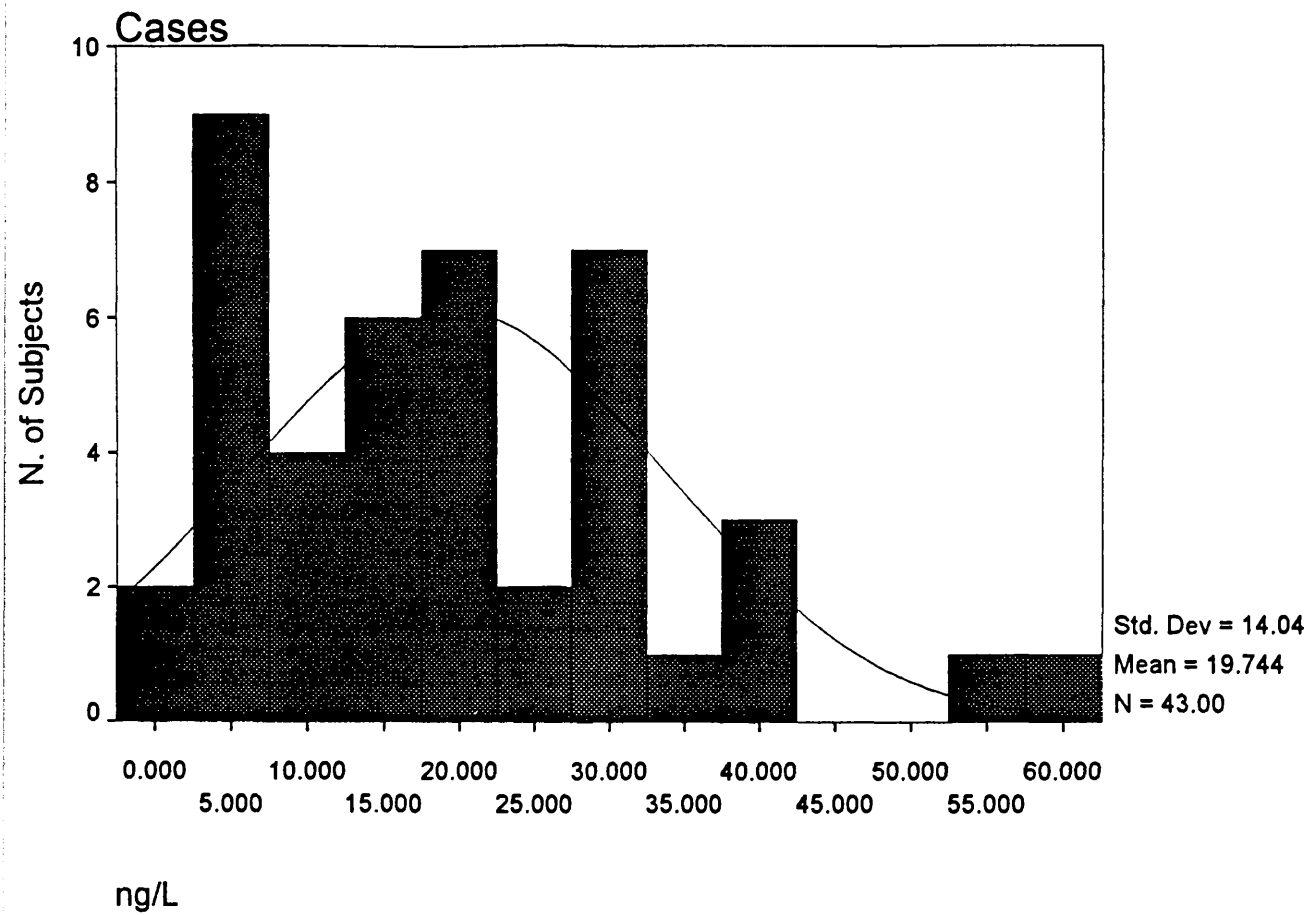
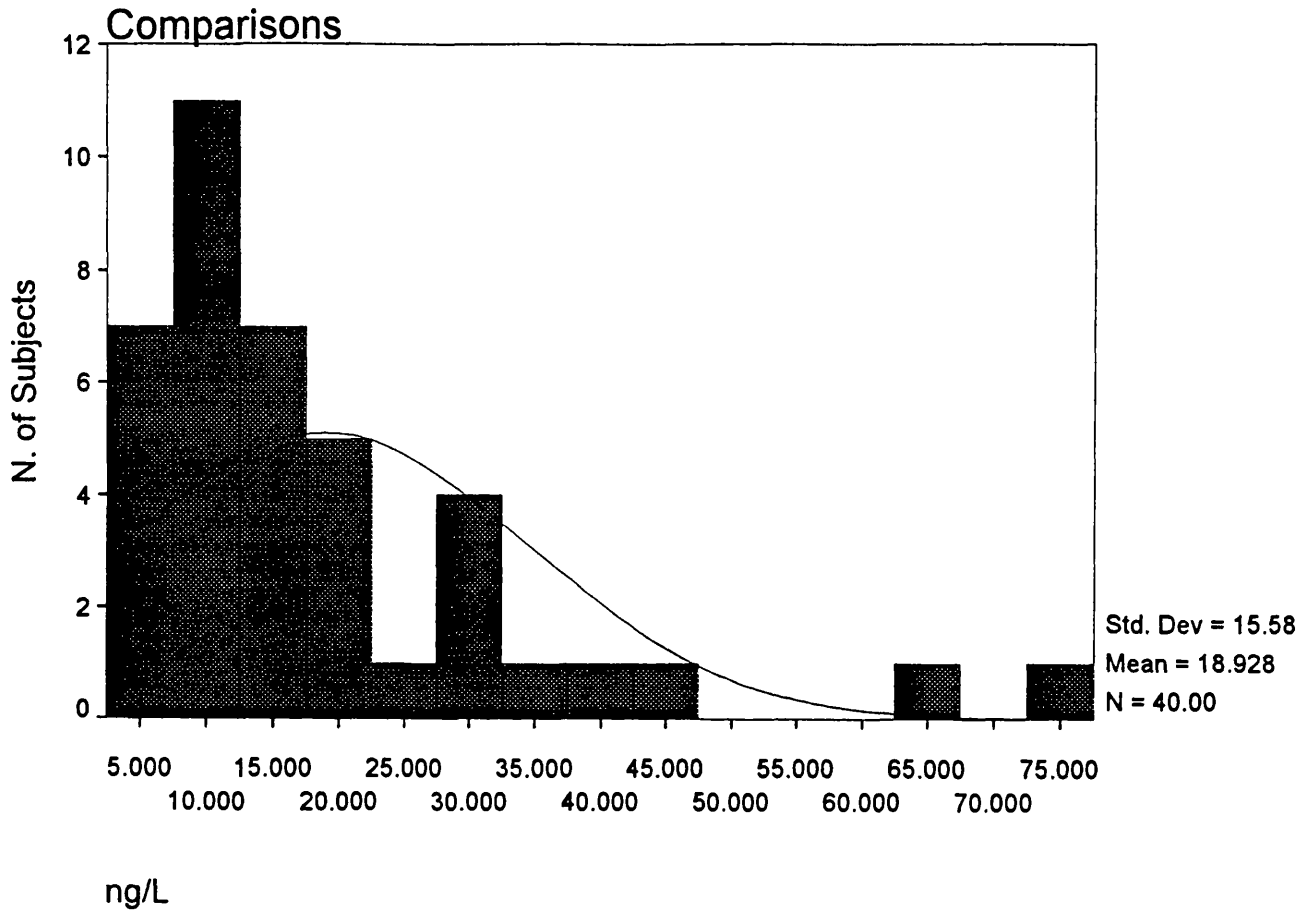


Figure 4.2.2d Serum ferritin at outcome (ng/l) - comparisons



sitting, optical placing reaction of hands were scored according to the weighting system recommended by Touwen (1976).

The total mean score of the comparisons was just significantly higher (mean = 23.4, SD 3.5) than that of the case group infants (mean = 21.6, SD 4.0,  $t = 2.12$ , d.f. 34;  $p = 0.042$ ) despite the fact that they were slightly younger (mean 14.2, SD 1.4 months, compared with mean = 14.6, SD 1.4 months). Other aspects of the physical examination did not distinguish the groups, and in no instance was a physical disorder discovered that could account for a case child's failure to thrive. Although an attempt was made to derive a composite score for fine motor skills the analysis was unsatisfactory owing to a high proportion of missing data. There was however a tendency for the controls to obtain higher scores than the cases.

#### 4.2.4 Oral-motor competence

We examined total abnormality scores for infants' oral motor skills with a variety of food textures, according to the Schedule for Oral Motor Assessment (Reilly et al, 1995; Skuse et al, 1995). The cases were distinguished from the comparisons on the basis of significantly higher scores in respect of puree, semisolids, crackers, as well as liquid drinking skills from a trainer cup (although not from a bottle). We also found a <sup>negative</sup> positive correlation within the case group between a total SOMA abnormality score, summing across all the textures tested, and weights for age at 4 weeks ( $-0.33$ ,  $p=0.012$ ) , at 6 weeks ( $-0.32$ ,  $p=0.01$ ) and at 3 months ( $-0.35$ ,  $p=0.01$ ). Children with lower weight at these ages had greater oral-motor

dysfunction at 15 months, but the degree of oral-motor dysfunction at 15 months did not correlate significantly with weight for age at the same age.

This intriguing finding may indicate that early poor weight gain is causally related to later oral-motor dysfunction, perhaps by a direct effect upon the developing cerebellum. On the other hand failure to thrive in the early postnatal period may have been caused by an inadequate intake secondary to oral-motor dysfunction. Alternatively, some independent factor may have accounted for both the poor growth and the dysfunctional oral-motor skills. We do not have the data to enable these three competing hypotheses to be evaluated.

Weight at birth and weight at ages after 3 months did not correlate significantly with this score. When individual textures were looked at separately the maximum correlation was between weight-for-age at 3 months and difficulties with solids at 15 months ( $r = -0.46$ ,  $p = 0.001$ ).

There was also a significant negative correlation between the SOMA total abnormality score and the case infants' MDI ( $r = -0.36$ ;  $p = 0.014$ ) but no significant correlation with the PDI. The correlations between MDI and total SOMA abnormality score in the comparisons was in the same direction ( $r = -0.26$ ) but it failed to reach significance ( $p = 0.07$ ). No significant correlations were found between weights at any age and the SOMA total abnormality score in the comparison group.

#### 4.2.5 Cognitive and psychomotor attainments

The infants' cognitive abilities were assessed with the aid of the Bayley Scales of Mental Development (Bayley, 1969). There were small but statistically significant differences between the groups. Cases' mean score on the mental development index was 98.2 (SD 18.9); that for the comparisons was 108.4 (SD 14.4). Cases' mean score on the psychomotor development index was 96.7 (SD 17.3); and that of the comparisons was 103.6 (SD 14.4). These differences were statistically significant at the  $p = 0.007$  and  $p = 0.038$  levels respectively.

The case infant's mental development scores were much higher than those values found (by the McCarthy Scales of Children's Abilities) for the 4 year old children examined in the earlier birth cohort survey, who had persistently failed to thrive since infancy (Dowdney et al, 1987).

We tested the hypothesis that infants in the case group would show less mastery- motivation behaviour during the administration of the Bayley Scales, as measured by the TRIB (Wolke, 1987). There were no significant differences between the groups in terms of expression of positive affect, in association with task directed behaviour, or in terms of task persistence. These data are presented on Table 4.2.5.

In neither cases or comparisons did measures of the degree of iron deficiency (serum ferritin, mean corpuscular volume, mean corpuscular haemoglobin concentration) correlate significantly with developmental indices.

**Table 4.2.5: Infant behaviours during testing on Bayley Scales as rated by TRIB\***

<b>Subscale of TRIB</b>	<b>Cases</b>		<b>Comparisons</b>	
	<b>mean</b>	<b>SD</b>	<b>mean</b>	<b>SD</b>
<b>Positive emotional tone</b>	<b>5.7</b>	<b>1.8</b>	<b>5.9</b>	<b>2.0</b>
<b>Motivation and endurance</b>	<b>4.9</b>	<b>1.7</b>	<b>5.2</b>	<b>1.7</b>
<b>Distractibility</b>	<b>5.1</b>	<b>1.9</b>	<b>5.2</b>	<b>2.0</b>
<b>Activity level</b>	<b>5.5</b>	<b>1.9</b>	<b>5.8</b>	<b>1.8</b>
<b>Vocalizations</b>	<b>4.2</b>	<b>1.9</b>	<b>4.6</b>	<b>1.7</b>
<b>Goal directedness</b>	<b>4.5</b>	<b>1.7</b>	<b>4.9</b>	<b>1.5</b>
<b>Difficultness</b>	<b>5.1</b>	<b>1.9</b>	<b>4.9</b>	<b>1.8</b>
<b>Cooperativeness</b>	<b>5.4</b>	<b>2.0</b>	<b>5.3</b>	<b>1.9</b>

**\*There are no significant differences between the groups on any of these variables**



In order to test the hypothesis that the consequences of early postnatal growth faltering were merely indicative of a more long-standing problem the duration of growth retardation was measured. This was taken as the time between the age at which each child's weight gain trajectory crossed the third centile and their age at the follow-up assessment. No significant correlation was found between the duration of growth retardation and mental outcome.

Nor did maternal intelligence contribute significantly to the variance in the MDI or PDI scores of either the case or comparison infants.

#### 4.2.6 Temperament

The main standardised measure of temperament was the Infant Characteristics Questionnaire (Bates, 1984). The proportion of infants falling into the four subscale categories of 'difficult' 'unadaptable', 'unsociable' and persistent' were virtually identical for the cases and the comparisons, and very similar indeed to Bates' original standardisation (Table 4.2.6). Thus there was no evidence on the basis of this instrument that there was a substantial group of excessively difficult infants among those who were failing to thrive.

X

This finding was in contrast to that we had made in the course of a pilot study (Wolke et al., 1990). We believe it reflects the greater representativeness of the sample of infants identified in the course of this investigation. In the earlier study cases had been identified

**Table 4.2.6: Mean scores on Bates' Infant Characteristics Questionnaire, compared with original standardisation sample\***

Subscales	Bates' Sample (N= 384)		Cases (N= 47)		Comparison (N= 47)	
	Mean	SD	Mean	SD	Mean	SD
Difficult	28.6	7.4	31.3	7.0	36.2	7.4
Unadaptable	13.8	4.4	15.8	5.1	15.3	4.1
Unsociable	6.9	2.3	7.9	3.3	7.7	3.0
Persistent	13.1	3.3	13.3	3.0	13.8	2.9

\*There are no statistically significant differences between case and comparison mean scores (paired t test)

from discussions with health visitors, therefore they were already a cause of clinical concern. It seems plausible that there was a systematic bias operating whereby the more 'difficult' infants had alerted their mothers to their poor growth, possibly because of feeding problems, and the mothers had in turn alerted their health visitors.

In our design of the community survey, arrangements were made to obtain multimethod assessments of temperament, in order to perform a rigorous check on the validity of the findings from the pilot investigation (Wolke et al, 1990). In the course of these assessments measures of temperament were obtained from both parental report and from direct observation of the infant. The reports of several independent observers were taken into account, as described in para. 3.2.6.

The results of our investigations on the temperament of case and comparison infants will now be considered under a series of headings, which pose specific questions about the nature of the relationship between failure to thrive, infant behavioural style, and parenting style in relation to maternal characteristics.

#### *4.2.6.1 Are failing to thrive infants temperamentally different to non-FTT infants in the non-feeding situation?*

The question was addressed in two ways. Firstly, mothers rated their child's temperament on the Infant Characteristics Questionnaire (Bates, 1984). Very similar proportions of infants with the four dimensions of temperament (Difficult, Unadaptable,

Unsociable and Persistent) were found the original standardisation of the schedule. These findings are presented on Table 4.2.6.

The second approach was to compare the ratings of the three independent observers on the Tester's Rating of Infant Behaviour scale (TRIB- Wolke, 1987a). The three raters examined the child in the course of the developmental assessment, in the course of an assessment of oral-motor skills and during the course of a medical examination.

Two subscales, devised from factor analyses, were common to all 3 raters; difficulty and activity. There was a slight but significant tendency ( $p < 0.05$ ) for case children to be more difficult than comparisons during the physical examination (Table 4.2.6.1A) . Because this included a fingerprick for a blood sample it was probably the most stressful of the three assessments.

Table 4.2.6.1A: Agreement between raters on infant behaviour in three independently rated situations

X

Rater observations	<u>Difficulty</u>				
	Tester's Rating of Infant Behaviour (TRIB)				
		Cases n= 47		Comparisons n= 47	
	Mean	SD	Mean	SD	p
Rater 1 (developmental test)	26.7	9.5	24.2	8.1	n.s
Rater 2 (physical examination)	25.5	12.5	20.5	10.4	0.04
Rater 3 (oral motor skills)	39.7	18.6	35.4	19.7	n.s

**Table 4.2.6.1B: Agreement between raters on infant behaviour in three independently rated situations**

Rater observations	Activity/Attentiveness Tester's Rating of Infant Behaviour (TRIB)					
	Mean	Cases n = 47		Comparisons n = 47		p
		SD	Mean	SD		
Activity						
Rater 1 (developmental test)	26.1	7.7	26.4	7.3		n.s
Rater 2 (physical examination)	10.7	3.0	10.7	2.4		n.s.
Rater 3 (oral motor skills)	9.7	2.9	10.4	2.5		n.s
Attentiveness						
Rater 1	22.7	6.6	24.9	6.3		n.s

The means for each observer were remarkably similar for the three ratings of activity (Table 4.2.6.1B). Rater 1 also rated the child's attentiveness; no significant group differences were found.

We investigated the possibility that infants in the case group showed less mastery-motivation behaviour (Yarrow and Messer, 1987) during the administration of the Bayley Scales, as measured by the TRIB. There were no significant differences between the groups in terms of expression of positive affect (in association with task-directed behaviour), nor in terms of task persistence, both of which are reported to be constituents of mastery-motivation (Yarrow and Messer, 1987).

#### *4.2.6.2 Do failing to thrive infants differ from comparisons in terms of their behaviour during feeding?*

The infant's behaviour was also rated from a videorecording made of a mealtime at home, by an observer who was totally independent of the actual data collection, and who had not met any of the families concerned. This research worker did not have access to any other of the data collected in the study that could have biased her judgement of the infant's or the mother's behaviour.

The schedule on which behaviour of both partners was rated (unpublished) is the Feeding Interaction Scale (FIS - Wolke, 1987). Nine variables that were rated on the Scale are presented with mean values for the cases and comparisons on Table 4.2.6.2A (p 170).

Three subscales of infant behavioural style were derived by principal components analysis of the FIS:difficultness (alpha 0.86); activity (alpha 0.81) and social referencing in terms of vocalisation (alpha 0.68). No significant differences were found between cases and comparisons on the mean scores on any of these derived subscales. Data on these derived variables are presented on Table 4.2.6.2B (p171). There are no significant differences in the mean scores between the groups. The reports by mothers on their infant's temperament seem to be born out by the findings for the observations of infant behaviour, and the hypothesis that there would be more feeding difficulties in the case group infants was not supported.

#### *4.2.6.3 Are mothers of failing to thrive infants accurate observers of their children's behaviour*

This question was addressed by looking at correlations between mothers' ratings of difficultness according to the ICQ, and the ratings of that dimension according to the three observers on the TRIB. The data are summarised on Table 4.2.6.3. Only the category of difficultness was common between mothers and all three observers. We found a strong correlation in the case group between mother's score and that of rater 1 (Bayley scale administration) 0.4  $p < 0.001$ , with rater 2 (the physical examination) 0.4  $p < 0.001$ , and to a slightly lesser extent with rater 3 (oral-motor assessment) 0.32  $p < 0.05$ . These three correlation coefficients are not significantly different from one another.



We then looked at the degree of correlation between mothers' ratings of difficultness and the infant's behavioural style, as rated by the observers and in the comparison group. There was a moderate correlation for rater 1 of 0.32  $p < 0.05$ , but no such significant agreement for rater 2 (0.18) and rater 3 (0.07). The average  $r$  was in this case 0.16. There was no significant difference between any pair of correlations for the comparisons, nor were the average correlation coefficients of 0.37 (cases) and 0.16 (comparisons) significantly different from one another.

#### *4.2.6.4 What personal or environmental factors influence mothers' perceptions of their children's temperament, and do these differ between failing to thrive and normally growing infants?*

There were few group differences on the instruments we used to measure mothers' personal or environmental characteristics. Firstly, on the basis of responses to the General Health Questionnaire - 28 item version (Goldberg and Hillier, 1979) we did find a higher mean score among the case group (mean 4.5 SD 5.1) than among the comparisons (mean 2.7 SD 3.7) ( $p < 0.05$ ). This indicates that, in general, they were suffering from a greater degree of minor psychiatric disturbance. Taking the recommended threshold score of 4/5 between probable cases and non-cases we found 42.6% of the cases and 23.4% of the comparisons scored 5 or more. This compares with 41.1% in the original validation study of the GHQ-28, which questioned 200 consecutive attenders at a family doctor's practice (Goldberg and Hillier, 1979). On examination of the subscales the cases obtained higher scores on the depression subscale

than the comparisons, with 42.6% obtaining scores of 2 or more (comparisons 15.2%) ( $p < 0.01$ ).

The groups of mothers were also similar in respect of their cognitive abilities, but on average their IQs were in the lowest 20% of the population. The means of the full scale IQs of the cases was 83.4 (SD 17.1) and that of the comparisons was 86.4 (SD 16.2). They were also similar in age (cases 27.6 SD 5.3; comparisons 26.7, SD 5.9), equivalent proportions were single parents (21% cases, 19% comparisons). About one third of each group was non-white (43% cases and 34% comparisons). Slightly more case mothers (34%) than comparison mothers were on welfare (23.4%). It has sometimes been suggested that mothers of infants who are failing to thrive are socially exceptionally isolated and lack social support. On our social support scale (Tietjen and Bradley, 1985) we found no difference between case and comparison mothers, either in terms of the aggregated score or in terms of any single variable.

The possibility that there would be an excess of disharmony in the intimate relationships of mothers of failing to thrive infants with a marital partner or cohabitee has been little explored to date. Yet it has been suggested that conflict in such relationships may contribute indirectly to an infant's failure to thrive. On the dyadic satisfaction subscale of the Dyadic Adjustment Scale (Spanier, 1976) we found a small statistically significant difference in mean scores between the groups.

**Table 4.2.6.2A: Ratings of infant behaviour during mealtime, from videorecording, according to the Feeding Interaction Scale\***

Infant	Cases		Comparisons	
	Mean	SD	Mean	SD
Amount of vocalisation	2.8	1.2	3.0	1.2
Vocalisation level	3.8	1.4	3.9	1.2
Tool use/ autonomy	2.5	1.2	2.6	1.2
Acceptance/ rejection	2.2	1.5	2.3	1.6
Social referencing	4.7	1.8	4.7	1.5
Activity	4.8	1.8	4.7	1.5
Intensity	4.5	0.9	4.5	1.0
Emotional tone	5.0	1.0	5.3	0.9
Communication signals	3.1	1.2	3.2	0.9

\* There are no significant differences between the groups on these measures

**Table 4.2.6.2B: Infant behaviour ratings on composite factors, including vocalisations, activity and difficultness, during mealtime observations**

Rater observations	Feeding Interaction Scale (FIS)				
		Cases n= 47		Comparisons n= 46	
	Mean	SD	Mean	SD	
Factor 1 (social referencing 'vocal')	19.3	5.7	20.0	4.4	n.s
Factor 2 (activity)	9.2	1.7	9.1	2.1	n.s
Factor 3 (difficultness around food)	5.7	2.5	5.6	2.4	n.s

**Table 4.2.6.3: Consistency in temperament (Difficultness) across situations measured by agreement between mother's ratings on Bates IFQ and three independent raters:**  
**correlation coefficients    average correlation coefficients**

<b>Difficultness</b>	<b>Rater 1 Developmental Test</b>	<b>Rater 2 Physical Examination</b>	<b>Rater 3 Oral Motor Skill assessment</b>
<b>Mother's rating on Bates IFQ Scale</b>			
<b>Cases</b>	0.4***	0.4***	0.32*
<b>Heterogeneity between r's <math>\Phi</math></b>		0.26	
<b>Average r</b>		0.37	
<b>Comparisons</b>	0.32*	0.18	0.07
<b>Heterogeneity between r's <math>\Phi</math></b>		1.47	
<b>Average r</b>		0.16	

\*\*\*       $p < 0.005$   
 \*\*       $p < 0.01$   
 \*       $p < 0.05$

$\Phi$  This is a measure of the statistically significant differences between the correlation coefficients

In order to compare the two groups in terms of their socio-economic status we used both a standard rating of social class and a composite index based on a wide range of variables (Osborn, 1987). Neither on individual variables, nor on the composite index was there any significant difference between the case and comparison families.

To see whether any of the above indices of personal or environmental disadvantage might be influencing a mother's perception of her child's behaviour we correlated each subscale of the GHQ, and the total GHQ score, the social support index, the dyadic adjustment scale score, the social index, and two measures of overcrowding (no. of resident adults and no. of resident children) with the subscales of the ICQ. We did this separately for the cases and the comparisons. After a correction had been applied for the number of significant associations that might have been expected by chance, none remained. However, it is worth noting that both in the case and in the comparison groups there was a weak but significant ( $p < 0.05$ ) positive correlation between the number of resident children and the rating of the child's unadaptability.

With the entire sample dichotomised into those mothers who were probable cases of psychiatric disorder (on the basis of high scores on the screening questionnaires) and those who were not (63 non cases, 31 cases) we looked at the correlation between the mothers' and the observers' (mean) rating of difficultness. There was greater agreement between the mentally disordered mothers and observers ( $r = 0.5$ ,  $p < 0.004$ ) than the others ( $r = 0.28$   $p = 0.026$ ), although the two correlation coefficients are not significantly different from one another.

The same set of analyses was now performed in respect of IQ, with the sample dichotomised according to whether or not the full scale IQ was more or less than 85 (50 subjects < 85; 44 subjects > 85). This cut-off was taken as it was 1SD below the population mean, and there were approximately equal numbers of subjects in each sample. Again there were no significant differences between groups in the ratings by mothers of difficultness or activity, nor in terms of the ICQ temperament dimensions, either between those of higher or lower IQ, or between case and comparison children within each category. The agreement between mothers in these two broad groups with the observers' ratings of difficultness was identical in the two instances ( $r = 0.36$   $p = 0.01$ ).

#### 4.2.7 Dietary intake

Out of 13 dietary constituents analysed from the 24 hour recall interview none distinguished the groups at a statistically significant level. These data are presented on Table 4.2.7A.

As illustrated in Table 4.2.7B, the energy intakes, as reported by mothers, of case and comparison infants were about 10% higher than has been found in a British survey (Black, Cole, Wiles & White, 1983) which used potentially more accurate weighed dietary records. Interestingly, Hoffman, Obermann De Boer, Florack, Van Kampen Donker & Kromhout (1986) also obtained lower values for energy intake than we did in their Dutch survey, despite using an identical procedure.

All mealtimes were videorecorded, and additional notes were made by observers at the time about food loss and so on. Using these data the quantity of food actually consumed by infants was calculated by a colleague who had never visited the families, on the basis of videotape ratings. All infants were fed in spoonfuls. Accordingly, it was possible to count the number of spoonfuls actually consumed during the observed and recorded meal, and then to multiply that figure by the quantity of food presented on each spoonful. This was done from a knowledge of the capacity of the implements used to feed the child (in mls), which were examined in the course of the home visit by Sheena Reilly, where the mealtime was observed. A similar technique allowed the quantity of liquid consumed by the child to be estimated.

Energy intake of the subjects was computed in the same way as before, and now a strikingly different pattern emerged. Only a proportion of the food offered was actually consumed, and that proportion was similar in both groups. For the cases a mean of 248 Kcal (SD 116) was offered, and the corresponding figure for the comparisons was 306 Kcal (SD 140). This difference is significant at  $p < 0.025$ . The cases' mean intake was 150 Kcal (SD 104), which was 60% of that offered. The mean intake of the comparisons was 202 Kcal (SD 91), which represents 66% of



**Table 4.2.7A: Dietary constituents of meals reportedly provided to child over 24 hours prior to interview\***

	Cases		Comparisons	
	mean	(SD)	mean	(SD)
Carbohydrate (gms)	122.7	(44.1)	130.2	(52.6)
Kilocalories	1024	(327)	1039	(375)
Protein (gms)	38.2	(20)	38.1	(13.9)
Folic acid (mgms)	85.7	(53.9)	94.6	(50.3)
Vitamin C (mgms)	75	(88.5)	97.6	(90.8)
Nitrate (mgms)	6.2	(3.2)	6.1	(2.2)
Water (ml)	657	(294)	713	(276)
Zinc (mgms)	5.0	(3.6)	4.9	(2.1)
Free Fatty acids (mgms)	52.4	(39.9)	58.9	(38.3)
Fibre (gms)	6.4	(4.1)	6.2	(3.7)
Iron (mgms)	4.7	(2.3)	4.5	(2.0)
Fat (gms)	42.8	(17)	44	(19.7)

\* There are no statistically significant differences between the groups on any one of these variables.

**Table 4.2.7B: Energy intakes of case and comparison infants (Kcal) as estimated by 24 hour recall**

	Mean	SD	CV % *
Cases	1024	328	32
Comparisons	1039	375	36
Black et al (1983)			
15 months	946	212	22.4
Hoffmans et al (1986)			
16 months	975	250	25.6

\* coefficient of variation =  $SD/Mean \times 100\%$

the food that was offered. There was thus a highly significant difference in the mean intakes of the groups ( $t = 2.64$ ,  $p = 0.011$ ). The high coefficients of variation (69% and 45% respectively) indicate the considerable variability within groups. It should be noted that the study determined that the meal that was observed should be the child's main meal of the day, whenever that took place.

#### 4.2.8 Risk of later abuse or neglect

##### 4.2.8.1 *Introduction*

Data collection on the children in the 1986 birth cohort was completed by the middle of 1988. Subsequently, we wished to discover whether any of the original cases or comparison children had become the subject of child protection investigations. This phase of the study commenced in December 1990, by which time all the original subjects would have been 4 years of age. At the time of the original survey no child in either the failure to thrive or the comparison groups had yet been the subject of an official investigation of abuse or neglect. No case or comparison child was investigated by social services or the NSPCC for alleged abuse and/or neglect directly as a result of the original research. We did not regard any child to be in such danger that proceedings ought to have been instituted.

In December 1990 we gained access to the Child Protection records held by the District Health Authority in which the original geographical area of our research was situated. It was then possible to cross-check names of children that appeared on the register with the names of the children in the original birth cohort ( $n=2510$ ). For this purpose all the

births registered in the geographical area we surveyed in 1986 were included, whether or not they met criteria for inclusion as potential cases of failure to thrive. The small area we surveyed had subsequently been incorporated into a much larger health authority, with approximately 3 times greater population. Many of the families who had moved out of the original area had gone to adjoining areas that were incorporated in this larger district.

Over the period from 1986 to 1990 a total of 64 children (2.5%) from the original birth cohort were placed on a Child Protection Register (CPR) within the larger health district. Local guidelines for categorisation on the Register are given in Table 4.2.8.1. A further 32 (1.2%) were subject to child protection conferences, but their names were not placed on the register (NCPR). Thus a total of 96 (3.7%) of the 1986 birth cohort fell into one or other of these categories, including 6 (12.7%) of the original 'non-organic' failure to thrive cases. Of these 4 (8.5%) had their names placed on the register, a further 2 (4.2%) had been conferenced only. In none of the 'non-organic' failure to thrive cases was the reason for concern failure to thrive alone.

Overall, where the information was available the reasons for registration (CPR) were given as follows: physical abuse (18.8% : 12); neglect (23.4% : 15); emotional abuse (3.1% : 2); sexual abuse (4.7% : 3); and grave concern (23.4% : 15). The corresponding figures for those who were conferenced only (NCPR) were: physical abuse (35.4% : 11); neglect (6.3% : 2); emotional abuse (0%); sexual abuse (18.8% : 6)

**Table 4.2.8.1: Local multidisciplinary guidelines used for 1990 Child Protection (previously 'At Risk') Register**

- A PHYSICAL ABUSE** is a physical injury to a child, where there is definite knowledge, or a reasonable suspicion, that the injury was inflicted or knowingly not prevented.
- This includes, for example, deliberate poisoning, attempted drowning, or smothering.
- B NEGLECT** is the persistent or severe neglect of a child which results in serious impairment of that child's health or development.
- a) this may be by exposure - to danger or by repeated failure to attend to the physical and developmental needs of the child.
- b) non-organic failure to thrive may result from neglect of a child but always requires medical diagnosis.
- C EMOTIONAL ABUSE** is the persistent or severe emotional ill-treatment of a child which has a severe adverse effect on the behaviour and emotional development of that child. (NOTE: all abuse involves some emotional ill-treatment; this category should only be used when it is the main or sole form of abuse).
- D SEXUAL ABUSE** is the involvement of dependent, developmentally immature children and adolescents in sexual activities they do not truly comprehend, to which they are unable to give informed consent, that violate the social taboos of family life or which have been knowingly not prevented by the carer.

**E GRAVE CONCERN** reflects a high degree of risk, substantiated by social and/or medical assessments, where there are no grounds for stating that abuse had already taken place.

This concern must state the form of abuse (as defined above) of which the child is felt to be at risk and may include those situations where another child in the household has been harmed or where the household contains a known abuser. It must not be used as a catch-all category.

and grave concern (34.4% : 11). The registered formerly failure to thrive cases included: i) grave concern due to special needs in the context of probable neglect, by a mother who was probably alcoholic; ii) a cannabis poisoning, with a mother who dealt in drugs; iii) neglect, in a family with a schizophrenic father; iv) neglect, in a family where the child was left in the care of a demented grandmother; v) a case of physical and suspected sexual abuse. An additional 'non-organic' failure to thrive case, vi) of neglect with suspected emotional abuse was not registered. 'Grave concern' was a non-specific category of risk, rather than an indication of actual abuse. Children registered for this reason were regarded as being at very high risk of abuse or neglect, but the confirmatory evidence was not available. The history of 'non-organic' failure to thrive was not a significant contributor to the decision to register grave concern in these cases, according to the records available to us. There are many reasons why grave concern might have been recorded. For example, a mother's association with a known sexual offender; repeated failure to bring a child with a serious medical condition to hospital appointments; neighbours' persistent reports that the children were being left on their own for long periods and so on.

#### 4.2.8.2 *Risk variables*

Data were available for a variable proportion of the original survey population at birth on a number of factors that could have been connected with their risk of subsequent abuse or neglect (Skuse and Bentovim, 1994). They included birthweight (92.3% : 2408), gestation (91.5% : 2387), parity (86.3% : 2252), ethnic origin (91.3% :

2382), maternal age (90.3% : 2356). Data were available on all these variables for 2206 (84.5%) of the original survey population.

Table 4.2.8.2 gives details of the relative risk of the child's name having been placed on the Child Protection Register if that child or mother fell into one of a number of specific risk categories, treated independently. The variable 'early failure to thrive' indicates the relative risk attributable to being a member of the original 'non-organic' failure to thrive group. For each risk factor only cases for whom the relevant data were available were included.

#### 4.2.8.3 *Other variables*

Data were collected on the original cohort (n=2610) for a number of other variables which could have been associated with an increased risk of later entry onto a Child Protection Register (Skuse and Bentovim, 1994). They included the sex of the child (data available on 100%), ethnic origin of parents (91.3% : 2382), and paternal age (40% : 1044). We also investigated the relevance of attendance at a child health clinic during the first postnatal year; about 1 in 5 (21.1% : 550) of women never brought their child to the clinic for a well-check during this period. Despite the supposition, commonly held among health visitors in our experience, that greater risk attaches to boys, certain ethnic minorities, young fathers and clinic non-attenders, we found no evidence that this was the case within our sample.



**Table 4.2.8.2: Variables associated with increased risk of entry onto Child Protection Register**

	(N)	Relative risk	95% confidence intervals
Birthweight < 2500gms	(2552)	1.96	1.01 - 3.82
Gestation < 35 weeks	(2354)	3.26	1.43 - 7.39
Maternal age < 20 years	(2357)	2.23	1.32 - 3.75
Parity ≥ 4	(2220)	1.53	0.72 - 3.23
Early failure to thrive	(2024)	4.43	1.65 - 11.94

#### 4.2.8.4 *Relative risks and odds ratios*

Table 4.2.8.2 presented the individual relative risks for a range of variables which appeared to be associated with an increased risk of emotional abuse and neglect. These were not all independent of one another, significant intercorrelations being found between birthweight and gestation ( $r = 0.65$ ;  $p < 0.001$ ) and between maternal age and parity ( $r = 0.49$ ;  $p < 0.001$ ).

The calculation of relative risk is based upon a prospective hypothesis. That is, children with certain risk factors (eg, an early history of preterm birth or failure to thrive) were hypothesised to be more at risk of later child abuse or neglect than the remainder of the birth cohort. It is also possible to consider the same dataset retrospectively. In this case the selection of subjects is based upon the outcome (whether they were abused/neglected or not). Then the relative importance of a range of risk factors is examined. Often only retrospective data are available in a study like this, subjects having been selected on the basis that they have, or do not have, the outcome of interest. For studies where the outcome of interest is rare the odds ratio offers a method of getting an approximate relative risk, despite the fact that the calculation is done retrospectively. When we compare a series of risk factors in this way, all of which bear some relationship to a binary outcome variable of interest, we can use logistic regression to develop a model that is equivalent to a multiple regression with a continuously distributed outcome variable.

Because of the procedure by which cases of failure to thrive were identified, this particular risk ( 'non-organic' failure to thrive) did not correlate with risk factors birthweight or gestation. There was no increased risk of failure to thrive among the offspring of very young mothers or those born into a large sibship (Werner and Smith, 1992). However, in order to compare conservatively the risk associated with *early* failure to thrive with other known risk factors these other factors were forced into the logistic regression analysis first. The results are shown in Table 4.2.8.4. The outcome 'abused and/or neglected' includes both cases entered on the Child Protection Register, and those who were conferenced but not entered.

Because of the significant correlations between gestation and birthweight, and between maternal age and parity, these were also entered as interaction terms instead of main effects in another series of hypothetical models employing the logistic regression procedure. The interaction terms did not fit the models as well as the individual variables, as judged by their associated goodness of fit values, so they were not considered further.

### 4.3 Outcome : Mother

#### 4.3.1 Mental state

The broader question of how our findings on the mental health of mothers in the case and comparison groups compares with other inner city surveys is hard to answer, for none of the mental health scales we used has published norms for a general population sample in this country which is exactly comparable to the population who were screened in our survey.

**Table 4.2.8.4: Logistic regression analysis of the outcome of abuse or neglect† in relation to key predictor variables**

	<b>Regression coefficient b</b>	<b>Standard error for b</b>	<b>Model <math>\chi^2</math> improvement</b>	<b>p value</b>
<b>Constant</b>	<b>0.577</b>	<b>0.87</b>	<b>-</b>	<b>-</b>
<b>Birthweight</b>	<b>-0.0005</b>	<b>0.0002</b>	<b>7.94</b>	<b>0.05</b>
<b>Maternal age</b>	<b>-0.882</b>	<b>0.28</b>	<b>2.28</b>	<b>0.13</b>
<b>Ordinal position</b>	<b>0.362</b>	<b>0.09</b>	<b>12.28</b>	<b>0.001</b>
<b>Early failure to thrive</b>	<b>0.736</b>	<b>0.25</b>	<b>6.31</b>	<b>0.01</b>

† includes all cases that were of concern, whether or not on the Child Protection Register

$$\ln\left(\frac{p}{1-p}\right) = 0.577 + \dots + 0.736(0.777)$$

Table 4.3.1: Mothers' mental state; measured by 28 item GHQ subscales

Subscale	Cases % (n=47)		Comparisons % (n=47)		Brooke et al (1989) %* (n=1513)	
	(N)		(N)		(N)	
0-1	10	21.3	14	29.8	466	30.7
2-3	11	23.4	14	29.8	347	22.9
4-6	12	25.5	10	21.3	355	23.4
>7	14	29.8	9	19.1	345	22.7
Depression†						
0	18	38.3	30	63.8	1089	72.0
1	9	19.1	5	10.6	187	12.4
2-3	10	21.3	5	10.6	127	8.4
>4	10	21.3	7	14.9	103	6.8

\* pregnant women at booking with antenatal clinic, approx. 17 weeks gestation; inner London population

† A chi-square analysis of the proportions in the various categories of scale score, with all 3 groups included, showed significant differences (chi square 34.4, 6 d.f.,  $p < 0.001$ ). An analysis of the proportionate differences between cases and comparisons did not reach a conventional levels of statistical significance (chi square 6.3, 3 d.f.,  $p = 0.096$ ).

Perhaps the closest set of comparison data is from Brooke, Anderson, Land, Peacock and Stewart (Brooke et al, 1989), who studied a consecutive series of 1860 white women booking for delivery at a district general hospital in inner London. The 28-item version of the General Health Questionnaire, administered at 17 weeks gestation, gave the following results (see Table 4.3.1).

Two subscales of the 28 item version of the GHQ are considered here. They are scored on the 0-1-2-3 system as recommended by Goldberg and Williams (1988, p. 63). On the Anxiety subscale the proportion of women scoring within each of the four categories was similar in each of the three samples. For the Depression subscale, the proportions were similar for the comparisons and the Brooke et al sample, but there was a tendency for the case women in our own survey to be over-represented among the higher scorers, and hence those who were more likely to have a significant depressive condition. However, this trend was not statistically significant. It should be emphasised that these subscales do not represent diagnostic categories, but are dimensions of psychopathology. Most studies have found threshold of 4/5 for the total GHQ-28 score gives the best discrimination between cases and non-cases of psychiatric disorder of clinical significance (Goldberg and Williams, 1988). Using this threshold value, 20/47 (42.6%) of the cases and 11/47 (23.4%) of the comparisons scored 5 or more. This difference does not quite attain a conventional level of statistical significance (chi square 3.08, 1 df,  $p=0.08$ ). The mean total scores were; cases 4.5 (SD 5.1) and comparisons 2.7 (SD 3.7,  $t$  1.98; 46 df,  $p=0.05$ ).

The measure of Locus of Control (Pearlin and Schoolar, 1978) aimed to assess the extent to which this was internalized. Higher scores implied mothers had a more internal locus, and consequently felt relatively more in control of their lives, on a day to day basis. A relatively externalized locus of control (indicated by a lower score) implied that the woman concerned felt that events were outside her control, in her everyday existence. The means for the cases and comparisons were very similar, with cases scoring a mean of 5.8 (SD 2) and comparisons a mean of 6.3 (SD 1.8). These values are very close to those found in by Belle (1979) in her study of women in the United States in a low income housing project in Boston, Mass.

#### 4.3.2 Cognitive abilities

All mothers in the 1986 birth cohort survey were tested using the Wechsler Scales (WAIS-R, Wechsler, 1974). Scores on the block design and picture composition (Performance, Vocabulary and Information (Verbal)) subscales were prorated in order to yield a full scale IQ score. There were no significant differences between the groups on verbal and performance scale scores and the means of their full scale IQs were very similar (cases mean 83.4, SD 17.1; controls mean 86.4, SD 16). The findings are given on Table 4.3.2.

#### 4.3.3 Social support

This question was addressed with the aid of a scale devised specifically for the purpose of our own investigation, based upon the work of Tietjen (1985) and Tietjen & Bradley (1985). The scale was filled in by the mother, with guidance from the research worker interviewing her where necessary. It comprises a number of multiple choice answers together with some Likert scaling. No differences between the case and comparison groups were found on the mean total scores, which were 28.2 (SD 5.8) for the cases and 29.2 (SD 5.3) for the comparisons.

#### 4.3.4 Marital relationship

Mother's relationship with her spouse was assessed with the Dyadic Adjustment Scale (Spanier, 1976; Spanier & Thompson, 1982; Sharpley & Cross, 1982; Antill & Cotton, 1982). Only the dyadic satisfaction subscale was rated. Although the difference in total scores between the groups was relatively small, it nonetheless achieved a high degree of



**Table 4.3.2: The cognitive abilities of mothers of case and comparison subjects, measured by the Wechsler Adult Intelligence Scales (WAIS)\***

WAIS scores	Cases			Comparisons		
	mean	(SD)	N	mean	(SD)	N
Verbal	85	(18)	43	87.9	(14.5)	43
Performance	86.2	(17.2)	47	88.7	(18.1)	47
Full scale	83.4	(17.1)	47	86.3	(16.1)	47

\* There were no statistically significant differences between the groups on any of these scales

statistical significance ( $t = 3.26, p < 0.003$ ), with the cases scoring their relationships as less satisfactory (mean = 32.4, SD 5.9) than the comparisons (mean = 35.6, SD 4.3). Both scores were well below the values for females (mean = 38.7, SD 6.1) reported by Antill & Cotton (1982), indicating less satisfaction for the women in our investigation than in the original population surveyed.

#### 4.4 Outcome: Infant-mother relationship

##### 4.4.1 Feeding interaction

##### 4.4.1.1 *Cognitive stimulation*

The hypothesis that mothers of FTT infants would differ in their parenting during feeding from mothers of infants who are growing normally was addressed in a number of different ways. Firstly, in terms of the degree of cognitive stimulation provided to the children as measured by the NCAST scales (Barnard et al, 1989) (Table 4.4.1.1) The mean values were almost identical in the two groups, showing that case mothers were not providing any lesser stimulation to their infants than the comparisons. The correlations between this subscale and the children's MDI scores were also very similar within each group (cases 0.44  $p = 0.002$ ; comparisons 0.31  $p = 0.03$ ).

Whilst there were no differences found on the cognitive growth fostering ratings made during the course of mealtimes, it was remarkable how little verbal interaction there was in either case or comparison dyads. Our view is that this is unlikely to be due to the presence of the videocamera, in that similar lack of vocalisation was observed by all observers, whether or not video recording was taking place. Also, in the course of the subsequent interview

**Table 4.4.1.1: Observational ratings on cognitive growth fostering subscale of NCAST\*, during mealtime**

	<b>Cases† % n=47</b>	<b>Comparisons % n=47</b>
<b><u>Mother's Behaviour</u></b>		
Verbally describes some aspect of food or feeding situation	29.8	31.9
Talks to child of things other than food, eating	25.5	14.9
Verbalises to child within 5 seconds of child vocalization	36.2	46.8
Talks to child using two words at least 3 times	85.1	80.9
Provides finger foods, toys, utensils or other objects	68.1	66.0

**\* Nursing Child Assessment Teaching Scale (Barnard, 1978)**

**† There are no statistically significant differences in the behaviour of case and comparison mothers**

mothers were asked whether they felt self conscious and whether they felt that their behaviour at the mealtime was representative of the way they would usually behave on that occasion. If any mother indicated that she had felt uncomfortable or that her interaction was in some other way constrained on the occasion of the first recording, a subsequent recording was made for the purposes of later analysis. The dearth of verbal interaction between mother and child during the meal was the most striking feature of these findings.

#### **4.4.1.2      *Other maternal behaviours***

Secondly, we looked at a number of dimensions of maternal behaviour that had been independently rated from the Feeding Interaction Scale (FIS) (Wolke, 1987b) on the basis of videorecordings of mealtimes. The dimensions included measures of the amount of vocalisation a mother engaged in during the meal, plus her vocal control and nonverbal control. Nonverbal control relates to negative physical interventions (such as force feeding). The scale also rated neutral physical contact, positive emotion (smiling/laughing), and negative emotion (shouting/criticising). Finally, sensitivity was measured by the degree to which a mother's handling of the mealtime was child-centred, the facility with which mothers picked up on their child's verbal and nonverbal cues, and the extent to which she interpreted them accurately. The means for each of these subscales of maternal behaviour were very similar for both case and comparison children, except in respect of sensitivity, where the latter group obtained slightly higher ratings ( $p < 0.03$ ). (Table 4.4.1.2)

**Table 4.4.1.2: Ratings of mother's behaviour during mealtimes, from videorecordings, according to the Feeding Interaction Scale**

	Cases		Comparisons		p
	Mean	SD	Mean	SD	
Maternal vocalisation	3.6	1.7	3.9	1.6	n.s.
Vocal control	8.8	1.6	6.8	1.6	n.s.
Non-verbal control	6.6	1.9	6.8	1.7	n.s.
Neutral physical contact	2.6	2.1	2.5	1.6	n.s.
Positive emotion	1.4	0.4	1.4	0.5	n.s.
Negative emotion	4.7	0.5	4.8	0.4	n.s.
Sensitivity	2.5	0.9	3.0	1.1	0.03

#### **4.4.1.3 Predictors of maternal parenting style**

We examined the correlations between the maternal behaviour FIS dimensions and same set of predictor variables that had been investigated in relation to mother's ratings of their infant's temperament. The hypothesis to be tested was whether the variables that appeared to influence mothers' ratings of their infant's temperament would also influence their interaction with their infant during feeding.

Correlations between maternal behaviours on the FIS were correlated with the subscales of the GHQ, and the total GHQ score, the social support index, the dyadic adjustment scale score, the social index, and two measures of overcrowding (no. of resident adults and no. of resident children). No significant correlations were found, for either case or comparison mothers. This finding held, both when the variables were examined individually, and subsequently when a risk index was compiled by computing a weighted score of disadvantage from the individual variables. In other words, it did not look as if a mother's parenting style observed whilst she was feeding her infant was influenced by her mental state or by other indices of psychosocial disadvantage.

There was, however, a substantial correlation between IQ and several of the FIS items, but the pattern differed somewhat for the case and comparison groups (Table 4.4.1.3, p 198). Case mothers' nonverbal control was significantly negatively correlated with IQ - 0.42 ( $p < 0.01$ ). In other words, mothers of failing to thrive infants, with a relatively lower IQ were significantly more likely to use physical interventions to control their infant's behaviour during feeding than those with a relatively higher IQ within the case

group. This negative correlation was weaker and statistically non-significant for the comparisons (-0.26).

Neutral physical contact was positively correlated with IQ for both groups (cases 0.37,  $p < 0.05$ ; comparisons 0.44,  $p < 0.01$ ). That is, mothers with higher IQs in both groups were more likely to be physically involved with their infant during the mealtime, in a neutral way. For example, they would be more likely to help the infant feed effectively.

IQ was correlated positively with positive emotion (smiling/laughing) within the case group (0.35,  $p < 0.05$ ) but not within the comparisons (0.03). Case mothers were only observed to show positive emotion to their infants during the mealtime if they had relatively higher IQ than the average for the group. There was no mean difference between the amount of positive emotion shown toward the infant in the case and comparison groups.

Vocal control of the child's behaviour (directive and prohibitive statements) was only correlated significantly with IQ within the comparisons (0.41,  $p < 0.01$ ), but not within the case group (0.28).

In both groups, the correlation between the sensitivity of mother's behaviour and her IQ was the highest of all (0.5 cases, 0.46 comparisons, both  $p < 0.001$ ).

**Table 4.4.1.3: Correlations between mother's parenting style during feeding, as assessed by observation, and her IQ: contrast between cases and comparisons**

**Correlation with IQ**

	Maternal behaviour					
	Vocal control	Non-verbal control	Neutral physical contact	Positive emotion	Negative emotion	Sensitivity
Cases	0.28	-0.42**	0.37*	0.35*	0.23	0.5***
Comparisons	0.41**	-0.26	0.44**	0.03	0.17	0.46***

\* p < 0.05

\*\* p < 0.01

\*\*\* p < 0.001



In neither group was mothers' expression of negative emotion significantly correlated with their intelligence.

#### 4.4.2 Play interaction

Interaction during play was assessed using the Play Observation Scheme and Emotion Ratings (POSER, Wolke, 1986). This procedure entailed mother playing with the child for six sessions of 2.5 minutes each. Sessions were video recorded in the family home and rated by an independent member of the team who had never visited the families. Three major domains of interest were rated (maternal behaviour, infant behaviour and joint behaviour). The subscales within each of these domains are shown on Table 4.4.2.

Significant differences were found between the groups on one subscale of maternal behaviour (maternal control, the case mothers being somewhat more controlling) and two items of infant behaviour (mouthing and clarity of communication). (Table 4.4.2). 'Non-organic' failure to thrive infants spent relatively more time mouthing the toys presented to them. The fact that they were markedly poorer in terms of their clarity of communication, measured in terms of non-verbal communication skills, suggested that their mothers may have experienced more difficulty interpreting their needs.

**Table 4.4.2: Mean scores on subscales of Play Observation Scheme and Emotion Ratings**

<u>Subscale</u> (No. of items in brackets)	Cases (N = 47)		Comparisons (N = 47)		t
	mean	SD	mean	SD	
<u>Maternal behaviour</u>					
i) Control (5)	5.2	1.0	5.5	0.8	-2.22*
ii) Positive Involvement (2)	4.0	1.0	4.1	1.0	-0.16
iii) Physical involvement (1)	2.4	1.3	2.3	1.5	0.40
<u>Infant behaviour</u>					
i) Task involvement (4)	4.9	1.2	5.1	1.0	-0.92
ii) Vocalization (2)	3.5	1.1	3.5	1.1	0.14
iii) Activity/Intensity (2)	4.8	0.8	4.8	0.7	0.16
iv) Mouthing (1)	1.6	0.8	1.3	0.4	2.77**
v) Clarity of communication (1)	1.6	0.8	3.3	1.0	-9.44****
<u>Joint behaviour</u>					
i) Reciprocity/Harmony (2)	5.1	1.3	5.3	1.0	-0.81
ii) Positive atmosphere (1)	4.8	1.0	4.7	0.8	0.89

\* p < 0.05

\*\* p < 0.01

\*\*\* p < 0.001

## 4.5 Outcome: Quality of home environment

### 4.5.1 HOME scale scores

The largest differences between the groups on any scales that have been analysed so far were on the Home Observation for Measurement of the Environment (HOME) scales (Caldwell and Bradley, 1984).

Highly significant differences in the scores between the groups were found on five of the six subscales, and these were all in the direction of the comparison group providing a more stimulating and nurturing home environment than was the situation for the cases (Table 4.5.1). That there was such a contrast between findings on this measure compared with most others needs explanation, and is indicative of possible rater bias. Although reliabilities were very good, on a sample of families that were rated independently by two observers, the data presented here are from David Skuse's own ratings, made at the time of the physical examination of the child and the medical interview. As he was the only member of the team who could not be blind as to case and comparison status, there is at least the possibility that the scores were biased. The alternative explanation is that this is a very sensitive instrument, and pooled data on the quality of the home environment from a far wider variety of sources than any other rating.

### 4.5.2 Other measures of quality of home environment

Other measures made of the home environment included a Family Cleanliness Scale derived from Davie, Hutt, Vincent & Mason, (1984). This is a 13 item scale which rates items such

as the smell in the infant's home, the need for interior decoration, soiling on furnishings, and so on.

There was a significant difference ( $p = 0.019$ ; paired t test) between the groups on their scores on this scale with the cases' homes appearing dirtier (mean = 3.0, SD 3.4) than those of the comparison infants (mean = 1.5, SD 2.2).

**Table 4.5.1: HOME inventory scores for cases and comparisons**

HOME inventory subscales		Cases		Comparisons		p value for sig*
		mean	SD	mean	SD	
i	Responsivity	8.5	2.2	9.7	1.8	0.003
ii	Acceptance	4.5	2.2	5.7	1.3	0.001
iii	Organization	5.4	0.9	5.8	0.5	0.004
iv	Play materials	6.7	2.5	7.5	2.0	0.033
v	Involvement	3.1	1.8	4.3	1.4	0.001
vi	Variety	3.2	1.4	3.3	1.3	n.s.
Total score		31.3	7.5	36.2	6.2	<0.001

\* paired t tests

## CHAPTER 5. Contrast within Cases between *early* and *late* Failure to Thrive in the First Postnatal Year

### 5.1 Introduction

### 5.2 Pattern of growth in first postnatal year

The pattern of weight gain in cases of growth faltering was studied carefully on a series of charts on which weights for age had been standardised. This preliminary exploration of the data led to the conclusion that the children could be approximately divided into two subgroups, those in whom the onset of their growth failure was before 6 months of age, and those in whom it was later.

Accordingly, the following calculation was performed: let  $x$  be birthweight (standardised) and  $y$  be weight at 12 months (also measured in standard deviation scores). Let  $w$  be weight at 6 months of age. The question was whether the value  $(w - x) > (y - x)/2$ ? If it was, this suggested the majority of the child's growth faltering in the first year had occurred before 6 months of age, (see Figure 5.2A) otherwise it was mainly the latter half of the year (see Figure 5.2B). Each child could be assigned on this basis to an *early* or a *late* growth faltering trajectory, and where the mean values for those trajectories were plotted (see Figure 5.2C) significant differences in standardised weight were found at 3, 6 and 9 months. There were no case children who could not be classified clearly into one or the other subgroups.

Figure 5.2a Weight gain trajectory from birth to 15 months of child with *early* growth faltering

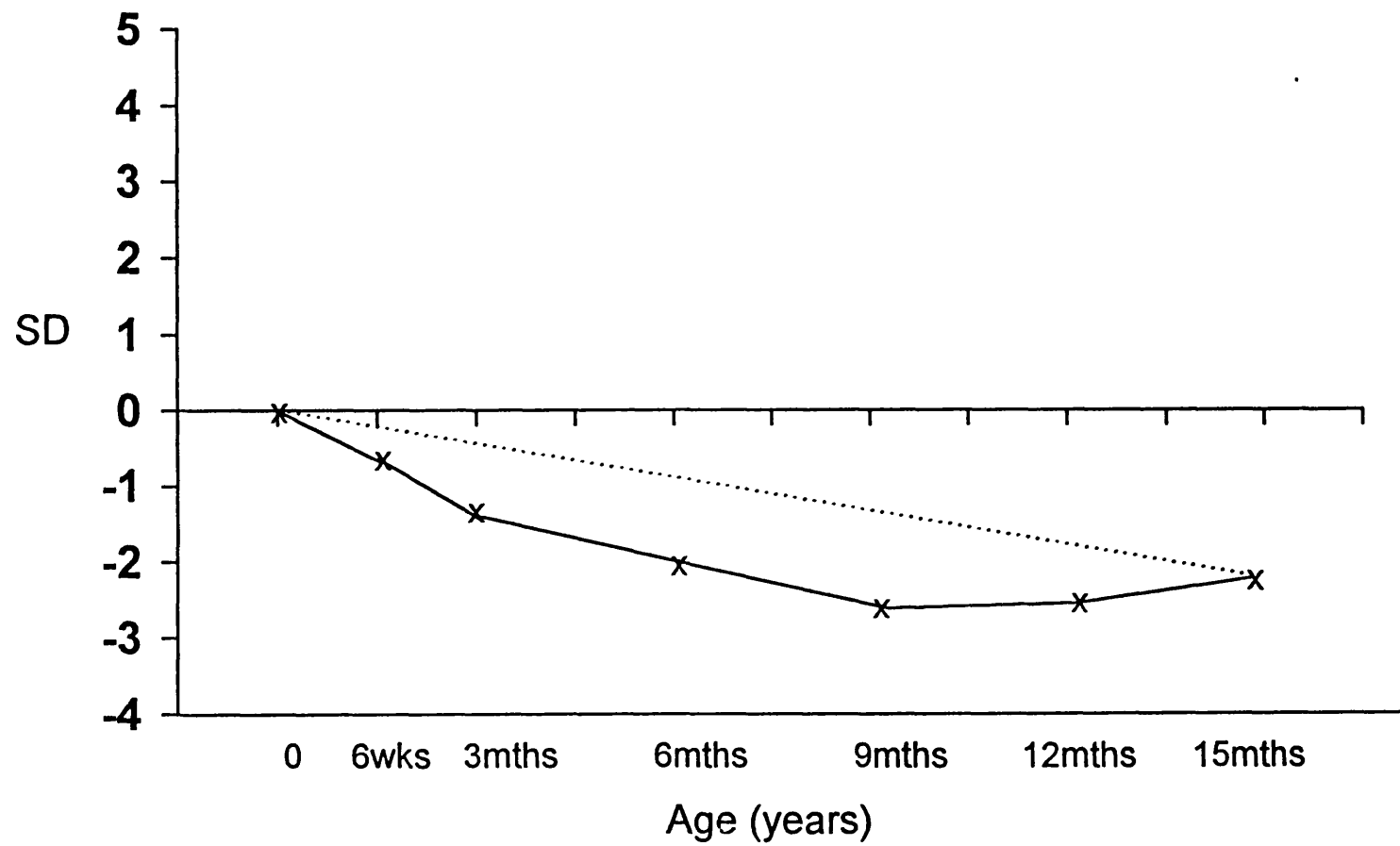


Figure 5.2b Weight gain trajectory from birth to 15 months of child with *late* growth faltering

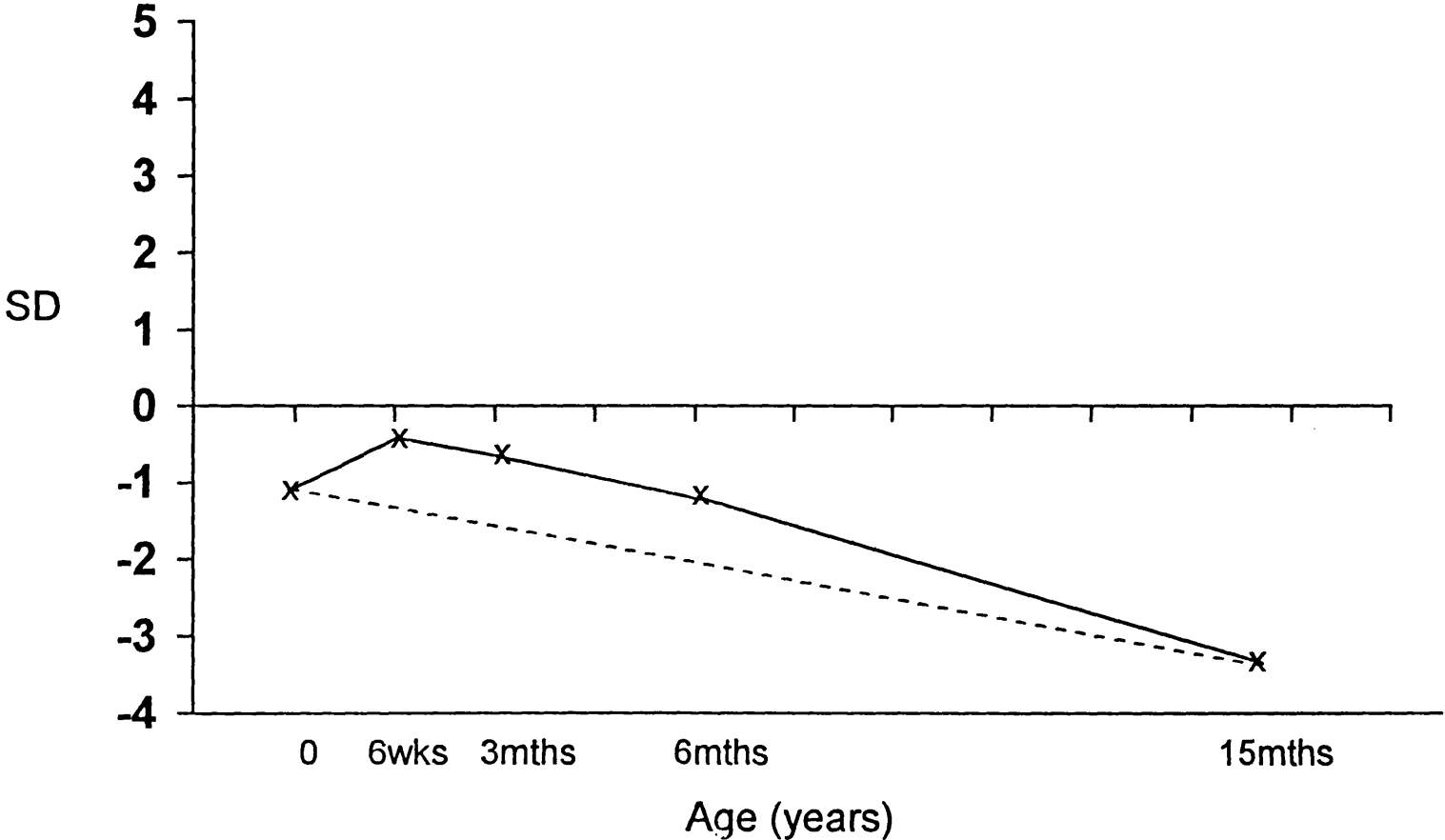
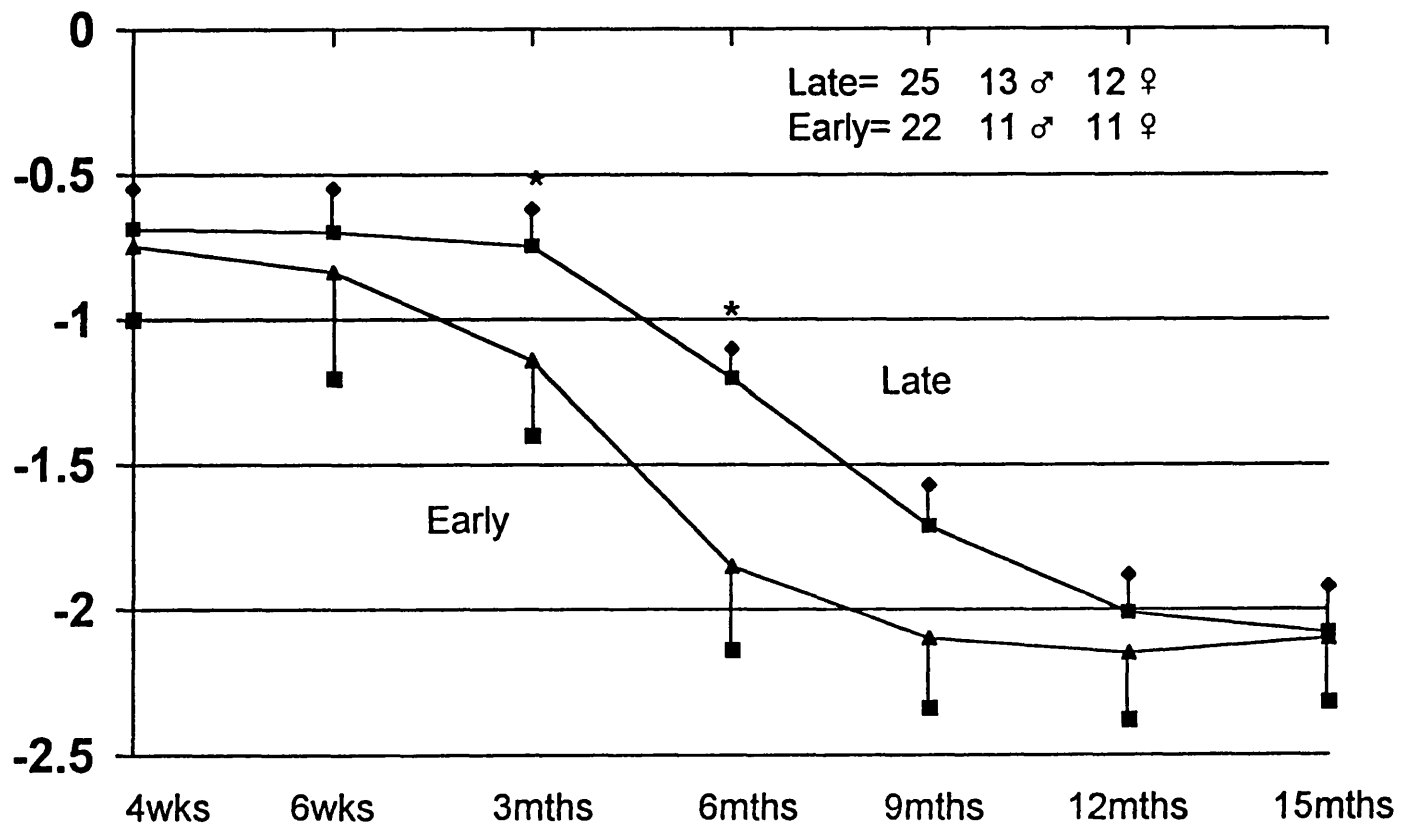




Figure 5.2c Weight gain trajectories of *early* and *later* growth faltering infants, from 4 weeks to 15 months of age



Error bars (2 standard errors) are shown

\* mean trajectories are significantly different at these ages  $p < 0.01$

The *early* growth faltering infants actually had higher birthweights than the others, a matter which will subsequently be discussed in greater detail. For simplicity of exposition standardised weights are shown only from 4 postnatal weeks in Figure 5.2C. The *early* growth faltering group will be referred to as 'early FTT' and the corresponding group 'late FTT'.

### 5.3 Background

#### 5.3.1 Family factors

##### 5.3.1.1 *Socioeconomic Status*

The items which make up Osborn's composite social index (Osborn, 1987) are shown in Table (5.3.1.1) together with data from the 1970 Child Health and Education Study (CHES), a national cohort survey of 16,000 children who were born in 1970. The figures in the right hand column are for the 9.1% 'most disadvantaged' families in that survey, for whom the data were collected in 1975. The values for socioeconomic status relate to father's last or current occupation, in homes where there was a stable cohabitee, where the father had not been unemployed for more than one year. In other words, if a cohabitee had recently lost his job, within the past year, socioeconomic status is based upon the previously held regular employment.

The proportion of families living in rented accommodation (the great majority renting from the local authority) was very similar in both groups (approximately 4 out of 5 families). However, there were significant differences in the state of repair of that accommodation;

Table 5.3.1.1: Social characteristics of sample, compared with 'most disadvantaged' families in CHES survey\*

	<i>early</i> FTT† %	<i>late</i> FTT† %	'CHES' sample %
<b>Father's occupation (OPCS)**</b>			
III manual	44.0	57.0	30.3
IV	11.0	5.0	25.1
V	17.0	14.0	26.3
Father has no educational qualifications	33.0	29.0	82.5
Single parent household	23.0	20.0	(17.3)***
Local authority rented accommodation	77.0	88.0	82.6
<b><u>Type of accommodation</u></b>			
Flat or maisonette	73.0	84.0	43.1
Terrace house	23.0	8.0	33.9
<b><u>Person per room ratio</u></b>			
> 2.0	5.0	4.0	5.8
> 1.5 ≤ 2.0	5.0	16.0	16.9
> 1.0 ≤ 1.5	45.0	52.0	43.4
≤ 1.0	45.0	28.0	33.9
Has no car	45.0	48.0	90.7
Has no telephone	18.0	36.0	91.8

\* Child Health and Education Study (CHES); a national cohort survey of 16000 children born in 1970. These data refer to the most disadvantaged 9.1% in 1975 (Osborn, 1987).

\*\* Office of Population Censuses and Surveys social class

\*\*\* estimated value - may be slightly in excess of true value (Osborn, 1987)

† there are no significant differences between the groups on the *early* and *late* FTT groups on any of these variables

only 23% of those in the *early* growth faltering group had problems such as dampness or draughts, whereas this was the case for 60% of the *later* group ( $p < 0.03$ ).

There was also a highly significant difference between the subgroups in response to the question 'How many times in the past year have you had no money in the house?'. Despite similar levels of mean weekly income, 64% (16) of families with *late* growth faltering infants said this had happened to them at least once, whereas this was true for only 27% (6) of *early* FTT families ( $p < 0.01$ ).

Similar proportions of families in both groups (82% and 83% respectively) said their first spending priority was food. At the time of the assessment 16% of fathers in the *early* FTT families were unemployed, and 24% of fathers in the *late* FTT group - a non-significant difference.

The relationship between the composite social index score within each of the three main social classes and the results of the CHES survey are shown in Table 5.3.1.2. These figures refer only to those families where there was a stable cohabitee, so that the data from our investigation can be directly compared with the CHES findings. There are no significant differences in the mean scores on the composite index between groups within each category. In other words, there was no trend for the failing to thrive families to be more disadvantaged than families from the equivalent OPCS social class subcategory in the CHES survey.

**Table 5.3.1.2: Social characteristics of sample, compared with 'most disadvantaged' Families in Child Health and Education Study (CHES)\* survey†**

(OPCS social class)**	<i>early</i> FTT (n=22)			<i>late</i> FTT (n=25)			'CHES' survey		
	mean	(N)	SD	mean	(N)	SD	mean	(N)	SD
I	63.5	2.1	2	60.0	-	1	66.4	842	4.4
II	60.5	7.8	2	55	-	1	59.7	2385	6.2
III non-manual	38	-	1	46	7.9	3	53.9	1058	6.7
III manual	43.6	4.0	8	41.5	3.7	12	47.1	5701	7.1
IV	37.5	3.5	2	36	-	1	43.0	1614	6.9
V	38.7	7.0	3	36.3	2.3	3	36.9	746	6.1
All	44.2	10.0	22	42.0	7.6	25			
Currently employed	36.0	3.5	3	40.2	3.3	5			

\* Child Health and Education Study (CHES); a national cohort survey of 16000 children born in 1970. These data refer to the most disadvantaged 9.1% in 1975 (Osborn, 1987)

\*\* Office of Population Censuses and Surveys social class

† there are no significant differences between the case and comparison groups on any of these variables

#### 5.3.1.2 *Family Composition*

The proportion of single parent families in both groups was very similar to that in the CHES survey.

#### 5.3.1.3 *Family Size*

Family size did not distinguish the groups either. Within the *early* FTT group there was a mean of 2.0 ; SD 0.7 resident adults and 2.2 ; SD 1.0 resident children. The equivalent figures for the *late* FTT group were 2.5 ; SD 1.1 and 2.0 ; SD 1.3.

#### 5.3.1.4 *Ethnic Composition*

The sample was ethnically mixed but there were no significant differences in the proportion of ethnic groups. The figures are given in Table 5.3.1.4. The Indian-Asian subjects were largely from India, Sri Lanka and Pakistan. The 'Chinese Asians' were Vietnamese or from Hong Kong.

#### 5.3.1.5 *Marital relationship*

Mothers' relationships with their spouses were assessed with the Dyadic Adjustment Scale (Spanier, 1976; Spanier and Thompson, 1982; Sharpley and Cross, 1982; Antill and Cotton, 1982). Only the Dyadic Satisfaction subscale was rated. There was only a small and non-

**Table 5.3.1.4: Ethnic compositions of *early* and *late* growth faltering groups**

	<i>early</i> n = 22 %	<i>late</i> n = 25 %
<b>White</b>	<b>64</b>	<b>44</b>
<b>Indian Asian</b>	<b>14</b>	<b>12</b>
<b>Chinese Asian</b>	<b>0</b>	<b>8</b>
<b>Caribbean</b>	<b>5</b>	<b>28</b>
<b>Mixed race</b>	<b>18</b>	<b>8</b>

significant difference between the reports of mothers of *early* growth faltering infants (mean 39.2; SD 5.5) and others (mean 35.7 ; SD 8.8). Both scores were similar to the values for a wider sample of women (mean 38.7 ; SD 6.1) given by Antill and Cotton (1982).

### 5.3.2 Anthropometry

#### 5.3.2.1 *Parental anthropometry*

Data on parental age, height and weight are given in Table 5.3.2.1. No significant differences exist between the groups on any of these variables. The data for fathers are for the biological fathers of the children, whether or not they were living in the family at the time of assessment.

#### 5.3.2.2 *Infant anthropometry at birth*

Information on the characteristics of our growth faltering infants at the time of their birth was obtained by a retrospective analysis of their birth records. Virtually all subjects had been born in a teaching hospital where it was a routine procedure to record birth weight, length and occipito-frontal head circumference. One of the children was born at home (precipitant delivery), a further mother who went into a precipitant labour gave birth in the ambulance taking her to hospital. Data were available on all subjects for birthweight, on 83% (39) for length, and 96% (45) for head circumference at birth. It was possible to standardise birthweights for maternal stature, mid-pregnancy weight, gestation, ordinal position of the child (first or other born) and gender according to the method of Tanner and Thomson



Table 5.3.2.1: Anthropometric characteristics of the parents of *early* and *late* growth faltering subjects

	<i>early</i> FTT			<i>late</i> FTT		
	Mean	SD	(N)	Mean	SD	(N)
<b><u>MOTHER</u></b>						
Age	29.1	5	(22)	26.3	5.3	(25)
Height (cm)	155.9	6.9	(22)	158.6	6.3	(25)
Weight (Kg)	55.4	9.0	(19)	59.8	13.2	(23)
<b><u>FATHER</u></b>						
Age	31.8	5.2	(21)	32.2	8.4	(24)
Height (cm)	175.3	10.6	(22)	170.7	8.6	(25)
Weight (Kg)	73.8	13.7	(20)	68.7	9.3	(21)

(Tanner and Thomson, 1970). These birthweights have been converted into standard deviation scores. A ponderal index was computed according to the method of Miller et al (Miller and Hasanein, 1971), based on the formula: [birthweight in gm x 100% (crown-heel length cm<sup>3</sup>)]. This formula was derived from the observation that the weight of an object of uniform density and dimensions increases on the cube of its length. Values have been corrected for gestational age. Birth length standards from Kitchen et al (1981) and head (occipito-frontal) circumference from Yudkin et al (1987) have been corrected for gender and gestational age. These data are shown on Table 5.3.2.2A.

As can be seen from Table 5.3.2.2B the distribution of ponderal indices, length and occipito-frontal circumferences is approximately similar within each of the centile channels, but there is already, among both *early* and *late* faltering groups, an excess of children below the 3rd population centiles. These are not the same children, in most cases, although a small proportion (about 15% : 7) did have both length and occipito-frontal circumference below the 10th centile at birth. What certainly is clear is there is no tendency for the *early* growth faltering group to show any substantial difference in distribution than the *late* faltering infants, on these variables. The possibility that differences in the mean values of these variables could exist between the groups on these three variables was investigated using a one-way ANOVA in which gestation was used as a control variable. No evidence was found to support this hypothesis, the values for occipito-frontal circumference (cm) for *early* and *late* growth falterers being 33.5; SD 112 and 33.1 ; SD 13.9 respectively; those for birth length (cm) 50.3; SD 25.9 and 50.1; SD 28.2 and those for the ponderal index were identical at 2.41; SD 0.4.

Table 5.3.2.2A: Anthropometry of *early* and *late* growth faltering infants at birth

	mean	<i>early</i> FTT SD	N	mean	<i>late</i> FTT SD	N
Birthweight** (SDS)	-0.42	0.78	22	-1.05	0.5	25
Head circumference (SDS)	-0.96	0.9	22	-1.36	1.1	24
Length (SDS)	0.11	1.1	19	-0.02	1.25	23
Ponderal Index	0.24	0.04	19	0.24	0.04	23

\*\*  $p < 0.01$

Table 5.3.2.2B: Anthropometric characteristics of *early* and *late* growth faltering infants, at birth, from birth records†

Centile channel	Ponderal index		Length		Head circumference	
	early %	late %	early %	late %	early %	late %
> 97	16	13	11	17	0	0
90 - 96	0	4	32	13	0	0
50 - 89	5	17	32	13	14	4
10 - 49	42	22	11	22	55	39
3 - 9	5	17	5	22	9	22
< 3	32	26	11	13	22	35
Totals (N)	19	23	19	23	22	23

† there are no significant differences between *early* and *late* growth faltering groups on any of the above variables

However, a different picture emerged when we came to compare these groups in terms of standardised birthweights which controlled for gestation, maternal height, and sex of infant. The mean values were, for the *early* and *late* FTT children respectively, -0.42 ; SD 0.78 and -1.05 ; SD 0.5 ( $p=0.002$ ). A test for the nonnormality of both distributions (Lilliefors) did not reach conventional levels of significance. No child had a standardised birthweight which was more than -2 standard deviations below the population mean (Tanner and Thomson, 1970). In absolute terms birthweights did not differ significantly, the mean values being (gm), *early* 3101 ; SD 398 and *late* 2931 ; SD 326.

### 5.3.3 Infant medical history

#### 5.3.3.1 *Antenatal and perinatal history*

An examination of specific prenatal and perinatal factors that could have been associated with impaired mental and psychomotor development was made from the birth records obtained. Choice of variables in this particular comparison was based on the Collaborative Perinatal Project of the National Institute of Neurological and Communicative Disorders and Stroke (62) in which there were 66 variables, for which we had measures, that were correlated with outcome on those dimensions. The scores were weighted in line with the recommendation of Broman et al (1975). If a mother had every one of those risk factors her antenatal/perinatal abnormality score would be approximately 110. Twenty-one of the variables that go toward computing the total score are weighted. Examples of the key variables which entered into the analysis, together with the proportions with positive values in the two groups, are given in Table 5.3.3.1. As can readily be observed, there are very few differences between these and

**Table 5.3.3.1: Examples of individual risk factors used to compute total Antenatal and Perinatal Risk Score for mothers of *early* and *late* growth faltering subjects**

<b>Antenatal or perinatal risk factor*</b>	<b><i>early</i> FTT % (N)</b>	<b><i>late</i> FTT % (N)</b>
Vaginal bleeding during pregnancy	14 (3)	9 (2)
Severe infection during pregnancy (eg, Rubella, Herpes)	0	9 (2)
Albuminuria with high BP (i.e., systolic > 140, diastolic > 90)	9 (2)	4 (1)
Diabetes	5 (1)	0
Epilepsy	0	0
Fetal distress	5 (1)	4 (1)
Meconium staining of amniotic fluid	14 (3)	4 (1)
Placental weight outside normal range (342-530gm)	0	4 (1)
Apgar score < 8 at 1 min	32 (7)	28 (7)
< 8 at 5 min	5 (1)	0
< 8 at 10 min	5 (1)	0
<b>Total scores</b>	<b>mean 6.18 SD 2.8</b>	<b>mean 6.04 SD 3.6</b>

\* there are no significant differences between the subgroups on any of the above variables.

the overall mean scores are very similar indeed. The main contributor to the apparently high proportion with some degree of fetal distress was a transient bradycardia (< 120) at some point during the delivery.

#### 5.3.3.3 *Early medical history*

An extensive interview was undertaken with mothers concerning their child's medical history since birth. This was supplemented where appropriate by further investigations of medical records and discussion with specialists who may have seen the child. It is worth emphasising at the outset that 19.1% (9) of the case infants had previously been referred to hospital specifically for investigation of their faltering growth. A further 12% (6) had been discussed by their mother with her family doctor or health visitor. 34% (16) of the remaining mothers were 'concerned' about their child's growth, but a further 34% (16) had no concerns at all. These four categories of infants could not be distinguished on their mean standardised weight for age.

Children with serious medical illness, which might have caused growth faltering, were excluded from the samples of infants discussed here. There were reports of only relatively minor illnesses during the first year of life, such as episodes of upper respiratory tract infection, diarrhea and otitis media. A weighted score was computed for 17 such variables, which took a maximum value of 25. Table 5.3.3.3 shows the relative frequency of some of the variables that went into the derivation of this index for each of the groups, together with mean total scores. Neither individual indices of risk nor the total score distinguished the *early* from the *late* growth falterers, suggesting that the frequency of -illness was not a relevant

**Table 5.3.3.3: Proportions of infants with minor physical disorders, reported by mothers, in the first postnatal year**

<b>Examples of Disorder</b>	<b><i>early</i> FTT % (N)</b>	<b><i>late</i> FTT % (N)</b>
Neonatal jaundice requiring treatment	27 (6)	20 (4)
Convulsions after 2 weeks of age	0	9 (2)
At least one episode of diarrhoea	67 (14)	64 (16)
At least one episode of vomiting	48 (10)	48 (12)
Loose bulky stools	35 (7)	20 (5)
> 5 upper respiratory tract infections	48 (10)	48 (12)
<b>Total scores</b>	<b>mean 8.5 SD 3.7</b>	<b>mean 8.0 SD 3.4</b>



factor in causing their disorder. However, because the data were collected retrospectively it was not possible to specify the timing of most of their illnesses within the first year; the data would have been too unreliable.

#### 5.4 Postnatal feeding history

Histories of how the children were fed as infants were obtained from mothers by interview at follow-up, when the infants were about 15 months of age. The information obtained was therefore retrospective and for that reason cannot be regarded as wholly reliable. Although a substantial amount of detail was obtained about early feeding practices, in view of the nature of the data this has been relatively simplified. Twenty percent (4) of the 'early FTT' group and 13.6% (6) of the 'late FTT' group were exclusively breast fed. Twenty-four percent (5) of the *early* and 32% (8) of the *late* group were exclusively bottle fed; the corresponding figure for those given a mixture of breast and bottle was 56% (12) and 54.5% (14) . None of these differences reached statistical significance. The mean age at which solids were introduced was virtually identical in the *early* and *late* groups too, being 17 weeks for both groups (SDs 6.7 and 6 weeks respectively).

There did not seem to be any major feature of their early feeding histories which distinguished the groups, although it might have been expected that the *later* FTT group began to show growth faltering around the time of weaning, possibly because of difficulties in getting the children to accept solid foods. We did attempt to 'map onto' standardised charts of the children's growth trajectories the times at which weaning occurred for individual subjects, according to mothers' reports, but the findings were inconclusive.

A substantial proportion of the infants in both groups were reported as having slept through feeds at some time in the first year. That is to say, when it was time for the infant to have a meal the child was asleep, or alternatively fell asleep during a feed. This was the case for 68% (15) of infants with *early* growth faltering and 64% (16) of the infants with *later* growth faltering, after six months or so. Although we attempted to discover whether there were systematic differences between the groups according to the timing and the duration of this behaviour, no differences could be detected.

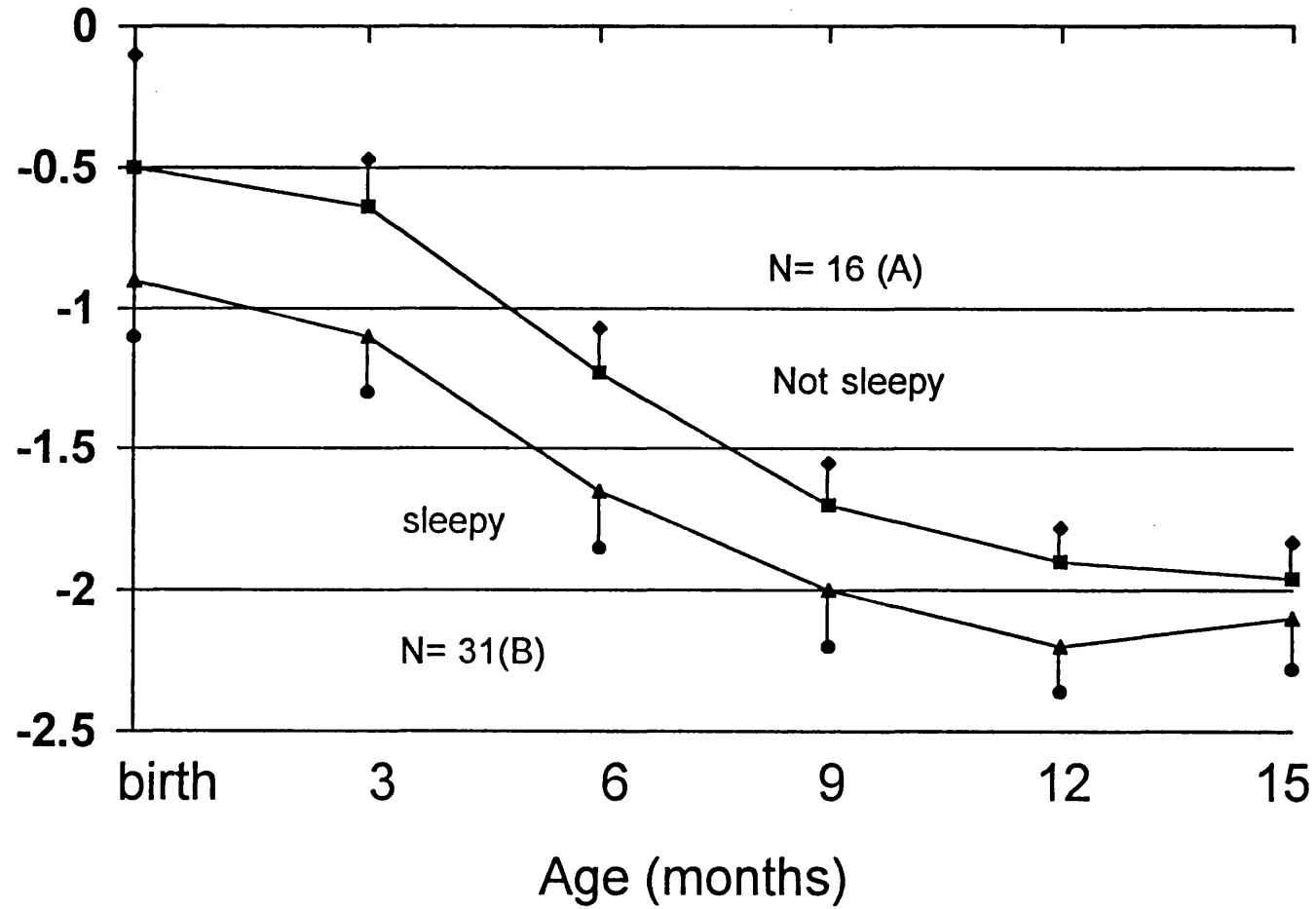
It is of course of great interest to know how mothers responded to this pattern of behaviour. Of those who slept through feeds at some time, in the 'early FTT' group 40% (9) were woken by their mother, according to their retrospective reports. In the 'late FTT' group 62% (14) were woken by their mother. Although these differences are relatively small, they are at least suggestive that perhaps infants who were sleeping through feeds at a time when their growth rate was at its most rapid, and who were not yet weaned, were being chronically undernourished because of missed meals. The interview material certainly raised the suspicion that overnight feeds were frequently missed in the early days if the infant was a 'good' baby and slept through the night without demanding to be fed. However, similar proportions of infants in both groups were said to sleep through the night, before 6 weeks of age, *early* 24% (5); *late* 25% (6).

## 5.5 Early feeding history and growth

If these mothers' reports of their babies lack of demandingness was correct, and they were indeed missing feeds because they were asleep, one would expect this to be reflected in their growth trajectories - although it could not of course explain the difference in the growth trajectories of the *early* and *late* groups. Accordingly, the groups were combined and then categorised according to whether their mothers reported them as having ever slept through feeds, or not. Remarkably, the weight gain trajectories of those who were in the 'sleepy baby' group fell below the remainder, and a significant discrepancy persisted from 4 weeks (the earliest standardised measurement) right up until 12 months of age (Figure 5.5).

Their birthweights were not significantly different from one another, whether measured in absolute terms (sleepy infants mean 2938 gms; SD 344: others mean 3150 gms; SD 380) or in standard deviation scores (Tanner and Thomson, 1970). Nor were their ponderal indices or occipito-frontal circumference, but the sleepy infants were shorter (mean 49.6 cm; SD 12.5: compared with mean 51.3 cm ; SD 2.7 ;  $p= 0.06$ ). Where the birth length was standardised for gestation and gender a much greater magnitude of differences emerged (mean -0.31 SDS; SD 1.1: compared with mean 0.66 SDS ; SD 1.1;  $p=0.01$ ). It is worth noting that, despite a difference in standardised length of about 1 SD, both mean values are well within the normal range.

Figure 5.5 Weight gain trajectories of growth faltering infants, according to whether they ever slept through feeds\*



\*Differences between groups A and B at 4 weeks, 3 months, 6 months  
12 months  $p < 0.01$  and at 6 weeks, 9 months  $p < 0.02$   
No significant differences at birth or 15 months

Error bars (2 standard errors) are shown

In order to explore this matter further a series of analysis of variance was undertaken with weights (standardised) at 4 weeks, 6 weeks, 3 months, 6 months, 9 months and 12 months as the

dependent variables, and a set of predictor variables which included whether the child had ever slept through feeds, whether mother reported that she regularly woke the baby for feeds or not, whether the child was breast, bottle or combination fed, and the gender and ordinal position of the child. Other potential explanatory variables included mother's IQ, various measures of her mental state and the summary score for the child's oral motor difficulties. Potential interactions between these variables were investigated but none of any significance was found. A series of multiple regression equations was then calculated for each of the above mentioned ages, in which only those predictor variables that had been found to be of relevance in the former exploratory analyses were entered. The results are shown in Table 5.5.

As can be seen, the variable 'slept through feeds' was significant at every age, and children who did so had lower weights for age. Interestingly, the variable 'mother woke baby' had no significant effect and was not included in the final models. Neither did mother's mental state, even when this was entered as a variable relating to the duration of postnatal depression. The ordinal position of the child had no significant influence once the other variables had been entered. However, mother's IQ had a substantial impact on the child's

**Table 5.5: Multiple regression of postnatal standardised weights on explanatory variables**

Dependent variable: standardised weight at	Explanatory variables	F ratio for R <sup>2</sup>			Change in adjusted R <sup>2</sup>	Standardised regression coefficient	t	p
		DF	F	Significance				
4 weeks	1. Exclusively breastfed				0.17	0.36	2.8	0.008
	2. Slept through feeds				0.10	-0.33	-2.5	0.016
	Total explained	2,44	8.3	.0009	0.27			
6 weeks	1. Exclusively breastfed				0.18	0.38	2.9	0.006
	2. Slept through feeds				0.08	-0.29	-2.18	0.035
	Total explained	2,44	7.8	0.0013	0.26			

Table 5.5 continued .....

3 months	1. Exclusively breastfed				0.19	0.40	3.10	0.003
	2. Slept through feeds				0.10	-0.33	-2.6	0.01
	Total explained	2,44	9.6	0.0004	0.30			
6 months	1. Slept through feeds				0.11	-0.34	-2.42	0.02
	Total explained	1,45	5.9	0.02				
9 months	1. Slept through feeds				0.09	-0.3	-2.1	0.04
	Total explained	1,45	4.5	0.04				
12 months	1. Solids				0.16	-0.3	-2.3	0.02
	2. Slept through feeds				0.11	-0.27	-2.1	0.04
	3. Gender (male=1, female=2)				0.05	0.22	1.7	0.09
	4. Mother's IQ				0.06	0.22	1.7	0.05
	Total explained	4,42	6.55	0.0003	0.33			

weight at 12 months only, children of mothers with higher IQs having a greater weight for age, presumably reflecting their better feeding practices. Gender had a small and nearly significant influence at this age too, girls being relatively heavier than boys.

## 5.6 Outcome : Infant

### 5.6.1 Anthropometry

The children were examined as close to 15 months of age as was possible, and the mean ages at examination of the two groups were similar (Table 5.6.1). A variety of anthropometric indices are presented, both directly measured and derived measures. There are no significant differences on any of them. Whether the groups are compared on the basis of mean values or on the basis of their centile distributions the findings suggest, despite contrasting trajectories of early postnatal growth, on average their anthropometric outcome at the age of 15 months or so is identical.

#### 5.6.1.1 *Other physical examination*

A composite score comprising five variables that related to the appearance of the children - whether skin or nails were clean or dirty, whether burns or scars were visible, and whether extremities were red, puffy or shiny in appearance - did not distinguish between the groups either (0.81  $\pm$  SD 1.1 and 0.88  $\pm$  SD 1.1). On the Waldrop et al (1968) scale of minor physical anomalies the total possible score was 24. The mean scores for the two groups were very similar: *early* FTT children 1.8 ; SD 1.8 and *late* FTT children 2.2 ; SD 2.9.



Table 5.6.1: Anthropometry of *early* and *late* growth faltering infants at outcome†

Variable	<i>early</i> FTT	<i>late</i> FTT
<u>At outcome</u> (n=47)		
Weight (SDS)	-2.07 ± 0.54	-2.07 ± 0.33
Length (SDS)	-1.31 ± 0.84	-1.22 ± 1.04
Weight for Length (SDS)	-1.63 ± 0.6	-1.71 ± 0.68
Head circumference (SDS)	-0.96 ± 0.9	-0.81 ± 1.08
Mid-upper arm circumference (cm)	13.7 ± 0.7	13.5 ± 0.76
Arm muscle circumference (cm)	11.05 ± 0.54	11.03 ± 0.67
Arm fat area (mm <sup>2</sup> )	15.9 ± 1.8	15.5 ± 1.7
Velocity of head circumference growth since birth (cm/yr.) (n=46)	9.86 ± 1.3	10.44 ± 1.8
<u>Change from birth to outcome</u> (n=47)		
Weight	-1.66 ± 0.9	-1.05 ± 0.6**
Head circumference (n=46)	0.01 ± 1.2	0.57 ± 1.1
Length (n=42)	-1.43 ± 1.2	-1.25 ± 1.3

† values are given as mean standard deviation scores ± 1 standard deviation. There are no significant differences between groups on any variables, except where indicated.

\*\* p < 0.01

### 5.6.2 Physiological measures

The mean haemoglobin levels of *late* faltering subjects were significantly lower than those of *early* faltering subjects (early 11.46 ; SD 1.13 ; *late* 12.11 ; SD 0.92 ;  $p=0.03$ ). Taking the WHO (1972) recommended cut-off of 11 gm/dl between 6 months and 6 years as an indicator of anaemia we found 14% (3) of the *early* FTT group and 36% (9) of the *later* FTT group had haemoglobin concentrations at or below this level. Despite the rather large differences in the magnitude of these proportions it failed to reach statistical significance. The most likely explanation for the anaemia was iron deficiency; we had screened for possible inherited anaemias such as thalassaemia or sickle cell anaemia but none of the children was found to be suffering from these conditions. Serum ferritin levels were very similar in the two groups: the mean values were *early* 20.3 ; SD 15.5 ng/ml; *late* 19.3 ; SDD 13.1 ng/ml and the proportions with values < 7 ng/ml (Siimes et al, 1974) were 14% (3) and 24% (6) respectively. Values of serum B12 and red cell folate were all within the normal range for infancy. Both mean corpuscular haemoglobin (26.0 ; SD 1.8; 24.8 ; SD 2.4) and mean corpuscular volume (80.1 ; SD 3.2; 76.9 ; SD 6.4) were significantly lower in the *late* failure to thrive children ( $p < 0.05$ ) suggesting that the anaemia was for the most part a microchromic microcytic one and that iron deficiency was most likely to have been responsible for their condition.

### 5.6.3 Neurodevelopmental attainments

Scoring was according to the weighting system recommended by Touwen (86). The total mean scores were very similar in respect of both gross motor skills (20.7 ; SD 4.8 and 21.2 ;

SD 4.0) and fine motor skills (6.8 ; SD 2.6 and 7.9 ; SD 1.4) for the *early* and *late* growth faltering infants, respectively.

#### 5.6.4 Oral-motor competence

Evidence from our previous research (Reyes et al, 1990) has shown that oral-motor skills may be important in determining growth faltering, by means of inefficient eating behaviour and possibly overt feeding difficulties, which could in turn lead to chronically impaired nutrition. We derived a composite risk scale from a series of 18 oral-motor skills (such as whether the child ever had problems sucking or swallowing liquids, or difficulties biting or chewing, had ever objected to lumpy foods) but the *early* and *late* growth faltering infants were not distinguished on the basis of their total scores (3.7 ; SD 2.7 : 3.6 ; SD 2.8).



#### 5.6.5 Cognitive and psychomotor abilities

Although it was shown that overall there was a significant difference in the mental and psychomotor abilities of case and comparison infants, when the analyses were rerun, this time comparing the outcome for the *early* and *late* growth faltering infants the findings were as shown on Table 5.6.5.

It can readily be appreciated that there was a major difference in the *early* group compared with the noncases, but the difference in mental and psychomotor abilities between the *late* growth faltering infants and the comparisons was not significant statistically.

Table 5.6.5: Bayley Scales of Infant Development mental (MDI) and psychomotor (PDI) development indices for *early* and *late* growth faltering infants, contrasted with their pairwise matched comparisons

	Unpaired comparisons within case group*				Pairwise Comparisons†			
	<i>early</i> FTT		<i>late</i> FTT		comparisons matched to <i>early</i> FTT		comparisons matched to <i>late</i> FTT	
	mean	SD	mean	SD	mean	SD	mean	SD
Mental development index	91.6	19.5	104	16.8	109.9	16.7	107.1	12.2
Psychomotor development index	90.8	17.1	101.8	16.1	104.7	16.3	102.6	12.8

\*Unpaired comparisons

MDI - *late* > *early*            p=0.02

PDI - *late* > *early*            p=0.03

†Pairwise comparisons were between *early* and *late* growth faltering cases and their pairwise matched comparisons. So, for example, the MDI of *early* FTT group (mean 91.6) is compared with the value 109.9.

early: MDI - cases < comparisons p=0.003

PDI - cases < comparisons            p=0.01

late MDI /PDI - no significant differences between cases and comparisons

### 5.6.6 Temperament

There were no significant differences between the groups in terms of the ways in which their mothers perceived their temperaments. Findings from the Infant Characteristics Questionnaire (Bates and Bayles, 1984) are presented in Table 5.6.6A, and the mean scores are compared with those of the original standardisation sample. They are seen to be very similar.

Findings are also presented on Table 5.6.6B for the analysis of the TRIB (Wolke, 1990), which was used to rate the infants behaviour during the administration of the Bayley Scales of Infant Development. No significant differences were found in respect of the infants' behavioural style as measured by the subscales' mean values.

Finally, the infants' behaviour on the Feeding Interaction Scale (Wolke, 1987) was measured, according to the three dimensions that had been identified from principal components analysis: social referencing; activity and difficult behaviour in regard to feeding. There were no significant differences found between the groups on these dimensions of behaviour, as shown on Table 5.6.6C.

**Table 5.6.6A: Mean scores on Bates' Infant Characteristics Questionnaire, compared with original standardisation sample\***

Subscales	Bates' Sample (N= 384)		<i>early</i> (N= 22)		<i>late</i> (N= 25)	
	Mean	SD	Mean	SD	Mean	SD
Difficult	28.6	7.4	31.6	7.0	30.9	7.1
Unadaptable	13.8	4.4	15.8	5.3	15.8	5.0
Unsociable	6.9	2.3	8.0	3.0	7.8	3.7
Persistent	13.1	3.3	13.6	3.7	13.0	2.3

\*There are no significant differences between the mean scores of the *early* and *late* faltering samples.

**Table 5.6.6B: Infant behaviours during testing on Bayley Scales as rated by TRIB\***

Subscale of TRIB	<i>early</i> growth faltering (n=22)		<i>late</i> growth faltering (n=25)	
	mean	SD	mean	SD
Positive emotional tone	5.5	1.9	5.9	1.6
Motivation and endurance	4.5	1.6	5.2	1.7
Distractibility	5.3	1.9	4.9	2.0
Activity level	5.7	2.1	5.4	1.8
Vocalizations	4.5	1.9	4.0	2.0
Goal directedness	4.0	1.6	4.9	1.5
Difficultness	5.3	1.7	4.9	2.0
Cooperativeness	5.1	1.9	5.6	1.9

\*There are no significant differences between the groups on any of these variables

**Table 5.6.6C: Infant behaviour rating on composite factors, including vocalisations, activity and difficulty, during mealtime**

Rater observations	Feeding Interaction Scale (FIS)				
		<i>early</i> n= 22		<i>late</i> n= 25	
	Mean	SD	Mean	SD	
Factor 1 (social referencing 'vocal')	18.9	6.0	19.6	5.5	n.s
Factor 2 (activity)	9.1	1.3	9.4	2.0	n.s
Factor 3 (difficulty around food)	5.4	2.7	5.9	2.4	n.s



## 5.7 Preliminary evidence for a sensitive period for growth and mental development

Further analyses were then undertaken to explore this finding in more detail. The results of an ANOVA, with both the psychomotor and mental development index of the Bayley Scales as dependent variables, and with mother's IQ as a covariate, are shown in Tables 5.7A and 5.7B.

The data show that their growth trajectory did indeed have a substantial and highly significant influence upon the cognitive and psychomotor abilities of the infants at 15 months, with the *early* growth faltering children doing poorly relative to those whose faltering began after 3-6 months of age. Mother's IQ does have a significant influence, but upon the Mental Development index only. Both MDI and PDI are depressed to an equivalent extent by the *early* growth faltering.

## 5.8 Outcome : Mother

### 5.8.1 Mental state

Both the overall scores on the GHQ-28 and the scores on certain of the subscales distinguished between the mental state of the mothers of *early* and *late* growth faltering infants. The overall mean scores of the 'late growth faltering' mothers were significantly higher than those in the 'early growth faltering' group (5.8 ; SD 5.6 and 2.9 ; SD 3.9 respectively;  $p=0.039$ ). In this, and in subsequent presentations of data analysis the figures  $x \pm y$  correspond to the mean value  $\pm$  one standard deviation. Taking the cut-off point of 4/5 - as recommended - the proportions of mothers who were 'probable cases' of psychiatric

**Table 5.7A: Analysis of variance for effects of postnatal weight gain trajectory on mental development index**

Source of variation	Degrees of freedom	Sum of squares	Mean square	F	P
Covariate: maternal IQ	1	1325	1325	5.0	0.03
Main effects: trajectory (early/late)	1	3512	3511	13.2	0.001
Explained	2	4838	2419	9.1	<0.001
Residual	44	11675	265		
Total	46	16512	359		

**Multiple classification analysis**

Grand mean 98.2

Variable and category	N	Unadjusted deviation (ETA)	Adjusted for trajectory and maternal IQ
late FTT	25	5.8	8.7
early FTT	22	-6.6	-9.9
Multiple R <sup>2</sup>			0.29

**Table 5.7B: Analysis of variance for effects of postnatal weight gain trajectory on psychomotor development index**

Source of variation	Degrees of freedom	Sum of squares	Mean square	F	P
Covariate: maternal IQ	1	214	214	0.83	n.s
Main effects: trajectory (early/late)	1	2115	2115	8.2	0.006
Explained	2	2330	1165	4.5	0.017
Residual	44	11397	259		
Total	46	13726	298		

**Multiple classification analysis**

Grand mean 96.7

Variable and category	N	Unadjusted deviation (ETA)	Adjusted for trajectory and maternal IQ
late FTT	25	5.2	6.7
early FTT	22	-5.9	-7.7
Multiple R <sup>2</sup>			0.17

disorder in the two groups differed substantially (56% (12) and 27% (7) respectively), but the magnitude of differences did not reach a conventional level of statistical significance, once a continuity correction had been applied ( $p=0.09$ ).

Looking now at the subscale scores, of the GHQ 28 which were coded according to the 0-1-2-3 system as recommended by Goldberg and Williams (1988), there was no significant difference between the groups in scores on somatic symptoms or anxiety (Table 5.8.1), although on an alternative measure of anxiety (the Multiple Affect Adjective Checklist; Zuckerman and Lubin, 1965) the mothers of *later* growth faltering children did obtain higher scores (3.8 ; SD 3.2 vs. 1.6 ; SD 1.7 ;  $p=0.007$ ). They were also more disturbed in terms of social dysfunction (a GHQ-28 subscale that asks about everyday activities) (mean scores 7.8 : SD 2.9 and 5.8 ; SD 2.8;  $p=0.02$ ). However, their most striking form of psychiatric disturbance was on the GHQ-28 subscale for severe depression when the 0-1-2-3 scoring system was employed (Goldberg and Williams, 1988) (mean for *early* group 2.7 ; SD 2.5; mean for *late* group 0.9 ; SD 1.2;  $p=0.003$ ). Conventional 0011 scoring gave the results presented on Table 5.8.1.

### 5.8.2 Cognitive abilities

Substantial differences were found between the *early* and *late* growth faltering infants' mothers, with those in the latter subgroup having lower IQs by a margin that amounted to about 0.75 SD (Table 5.5.2). All measures were made by a senior psychologist who was blind to case-comparison group status.

Table 5.8.1: The mental state (severe depression of mothers of *early* and *late* growth faltering subjects, compared with population sample

Depression scale score† (GHQ)	<i>early</i> FTT mothers (n=22) %		<i>late</i> FTT mothers (n=25) %		Brooke et al 1989* %	
		N		N		N
0	54.5	12	24	6	72	1089
1	22.7	5	16	4	12.4	187
2-3	13.6	3	28	7	8.4	127
> 4	9.1	2	32	8	6.8	103
Anxiety scale score‡						
0-1	18.0	4	24	6	30.7	464
2-3	31.8	7	16	4	22.9	347
4-6	31.8	7	20	5	23.4	354
>7	18.0	4	40	10	22.7	344

\* pregnant women at booking with antenatal clinic, approx. 17 weeks gestation, inner London population (see para. 4.3.1)

† a chi-square analysis of the proportions in the various categories of scale score, with all 3 groups showed included significant differences (chi square 43.7, 6 df,  $p < 0.001$ ) and a comparison of the *early* vs *late* growth faltering subgroups came close to a conventional level of significance (chi square value 7.15, 3df,  $p = 0.067$ )

‡ a chi-square comparison of the proportion in all 3 groups, by category of anxiety score, was non-significant, as was a comparison of *early* vs *late* growth faltering subjects' mothers.

Table 5.8.2: The cognitive abilities of mothers of *early* and *late* growth faltering subjects, measured by the Wechsler Adult Intelligence Scales (WAIS)

WAIS scores	<i>early</i> FTT			<i>late</i> FTT			p*
	mean	(SD)	(N)	mean	(SD)	(N)	
Verbal	91	(20.5)	(22)	79.3	(3.2)	(22)	0.03
Performance	92	(18.5)	(22)	81.1	(14.6)	(25)	0.03
Full scale	89.9	(19.6)	(22)	77.8	(12.4)	(25)	0.02

\* all analyses were comparisons of means using unpaired t tests

### 5.8.3 Social support

Significant differences were found, with the mothers of the *early* failing to thrive babies having a substantially higher social support score, on average, than mothers in the *later* failure to thrive group (31.1 ; SD 5.1 vs. 25.7 ; SD 5.4 ;  $p=0.001$ ).

## 5.9 Outcome : Infant-mother relationship

### 5.9.1 Feeding relationship

This was firstly investigated in terms of the cognitive stimulation provided by mothers to their infants during mealtimes. There had been shown to be a reasonably high correlation between the measure of cognitive stimulation on the NCAST scale (Barnard et al, 1989; Barnard, 1978) and the infants' mental abilities as measured by the Bayley Scales (Bayley, 1963). However, there was no significant difference between the groups on this variable, the mean value for the *early* growth faltering group being 4.8 (SD 2.7) and that of the *late* faltering group being a mean value of 4.6 (SD 2.1).

Secondly, the two groups were compared on the Feeding Interaction Scale (Wolke, 1987), in terms of both mother and infant behaviours (as in Tables 4.2.6.2A and 4.4.1.2 ). No significant differences were found between the groups on any of these variables.

Finally composite variables of infant behaviour were analysed, also derived from the Feeding Interaction Scale (Table 5.6.6C). No differences in behaviour between the groups were detected from this analysis either.

### 5.9.2 Play interaction

The two groups were compared on a variety of subscales derived from the Play Observation Scheme and Emotion Ratings (Wolke, 1987), the results of which are shown on Table 5.9.3. It is clear that the mean scores are very similar indeed, and none distinguish the groups at a statistically significant level.

### 5.9.3 Outcome: Quality of home environment

Finally the two growth faltering samples were compared on the HOME scales (Caldwell and Bradley, 1984). When discussing previously the positive differences between the cases and the comparisons on this scale, but not on many other measures, it was suggested that the finding could have been influenced by rater bias. In this instance there could have been no bias, for the decision to look at *early* and *later* growth faltering infants was made long after all the data had been collected. Yet there were small but nevertheless significant differences observed between the case and the comparison infants, as shown on Table 5.9.4. Only that for mothers' involvement with their children reached a conventional level of statistical significance, but 'acceptance of the child's behaviour' was close to significance too. More importantly, both variables show differences in the direction that is compatible with the hypothesis being tested, to the effect that mothers of *late* -growth faltering infants represent a group whose care is suboptimal, despite the fact that such infants have less good outcomes in terms of mental and psychomotor attainments than those subjects in the *early* growth faltering subgroup.



**Table 5.9.3: Mean scores on subscales of Play Observation Scheme and Emotion Ratings\***

<u>Subscale</u>	<i>early</i>		<i>late</i>	
	(N = 22)		(N = 25)	
(No. of items in brackets)	mean	SD	mean	SD
i) Control (5)	4.6	1.2	5.0	0.7
ii) Positive Involvement (2)	8.2	1.8	8.0	2.1
iii) Physical involvement (1)	2.0	1.1	2.0	1.2
<u>Infant behaviour</u>				
i) Task involvement (4)	4.8	1.4	5.1	1.1
ii) Vocalization (2)	6.9	2.3	7.1	2.3
iii) Activity/Intensity (2)	4.9	0.9	4.7	0.6
iv) Mouthing (1)	1.7	0.8	1.5	0.9
v) Clarity of communication (1)	2.8	1.1	3.3	1.1
<u>Joint behaviour</u>				
i) Reciprocity/Harmony (2)	5.6	1.5	5.8	1.3

\* there are no statistically significant differences between the groups on any of these variables.

Table 5.9.4: HOME inventory scores for *early* and *late* growth faltering infants

HOME inventory		<i>early</i>		<i>late</i>		p*
subscales		N=22		N=25		
		mean	SD	mean	SD	
I	Responsivity	8.6	2.0	8.4	2.3	n.s.
ii	Acceptance	5.1	1.9	4.0	2.3	0.075
iii	Organization	5.4	0.8	5.4	1.0	n.s.
iv	Play materials	7.2	2.3	6.2	2.7	n.s.
v	Involvement	3.7	1.7	2.5	1.7	0.02
vi	Variety	3.2	1.2	3.1	1.2	n.s.
Total score		33.2	7.5	29.6	7.3	n.s.

\* paired t tests

### 5.9.3.1 *Other measures of quality of home environment*

The mean Family Cleanliness Scale (Davie et al, 1984) values were very similar in both the *early* (mean 3.13; SD 3.8) and the *late* (mean 2.9 ; SD 3.1) growth faltering subgroups. There was thus no evidence that the homes of the *later* failing to thrive infants were in a poorer state of cleanliness than those of the *early* faltering group.

### 5.9.4 *Intrafamilial patterns of failure to thrive*

The distinct psychosocial characteristics of families whose children had *early* or *late* growth faltering led to the hypothesis that similar patterns of growth would tend to be found in the siblings of affected individuals. If the mechanisms producing the growth trajectories were different in the groups there might be a tendency for affected siblings of the probands to have similar profiles of growth faltering in the first year. Accordingly, a search was made for data on sibling growth patterns in infancy. These were obtained from child health clinic records.

Thirty-six percent (8) of those in the *early* growth faltering group and 24% (6) of those in the *late* growth faltering group had no siblings at the time this investigation was undertaken. Fourteen children in the 'early FTT' group had 20 siblings between them, but data on growth in infancy was available on only 11 of these. Of the 'late FTT' group 19 had siblings, 31 in total, but growth data were available on only 21.

There was no obvious source of bias in the availability of the measures. The reasons why records were not available included the fact that the child was born overseas, or in a distant city, or was of such an age that the records had been lost or destroyed. No evidence was

found to support the hypothesis that records were more likely to be available on siblings who had had growth failure at some time. All information came from child health or 'well baby' clinics, not from paediatricians or other hospital records.

In the group with *early* failure to thrive there were 20 siblings in total. Just 35% (7) of these siblings could be said with certainty to have grown entirely normally in the first year, without any degree of growth faltering that was detectable from the available records. Thirty percent (6) had a similar pattern of *early* growth failure to the probands but this was not necessarily sustained for as long a period. However, these 6 siblings did have weights for age which fell clearly below the 3rd population centile at some point in the first six postnatal months. Just one of the 20 siblings had equivalently severe growth faltering which clearly commenced after six months.

The other 30% (6) had some degree of growth faltering at some point in the first year but it was not possible to ascertain the onset because insufficiently frequent measures had been made of the child's pattern of weight gain. In several of these borderline cases the degree of growth faltering recorded was not sufficiently severe (i.e. weight for age fell to below the 10th but not to below the 3rd population centile) to meet diagnostic criteria for failure to thrive.

In the group with *late* growth faltering 57% (12) of the siblings grew normally through the first year. Just 10% (2) had a pattern of failure to thrive which was equivalent to that of their

sibling and which commenced in the latter part of that year. In 20% (4) the onset of growth faltering was in the first six postnatal months. There were an additional 14% (3) of siblings whose degree of growth faltering did not quite meet criteria for failure to thrive, or for whom the onset was uncertain.

The proportion of siblings of children in the *early* and *late* FTT groups who could clearly be categorised as *early* or *late* onset FTT was then examined. The hypothesis to be tested was that there would be a tendency for the pattern of FTT to 'run true' in families. The fact that families of the probands could be distinguished on a variety of indices of psychosocial disadvantage lent support to the hypothesis. However, cross tabulating growth trajectory by the timing of the growth failure onset among siblings (i.e. whether *early* or *late* onset) revealed no significant differences between the groups.

However, it is important to note that overall 54% (17) of the siblings of our subjects had had some degree of growth faltering within the first postnatal year, and in 32% (10) it was relatively severe although not necessarily sustained for as long a period as in the probands.

## **PART THREE**

# **CONSTRUCTION OF A STATISTICAL MODEL TO PREDICT MENTAL AND PSYCHOMOTOR OUTCOME FROM WEIGHT-GAIN TRAJECTORY**

## CHAPTER 6. CONSTRUCTION OF STATISTICAL MODEL

### 6.1 Introduction

Within the case group neither birthweight nor weight at 15 months was significantly correlated with the mental development index (MDI) or the psychomotor development index (PDI) of the Bayley Scales of Infant Development. Yet at the intermediate ages, around 6 months, a strong correlation with outcome was observed. These remarkable observations are presented on Table 6.1. There are significant correlations of weight for age with MDI between 6 weeks and 9 months, and these are maximal at 3 months and 6 months of age. Multiple regressions of MDI and PDI against birthweight, weight at 6 months and weight at 15 months (entered simultaneously) were then undertaken. The estimated regression coefficients for standardized weight at 6 months were large and significant; MDI 15.16 ( $p = 0.004$ ) and PDI 10.79 ( $p=0.028$ ), but those for birthweight and weight at 15 months were small and non-significant. Neither birth weight nor outcome weight predicted subsequent mental or psychomotor attainments at 15 months.

In order to investigate the importance of poor *early* growth as a predictor of later mental and psychomotor abilities, a formal analysis that directly related the timing, severity and duration of growth failure to developmental outcome (Dobbing, 1990) was undertaken using a nonlinear regression model. (Statistical software SPSS-PC 4.1). The period from birth to fifteen months was divided into short intervals of age. We hypothesised that within each interval ( $t$ ) the effect on developmental outcome would be determined by the multiplication of two age-specific measures. Firstly, the sensitivity of mental abilities to growth faltering in

**Table 6.1: Standardised weights-for-age from birth, and their correlation with mental and psychomotor development scale scores at 15 months - cases (n=47)**

Age	Standardised weight for age		Correlations with 15 month scale scores	
	Mean MDI	±	SD	PDI
Birth	-0.76		0.72	
	-0.06		-0.14	
4 weeks	0.72		0.51	
	0.26		0.10	
6 weeks	-0.77		0.55	
	0.31*		0.14	
3 months	-0.93		0.51	
	0.45**		0.22	
6 months	-1.51		0.58	
	0.42**		0.33*	
9 months	-1.88		0.50	
	0.33*		0.15	
12 months	-2.08		0.42	
	0.26		0.20	
15 months	-2.09		0.48	
	0.13		0.11	

\* p < 0.05

\*\* p < 0.01



that interval; secondly, the severity or degree of growth failure. The overall impact of the child's growth trajectory on outcome was obtained by summing the effects for all the intervals.

## 6.2 Preliminary model

The model for data over n time intervals can be summarised by the following equation:

Mental development outcome score is given by:

$$\sum_{t=1}^{t=n} \{sensitivity\ at\ age\ t\} \{severity\ at\ age\ t\}$$

$$= a + \sum_{t=1}^{t=n} \{b + ct\} \{w_t - w_{t-1}\} \quad (1)$$

The coefficient  $a$  is the simple regression constant. The expression in the first set of braces allows sensitivity to vary with age; that is to say, it expresses the magnitude of the decrement of the mental outcome score to a unit of severity (or unit dose) of growth faltering occurring within the short interval  $t$ . The coefficient  $b$  represents the sensitivity at birth, a value that may increase or decrease with age, depending upon the value of the coefficient  $c$ . With a positive value of  $c$  sensitivity increases linearly. With a zero value for  $c$  sensitivity remains constant with age. With a negative value of  $c$ , sensitivity falls progressively to zero and then could potentially take on meaningless negative values. This possibility was avoided by setting such values of sensitivity automatically to zero. The expression in the second set of braces is the difference in weight between successive time intervals, measured in standard deviation scores, and represents the trajectory from one time interval to the next. If the infant's

standardized weight is falling it will yield a positive value. If the weight, relative to international norms, remains unchanged the value in the second set of braces will be zero.

Now, it is possible that any association found between the shape of the *early* weight gain trajectory and later mental functioning could be due, in part or in whole, to a shared dependence on some factor other than somatic growth. In view of the importance of structured stimulation for the normal acquisition of cognitive skills, the measure we had made of mother-infant interaction (NCAST scales; Barnard et al., 1989) was added to the model as an independent variable with linear effects (coefficient *d*). We found no evidence that the HOME scale total or subscale scores (Bradley et al., 1989) added significantly to the variance in mental outcome explained, over and above that explained by the NCAST scores. The measure of minor congenital malformations (square root transformed because of positive skew) appeared to make a small but significant independent contribution to the variance in outcome (psychomotor scale only), and so this was also added (coefficient *e*).

None of the other variables discussed, whether physiological, anthropometric or psychological, significantly improved the explanatory power of the model. This included the children's head circumference at birth which, although significantly distinguishing the groups at that time, did not correlate with outcome (MDI;PDI). Nor did a change score, computed as (head circumference at outcome (SD) - head circumference at birth (SD)).

### 6.3 Final model

This gives the final model equation of the form:

Mental development outcome =

$$a + \sum_{i=1}^{i=n} \{b + ct\} \{w_i - w_{i-1}\} + d + e \quad (2)$$

The actual values of coefficients  $a$  to  $e$  were estimated from the sample data and are shown in Table 6.3. Standard F-test statistics, like those for ordinary linear regression, were then obtained for various hypotheses which involved restrictions on each of the parameters. Because only the case infants had faltering growth in the first postnatal year the following calculations are presented for case group subjects alone ( $n=47$ ). For the sake of simplicity we define a single outcome variable, the average of the MDI and PDI scores for each child. The model explained 37% of the variance in this outcome variable. Weight trajectory effects showed a significant independent effect ( $F(2,42) 4.12, p= 0.02$ , when restricting  $b$  and  $c$  to zero) as did cognitive stimulation ( $F(1,42) 6.59, p=0.01$ ) and the congenital malformation score (coefficient  $e$ ) ( $F(1,42) 8.61, p=0.005$ ). These parameter estimates suggested that sensitivity to growth failure was highest at birth (in this full term sample), and declined rather quickly with age so that by about 8 months sensitivity was zero. Growth faltering after that date had no further impact upon mental or psychomotor outcome. A test of no change over time in sensitivity to growth failure (i.e. restricting parameter  $c$  to zero) was strongly rejected ( $F(1,42) 6.43, p= 0.02$ ). The estimates for the initial sensitivity to growth failure (parameter  $b$ ) and the change per month in sensitivity (parameter  $c$ ) were remarkable stable, whether the combined MDI/PDI score was used in the analysis or whether they were entered as separate variables. What did differ was the relative importance of the cognitive stimulation

X

variable and the score of minor congenital abnormalities. In line with predictions, the former variable was more important for the MDI ( $p = 0.003$ ), ( $p = 0.3$  for the PDI) and the latter variable was more important for the PDI ( $p = 0.007$ ), ( $p = 0.05$ ) for the MDI.

The model suggests contrasting outcomes will be found for those with *early* or *late* growth failure. A child whose standardised weight begins to fall immediately after birth, from 0 SDS to -2 SDS uniformly over the first six months post-term, would suffer a loss of 10 points in predicted mental/psychomotor abilities in the second postnatal year. A child with the same ultimate loss of weight (by 10 months), but for whom the onset of the growth faltering was delayed by four months, would suffer a loss in predicted abilities of only 3 points. If the weight loss commenced only after 8 months of age the model predicts no detriment to mental abilities at all. No evidence was found to support the alternative hypothesis that this finding simply reflected a low birthweight or a longer duration of low weight-for-age among the infants with the worst outcome.

X

**Table 6.3: Coefficient estimates for the model relating growth trajectory to mental development**

	(MDI + PDI)/2	95% confidence intervals	MDI only	PDI only
<b>a</b> Regression constant	100.2	90.1 to 110.5	101.8	99.4
<b>b</b> Sensitivity at birth	8.0	2.1 to 13.9	8.2	7.7
<b>c</b> Change per month in sensitivity	-1.0	-3.2 to 0.0	-1.0	-1.0
<b>d</b> Effect of cognitive stimulation	2.1	0.4 to 3.8	3.2	1.0
<b>e</b> Effect of congenital malformation score	-6.45	-10.9 to -2.0	-5.5	-7.4

## **PART FOUR**

### **DISCUSSION AND CONCLUSIONS**

## CHAPTER 7. DISCUSSION AND CONCLUSIONS

### 7.1 General conclusions

The investigation aimed to test the main hypothesis that there would be an association between failure to thrive in the first postnatal year and detriment to mental and psychomotor development. The general design was intended to identify factors that would discriminate between infants who were failing to thrive - without organic disease or disorder - and comparisons who were growing within normal limits. The main hypothesis was confirmed, and a relationship was found between the severity of growth faltering in the first six postnatal months and the magnitude of the detriment to mental and psychomotor outcome at the commencement of the second postnatal year. The main differences found between case and comparison infants that reached conventional levels of statistical significance are shown in Table 7.1

### 7.2 Significance of findings as indicative of a 'sensitive period' for growth and mental development

We have shown that, in a population of otherwise healthy full term infants drawn from an inner city birth cohort, severely impaired somatic growth (weight gain) in the first six postnatal months is associated with poorer mental and psychomotor development in the second year. The degree of growth restriction alone seems to be of major importance. When the timing, duration and severity of growth faltering is taken into account by a relatively simple statistical model, it is possible to specify with a fair degree of confidence the magnitude of the detriment to mental outcome.

**Table 7.1** Summary of key differences between case and comparison groups

**Anthropometry**

**Parents:** mothers of FTT cases significantly shorter than mothers of comparisons

**Infants:** at birth: FTT cases higher ponderal index than comparisons. Comparisons longer with larger head circumference than cases

at outcome: (approx. 15 months): FTT cases significantly lower weight, length, weight for length and smaller head circumference

**Feeding histories**

mothers of FTT cases significantly less likely to waken their infants for feeds, or to persist with feed if infant sleepy

**Neurodevelopmental attainments**

Comparisons scored higher on composite index of gross motor skills (Touwen, 1976)

Cases obtained higher mean total abnormality scores on Schedule for Oral Motor Assessment (Reilly et al, 1995; Skuse et al, 1995)



Cases scored lower on both mental development index and psychomotor development index, on Bayley Scales of Infant Development (Bayley, 1969)

#### Temperament

Case children tended to be more 'difficult' than comparisons during the physical examination, according to Tester's Rating of Infant Behaviour Scale (Wolke, 1987a)

#### Nutritional intake

Both in respect of total energy intake offered/observed mealtime and total consumed by infant, cases obtained significantly lower values than comparisons

#### Mother's mental state

Case mothers obtained higher mean total scores on GHQ-28 (Goldberg and Hillier, 1979) than comparisons; indicating greater risk of minor psychiatric disorder

#### Mother-Infant interaction

Case mothers were significantly less sensitive to their infants during a feeding observation (Feeding Interaction Scale, Wolke, 1987b) than comparison mothers

Case mothers were significantly less controlling of their infants during play (Play Observation Scheme and Emotion Ratings, Wolke, 1987c). On the same instrument FTT infants were rated as showing more mouthing behaviour and less clarity of communication than comparisons

### Home environment

On the HOME scale (Caldwell and Bradley, 1984) highly significant differences found on 5 out of 6 subscales, with cases obtaining significantly lower scores than comparisons

Our finding begs the question, what was the aetiology of the growth failure of our case group children? Are we likely to be correct in assuming that the explanation is that they were all chronically undernourished? Mathematical modeling of the human growth curve has shown there to be two components in early childhood (Karlberg et al. 1987; Tse et al, 1989): the infancy phase, which commences at birth and is thought to be largely nutritionally determined, and the childhood component, which is dependent upon growth hormone secretion. The childhood phase begins to assume significance only toward the end of the first postnatal year.

Growth failure during the first postnatal year is hypothesised to indicate undernutrition in the absence of organic disease or disorder. The nutritional status of our subjects can be inferred from anthropometric indices such as weight for length and MUAC:HC ratio, even in developed countries (eg Thieriot-Prevost et al. 1988).

The majority of our case infants were seriously underweight for their length. This was not so for any child in the comparison group. Other nutritional indices were in line with the same conclusion, that case infants had indeed been chronically undernourished. However we cannot be certain about the mechanism by which this happened. Nor can we draw any firm conclusions about the relevance of that putative mechanism to their mental and psychomotor outcome in the second postnatal year.

## 7.3 Alternative explanations for findings on a 'sensitive period'

### 7.3.1 Introduction

It is unlikely that one explanation could account for all cases of growth failure in the case group. Evidence that there are probably at least two main mechanisms is presented in Chapter 5. Briefly, it was possible to partition, by a simple arithmetical procedure, the sample of growth faltering infants into two subgroups: those in whom the growth failure began immediately after birth, and those for whom it began 3 to 6 months later. Remarkably, the outcome for the two subgroups of infants was quite distinct in terms of mental and psychomotor development, but not in terms of anthropometric criteria. Mental development was relatively impaired only for those children whose growth failure began early; for infants in the *late* faltering subgroup it was no different to the outcome of the comparisons.

Surprisingly, the children with *early* growth failure came from relatively advantaged homes in which the burden of psychosocial adversity was actually lower than for the *later* growth faltering subjects; they were even slightly advantaged relative to the comparisons.

Essentially there are three possible explanations for the association we found between postnatal growth and mental and psychomotor development. Firstly, that the growth failure was primary and was due entirely to environmental factors. According to this explanation chronic undernourishment would have been the crucial factor, due perhaps to maternal neglect, and this led to an impairment of mental and psychomotor abilities which was proportional to the timing, duration and severity of the nutritional deficiencies.

Alternatively, poor mental and psychomotor development could have been the primary disorder, possibly due to pathology such as covert organic disease or congenital anomaly. We were of course unable to find other than tangential evidence in favor of this hypothesis. Manifestations of the underlying disorder could have included a disinclination to feed, or disordered development of oral-motor skills, both of which put the child at risk of being undernourished. Covert organic pathology may even have led directly to the growth failure.

Thirdly, both the growth failure and the mental and psychomotor outcome could have been due to the same underlying mechanism. There could, according to this explanation, have been a relatively subtle interaction between the characteristics of the child, which put it at risk (but did not reflect any underlying pathology) and the quality of parenting provided by the child's mother. The child's contribution to this interaction may merely have been a temperamental predisposition to be undemanding. A detrimental outcome would have been dependent upon the child's potentially nurturing environment failing to provide compensatory experiences.

### 7.3.2 Postnatal growth failure as the primary disorder

Considering first the hypothesis that the postnatal growth failure was the primary disorder, we did not find any evidence that case group children suffered any more serious or frequent infections during the first postnatal year than the comparisons. Nor was there any convincing evidence that the great majority of mothers were very neglectful of their children's welfare. We established during the course of home visits that adequate and suitable food was available for the index child, although we could not of course ensure that it was always given exactly

as the mother claimed. Only a handful of mothers had come, or subsequently came, to the attention of social services because of parenting difficulties. Nevertheless, we have evidence that this may have been the explanation for the failure to thrive of a small minority of the case group whose growth problem began in the latter part of the first year.

### 7.3.3 Covert organic disease or disorder

Secondly, there is the possibility that poor mental and psychomotor development could have reflected covert organic disease which was present at birth or soon thereafter, but was missed by our screening procedure. Certain metabolic disorders, such as subclinical thyroid deficiency, may have been responsible (Fisher, 1989) and might not have been detected. We did not routinely test for this disorder. However, besides the screening procedure undertaken with all subjects, nearly 1 in 3 cases was referred for further hospital-based investigation. Yet no positive findings of any significant metabolic or endocrine dysfunction were made.

All subjects have now been followed up for a further five years. They were traced and reexamined in 1991-2. These data are not presented here but are the subject of a separate thesis (Boddy, 1996). In the course of that investigation no additional cases of relevant organic disorders were identified.

Breitmayer & Ramey (1986) claimed that suboptimal perinatal status (as measured by the modified Prechtl index) could act with subsequent environmental 'insufficiency' as a cumulative risk factor in impairing infant mental development. We found no evidence to substantiate this hypothesis. We could not differentiate the cases from the comparisons, nor

the *early* from the *late* growth faltering infants on the basis of a history of antenatal or perinatal adversity.

Some case infants - especially those in the *early* FTT group - did have unusual physiognomies, although in no case was it possible to identify a recognizable pattern of human malformation. A small minority may have had a poor outcome in terms of growth and/or mental development as a consequence of a congenital disorder that could not be characterised as fitting any known syndrome.

The finding that in general case infants were born with heads that were small relative to their body length demands explanation. However, infants in the *late* FTT subgroup (whose mental outcome was no different to the comparisons) had heads that were no bigger on average than the *early* FTT subjects, whose mental outcome was relatively poor (see Skuse et al, 1994b). From these observations it seems unlikely that the poor intrauterine head growth of cases in general could be of great significance for the poor mental and psychomotor outcome of the *early* failing to thrive subgroup.

#### 7.3.4 Interaction between infant and maternal characteristics

The growth faltering and the poor mental development of the case group children could have reflected a subtle interactional disorder between the child and his or her caregiver. We do not have any measures of the children's temperament early in the first year, only at outcome in the second postnatal year. Stability of temperamental qualities is not to be expected over that period (Bates, 1987). Overall, we found no significant differences between cases and

comparisons in infant behavioural style at follow-up examination (Skuse et al. 1992). However, there was some evidence in favor of the hypotheses that there would be an excess of difficult, over-reactive, case infants, and that others would be sleepy and undemanding, consequently being at risk of not being fed regularly.

A proportion of case infants may have shown a relatively low motivation to feed, and poor communication of hunger signals early in postnatal life. We hypothesize that failure to thrive at the breast may have occurred in the group, as indicated by the fact that relatively more of the case infants were breast fed, and they were fed in this way for significantly longer than the comparisons. Undemanding behaviour is well recognised clinically in some infants who are failing to thrive, and appears to be a cause rather than a consequence of their growth problem (Skuse and Wolke 1992) . The behaviour could reflect a mild degree of delay in the development of normal cognitive processes, and thereby could account for their poorer mental and psychomotor outcome too.

We hypothesize that case group mothers may have failed to feed their infants adequately because they were passively responding to the child's demands, rather than actively keeping to a schedule of regular mealtimes. For example, many mothers admitted their children were often left to sleep through feeds, both during the day and overnight, rather than routinely woken (paras 5.4-5.5).

A further proportion of case group infants may have failed to thrive because they were difficult for their mothers to feed. Their mothers did not report a greater incidence of



feeding problems among case than comparison children. However, we have evidence from our own investigation of their oral-motor skills that those cases with the lowest weight-for-age at 3 months had the greatest difficulty eating solid food at 15 months (Skuse et al. 1994b).

Few children were weaned before 4 months of age. Weights at birth and after 3 months of age were not correlated with any abnormality in oral-motor functioning at follow-up. Our observation does suggest that there was a relationship between growth failure early in the postnatal period and later oral-motor dysfunction but it does not tell us the direction of the causal process.

Could it be that early failure to thrive impairs the development of brain circuits that are necessary for the control of complex oral-motor movements? Or is it more likely that infants with immature or dysfunctional oral-motor skills are difficult to feed in the first few postnatal months and so a degree of undernutrition ensues. This may be slight, yet its impact on growth would be greatest at that time because of the exceptional velocity of weight gain early on in the first year.

It might be supposed that the case subgroup whose growth faltered relatively late in the first year were undernourished as a consequence of feeding difficulties subsequent to the introduction of mixed feeding. We attempted to 'map' onto each child's growth chart the age at which solids were said to have been introduced. We aimed thereby to demonstrate that

there was an association with the onset of failure to thrive in the later cases, but no such simple temporal relationship existed (Skuse et 1994a).

### 7.3.5 Possible role of genetic influences

A number of alternative hypotheses which could explain the poor mental outcome for case group children also need to be considered. First, there is the potential role of genetic influences. These cannot be excluded unequivocally, but several strands of evidence against their importance can be cited.

No significant differences in mean IQ were found between case and comparison mothers. In any event, maternal IQ did not independently contribute significantly to the variance in either the MDI or the PDI. That finding is not surprising when it is considered that heritable variation in general mental development is believed to become increasingly important after infancy (Fulker, DeFries & Plomin, 1988). It has recently been shown the correlation between biological mothers' cognitive abilities and those of their adopted-away offspring is only 0.1 or so, at 1-2 years of age (Plomin, DeFries & Fulker, 1988). In other words, it is not to be expected that the intellectual abilities of mothers will account for much of the variance in their infant's mental abilities in the second postnatal year, independent of the parenting the child is actually receiving.

### 7.3.6 Indirect influences upon infant mental and psychomotor development

There may have been an indirect influence on mental and psychomotor development as a consequence of the growth failure. Young infants who are malnourished may become lethargic. Because of their lethargy they may be neglected or otherwise treated differently by their mothers, setting up a cycle of malnutrition and environmental isolation (eg, Chavez & Martinez, 1984; Graves, 1978).

We found the contribution to the variance in MDI at outcome attributable to concurrent cognitive stimulation was very similar for both *early* FTT and *late* FTT subjects. It was also similar for the comparisons. In all instances it amounted to about 10 percent.

However, we do not have any measures of the quality of the mother-infant relationship in early infancy. An explanation of the poorer mental outcome for those whose growth faltered soon after birth is that mothers in the *early* FTT group were more inconsistent than those in the *later* FTT cases and the comparisons. It is possible that they provided relatively less mental stimulation to their infants in the first few months after birth than they did later on, and that this relative neglect early in the child's life had an impact upon mental and psychomotor development that was still detectable in the second postnatal year. A summary of the main differences between *early* and *late* growth faltering infants and their families that reached statistical significance is shown on Table 7.3.6.

No difference between the *early* FTT and *late* FTT groups was found in terms of the cognitive stimulation observed to be provided in the second postnatal year. If relative neglect

Table 7.3.6. Summary of key differences between *early* and *late* failing to thrive subjects

#### Socioeconomic circumstances

Families of *late* growth faltering infants were significantly more likely to live in accommodation that was substantial, with dampness or drafts. They were significantly more likely to have times when there was no money in the house

#### Anthropometry

At birth: early growth faltering cases had significantly higher standardised birthweights (Tanner and Thomson, 1970) than *late* growth faltering subjects

#### Physiology

Both mean corpuscular haemoglobin and mean corpuscular volume were significantly lower in the *late* failing to thrive children

#### Neurodevelopmental attainments

Early growth faltering infants obtained significantly lower scores than both *late* growth faltering cases, and their pairwise matched comparisons, in respect of Mental and Psychomotor Development Indices (Bayley, 1969)

#### Mothers' mental state

Mothers of *late* growth faltering cases obtained significantly higher scores on

the GHQ-28 (Goldberg and Hillier, 1979) than the mothers of *early* growth faltering infants. They also obtained higher scores on a measure of anxiety (Zuckerman and Lubin, 1965), in terms of social dysfunction and on a measure of severe depression. They had significantly lower levels of social support

Mothers of the *late* growth faltering cases had mean IQs that were significantly lower than that of *early* growth *later* faltering subjects, in terms of verbal, performance and full scale scores

#### Mother-child interaction

On the HOME inventory (Caldwell and Bradley, 1984) mothers of *late* growth faltering infants obtained significantly lower mean scores in terms of involvement with child than those of *early* growth faltering subjects

during an earlier period of a child's life was the aetiology of the deficit in the abilities of the *early* FTT cases, mental abilities at outcome for infants with *early* growth faltering would have to be correlated more closely with what had been going on between mother and infant one year previously than what was happening contemporaneously. This is not a parsimonious hypothesis .

Alternatively, it is possible that poor nutrition early in postnatal life renders a child more vulnerable to a low level of stimulation, either contemporaneously or subsequently, than if it had been adequately nourished.

#### 7.3.7 Measure of mental and psychomotor development

The Bayley Scales are a widely used measure of infant performance, but they are not a good measure of 'intelligence' at 15 months, insofar as there is poor stability with developmental test performance at *later* ages. Bornstein and Sigman (1986 ) argued that traditional tests such as this depend largely upon sensorimotor tasks that depend on infant motor abilities or affective expressiveness. Such skills have little in common with processes that underlie intellectual performance in later childhood.

As an alternative Bornstein (1989a) suggested that measures of visual attention and habituation be considered as preferable measures of intellectual functioning in infancy. They are claimed to reflect basic information-processing abilities and are not subject to potential bias caused by the infant's affective expressiveness or motoric abilities, socioeconomic or

cultural variables. Several studies have shown that individual differences in information processing can predict later childhood IQ scores (see review by Bornstein 1989b).

We considered at the outset using measures of novelty preference (eg Rose et al. 1991) to assess infant cognitive abilities. However, the practical difficulties of arranging for children to be tested by these methods in their homes proved insuperable. Nevertheless, if the study were to be replicated with the aim of picking up children with growth failure much earlier in postnatal life, with a view to undertaking an intervention using a case-control design, it would be essential to use more sensitive measures of cognitive processing.

In summary, the reasons for the failure to thrive of our case group infants are likely to be varied. There are however grounds for drawing a distinction between those with an early postnatal onset, and those for whom the onset was later in the first year. We suggest different mechanisms were operating for those with onsets in the two time periods.

The children with the early onset of failure to thrive may have been congenitally vulnerable. We hypothesize they were relatively undemanding from birth. They did not complain when they were hungry. They also had poor oral-motor skills. Their mothers were relatively insensitive to their child's nutritional needs, were not assiduous in ensuring the infants were fed regularly. No one risk variable could be singled out as paramount. It seems plausible that, for this group, differences from comparisons were greater between the children than between the mothers of the two groups within the first six postnatal months.

Accordingly, we hypothesize that, if the *early* FTT children did not demand food they were not fed regularly. Perhaps when they were fed in those first few postnatal months they were not fed efficiently because of the oral-motor difficulties. However, it has not been possible to demonstrate that the severity of oral-motor dysfunction at outcome was any different in the two subgroups of failing to thrive infants. Nor were there any clear differences between the groups in the pattern of correlations between the degree of dysfunction and weights for age through the first year.

Children in the *late* growth faltering group also failed to thrive, we hypothesize, on the basis of a poor nutritional intake. But this is hypothesised to have come about because of relative neglect and/or infant-mother conflict. The children in this subgroup were growing reasonably well until the introduction of mixed feeding. It has not been possible precisely to map the onset of growth faltering in this subsample to the date mothers said they introduced solids. The accuracy of the information we were given on timing may have been inaccurate. A high proportion of children in this group also had dysfunctional oral-motor skills that may have made it more difficult for them to make the transition to solid food.

We hypothesize that infants in the *later* FTT subgroup were temperamentally relatively difficult for their mothers to manage. They did not respond well to change, and their mothers, who were generally of low intellectual abilities, were not sensitive to their child's individual needs. Their lack of sensitivity may have been due in large part to their lack of intellectual capacity.



It was among the *later* FTT group that the hypotheses there would be an excess of social and marital adversity among mothers of failing to thrive infants were confirmed. Mothers of these children were generally subject to a greater degree of psychosocial adversity than those of *early* failing to thrive infants, and a majority were probably clinically depressed.

Whether the growth faltering commenced early in the first year, or in the latter part, we hypothesize both mechanisms led to the child being fed a diet that was deficient in energy for growth. Because the deficit was not large the child accommodated to the shortfall by slowing the rate of weight gain. To an extent linear growth was compromised too, hence the reduction in length for age in case group infants after birth.

By the time of measurement in this survey, at approximately 15 months, the failure to thrive had persisted by definition for at least 3 months. An equilibrium between energy intake and energy needs for growth and other activities had been reached. In a sense the mechanism of growth retardation could be regarded as an adaptation to the environment, that environment being relatively deficient in energy availability. By the commencement of the second year the measured intake of Kcal per unit body weight was similar in the failing to thrive group to that of well-growing children. The anthropometric characteristics of both the *early* and the *late* growth faltering children were by that stage also very similar.

#### 7.4 Risk of later abuse or neglect

We hypothesised that the significance of 'non-organic failure to thrive' as an indicator of concurrent or future abuse or neglect has been exaggerated by former literature. Adverse social factors are likely to have influenced the referral of cases to hospital, from which 'non-organic' failure to thrive subjects were recruited in earlier studies (Skuse, 1993). Our own data have shown that only about one quarter of 'nonorganic' cases are likely ever to receive hospital investigation or treatment by the age of 4 years, at least in the inner city area of London in which we conducted our investigation (Skuse and Wolke, 1992). Accordingly, former follow-up studies of failure to thrive showing a substantially increased risk of abuse or neglect (eg, Goldson et al, 1976; Oates and Hufton, 1977) are potentially subject to ascertainment bias.

The data presented here suggest there is indeed a heightened degree of risk of subsequent child abuse or neglect among infants who have failed to thrive without organic disease or disorder. It appears to be in the order of 4 to 5 times that of other full term infants. Nevertheless only one in eight of the original cases had been subject to an investigation or an intervention for this reason by the age of 4 years.

This was the first study to identify the outcome of failure to thrive from a whole population prospective survey, rather than from retrospective analysis of records in children referred to child health clinics or hospitals for investigation of poor weight gain (Bithoney and Rathbun, 1983; Elmer et al, 1969; Fitch et al, 1976; Oates and Yu, 1971).

There are also a few investigations that have attempted to show the same risk factors, which are associated with abuse or neglect, predict a heightened risk of failure to thrive.

Such risks include low birthweight (Lynch and Roberts, 1982), and difficult temperament, mother characteristics (low social support and mental state), and family characteristics (low socio-economic status, poor quality of housing) (Oates and Peacock, 1984; Dubowitz et al, 1989; Hergenraeder et al, 1985; Newberger et al, 1986).

Although we did find low birthweight and prematurity to be important risk factors for abuse or neglect they were, because of our selection criteria, unrelated to our failure to thrive sample. Failure to thrive in a preterm/low birthweight sample, and failure to thrive commencing after one year of age, may be risk factors too but their magnitude will have to be determined by further investigation.

Because this study was conducted prospectively with a large whole population birth cohort it is inevitable that some bias will have intruded. Some 'at risk' families will have moved from the area surveyed during the course of follow-up, and were falsely assessed not to have abused or neglected their children. The overall proportion we identified as having been subject to an investigation of suspected abuse or neglect, or a related intervention, is (at 3.7%) in line with the health district's own figures of annual prevalence. At first sight this might suggest no such 'removal' bias was operating.

However, our figures include those whose names had ever been a cause for concern at some time as well as those who were still under review in 1990. In other words, the cumulative proportion of children who had at one time been a cause for concern, before

their 4th birthday, would be much higher than the annual prevalence figure.

Accordingly, 3.7% is almost certainly an underestimate of the risk of a child born in 1986 in this inner London health district having been identified as abused or neglected by their 4th birthday.

## 7.5 Summary

In conclusion, we have shown that, in a population of otherwise healthy full term infants drawn from an inner city birth cohort, severely impaired somatic growth (weight gain) in the first half year of life is associated with poorer mental and psychomotor development measured in the second year. The degree of growth restriction alone, especially an early sharp decline in growth trajectory, seems to be of major importance. When the timing, duration and severity of growth faltering is taken into account by a relatively simple statistical model, it is possible to specify with a fair amount of confidence the magnitude of detriment to mental outcome.

Our results are compatible with the findings of a number of previous studies which have suggested the first six postnatal months do constitute a sensitive period (eg, Lloyd Still, Hurwitz, Wolff & Shwachman, 1974; Cravioto & Robles, 1965; Chase & Martin, 1970; Carmona da Mota, Antonio, Leitâyo & Porto, 1990) as is our finding that growth restriction and cognitive stimulation contribute independently to mental development (eg, Bedi & Bhide, 1988; Grantham-McGregor, Powell, Walker & Himes, 1991). The degree of growth failure observed was equivalent to that described in malnourished children from developing countries (eg Karlberg, Ashraf, Saleemi, Yaqoob & Jalil, 1993).

We cannot at this stage state unequivocally that for the majority of our sample it was undernutrition *per se* that accounted both for the growth faltering and the detriment to mental outcome. This is a matter that will have to be investigated with a suitably controlled intervention study, designed to pick up potential cases as soon after birth as possible. However, it may be possible for others to attempt to replicate our findings on already existing longitudinal data sets.

The potential magnitude of morbidity caused by preventable growth failure in chronically undernourished at-risk populations is considerable if our findings are shown to be generalisable. The mean growth trajectories of children born into such communities fall rapidly soon after birth to levels far below international norms (eg, Karlberg et al., 1993). Assuming the influence of growth impairment is similar across the whole range of potential attainments, a mean decrease in a population's mental development score of only 0.5 SD (about 8 points) due to a uniformly poor rate of growth would result in a doubling of the number of subjects with intelligence quotients in the mentally retarded range (i.e. <70 IQ points).

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